# Understanding the Relationship Between the Biopsychological Development of Adolescent Boys and their Behaviour in the School Context


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This dissertation is submitted for the degree of
*Doctor of Education*

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December 2019

# Declaration

This dissertation is the result of my own work and includes nothing, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or whole, to any university or institution for any degree, diploma, or other qualification. Minimal qualitative data used in this dissertation was collected as part of a previous Master of Arts in Education degree awarded by the Open University.

This dissertation is within the prescribed dissertation word limit including headings but not including appendices, primary source material, illustrations, footnotes and references.

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# Abstract

*Puberty is associated with a period of psychological change concomitant with structural changes in the brain, particularly that of the prefrontal cortex. Recent evidence suggests an endocrinological relationship. In the context of education, the effect of these biopsychological changes on executive function, particularly social cognitive ability and that of behavioural responses to challenges in the school environment, is of particular interest to teachers, who are required to manage behaviour in the classroom, school leaders who devise behaviour management strategies and those in government who decide policy.*

*In this dissertation, potential associations were explored between plasma concentrations of cortisol and testosterone, physical development, psychological difficulties, social cognitive function and the behaviour of adolescent boys aged between 11 and 16 in the school context. It was conducted through the quantitative analysis of secondary data taken from the United Kingdom's Avon Longitudinal Study of Parents and Children (ALSPAC) followed by a case study approach for normal and extreme biopsychological outlier cases in the secondary school setting.*

*The research outcomes were not supportive of hypotheses that associate poor psychosocial outcomes with biological data in the general population. However, strong associations exist between biological measures, psychosocial problems and the behaviour of a small number of individuals with extreme biological and psychological values.*

*It was evident that some schools engage in exclusionary practices that may go against Government policy and may even be illegal. It is hoped that dissemination of the project findings and the recommended behaviour interventions will help schools to improve the inclusion and achievement of boys with challenging behaviour.*

# Acknowledgements

I firstly thank my supervisors, Dr Rosalind McLellan, Dr Ricardo Sabates and Ruth Kershner for their direction, advice and mentorship. This project was strongly supported by their knowledge, skills and dedication and without their encouragement, I may not have concluded this research. Their guidance has helped me develop as an academic and they have been sympathetic to my needs as a part-time doctoral candidate and researcher, giving encouragement during the inevitable periods of self-doubt and the extrinsic pressures that employment and life exerts on one during the doctoral journey. I should like to thank Ruth for her help with theoretical frameworks and structuring; Ros for her guidance in the practical aspects of data collection and analysis; Ricardo for his invaluable guidance and assistance with statistical analysis of the large secondary data set used in the project and Dr Aliandra Lazzari Barlete for her diligent proof-reading. I should also like to thank Richard Byers for his support and guidance both as my advisor and as the facilitator of the Wellbeing, Inclusion and Diversity Research Community. I am very grateful for the kind sponsorship of my employer, Anglia Ruskin University, in providing me with the funds to complete this project, including covering the costs of the secondary dataset and giving me time to complete my doctorate. I'm also very grateful to Linda Langham and Lynne Horsfall at the school where my research began[1] and Dr Bob Sproson, who was inspirational to me as my Open University M.Ed. supervisor. Finally, I wish to thank my family and friends for their support of my studies, particularly my civil partner, David Monk who has been a 'doctoral widower' since Michaelmas Term, 2012. My parents, Ivan Butler and Margaret Draper, have seen much too little of me as they should have during their twilight years. Everyone close to me has tolerated and, to an extent, absorbed my stresses and anxieties throughout this long doctoral journey.

[1] The school wished to remain anonymous. I am grateful to them for providing the first year of funding for my doctorate.

# Dedication

*This project is dedicated to all the children I have worked with and helped over the years as a teacher, head of year, mentor and friend, particularly members of the Class of 2013 Boys Academy who inspired my first research into adolescent behaviour in the school setting.*

**A former participant said:**

"Miss M is funny and doesn't nag so we behave. She just says things like, 'Stop talking or I'll staple your lips together."

"Miss F makes such a huge fuss about the smallest things, it's just not worth being naughty."

James, aged 13, May 2009

**A parent said:**

"My son has ADHD, which is a learning disability. If he had a physical disability the school wouldn't continually punish him, would they?"

Mr M. R., December 2008

**The Wind and the Sun**

THE WIND and the Sun were disputing which was the stronger. Suddenly they saw a traveller coming down the road, and the Sun said: "I see a way to decide our dispute. Whichever of us can cause that traveller to take off his cloak shall be regarded as the stronger You begin." So the Sun retired behind a cloud, and the Wind began to blow as hard as it could upon the traveller. But the harder he blew the more closely did the traveller wrap his cloak round him, till at last the Wind had to give up in despair. Then the Sun came out and shone in all his glory upon the traveller, who soon found it too hot to walk with his cloak on.

"KINDNESS EFFECTS MORE THAN SEVERITY."

Aesop Fable of the Wind and Sun

# Key words & terms

Adolescence

ADHD

Autism

Behaviour strategy

Biopsychology

Challenging behaviour

Conduct disorder

Inclusion

Physical development

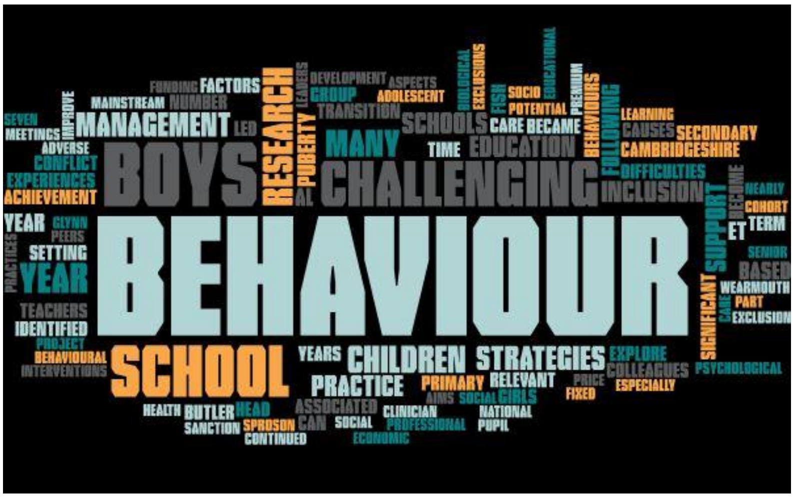
Psychosocial

Puberty

School behaviour

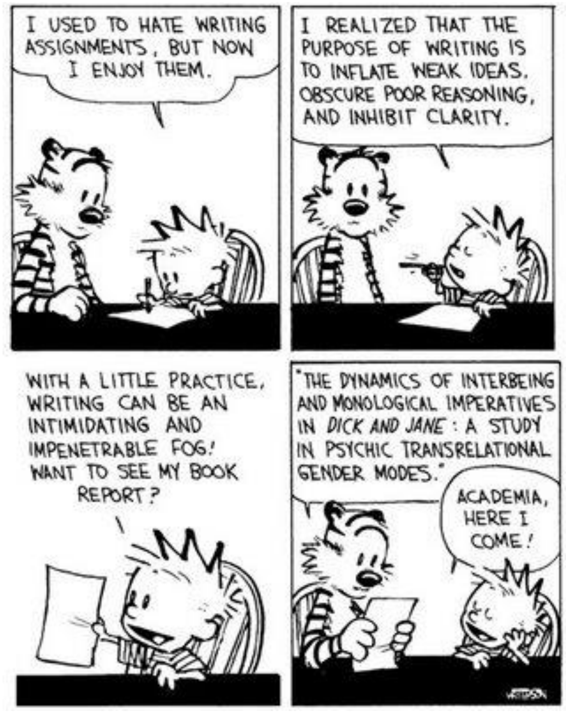
Social cognition

Word cloud generated based on the frequency of words used in the thesis.



# Writing Style

In accordance with academic convention, the writing of this dissertation is in the third person except for elements that provide a reflective account; here, the first-person writing style is appropriate. Sections within Chapter 6 are also reflective and are written in the first person. Where possible, American Psychological Association (6th ed.) guidance has been followed, which includes Times New Roman 12-point font, 1.5 line spacing and paragraph first line indentation. To follow best practice in supporting readers with literacy difficulties, left alignment has been used rather than justified alignment. For reasons of clarity, tables have been completed using the Arial font and are colour coded according to chapter to ease navigation.




***Calvin and Hobbes, "Academic Writing" ©1993 Universal Press Syndicate.***

From the inception of the project, I was determined to write in plain English as much as possible (my opinion is harmonised with the sentiments in the cartoon). A document with highly specialised content will inevitably need to include a rich vocabulary of technical terms and this dissertation is no exception. Much of the technical content has been written in a way that should be accessible to many senior and specialist teachers without a science background. It must be noted that footnotes are not a part of APA convention, but are included in this dissertation to improve the reader experience whilst at the same time, allowing an outline explanation of complex terminology and theories. Much of the biopsychological theory necessary to understand later chapters is introduced in Chapter 2.

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# Chapter 1: Introduction

The behaviour, inclusion and achievement of boys in the school setting have been of significant concern for a number of years as it affects not only their wellbeing, but that of their peers and teachers (Sproson, 2004; Wearmouth, Glynn, et al., 2004). The behaviour exhibited by a few boys is so severe that it presents significant challenges to teachers and school leaders, especially when considering the recent decline in the number of specialist places for children with behavioural, emotional and social difficulties (BESD) (Price, personal communication, 2011). This project aims to explore potential biological and psychological correlates with adverse adolescent behaviour in boys to inform the development of future strategies or interventions to support their inclusion in mainstream education.

## 1.1 Background of the Study

I was a Teacher of Science, Information Technology, Health and Social Care between 2005 and 2016. Before that, I was a medical scientist and paramedical clinician. I held a senior lectureship in biomedical aspects of clinical practice at the University of East Anglia and continue to practice part-time as an emergency care clinician for the National Health Service. These experiences led me to develop an interest in behaviour management, learning disabilities and pastoral care shortly after beginning my career as a teacher in 2004 in rural Cambridgeshire, England.

In 2008, I was appointed Head of Year[2] for the Class of 2013 who were at that time in their last term of year six attending partner primary schools[3]. During preliminary transition meetings with primary school colleagues, it became apparent that the cohort had within it many boys with challenging behaviour. Several professional concerns developed regarding non-inclusive, sanction-based strategies that were unsuccessfully employed to improve their behaviour. Such strategies included fixed-term exclusions[4], managed moves between schools,

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[2] A senior member of school staff, usually a qualified teacher, who is responsible for the discipline, progress and pastoral care of students in a year group.
[3] In the UK, year six is the final year of primary education for children aged between 10 and 11.
[4] Fixed-term exclusion is a period of suspension from school and legally may only be sanctioned by a headteacher. It can last between 1 and 45 days.

internal exclusion (isolation from lessons working with senior teachers), being on report[5] and detentions. These practices continued into year seven, still without success.

Nearly all the boys were from families in the socio-economic classification categories 5 to 8[6] (Office for National Statistics, 2010). Their schools received additional funding to support these children in the form of the Pupil Premium Grant (GOV.UK', n.d.). Many of them had been identified as having 'special educational needs' such as dyslexia, moderate learning difficulties or developmental disorders such as Attention Deficient Hyperactivity Disorder (ADHD). In a November 2014 analysis of whole-school (years seven to eleven) fixed-term exclusions in the same setting[7], 47% of those excluded were on the Special Needs Register and 80% were allocated Pupil Premium funding, providing evidence of a relationship between poverty and disadvantage. The most common cause of exclusion was verbal abuse or threatening behaviour against an adult (Annual Exclusion Data for Fenland District Schools, Cambridgeshire, 2014). Interestingly, evidence suggests that many adolescents with challenging behaviour will become aggressive and challenge those in authority if they have been adversely affected by their experience of school behaviour policies, that is, those that punish indiscriminately, especially in cases where the child has a psychosocial difficulty (Fayso, 2018; Mota et al., 2016). Furlong (1991), blames the movement of school practices in the 1980's to become more 'policy-relevant' (i.e. policies that are constructed from research based on identified groups) rather than relevant to individuals with challenging behaviour. Demonising individual children, labelling them as 'deviants' frequently fuels a self-fulfilling prophecy (Wearmouth, Richmond, & Glynn, 2004). They also feel resentment at what they perceive to be the biased application of unjust rules by school staff (Butler, 2010).

Exclusion from school is associated with poor socio-economic outcomes in adult life and males are affected more than females, manifested in youth unemployment, youth crime and educational underachievement (Centre for Economic Performance London School of Economics, 2007; Shepherd, 2010; Younger et al., 2005). Analysis of school leavers' destinations for the year group supported this assertion: 98% of the cohort entering post-16 education or employment with training compared to only 47% of boys and girls with

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[5] Being on report means that the child is given a report card which must be signed by the teacher after every lesson, mostly commenting on behaviour. A senior teacher monitors children on report and will give sanctions in response to adverse comments.

[6] The National Statistics Socio-economic classifications are widely used in the UK for official Government statistics and research. The 8 class version categorises "higher managerial, administrative and professional occupations" as class 1 with "never worked or long-term unemployed" as class 8. Class 5 is "lower supervisory and technical occupations."

[7] The school in this case wish to remain anonymous so have not been named for ethical reasons.

challenging behaviour ('Targeted intervention for students not in education, employment or training (NEET)', 2013).

Consideration of these complex and often interrelated factors and their possible relationship to the behaviour of the boys with challenging behaviour in my care, inspired me to undertake relevant post-graduate studies. I took a masters degree in education hoping the knowledge and skills gained would help improve their behaviour, achievement and inclusion in mainstream education (Butler, 2010). As part of this programme, I conducted research into potential causes and effects of the participants' disruptive behaviour. The principal findings were: (1) that the behaviour of many boys with challenging behaviour is resistant to punitive, sanction-based strategies; and (2) that there are indeed diverse, complex and interrelated causes of challenging behaviour and so individualised assessments of specific difficulties followed by personalised behaviour support plans are imperative to support behaviour and inclusion. My research lacked the scope to investigate fully the factors that contribute to challenging behaviour, which is a major theme of this doctoral research. My professional experiences and prior research placed me in a position to undertake this project and disseminate the findings which will hopefully benefit a significant number of children, their peers and schools.

Dialogue with colleagues, school leaders and articles in publications from teaching unions about aspects of practice relating to behaviour management show a lack of understanding of many of the common neuropsychological and biological changes associated with puberty. These include a combination of anxiety, stress, risk-taking and impulsive behaviours, defiance, disruption to cognitive and social cognitive function among other factors. Following day-to-day discussions with colleagues, parents and professionals from organisations such as the Locality Team[8] and Social Care[9], it is the subjective opinion of many in my experience, that children with challenging behaviour are simply 'naughty' and that their behaviour is merely the result of their upbringing or sociocultural influences. I am a proponent of the view of many behavioural scientists who claim that puberty is a normal constituent of human development; but that, in some individuals, the psychological effects

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[8] Locality (District) Teams are local government led organisations. They coordinate education, care and legal services around children in need aged 0-19 and their families.

[9] Social Care for Children, sometimes called Social Services for Children are also the responsibility of local government, which most of the accountability held by specialist social workers. Responsibilities include safeguarding and making sure that adopted children or those in care homes or foster placements are cared for.

result in exaggerated and deleterious behaviours that often lead to conflict (Ge, Conger, & Elder, Jr., 2001; Inoff-Germain et al., 1988; Sproson, 2004). I can see no advantage in punishing an adolescent for exhibiting adverse behaviours associated with puberty. Any research that aims to explore the origins or nature of challenging behaviour as boys traverse puberty and explores positive behaviour support strategies for them can be justified in terms of inclusion, achievement, prospects and the moral dimension.

**1.2 Problem Statement**

I became interested in boys' behaviour and in their involvement as research participants, following my experiences as Head of Year, since nearly all the children with challenging behaviour I supported in that role were boys. As Head of Year, I was responsible for overseeing the welfare, discipline and academic progress of all children in my year group, however, the overall behaviour of the girls was not problematic.

> *"The girls are all lovely, but the boys are a nightmare."*
> *"You couldn't pay me enough to be their head of year, the boys are vile."*
> *"Oh Simon, what have you done? They're awful. The best thing you can do is lock yourself in your office with a large bottle of gin and come out again in five years time!"*

(Year Six Primary School Teachers' comments
during transition meetings to secondary school, 2008).

The school behaviour management policy plus established practice required me to be very firm and decisive in my management of these boys. I responded with the usual battery of sanctions and admonishments that is standard practice in secondary school (Cambridgeshire County Council, 2010; Greene, 2009; Price, 2008). During their first year, of the thirty boys identified as having challenging behaviour, the behaviour of sixteen of them drastically improved. As no investigation was conducted to explore the reasons at the time, it is difficult to state for certain why this improvement occurred. Current theories suggest that boys jostle for position in a developing hierarchy following transition and that this causes conflict. 'Big fish in a little pond become small fish in a big pond' following the move to secondary school, where the dominant 'fish' from a collection of smaller primary schools are thrown together to 'fight it out' (Jindal-Snape & Miller, 2008; Pellegrini & Bartini, 2001; Pellegrini & Long, 2002). After a few months, conflict is significantly reduced as a new and stable hierarchy is established.

However, despite my best efforts in robustly applying the expected behaviour management strategies, there remained fourteen boys whose behaviour continued to be highly problematic. In the setting, heads of year led their year groups for five years (until they left school at age sixteen). It became obvious that a strategic review was required. I enrolled on a research-based behaviour management course, which led me to set up an experimental group dubbed by a colleague 'The Boys Academy' (Butler, 2010). The sessions provided solution-focussed interventions to help them manage their own behaviour. These helped some of the remaining boys and, as their behaviour improved, they 'graduated' from the Academy leaving nine boys whose challenging behaviour was resistant to the interventions provided. Five of them continued to risk permanent exclusion from school due to severely disruptive behaviour that, in some cases, caused risk to others. It was apparent that these boys required a detailed analysis of their behaviour and assessment of needs followed by tailored intervention to help them develop coping strategies.

> *"There is not a single, 'one size fits all' approach to the different needs of children with emotional, social and behavioural difficulties (ESBD). [...] we found no blueprint in terms of systems or particular approaches for the effective inclusion of pupils with ESBD in every mainstream school."*
>
> (Visser et al., 2002, p. 23)

Sproson (2004, p.77) writes of a "metaphorical suitcase" in which, as an experienced adult, he has a variety of items that help him cope with aspects of life. A student with challenging behaviour may only have a "smelly sock and dirty underwear in theirs with no choice but to use them." Two of the boys would not engage in times of conflict and several appeared to lack the ability to link their behaviour to consequences such as bullying, poor achievement and exclusion. My intention, by setting up the Boys' Academy, a solution-focussed intervention group, was to help the boys add useful items to their 'suitcases.' I hope to explore further interventions to support the inclusion of boys with challenging behaviour using knowledge gained by the completion of this project.

Chapter 1: Introduction to the Study

The boys were fascinating participants and later became interested in the masters research in which they were participating. Some of my research findings are relevant to this doctoral research. For example, some of the boys developed their social cognitive skills with age and progression through puberty. Some became less impulsive and less engaged in poor behaviour as they appeared to develop an appreciation of the potential risks and consequences of such behaviour. I have included a study of these aspects of executive function in this project to discover if development in this psychological domain reduces the incidence of adverse behaviour.

It is known that hormone levels, including those of androgens, can fluctuate. Hormones, especially androgens, are known to have significant correlates with behaviour (Johnson & Everitt, 2000) and I was able to verify this in my previous research. One boy personified behavioural changes that are associated with puberty. At the time of onset of puberty (self-disclosed), there was a dramatic change in his personality and behaviour. He faced serious sanctions in school for poor behaviour, there was a decline in his achievement. He became moody, defiant, and unkind towards others with an apparent lack of empathy with them. There was evidence of a lowering of social cognitive ability in that his predictive adeptness of the probable actions of others declined significantly. He was also arrested twice (theft and the outcomes of anti-social behaviour). He found these psychological changes very upsetting, confusing and frustrating. Approximately a year later, concurrent with a slowing of growth, there was an almost complete reversal and, except for an increase in social and cognitive maturity, his personality reverted to that of pre-adolescence. This led me to question if testosterone or other psychobiological aspects of puberty played a role in his difficulties. Two other boys experienced cyclical changes in their behaviour as they progressed through puberty.

The behaviour, engagement and achievement of boys has been a concern for successive governments as well as researchers and educators (Ofsted, 2008; Younger et al., 2005). With a significant body of evidence to suggest that puberty is occurring at an increasingly younger age in boys (Chalabi, 2013; Moorhead, 2010; Parent, 2003), such concerns are likely to become even more prominent in the future. As larger numbers of boys enter puberty at a younger age, schools and teachers working in the upper primary and secondary settings need to consider how changes in cognition and behaviour will be accommodated and supported. Assessment of need and sound interventions such as nurture groups, solution-focussed interventions, supportive timetabling with withdrawal sessions, could offset any potential deficit in behaviour and learning that earlier puberty may bring. These would be applied to individuals and groups of boys according to assessed need, including pubertal stage, social cognitive ability and behaviours such as risk-taking and impulsivity.

My personal experiences and review of the literature lead me to conclude that boys are the most suitable research participants within the context of school behaviour. Although some girls also demonstrate challenging behaviour, boys are more commonly excluded from school and those who are excluded from school are more likely to end up in prison or a young offenders' institution (Parker et al., 2016; Shepherd, 2010). The challenging behaviour of boys appears to be more resistant to change and some boys seem to lack social cognitive skills with a predisposition towards impulsivity and poor risk aversion. The endocrinological (hormonal) factors associated with puberty and behaviour are less complex to study in males (Johnson & Everitt, 2000). As part of this project, I have conducted an analysis of existing biomedical, psychosocial and behavioural data collected as part of the Avon Longitudinal Study of Parents and Children (ALSPAC) project (Pembrey & ALSPAC Study Team, 2004). I focussed specifically on a comparison of plasma testosterone assays, pubertal staging, psychosocial data and school behaviour data (Section 1.7).

In summary, despite the robust application of school-based behaviour strategies and common interventions, the challenging behaviour of some boys is resistant to change. There are several possible reasons for this that include features from the domains of psychology, endocrinology and biophysiological development in adolescence. These may be linked to behavioural themes such as poor coping strategies including poor social cognitive function. In this dissertation, I propose to analyse these factors in depth by exploring those relating to the challenging behaviour of some adolescent boys.

**1.3 Purpose of the Study**

My research aim is to explore factors associated with the behaviour of adolescent boys, particularly in the context of the school setting. These include biological factors relating to the physical changes associated with puberty and psychological factors such social cognition and challenging behaviour. It is hoped that the evidence obtained through this research will support a model of behaviour provision that is inclusive in the mainstream school setting for boys exhibiting challenging behaviour, based on an understanding of their responses to psychological and biological factors.

### 1.4 Research Questions

The principal research question is, “Do associations exist between endocrinological factors, pubertal stage, social cognition and the behaviour of adolescent boys in the school setting?” The following questions will be explored.

(a) Does the behaviour of adolescent boys change in school as pubertal development progresses?

(b) Are endocrinological factors, particularly plasma testosterone and cortisol concentrations, associated with adverse behaviour in the school setting?

(c) Do relationships exist between biological factors (pubertal stage, testosterone and cortisol levels) and psychosocial functioning?

(d) Is there a relationship between psychosocial measures in adolescent boys and their behaviour?

## 1.5 Nature of the Study

The focus of this study is to identify factors that contribute to the deleterious behaviour of some boys, principally in school. Some factors, such as pubertal stage and other anthropometric and biomedical data including hormone assays, would involve intrusive investigation, inappropriate in the school setting. This quantitative data already exists within ALSPAC and has been obtained for use in this project. From the project conclusions, intervention design might follow as part of a post-doctoral project follow-up.

The ALSPAC project resulted in an extensive resource of phenotypic, environmental, genetic and linkage data collected over twenty-five years from children born in the 1990’s and their families. Data is grouped into responses to questionnaires, biological measures and clinical records. These data, amount to thousands of variables collected from more than 15,000 families and are available to other researchers upon payment of a fee. An outline of the ALSPAC variables acquired for the purposes of secondary data analysis are as follows.

**1. Calculation of Tanner Staging (Section 1.8) at ages 10, 12, 13, 14, 15, 16 & 17 years from the following variables:**

- Genital development (development stage of penis, scrotum and testicular volume in millilitres measured using a Prader orchometer);
- Pubic hair distribution using a standard chart;
- Axillary hair, absent or present;
- Voice change – deepening of male voice due to laryngeal enlargement in puberty;
- Body Mass Index – a function of body mass (kg) divided by the height squared ($m^2$) - height growth velocity accelerates during puberty;
- Determination of each participant's Tanner Stage follows an established formula (Tanner, 1978).

**2. Endocrinological salivary assay data in nmol/l (footnotes 1 & 2, page 12):**

- Testosterone at age 15;
- Cortisol at age 8.3;
- Plasma testosterone concentrations at ages 7, 9, 11, 13, 15 & 17;
- Sex hormone binding globulin (SHBG) concentration at same ages.

**3. Social cognitive variables:**

- Social & Communication Disorders Checklist (SCDC)at ages 11, 13 & 16 years;
- Strengths and Difficulties Questionnaire (SDQ) data divided into scores for emotional symptoms, conduct problems, hyperactivity problems, peer problems, prosocial and impact on daily living at ages 9, 11, 13 & 16 years.

**4. In-school behaviour variables:**

- One detention as punishment in past year;
- More than one detention in past year;
- Has been fixed-term excluded (suspended) during past year;
- Has been permanently excluded (expelled) from school;
- School has contacted caregiver with concerns about behaviour in school during past year;
- School has contacted caregiver due to child's attitude to school or schoolwork.

## 1.6 Theoretical Foundation

It is not possible to understand young peoples' behaviour without looking into the biological structure of human beings, particularly that of the brain. Over the past ten years, many histological and magnetic resonance imaging studies have shown that several neuroanatomical changes occur around the time of commencement of puberty in brain regions implicated in social cognition and behaviour. The most notable changes include: (1) a decrease in pre-frontal cortex (PFC) synaptic density during a period of 'synaptic pruning' and (2) a decrease then increase in PFC grey matter density (Choudhury, Charman, & Blakemore, 2008). Synapses occur between networks of neurones where the actions of nerve impulses are modulated by chemical neurotransmitters and in some cases, by hormones. Grey matter is comprised of the cell bodies of nerve cells and therefore give an idea of the number of neurones present in a given brain area. Both neurotransmission and the number of active neurones correlate with function, including the manifestation of all forms of behaviour (Carson, 2007). Although undertaking functional neuroimaging of participants is beyond the scope of this project, inferences derived from known structural and functional changes during adolescence can validate investigation of research question (a) that the behaviour of adolescent boys changes as pubertal development progresses (Sisk & Zehr, 2005).

The anatomical changes associated with puberty such as physical growth and the appearance of male secondary sexual characteristics are due to a dramatic increase in serum levels of gonadotropins[10] and sex steroid hormones[11] including testosterone. Sex hormone binding globulin (SHBG) is reduced by 75% in boys at the point of puberty and so could be used as a reliable marker of pubertal onset (Khairullah et al., 2014). Cortisol, another steroid hormone, released in response to extrinsic stressors, is also implicated in the personality of adolescent boys and externalising behaviour including aggression (Lenneke et al., 2008; Shoal, Giancola, & Kirillova, 2003). Although cortisol levels fluctuate in response to stressors, a high residual level could correlate with adverse behaviours. Testosterone has been implicated in mediating a neurological processing shift from the prefrontal cortex to the brainstem, associated with primitive ‘fight, flight or fight’ responses to threat. This can lead to social aggression in the case of fear of a proximate threat (Booth, Granger, Mazur, & Kivlighan, 2006; Honk, Terburg, & Bos, 2011). This may explain why boys whose behaviour is challenged by staff in school sometimes flee or respond aggressively. Other deep brain structures such as the hippocampus and amygdala are associated with experiential learning including avoidance of past negative experiences such as the guilt and anxiety of being in trouble or experiencing punishment (Zitzmann & Nieschlag, 2001).

High plasma concentrations of both hormones would support an association between endocrinological factors and difficult to manage behaviour in boys (Research Question (b)).

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[10] Gonadotropins are protein hormones secreted by the anterior pituitary gland. They include follicle-stimulating hormone (FSH) and luteinizing hormone (LH) both relevant to the regulation of growth, sexual development and reproduction. FSH regulates the growth, development, pubertal maturation and reproduction. In males, LH stimulates Leydig cell (specialised cells in the testicle) production of testosterone. Some testosterone is produced in the adrenal glands also (Johnson & Everitt, 2000).

[11] Sex steroids are often referred to as “sex hormones”. In males, they are principally produced in the testes the most important of which is testosterone, which has a masculinizing effect associated with testis and prostate size, increased musculoskeletal mass and the growth of body hair. It has also been associated with brain masculinisation and aggressive behaviour (Booth, Granger, Mazur, & Kivlighan, 2006).

SHBG data could allow a comparison with variables relating to pubertal stage gathered by questionnaire.

However, not all boys exhibit challenging behaviours during puberty. Should testosterone levels show the same projection during puberty in all boys, it is feasible that some are more susceptible than others to its effects (Shoal et al., 2003). Some individuals show increased receptor sensitivity to hormones and drugs, which would make the effect of testosterone more potent. A possible genetic basis to androgen receptor sensitivity has been proposed (Waal, 2005). It could be that receptor sensitivity to testosterone could cause an increase in adverse behavioural effects in adolescents rather than the plasma concentration *per se*.

Commonly, executive function is a term used to describe an individual's capacity to control and coordinate their thoughts and behaviour (Baggetta & Alexander, 2016). Social cognition is the encoding, storage, retrieval and processing, of information in the brain, which relates to conspecifics and their behaviour. It is a skill subset of executive function that includes psychosocial aspects of personality that allow appropriate social interactions and expectations and the ability to understand and accept the viewpoint of others. All these skills are essential for collaboration and appropriate behaviour in the learning environment (Meltzer, 2010). Evidence cited in two separate studies suggest that boys with challenging behaviour have difficulty attending to, or accurately interpreting, social cues and have a poor perception of social nuances. Several other theories also propose that social information processing skills may be lacking in some individuals, explained by their different reactions to the same situation, including maladaptive behaviour (Crick & Dodge, 1994). Erdley et al., (2010) cite the example of two children who are teased in the same way by their peers. One may perceive this as play and respond by laughing whereas the other may interpret it as threatening and respond aggressively. A correlation may exist between social cognitive ability and adverse responses to actual or perceived actions of others. Furthermore, biological changes during puberty (brain structure, physical development with the implication of endocrinological influences) provide support for a potential relationship between these factors and social cognitive function in adolescents (Research Question (c)).

Although causality is implied by potential associations between variables, data sourced from ALSPAC may support alternative associations or ideas, thus providing evidence that would support further investigation in the qualitative stage of the project.

## 1.7 Brief Conceptual Framework

In this Section, the conceptual framework is briefly discussed to add clarity to the discussion in the remainder of this chapter. It also sets out the broader themes which will be further explored in the literature review (Chapter 2). Figure 1.1 includes all of the project's theoretical themes linking those that are pertinent to the literature review. Although the model allows probable causalities to be explored and considered, no causal relationships are implied at any stage. This conceptual framework is deliberately holistic and non-hierarchical because it is probable that the various components relate to, and exert influences, on each other. Inferred relationships are illustrated with directional arrows in Figure 1.1.

Miles and Huberman (1994) state that a conceptual framework may be presented in diagrammatic form with or without narrative (Figure 1.1), which is the case here. ALSPAC test instruments used to assess each area of interest are in yellow in Figure 1.1 along with the aspect that they assess. For example, the endocrinological component of biological factors will be analysed using ALSPAC testosterone, SHBG and cortisol assay data. Topics included in this conceptual framework that are relevant to the study are fully discussed in Chapter 2 along with a brief outline of exclusion criteria.

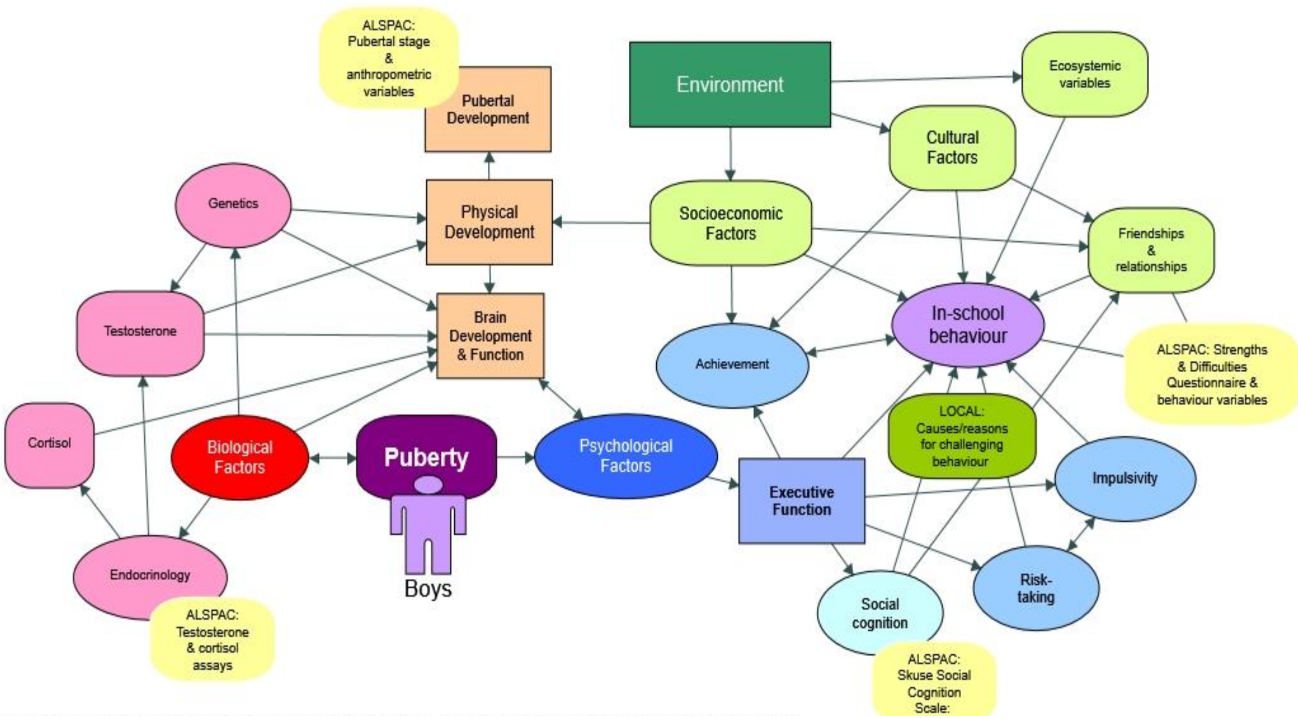


*Figure 1.1: Conceptual framework illustrating all pertinent considerations at the commencement of the literature review.*

Note that I am aware the theories which I will introduce in Chapter 2 give perspectives that may affect the study outcomes. For instance, although this study focusses on biological and psychosocial outcomes associated with puberty, there are many other, principally extrinsic factors that may influence outcomes during analysis. These theoretical debates will be addressed in Chapter 2.

### 1.8 Scope, Delimitations and Limitations

There are several boundaries to this project, all of the data for which comes from a secondary dataset (ALSPAC), not primary data collection. All the ALSPAC data was generated from participants born and growing up in the Avon area of Somerset, including towns, villages and farming communities, excluding the affluent city of Bath. In 1991, the population of the area was ~0.9 million, with ~0.5 million residing in the City of Bristol (Bristol, n.d.-b). Although the study includes participants from differing socioeconomic groups, the cohort is not ethnically diverse with over 95% of continuing participants being white British or European compared to a national consensus report of 7.6% being 'non-white'. Nationally, 14% of secondary pupils identify as being 'non-white' compared with 8% in the study (Boyd et al., 2013). The South West of England ranks fourth highest in terms of disposable household income. So, although there were advantages of a regional study, in terms of external validity, these have been offset when generalising ALSPAC findings to the national population. However, for the purposes of this project such regionalisation is unlikely to be problematic since the variables of interest are unlikely to be specific to local UK populations. For example, pubertal development, social cognition and in-school behaviour would not be expected to show regional variation. Causality cannot be proven or supported since the data relating to psychosocial and behavioural variables is observational. No assumptions have been made that are critical to the meaningfulness of the study except those required as an inevitable part of statistical analysis.

## 1.9 Signposting

This dissertation follows the form of a traditional scientific methods study. Following this introduction, a review of the literature takes place (Chapter 2). This informed the research questions and provides important background information to help the reader understand some of the scientific concepts discussed during the methods chapter (Chapter 3), quantitative analyses (Chapter 4) and the case studies involving participants constituting extreme biopsychological outliers (Chapter 5). The methods chapter and Appendix 5 includes justification for the inclusion and exclusion of some of the ALSPAC variables in the data analyses. Finally, Chapter 6 concludes the dissertation with a discussion of the implications of the study findings together with recommendations and concluding remarks.

# Chapter 2: Literature Review

## 2.1 Introduction to the Literature Review

As well as providing a critical review of the literature, the purpose of this chapter is to provide information and clarification of behavioural and psychosocial concepts from a bioscientific viewpoint to make clear their application in the educational context. These arguments contextualise elements of behaviour and determine what aspects need to be explored in the study and are presented in such a way that is clear to educationalist readers and others from non-scientific backgrounds. A traditional critical review of the literature scrutinises and searches for gaps in the literature or provides conflicting evidence or accounts, which will be included in the Chapter when relevant to either providing knowledge or context for the study and to justify the choice or exclusion of measures relating to the study research questions. Although the secondary (ALSPAC) dataset provides a rich source of data, there are limitations regarding many of the variables that are available to this project. Limitations relating to the available variables were discussed in Section 1.9. As this project solely uses ALSPAC data, there are 'gaps' in the literature, the omissions of which will not be pursued, particularly if they are less relevant within the context and confines of this particular doctoral study. In the methods Chapter and Appendix 5, a justification is made for matching what could be included against what can actually be, bearing in mind these gaps.

Many theories have been proposed to explain the behaviour of adolescents. Such theories relate to the domains of psychology, neurobiology, endocrinology and extrinsic (environmental) factors such as culture, socioeconomic status and the learning environment (ecosystemic variables). Although the literature is rich with such theories, this review will focus upon three major themes that are of contemporary interest and that are of most relevance to this research project: (1) physical development (neurobiology, endocrinology and the assessment of physical development); (2) social cognition, a domain of executive function (psychology, neurobiology and endocrinology); and (3) behaviour in school (all domains). As they are inextricably linked, their sub-categorisation is only for the purposes of clarity in the context of this review. However, as the study findings relating to these three principal domains are likely to be influenced by the extrinsic factors stated above and summarised in the project conceptual framework (Section 1.7), this literature review includes a brief outline of environmental and ecosystemic themes (Section 2.2). An exploration of the relevant psychosocial theory relating to adolescence, the nature of which itself is also explored as it adds dimension to the participants from whom data was collected (Section 2.3), will also be explored. Biological factors relevant to the study themes are reviewed in Section 2.4.

Relevant psychosocial and behavioural theories are discussed in the context of this study in Section 2.5.

This systematic literature review took place between October 2012 and September 2013 with a revision undertaken just before completion of this dissertation, in 2019. As well as using the University of Cambridge Library iDiscover web-based search engine, the following databases available via the Faculty of Education Library were used to search for literature:

- British Education Index
- Child Development and Adolescent Studies
- Education Information Resource Centre
- PsychINFO

Relevant articles were retrieved including those from journals, papers and reports. The author's own works, personal communications, handouts, conference papers, employers' documents and course study materials were organised, stored and annotated within Zotero[12]. No specific search exclusion terms were used due to the diverse nature of the project in development, rather broad inclusion terms were used such as 'pubertal self-assessment' or 'puberty AND social cognition'. In some cases, article reference lists were reviewed in detail to find other publications. The following approximate numbers (in parenthesis) of papers in each discipline were studied: educational neuroscience (15); psychological testing (7); impulsivity and risk taking (7); interventions (19); interviews and questionnaires (9); puberty, growth and endocrinology (25); research methods (13); cognition including social cognition and executive functioning (27).

To assist with the writing of this review, a novel process of cataloguing the literature collection in nVivo®[13] was devised. A series of 'nodes' (categories in nVivo) relating to each aspect of the study were created, then annotated literature sources were allocated to single or multiple nodes. When writing each section of the registration portfolio and this dissertation, relevant articles were easily located using nVivo then referenced using Zotero.

Although the literature presents themes that are generally relevant to this project, their context varies. This literature review will, therefore, contextualise the literature so that the primary focus is its application to boys' behaviour in the school-setting. The main themes

[12] Zotero is an open source bibliographic software that allows note-taking and highlighting of downloaded sources.
[13] nVivo is specialist software designed for the input and analysis of qualitative data such as video evidence, recorded and transcribed interviews, etc.

have been summarised and considered in relationship to their place within the study's conceptual framework.

## 2.2 Extrinsic and Environmental Factors

A doctoral research literature review is not required to be a detailed review of all the pertinent literature, rather it is an argument for the study and an investigation of publications that relate closely to the particular research questions (Bryman, 2008). In this section, an *outline* is given of themes that may be important when considering boys' behaviour but are beyond the scope of this project, rather than a detailed discussion of the literature relating to all of the themes included in Figure 1.1 (Section 1.7). These outlines were considered when the findings of data analyses were interpreted in Chapters 4 & 5).

It is believed that environmental factors, such as socioeconomic, cultural and ecosystemic variables, influence all theoretical levels within the conceptual framework. They may directly affect behaviour in school or exert effects via friendships and other interpersonal relationships. For example, diet, exercise and the built environment are known to influence physical and psychological development and behaviours. Compelling evidence exists to support the idea that other extrinsic factors influence the behaviour and learning of children and young people linked with planned and unplanned life events such as early childcare, transitions or transfers between educational settings and other significant, transient stressors (Sigman, 2011; Wearmouth, Glynn, et al., 2004). Socioeconomic factors are thought to exert an influence on the timing and tempo of puberty principally through stress, nutrition and obesity, with individuals from lower socioeconomic groups being prone to earlier puberty, especially if disadvantage occurred during pre-school age (Sun et al., 2017). A study involving a measure of childhood socioeconomic status and brain development found a correlation between childhood poverty and hippocampal volume at age 60 (Murray et al., 2014). The hippocampus is associated with long-term memory and learning. This validates the investigation of pubertal timing and tempo in this study (Chapters 4 & 5). Although direct measures of nutrition cannot be assessed, body weight and height data are available which allow Body Mass Index, a measure of obesity, to be calculated (Appendix 5).

Valuable personal friendships and positive relationships with adults (outside their family realm) are thought to significantly influence behaviour for the better. This is relevant to the school setting, where students interact with their peers, teachers and other adults in school. Teacher and parental questionnaire data is, therefore, included within the behavioural aspects of this study. Peer culture significantly influences behaviour and achievement, particularly in boys (Kimmel & Weiner, 1995). The strong influence of peers on adolescent behaviour is well known but lacks empirical evidence, hence it is an emerging theme in contemporary research: “Adolescents make very different decisions when they’re with their friends compared with when they’re on their own or with their parents. We all do – social influences are a big influence on everyone’s decision-making – but in adolescents it’s particularly strong” (Blakemore, 2017, p.28) (explained below). The differences in susceptibility of individual participants to this effect may have affected outcome variables in the ALSPAC dataset, instead for example, endocrinological measures. There are several cultural considerations relating to friendships, relationships and behaviour in school. For example, if parents value education, probably having had a positive and successful experience of school themselves, they are likely to exert positive influences on their children. Conversely, due to negative personal experience of school, some parents undervalue education and transfer these negative views to their children and possible interventions linked to parental engagement have shown promise (Price, 2011; Taylor, 2012). However, the ability of an individual to form appropriate relationships with others is often linked to their socioeconomic and cultural background, evidence for which suggests that children from deprived socioeconomic backgrounds are significantly more at risk of behavioural and emotional difficulties in school (Forman et al., 1993; Furlong, 1991). Interestingly, there are indications that these children can more accurately determine negative facial expressions, a measure of social cognitive function. It is thought that this is due to their exposure to high-stress living environments where these are salient signals, important to recognise (Herba & Phillips, 2004). Such direct tests of facial recognition are not included in this study since primary data collection will not be undertaken and the secondary dataset does not include variables relating to this. However, an assessment of social cognition may be undertaken by utilising ALSPAC questionnaire data and will be considered since this theme is pertinent to two of the four research questions (Section 1.4). There is evidence that new social experiences may influence the development of social cognition, for example during transition or transfer between schools (Blakemore & Choudhury, 2006). As the data analysis in this project involves that of social cognition at ages 11 (transition from primary to secondary school in the UK) and 16 (transition from secondary school to work of further education), the potential effects on outcomes must be considered. Unfortunately, ALSPAC variables relating to social cognition are not available immediately before these transitions and so cannot be included in the analysis. Wider socioeconomic factors and the effect of peers cannot be included in the study since the related variables are either unavailable in the ALSPAC dataset or were not made available for this project.

Ecosystemic factors such as the learning environment, teaching practices and support mechanisms are vitally important to all children but especially those with challenging behaviour. The ecosystemic model contradicts the child-deficit model suggesting that learning and behaviour problems are due to an unsuitable learning environment for the individual and not due to a ‘defective’ child (Wearmouth, Glynn, et al., 2004). Ecosystemic factors may exert strong influences on the participation and behaviour of research participants and for this reason should be considered during the interpretation of data analyses. Altered behaviour and cognitive functioning are also associated with factors such as fluctuating or acute stressors, poor coping strategies, family issues, resentment for sanctions previously applied, cultural and socioeconomic background; or purely psychosocial elements such as personality type (Greene, 2009; Sproson, 2004; Wearmouth, Glynn, et al., 2004). Due to the lack of available data, ecosystemic variability cannot be incorporated into the study.

Adolescence is associated with a heightened potential for risky behaviours compared to other life stages. In a study conducted by Gullone et al. (2000), male adolescents reported a lower level of risk aversion and perception than men, girls and women. For boys, in particular, risk-taking behaviours include smoking, taking drugs and dangerous driving, which they tend to do with their friends but not on their own. This can also account for poor behaviour in school where boys on their own and without distraction often behave differently when with their friends (Wearmouth, 2004). Blakemore (2017) suggests that they understand the risks but when with friends, they worry more about being excluded by the social group for exhibiting conformist, non-risk-taking behaviour. It is thought that boys with challenging behaviour are particularly vulnerable to risky behaviours and find it more difficult to appreciate the likely outcomes of such behaviours, as illustrated in Figure 2.1 (Sproson, 2004; Wearmouth, Glynn, et al., 2004)


***Figure 2.1: A cartoon with the title. “The Teenage Mouse” illustrating the common belief that adolescent boys demonstrate poor risk aversion and find it difficult to consider the consequences of their actions (anon.).***

making their inclusion in the mainstream setting difficult. Variables are not available that would allow for the consideration of risk-taking behaviour in this study but they can be assessed using a suite of psychometric tests (*Cambridge Cognition (CANTAB Tests)*, 2013), a potential and useful topic for post-doctoral research.

Adolescence is also associated with impulsive behaviours often linked with risk-taking. Interestingly, stock traders show higher testosterone levels if their daily profits are above average and the winners of football matches show higher testosterone levels than do losers. These surges can represent a 40% increase from baseline levels (van Bokhoven et al., 2006). Poor control of impulsivity can explain misbehaviour in school and the results suggest that early intervention can improve late adolescent outcomes of impulsivity and aggression even when mediated by genetic factors (to be explored in Chapter 6). Poor control of impulsivity often leads to delinquent behaviour including gambling and substance abuse in adolescence and early adulthood (Vitaro et al., 1998). Impulsivity is partly associated with hyperkinetic learning disabilities such as ADHD and childhood conduct disorders, both of which are considered in this study (Babinski et al., 1999). Blakemore et al. (2017) are exploring potential methods to 'train' adolescents in self-control and risk-aversion as self-control in childhood strongly predicts many positive adult outcomes.

Boys have been behind girls in achievement for many years and the gap is widening. The reasons for this are complex, with many important interlinked factors (Ofsted, 2008b). It has long been known that pubertal timing and status play a significant role in behaviour and achievement orientation including during pre- and early-adolescence. In a longitudinal study conducted by Dubas et al. (1991), the achievement orientation of nine to twelve-year-old boys were followed up to age sixteen. It has been known for some time that late-maturing boys had the lowest school achievement, even those classified as high achievers (Wieczerkowski & Prado, 1993). Whatever the timing of puberty, when it occurs it is often associated with a decline in educational performance in both genders from onset to its conclusion. The data analysed within this doctoral project may provide biopsychological insight into the underachievement of boys although this cannot be specifically investigated here due to relevant data variables being unavailable.

As social and emotional functioning shape learning and academic achievement the neurological basis for social behaviour, educational success and failure, they are of fundamental concern to educators (Burnett, Thompson, Bird, & Blakemore, 2011). It has been recently reported that children with undiscovered learning disabilities, for which there may be a biological basis, are frequently off-rolled or illegally excluded from school (Perraudin & McIntyre, 2018). Although not an extrinsic or environmental factor, it is worth mentioning here that there is evidence of a genetic basis for learning difficulties and developmental disorders such as dyslexia, ADHD and autism.[14] More recently, Walton et at. (2017) conducted a study into potential epigenetic[15] mechanisms for psychological functioning in ADHD using ALSPAC data. Their study involved chemical changes to DNA in early life and showed the potential for differences in neurodevelopment and thus neurobiological functioning and mental health. Furthermore, research conducted by Pingault et al. (2015), showed that genetic influences as well as environmental factors may account for the variability in symptoms and externalising behaviours of individuals with ADHD, again due to neurological development.

It is likely, therefore, that both genetic and epigenetic factors influence child and adolescent behaviour, particularly in the case of these disorders, that is that there may also be an underlying genetic association with behavioural, emotional and social difficulties (BESD) and underachievement in school. Other twin studies involving childhood conduct disorder, aggression, delinquency and psychopathic traits showed that these were strongly heritable in ethnically and economically diverse participants (Baker et al., 2007).

There is compelling and interesting evidence suggesting that there are also genetic bases for school achievement, cognitive ability, self-efficacy, personality, health and well-being, and even perceptions of home and school environments (Korkmaz, 2011; Thomas et al., 2015). Sufficient data is not available to this study for an analysis of heritable factors, although the biopsychological basis of behaviour including potential hyperkinetic and social and communication disorders is included and so will be explored later in this Chapter.

In conclusion, there are a significant number of extrinsic variables that may influence this findings of the analyses conducted within this doctoral research that must be considered together with any outcomes. Although the analysis of extrinsic variables does not form part of this project, some of the analyses may allow impressions to be formed regarding the themes discussed in this Section. It is important to place any of these proposed data analyses within the context of adolescence, the life stage at which the secondary data variables were collected.

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[14] Loci on chromosomes 6 and 18 have shown strong and replicable effects on reading abilities (Reid, 2009) and twin studies have shown a strong genetic basis to autism. The exact genetics of autism is complex and may involve multigene interactions or rare genetic mutations. Interestingly, when only one identical twin is autistic, the other often has a learning or social communication difficulty (Freitag, 2007).

[15] Epigenetics is a field of biological study of heritable phenotype changes attributable to alterations in DNA caused by factors that are not heritable such as environment. These do not involve alterations in the DNA sequence, which are caused by genetic variation and are, therefore, heritable.

## 2.3 The Nature of Adolescence

Adolescence is the transition between childhood and adulthood and could be defined as the stage when an individual is too old to be a child but too young to be an adult (Sawyer et al., 2018). To biologists, adolescence is associated with the beginning of the reproductive lifespan: sexual maturity in terms of hormones and physical development of the body (Tortora & Derrickson, 2011). To psychologists it is characterised by enhanced complexity of group interactions and therefore social behaviour (Carlson, 2006). The psychosocial context of adolescence is significantly different to that of children and adults with changes in peer relationships as well as those with family and society. Adolescents become progressively self-conscious and concerned with the opinions of others in respect of self-image and develop understanding of the self in relation to their social world (Choudhury, Blakemore, & Charman, 2006). Anecdotally, the parents of teenagers and those who work closely with them cite behaviours such as ‘pushing boundaries’, an unwillingness to conform to adult expectations, aggression and disrespect. This occurs as they explore and define their individuality, think more abstractly in forming their own moral code and become more assertive as they push for independence. The ALSPAC dataset includes parental questionnaire data that will allow some negative aspects of behaviour to be analysed which may provide evidence for these assertions or discredit them, particularly in the case of extreme outlier cases (Chapter 5).

It is impossible to place an age on adolescence because of the variance in biological and psychological elements between ages ten to eighteen. Spermarche[16] can have a five year variance as can dental, skeletal and intellectual markers (Kimmel & Weiner, 1995; Marshall & Tanner, 1970) but is probably the most accurate, if not practical, method of determining the passing of puberty as menarche is in girls. In a study of 86,744 Chinese Han boys by Cheng-Ye Ji (2001), it was shown that the median age of spermarche in all socioeconomic groups was 14.4 (urban) and 14.6 (rural). Although Marshall and Tanner’s studies were conducted throughout the entire duration of the 1970’s, their work is still considered seminal to the classification of puberty. Collection of such personal biological data would obviously be problematic in UK schools and so no direct measures of pubertal timing are included in this study. Whatever the precise age of pubertal onset, early adolescence is characterised by

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[16] Spermarche (semenarche) is the first ejaculation emission of functional sperm in males of all species. Boys may react with fear or excitement depending on their culture, upbringing and prior sexual knowledge or education. It contrasts with menarche (first period) in girls.

emotional upheaval and challenging behaviour that temporally coincides with its associated physical and endocrinological changes (Nottelmann, Susman, Inoff-Germain, et al., 1987), which are discussed in the next Section.

## 2.4 Biology: Endocrinology and Physical Development

This section concerns the biological factors associated with puberty, that is: endocrinology (testosterone, SHBG and cortisol); neurological function relating to psychosocial factors and behaviour; and pubertal development (secondary sexual characteristics, measures of puberty and anthropometric measures). Three of the four research questions require the exploration of these factors in the context of behaviour and psychosocial development, justifying the explanatory narrative that follows.

### 2.4.1 Endocrinological factors

Puberty results in obvious anatomical changes such as physical growth and the appearance of secondary sexual characteristics. These changes are due to a dramatic increase in serum levels of gonadotropins[17] and steroid hormones[18] including testosterone, which stimulates and controls the development and maintenance of male secondary sexual characteristics and spermatogenesis. Androgens (steroid sex-hormones) can influence human behaviour as some cerebral neurons are sensitive to them. Action in the body may result in,

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[17] Gonadotropins are protein hormones secreted by the anterior pituitary gland. They include follicle-stimulating hormone (FSH) and luteinizing hormone (LH) both relevant to the regulation of growth, sexual development and reproduction. FSH regulates the growth, development, pubertal maturation and reproduction. In males, LH stimulates Leydig cell (specialised cells in the testicle) production of testosterone. Some testosterone is produced in the adrenal glands also.

[18] Sex steroids are often referred to as "sex hormones". In males, they are principally produced in the testes the most important of which is testosterone, which has a masculinizing effect associated with testis and prostrate size, increased musculoskeletal mass and the growth of body hair.

for example, aggression (Johnson & Everitt, 2000). The neuro-endocrinological pathway to puberty is complex and is summarized in Figure 2.2.

The hypothalamus releases pulses of gonadotrophin releasing hormone (GnRH). This causes the anterior pituitary cells to respond by secreting luteinizing hormone (LH) and follicle stimulating hormone (FSH) into the circulation. These two hormones activate testicular growth (a measure of pubertal stage) and stimulates cells within the testes to produce and release into the circulation pubertal levels of testosterone. A higher plasma testosterone concentration causes the development of secondary sexual characteristics as well as brain structure changes with an associated effect on behaviour.

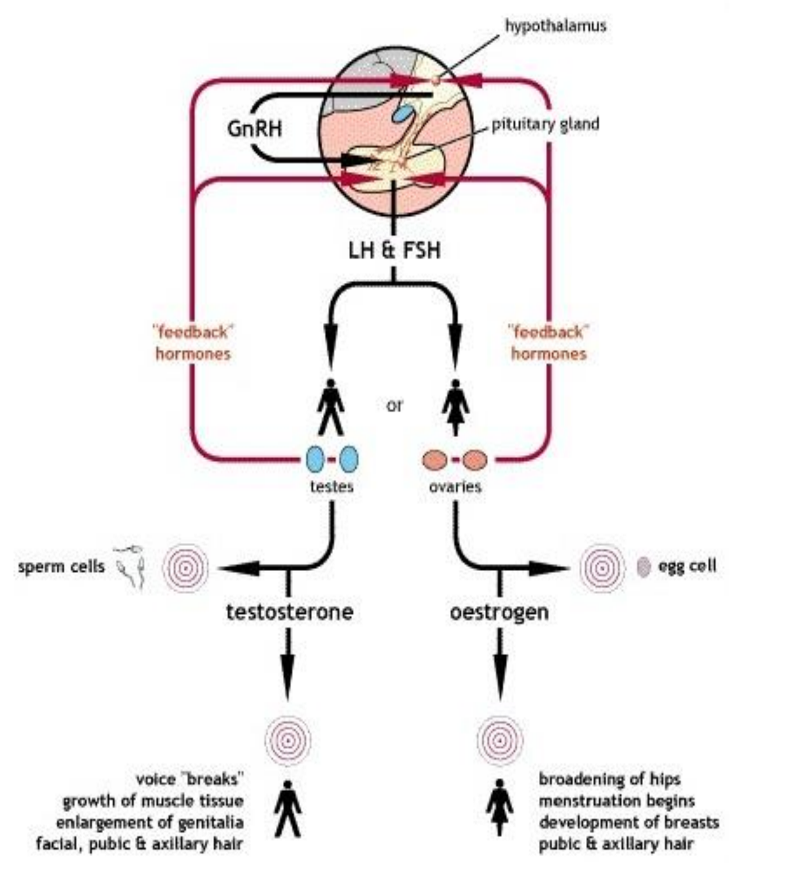


*Figure 2.2: The neuro-endocrinological process of puberty in both males and females ('Developmental Biology Interactive: Figure 2, Puberty Initiation in Mammals', n.d., p. 2).*

It has been demonstrated in numerous studies that androgens alter brain structure producing differences in brain structure and behaviour between genders (Burnett et al., 2010; Byrne et al., 2017; Herting & Sowell, 2017; Peper et al., 2009; Piekarski et al., 2017; Schulz et al., 2009; Schulz & Sisk, 2016; Sisk & Zehr, 2005; Travis, 1999). It is evident that testosterone in puberty influences the development of a 'masculine' brain structure associated with gender orientated cognitive functions and behavioural characteristics (Travis, 1999). Although no specific hormonal trigger has been identified as the responsible agent for activation of the gonadotropin-releasing hormone axis (GnRH), leptin (a hormone produced by fat cells) has been proposed as the hypothesised permissive factor linking body fat and the initiation of puberty for both boys and girls (Kimmel & Weiner, 1995). Interestingly, girls with a high proportion of body fat go through puberty earlier than their leaner peers. The reverse is true of boys. A study of the possible effects of body mass index (BMI) and behaviour for extreme outlier participants is included in Chapter 5, including those with the potential for autism, which can be considered to result from extreme brain masculinisation during development (Baron-Cohen, 2004; Tordjman et al., 1997) explained below.

The exact biological basis for the commencement of puberty is unknown. Low levels of sex hormones in children aged one to five seems to be linked to a high plasma concentration of the hormone melatonin. Melatonin is produced by the pineal gland in response to changes in ambient light. When injected in adults it lowers secretion of LH, suppresses secretion of sex hormones and causes sleepiness. Children aged over thirteen and adults have low levels of melatonin and high levels of LH (Ge, Conger, & Elder, Jr., 2001). It has been shown that testosterone levels in pre-pubescent boys is stable and does not vary significantly between the ages of six and nine (Ostatníková et al., 2002).

The emotional states and behaviours associated with adolescence are not only connected with fluctuating or increased plasma concentrations of androgens. The social aspect of change, for example, pubertal stage or chronological age may contribute to challenging behaviour. Very young adolescents with high testosterone levels may experience increased rebelliousness or aggression (Kimmel & Weiner, 1995a). It must also be remembered that not all boys who traverse puberty and, therefore, have higher than pre-adolescent levels of testosterone, experience adverse behaviours. Perhaps other pubertal influences are involved. If testosterone levels show the same projection during puberty in all boys but the behaviour of some is significantly different, are some more susceptible than others to its effects (Shoal et al., 2003)? Some individuals show increased receptor sensitivity to other hormones and some drugs, which would make the effect of testosterone more potent. A possible genetic basis to androgen receptor sensitivity has been proposed (Waal, 2005). Excessive behavioural responses with low plasma testosterone concentration could indicate high receptor sensitivity, although the converse could also be true. These factors must be considered when undertaking quantitative comparisons between testosterone and behaviour variables for the general ALSPAC population in Chapter 4 and in the case of extreme outliers (Chapter 5).

The relationships and influences between testosterone and multiple biological and psychological elements are complex. A summary of these influences is summarised in Figure 2.3, reproduced from Zitzmann and Nieschlag (2001 p. 191). Dihydrotestosterone is the precursor molecule of testosterone and GH is growth hormone, naturally secreted by the pancreas as is insulin-like growth factor (IGF). Sex hormone binding globulin (SHBG) is a glycoprotein responsible for transporting androgens in the blood to the tissues (considered in subsequent chapters and Appendix 5). Negative arrow labels show negative feedback, where one factor reduces the effect of another. Positive feedback increases an effect.

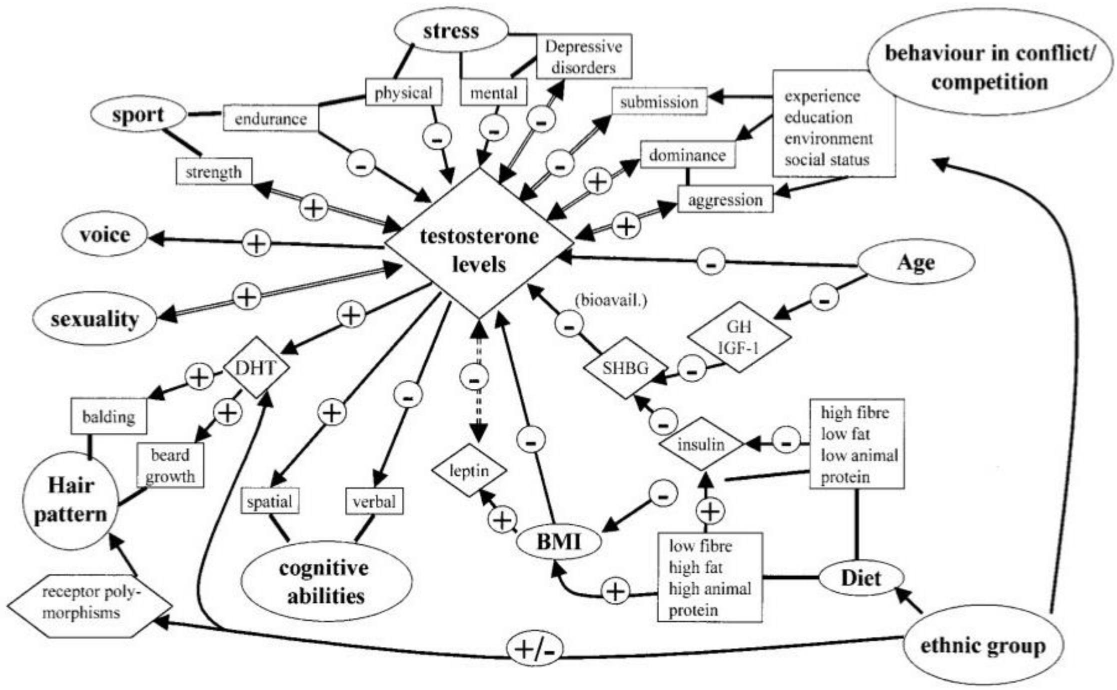


***Figure 2.3: Interactions and feedback mechanisms of testosterone levels with physical and behavioural dimensions.***

Although hormone levels are linked closely to pubertal stage, there appears to be a time lag between their increased plasma concentration and the appearance of secondary sexual characteristics. However, their effect on brain structure and behaviour, including psychosocial adjustment, seems to be relatively immediate. Sensitivity of the central nervous system to testosterone may vary with chronical age or with prior exposure (Nottelmann, Susman, Inoff-Germain, et al., 1987). Emerging evidence is suggestive of central nervous system sensitivity to testosterone occurring *in utero* (Shors & Miesegaes, 2002). Research is currently being undertaken by Penton-Voak et al. (University of Bristol) to explore an interesting correlation between foetal testosterone, 2D:4D digit ratio, and social cognition. Growth of the 4th digit, is promoted by *in utero* testosterone. Digit span ratio differences has been associated with mental health disorders such as depression, psychopathology and ADHD and most frequently with poor social cognition and autism. Autism is thought to be associated with a hypermasculine brain, characterised by low empathising and high systemising traits (Baron-Cohen, 2004; Manning et al., 2001). Analysis of testosterone assay, pubertal stage and behaviour data from the ALSPAC study will allow for potential confirmation of the theories generated by these two studies also allowing analysis of pubertal stage and testosterone levels at different stages of adolescence.

Cortisol[19] is commonly associated with stress. Following a longitudinal study, Shoal et al. (2003), reported that low salivary cortisol concentrations were linked with altered personality and aggressive behaviour in adolescent boys and that this was due to a lack of self-control rather than an aggressive personality. Sigman (2011) conducted research into the neurobiological consequences of day care for very young children. His research provided evidence for an interesting array of consequences of early life experiences including deranged behaviour and learning in later childhood. These were linked to structural and endocrinological changes within the brain. Children exposed to early stressors showed elevated salivary cortisol concentrations in adolescence and a greater vulnerability to stress (McEwen, 2007; Roisman, 2009). Interestingly, a less secure early child-rearing environment was associated with earlier puberty (Belsky, 2010), which can have both positive and negative effects on behaviour and achievement[20]. Cameron et al. (2017) conducted two linked studies involving Euro-Canadian middle class teenagers in which they measured cortisol responses to psychosocial stress. The first cohort numbered 120 with a median age of 13.3. The second cohort included 166 participants with a median age of 14.5. As responses to stress may be different according to culture and socioeconomic status, care must be taken when making inferences from these findings to the population in general due to the ethnicity and affluence of the participants. However, the findings of this research are compelling and provide evidence for a longitudinal effect of cortisol levels. This is of interest in the design of this study, for although it is counterintuitive that cortisol levels at age 8 would be associated with psychosocial difficulties and adverse behaviours during adolescence, there is evidence to the contrary (Cameron et al., 2017; McEwen, 2007). There is, therefore, an argument for cortisol to be included in longitudinal studies such as this. Potential psychosocial and behavioural effects of cortisol are analysed in chapters 4 & 5.

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[19] Cortisol (hydrocortisone) is a steroid hormone released into the blood from the adrenal glands in response to stress. It has many effects on the body including suppression of the immune system (prolonged stress leads to illness), increased heart rate and blood pressure and impaired learning due to cell damage in the hippocampus ('Cortisol', 2013; Elliott & Elliott, 2004; Stryer et al., 2002a)

[20] Early maturation is associated with increased social prestige but as they look older, boys often have to live up to increasing adult expectations. They tend to be popular with peers, relaxed and good-natured. Late maturing boys often have poor body image, risk of deviant behaviours such as drug abuse, school refusal and psychopathology such as depression (Lerner & Steinburg, 2009). Puberty is activated by hormones released via the same part of the endocrine system as stress hormones. It is possible that delayed puberty can be caused be childhood stress (Tanner, 1978).

### 2.4.2 Pubertal Development

Puberty is the key physiological and anatomical change that occurs during adolescence. It is defined by accelerated physical growth, the development of secondary sexual characteristics, reproductive maturity and structural changes in the central nervous system with associated changes in behaviour and self-image (Burnett, Dahl, & Blakemore, 2010). During puberty there are also changes in many other areas of the body including the heart, lungs and the muscles. However, puberty is not a single event or unitary process rather it is comprised of several processes that occur during adolescence, which lasts for years (Burnett, Thompson, Bird, & Blakemore, 2011). Since humans develop at different ages and over different timescales, pubertal development is distinct from chronological age (Marshall & Tanner, 1970). The physical changes during puberty are summarised and illustrated in Figure 2.4 reproduced from Abreu & Kaiser (2016, p. 255).

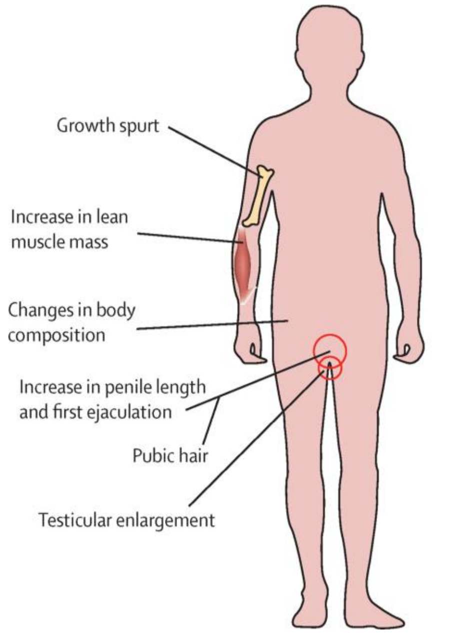


***Figure 2.4: A summary and illustration of the physical changes that occur during puberty in boys.***

The most accurate and reliable method for determining pubertal stage requires assessment by a paediatrician and involves a scale known as Tanner staging. The scale ranges from Tanner Stage I (pre-pubertal absence of secondary sexual characteristics) to Tanner Stage V (adult characteristics). In clinical settings, Tanner staging is most commonly based on testicular volume measured using a Prader orchidometer[21] and the distribution of pubic hair (Tanner, 1978). It should be noted that the point of spermarche (Section 2.2.1) indicates the point of sexual maturity but occurs independently of pubertal stage. As Tanner staging is highly intrusive and requires professional skill for accurate interpretation, it is not available to most researchers in educational settings. The reasons are many: ethical approval would prove difficult; the employment of a clinician would be cost-prohibitive; and it would deter research participants. For these reasons, most non-clinical research studies use self-reporting measures of pubertal development (Biro et al.,

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[21] A Prader Orchometer consists of a string of oval beads of varying volumes similar to those of testicles. Physicians compare the size of a patient's testicle with the bead size to give an approximate volume. Prepubertal testicular volume is < 4ml.

1995; Earis et al., 2000; Herman-Giddens et al., 2001; Taylor et al., 2001). The Pubertal Development Scale (PDS), created by Petersen *et al*. (1988), was found to be highly accurate and was used in several studies including in the collection of ALSPAC data used in this study (Appendix 1). The ALSPAC version avoided direct interviews with children, which would be embarrassing, instead involving a questionnaire with illustrations of genitals and pubic hair distribution at different Tanner stages, seeking a self-comparison. It was found that self-assessment of genital development was the most inaccurate measure with self-assessment of body hair distribution being the most reliable (Taylor et al., 2001). The ALSPAC data includes several variables relating to pubertal staging but for the quantitative analysis of this study, pubic hair distribution was used based on this evidence. ALSPAC variables of anthropometric variables were also used as a confirmatory measure.

### 2.4.3 Anthropometric values

Anthropometric measures are also associated with pubertal development and tempo and are easy to measure and combine or compare to give an accurate assessment of pubertal stage. Pubertal stage can also be extrapolated from physical growth data, assessed by measuring and comparing anthropometric variables such as height, body mass (combined can allow calculation of BMI), hand span, foot length, chest and hip measurements and fat versus muscle mass (Kimmel & Weiner, 1995). However, these variables should not be considered in isolation as no one variable can provide accurate pubertal staging. The most widely reported anthropometric variable associated with puberty is accelerated growth and the associated changes in BMI. It is common for boys to attain peak height velocity (PHV) when they reach Tanner Stage III but an earlier onset of PHV could represent earlier initiation or progression of puberty or could indicate accelerated growth independent of puberty (Tanner & Davies, 1985). Anthropometric measures are accurate, objective and are either included as ALSPAC variables available to this project or, as in the case of BMI and PHV, can be calculated from other variables (Appendix 5).

The importance of anthropometric measures is not restricted to assessing pubertal stage. The literature is suggestive of an association between BMI, the age at which children enter puberty and pubertal tempo, that is, girls with a high BMI enter puberty earlier and boys do so later (Aksglaede et al., 2009) and pubertal tempo is shorter for individuals with a high BMI. Anthropometric factors such as height, body mass and BMI are shown in several studies to exert psychological influences on individuals, obesity having been linked to mental health problems and increased odds of psychosocial dysfunction. Tershakovec, Weller & Gallagher (1994) identified abnormal scores on the Child Behaviour Checklist and the hyperactivity subscale of the Conner Parental Questionnaire (standardised test for Attention Deficit Hyperactivity Disorder) for overweight boys. They also found that the proportion of children in special education classes who were clinically obese was twice that for children with a normal BMI (Halfon et al., 2013). This is relevant for this dissertation because, as it will be shown later, analysis of extreme outliers (Chapter 5) will indicate that several participants exhibiting psychosocial or behavioural difficulties had abnormal BMI values, both low and high.

## 2.5 Puberty, Psychosocial and Behavioural Considerations

In section 2.4, biological factors associated with puberty were discussed. This Section builds upon this biological foundation to focus on the many factors associated with pubertal timing and tempo (time for passage through puberty) and potential psychosocial and behavioural outcomes. These factors can be placed into two principal domains of genetic and environmental influences. There is evidence to suggest genetic influences result in earlier timing and shortened pubertal tempo. Environmental factors on pubertal timing and tempo include environmental toxins, stress, diet and obesity. A number of studies have been conducted that involve these genetic and environmental influences on puberty and will be discussed in this Section. Passing through puberty earlier or with a faster tempo than peers is a risk factor for externalising problem behaviours at age 15 (Marceau et al., 2011), with genital growth tempo predicting externalizing behaviours the most. Likewise, there are a number of papers that state an argument for the prevalence of challenging behaviours in late maturing participants (Bloxham, 2010; Michaud et al., 2006). This contradicting evidence is discussed below.

The age of onset (timing) is not the only pubertal factor associated with psychosocial and behavioural outcomes. There appears to be a lengthening of time (tempo) according to societal norms for individuals to gain adult status, a mismatch called the ‘maturational gap’ (Rutter, 1989). An apparent decline in the age of pubertal onset in recent years (Chalabi, 2013; Walvoord, 2010) heightens concerns regarding the psychological and behavioural effects of a lengthening period of adolescence. This proposed secular trend over the past fifty years is controversial but remains widely accepted as are the psychological consequences (Lee & Styne, 2013).

The impact of puberty will be discussed in two parts. First, factors associated with pubertal timing and tempo will be approached, followed by potential psychosocial and behavioural outcomes associated with atypical pubertal development. Third, a review of the literature and potential evidence for these outcomes, specifically for early physically maturing boys to finally produce a comparison between late and early maturing boys. Finally, a discussion of social cognition and challenging behaviour during adolescence will take place.

### 2.5.1 Factors associated with early or late pubertal timing and tempo

As aforementioned, there are a number of extrinsic factors associated with pubertal timing and tempo: genetics, environmental influences, stress and anxiety, and socioeconomic variability. However, the secondary dataset adopted for this project will only allow some aspects to be included in the data analysis conducted in Chapters 4 & 5, namely pubertal stage, endocrinological measures, psychosocial and behavioural outcomes. It is therefore appropriate to consider these extrinsic variables as they may influence the findings of this project.

In a study involving 846 boys, Wohlfahrt-Veje et al. (2016) concluded that pubertal onset was significantly associated with the pubertal timing of both parents suggesting a heritable trait. Several genes and genetically determined endocrinological pathways have been implicated (Banerjee & Clayton, 2007). It would be interesting to undertake a study in order to compare parental onset of puberty and their behaviour in school with that of their offspring as research into a genetic basis for school behaviour has not yet been conducted.

A large systematic literature review showed that environmental factors such as environmental toxins (e.g. phthalates and pesticides), the use of soy formula milk as opposed to breast milk, dietary fibre and some topical solutions such as tea tree oil, all affect pubertal timing (Fisher & Eugster, 2014). The mechanisms for this are not understood but, again, they offer a promising avenue for research, especially if linked to psychosocial outcomes. A large number of studies show a relationship between obesity, pubertal timing and tempo (Aksglaede et al., 2009; Holmgren et al., 2017; Lumeng, 2013). As the secondary dataset available to this study allows for Body Mass Index (BMI) to be calculated and compared with variables relating to pubertal development and tempo, it will be interesting to note if the same conclusions regarding psychosocial and behavioural outcomes can be drawn. For example, in

Chapter 5, participants with atypical BMI values are included in the analysis of extreme psychosocial and behavioural outlier cases.

Fisher and Eugster (2014) also discovered that emotional stress and anxiety was associated with earlier pubertal development and rapid tempo, for example, in cases of international adoption. Furthermore, a longitudinal study by Ge, Conger and Elder (2001) found a relationship between adjustment problems such as internalised distress symptoms and externalised hostile feelings and earlier pubertal timing in adolescent boys.

Socioeconomic factors are also thought to exert an influence on the timing and tempo of puberty principally through stress, nutrition and obesity, with individuals from lower socioeconomic groups being prone to earlier puberty, especially if disadvantage occurred during pre-school age (Sun et al., 2017).

### 2.5.2 Psychosocial and behavioural challenges for atypical physical development

The psychosocial challenges for boys exhibiting either early or late physical maturity are manifold and, in many cases, appear to be associated with their psychosocial development and behaviour. Table 2.1 outlines both the positive and negative factors that present throughout puberty and early adulthood that are associated with early and late physical maturity in boys. The table was constructed from a number of published sources (Ge & Natsuaki, 2009; Graber et al., 1997, 2004; M. C. Jones & Bayley, 1950; Mendle & Ferrero, 2012; Michaud et al., 2006; Monteilh et al., 2011; Petersen & Crockett, 1985). Contradictions in the table are explained by the variation in the research findings and conclusions of these studies.

The outlines that follow are intended to give context to the analyses and whether the findings support or refute that cited in the literature. Indeed, an examination of the literature reveals inconsistencies of findings when examining associations between pubertal timing, psychosocial factors and challenging behaviour, many of which are confirmed here.

***Table 2.1: Outline of positive and negative factors associated with both early and late puberty in boys.***

| **Early maturing boys - positive factors** | **Late maturing boys - positive factors** |
|---|---|
| More favourable self-image<br>Leadership potential esp. sports<br>Peer popularity<br>Independence<br>Maturity<br>Fewer problems with parents<br>Higher IQ and achievement<br>Hold more adult aspirations<br>Increased exploratory behaviours leading to personal development | More positive about their facial looks rather than muscles and height<br>Less drug taking<br>Less sexualised behaviour |
| **Early maturing boys - negative factors** | **Late maturing boys - negative factors** |
| Increased anxiety & depression<br>Increased suicidal thoughts and attempts<br>More rigid and conformist in adulthood<br>Eating disorders<br>Feels in bad health<br>Feels victimised<br>Decreased activity and exploration<br>Hostile behaviour<br>Deviant behaviour | Delinquent behaviour<br>Maturational-deviance hypothesis leading to heightened emotional distress<br>Eating disorders esp. binge eating<br>Mental health esp. depression & behaviour problems esp. when peer relationships inharmonious<br>Social rejection and inferiority<br>Dissatisfaction with body |

Several studies provide evidence to suggest that early pubertal timing has a deleterious effect on psychosocial adjustment and behaviour (Chen et al., 2015; Dimler & Natsuaki, 2015; Ge & Natsuaki, 2009; Moorhead, 2010; Zehr et al., 2007). It results in the sorts of negative behaviour and externalising signs and internalising symptoms such as depression and anxiety (Table 2.1). They also report that these symptoms are made worse if mothers are depressed and the family face stress and adversity (McCrory et al., 2010). The Deviance Hypothesis (Duncan, Ritter, Dornbusch, GJosh, & Carlsmith, 1985) posits that being different from the majority of one’s peers as an adolescent can be of detrimental psychological effect. In addition, it indicates that young people who are physically deviating from the norm identified from their peers can present psychological difficulties especially in terms of self-esteem. Anecdotally, early-developing boys and girls have been known to remove their pubic hair and state the reasons for doing so as feeling helpless that they are growing up at a pace with which they are unhappy and because they are overwhelmed at being different to their friends. Early developers at ages 11 to 13 or later developers ages 14 to 16 may experience these negative psychological effects, extreme early developers in particular, and this can have severe consequences on behaviour. Butler (2010), reports that one early-maturing participant was arrested twice at age 13 for vandalism, shoplifting and anti-social behaviour. Another participant found it difficult maintaining friendships with boys of age-norm development, preferring to associate with an older social group. Deviant peer relationships increase the risk factors for externalising behaviours associated with later adolescence.

Despite the many negative outcomes associated with early puberty, the existing literature suggests that the majority of boys prefer to be early maturing as this is associated with more positive self-esteem and body image (Jindal-Snape & Miller, 2008). Mendle and Ferro (2011) report that early development is more of an advantage for working class boys where status is awarded to size and strength. In other words, early maturing boys are admired by their peers due to their increased height and stature. In Western cultures, these are seen as cultural ideals in males, the Cultural Ideal Hypothesis espousing the benefits of greater masculinity in boys (Simmons et al., 1987a). They appear to enjoy more peer popularity and are encouraged to take leadership roles both in sports, athletic pursuits and more generally. Early physical maturity is associated with greater independence, adult aspirations and emotional maturity although this may lead to deviant behaviour partly due to increased exploratory activities. These can also positively enhance personal development (Lee & Styne, 2013). A number of studies conducted between 1957 and 1985 show that early puberty is correlated with a higher IQ, greater school achievement and less conflict with parents, the converse of which is presented in other studies (Brooks-Gunn, Petersen, & Eichorn, 1985; Mussen & Jones, 1957; Weatherley, 1964). Contemporary research supports these findings; for example, Mendle & Ferro (2014) report that early maturing boys not only do better educationally, they have higher expectations of education and more positive teacher reports.

### 2.5.3 Outcome variability between early and late development

Late maturing boys exhibit some of the same or similar psychosocial and behavioural issues and positive outcomes as early maturing boys (Table 2.1), which are significantly less common in boys with normal pubertal onset and tempo. Whereas early maturing boys are more positive about their musculature and height, late maturing boys report being positive about their facial looks (Mussen & Jones, 1957). However, this is contradicted in a much more recent study by Michaud et al. (2006) involving Swiss adolescents who report an overall dissatisfaction with body image associated with late maturation. Height is strongly correlated with pubertal stage, so late maturing boys are usually shorter than their peers (Frisancho, 2011; Garcés et al., 2008). Michaud et al. (2006) also identified that late maturing boys are less likely to engage in risky behaviours such as drug taking and early or promiscuous sexualised behaviour. However, Graber et al. (2004) report that late maturing children exhibit disruptive behaviour and engage in substance abuse for an extended time after puberty.

In terms of mental health problems such as depressive symptoms, eating disorders, feelings of inferiority and social rejection, early maturing boys differ from their typically maturing peers. There is a biopsychological basis to eating disorders including binge eating. Boys as well as girls undergo a surge in plasma oestradiol[22] during puberty, much more marked in early maturing children. An association has been shown to exist between plasma oestradiol concentrations and an increased risk of eating disorders. Testosterone can metabolise to oestradiol increasing its concentrations further (Zehr et al., 2007). The adolescent brain shows plasticity and is sensitive to the organisational effects of hormones; it is thought that this not only causes concurrent disordered eating but neural changes that maintain these disorders longitudinally (Burnett et al., 2010; Sisk & Zehr, 2005). Late maturing boys also report a prevalence of externalising symptoms such as delinquent, disruptive and rule-breaking behaviours and other challenging behaviours that are compounded when peer relationships are inharmonious (Graber et al., 2004; Susman et al., 2010), whereas early maturing boys are more popular, relaxed, confident and independent (Mendle & Ferrero, 2012). Though the 'maturational gap' stated above is concerned with prolonged pubertal tempo, the Maturational Deviance Hypothesis emphasises difficulties faced by late maturing adolescents, the Change Hypothesis differing in that it is suggestive of causality between experiencing stressors close to pubertal initiation and challenging behaviour or psychosocial difficulties regardless of pubertal timing. As a number of papers support both hypotheses, it is difficult to ascertain which of them is most likely to account for the problems they espouse. However, there is evidence from neuropsychological studies that the behavioural manifestations of maturational deviance are due to late brain (immature) maturation in those with delayed pubertal development. For example, children with ADHD tend to behave like younger children, the norm for which is to be more impulsive, active and have a shorter attention span[23]. An analysis of SDQ hyperactivity scores from within the study data will be undertaken to explore this idea further.

Although the empirical studies examined above provide strong evidence for externalising behaviours in late-maturers, early-maturers seem to suffer more from

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[22] Oestradiol is a steroid hormone secreted mainly by the ovaries but also the adrenal glands and testis. At puberty, its levels rise producing secondary sexual characteristics and mammary glands including transient breast enlargement in boys (gynaecomastia).

[23] The DSM-IV (American Psychiatric Association, 2013) characterises ADHD as an "age-inappropriate display of inattention, hyperactivity, and impulsiveness (Rubia, 2007).

internalising symptoms. Late maturing boys report a prevalence of externalising symptoms such as delinquent, disruptive and rule-breaking behaviours and other challenging behaviours which are compounded when peer relationships are inharmonious (Graber et al., 2004; Susman et al., 2010).

Contrary to earlier and later studies, Duncan (1985) provided evidence that there was no effect of maturational timing on school attendance, adjustment, popularity, disciplinary issues or the need to resubmit school work. Nearly all other studies state that both early and late maturing children are responsible for a higher incidence of school behaviour problems. Although the study was conducted in 1985, it related to a large dataset (*n*=5735) collected in 1963. As the pubertal staging of participants in this study should be considered reliable as it was conducted by physicians, the remaining data was collected by participant and teacher questionnaires, which could be open to subjectivism. Possible discrepancies between the reliability of highly objective biological data and questionnaire data must be considered during the course of this study since similar methods exist. However, as stated above, puberty is likely to be influenced by environmental and cultural factors. Society has changed considerably in the past 55 years and evidence is suggestive of, but not conclusive, that puberty is occurring earlier, which must be remembered when considering the findings of historical studies such as these.

Data analyses relating to pubertal timing and tempo are explored in Chapters 4 & 5 as part of the quantitative and case study analyses. As stated before, it is beyond the scope of this study to explore potential causes of timing and tempo but the narrative above provides an interesting background to an important element behind the chapters that follow.

### 2.5.4 Psychosocial considerations of atypical puberty

The term executive function (EF) is open to interpretation and has been strongly contested by some academics and psychologists (Baggetta & Alexander, 2016) although widely accepted in the field of cognitive psychology (Benson et al., 2012; Carlson, 2006; Cash, 2013; Lerner & Steinburg, 2009). Most commonly, it is used to describe an individual’s capacity to control and coordinate their thoughts and behaviour. It involves a skill subset that includes: selective attention, decision-making, voluntary response inhibition and working memory (Blakemore & Choudhury, 2006). These executive functions play a key role in cognition, for example, being able to hold a goal-directed plan in mind at the same time excluding unimportant thoughts and information and inhibiting impulsivity. EF also involves the mental processes associated with knowing, imagining, perceiving, reasoning, problem solving and multiple tasking.

Choudhury et al. (2008) hypothesise that pubertal stage may account for cases where there is a lack of improvement in performance in adolescents aged between ten and fourteen. McGivern, Andersen, Byrd, Mutter, & Reilly (2002) conducted research to measure cognitive and emotional efficiency in adolescent participants and noted a decrease at the onset of puberty. This age-related dip during adolescence may represent a phase shift between grey-matter proliferation and the onset of synaptic pruning (Section 2.4) and could be used to optimise the use of interventions to support intellectual and emotional growth during the neurological changes occurring during adolescence (Chapter 6).

The period from middle childhood to adolescence is accompanied by an increased ability to engage in multi-dimensional and abstract thinking when considering the many and diverse aspects of other peoples' thoughts and feelings. It is, therefore, feasible that adolescence results in an increasingly complex understanding of self-emotions and those in others. Behavioural and neuroimaging studies suggest that interpersonal relationships, hormonal and physical changes may contribute to behavioural and neural changes (Burnett et al., 2011). Social cognition, a component of EF, is an important aspect of behaviour and a major component of this study.

### 2.5.5 Social Cognition During Adolescence

Social cognition is the encoding, storage, retrieval and processing, of information in the brain, which relates to other human beings. It involves social interactions, social expectations, the ability to understand and accept the viewpoint of others, all essential for collaboration in the learning environment (Meltzer, 2010) and for appropriate behaviour in school. In children and adolescents, it could include qualitative measures such as: 'Why do people do that?', 'Can you understand how others feel?', 'What are the consequences of my interactions with others?' People with ASD perform poorly in tests of face and emotion recognition, often used to assess social cognition. Interestingly, it is thought that autism affects information processing in the brain due to deranged neural and synaptic structures in the PFC as a consequence of the effects of testosterone on early neurological development. Social cognitive function is measured in this in this project through the use of data from the Social Communication Disorders Checklist (Erdley et al., 2010).

During adolescence, individuals are engaged in increasingly complex group interactions and thus social behaviour. It is a period when adolescents either consciously or subconsciously develop themselves socially and begin to understand how they relate as an individual in the social world (Lerner & Steinburg, 2009). They appear to become progressively more self-conscious and concerned with the opinions of others, particularly valued adults and their peers. Adolescents begin to assert more autonomous control over their decisions, emotions and actions, and start to disengage from parental control. These changes are suggestive of an alteration in social cognition, that is, new experiences may leave an imprint on neurological changes in the prefrontal cortex such as selective synaptic pruning (Blakemore, 2017). New social experiences (e.g. new school), may develop social cognitive processes but research in this area is still underdeveloped (Blakemore & Choudhury, 2006). This period of synaptic reorganisation may also be a time of particular sensitivity to such experiential inputs akin to other sensitive periods in brain development such as visual and language acquisition in early childhood. It may be more difficult to acquire executive and social cognitive function by incorporation into the brain network following this sensitive period.

The social challenges for boys exhibiting early physical maturity are associated with their psychosocial development and behaviour. Several hypotheses attempt to explain externalising behaviours exhibited by adolescents and are important to consider in this study, particularly Chapter 5. The Adult Resemblance Hypothesis (Simmons et al., 2008) suggests that a more advanced pubertal stage gives the individual a closer approximation to adult status with benefits and challenges such as unrealistic expectations of cognitive and maturational abilities. These can lead to conflict, anxiety and stress resulting in mental health issues as presented in Table 2.1 above. This corresponds with the Development Readiness Hypothesis (also known as Stage Termination Hypothesis), which suggests that children who develop earlier than their peers may experience negative effects during late adolescence due to ‘a lack of developmental readiness’ (Ge, Conger, & Elder, Jr., 2001). This can be thought of as an immature brain in an adult body.

As these ideas are yet largely speculative, evidence from multiple disciplines including educational researchers, cognitive scientists and neuroscientists may improve understanding, which is one of the aims of this project.

### 2.5.6 Challenging Behaviour During Adolescence: Impact on Schools

The behavioural level of analysis concerns observable responses to psychological inputs and stimuli. The development of behaviour is thought to involve a two-way relationship between the neurological and cognitive domains. Behaviour often fluctuates as neuropsychological development occurs rather than following a linear trajectory (Cash, 2013). For example, case studies of adolescent boys with behavioural difficulties have shown that their behaviour often fluctuates between periods of what could be considered as 'good' and those periods where their behaviour is severely disruptive (Butler, 2010; Linn & Songer, 1991). There is quantitative, empirical evidence to suggest that challenging behaviour in boys most often occurs between the ages of eleven to fourteen years (Butler, 2010). Adverse behaviour may be observed through negative interactions with others including poor response to reasonable requests made by those in authority, bullying and a lack of empathy.

It is widely known that the challenging behaviour of many school-age students has an adverse effect not only to their own wellbeing and achievement, but that of their peers. Highly emotionally charged social situations in the educational environment could interfere with the mental resources that are devoted to learning. The behaviour displayed by a significant proportion of adolescents is so severe that it presents significant challenges in ensuring the effective functioning of schools (Sproson, 2004a). Such behaviour is becoming an increasing concern to primary educators as a recent decline in behaviour coincides with an increasingly younger onset of puberty in Western cultures (Herman-Giddens et al., 2001; Parent, 2003). In fact, a recent Ofsted report estimated that over an hour of teaching a day is lost to general disruptive behaviour in lessons (Chapter 6). In the past, students presenting such challenges were simply excluded from mainstream education. In many local authorities, the number of specialist places for children with challenging behaviour has declined significantly in recent years (Didaskalou and Millward, 2002). This is partly due to funding issues but also reflects policies that support an inclusive ethos (Department for Education and Skills, 2001; Barton, 1995; Simmons and Nind, 2004). In schools, undesirable behaviour can be recorded quantitatively using database software such as the Student Information Management System (SIMS) to analyse punishments such as detentions or isolation from normal lessons and social interactions ('internal exclusion' or 'isolation'). Other, often web-based systems such as Go4Schools® give a qualitative view of behaviour and rewards to parents or carers and the students themselves which is often used as an incentive to good behaviour. However, for some children and adolescents, behaviour improvement is resistant to commonly used strategies (Chapter 1). The individual's behaviour may then be classified as 'difficult to manage' (Sproson, 2004b). Younger et al., (2005) report that these boys, in both primary and secondary school settings, project a stereotypical 'macho' image enhanced with their peers by non-conformist, disengaged behaviours and by demonstrating what they would like others to believe is a self-fulfilling prophecy of underachievement. When combined with the biological features shown earlier in this Chapter, this 'cool' image protects them psychologically from feelings of failure and an anti-learning, anti-establishment stance is often expressed in anger, disruption and displays of dominance. These boys often influence the tone, engagement, response to authority and the learning philosophy of a significant number of peers, exerting a behavioural influence on both genders (Price, personal communication, 2011; Younger et al., 2005).

Misbehaviour is sometimes considered to be a manifestation of developmental immaturity. Symonds (2009) found that younger adolescents exhibit variable daily emotional states than older adolescents and that emotional stability increases with time, stabilising after age 16. Early adolescence is characterised by emotional instability, poor emotional functioning and an increase in negative emotion (Mendle & Ferrero, 2012).

Evidence also suggests that boys exhibiting challenging behaviour have difficulty attending to, or accurately interpreting, social cues and have a poor perception of social nuances. Nearly all lack coping strategies for dealing with the conflict that invariably follows these 'lagging skills' (Greene, 2009; Sproson, 2004a). A number of other theories also propose that social information processing skills may be lacking in some individuals, explained by their different reactions to the same situation, including maladaptive behaviour (Crick and Dodge, 1994). Erdley et al. (2010) cite the example of two children who are teased in the same way by their peers. One may perceive this as play and respond by laughing whereas the other may interpret it as threatening and respond aggressively. Testosterone has been implicated in mediating a neurological processing shift from the PFC to the brainstem, associated with primitive 'fright, flight or fight' responses to threat. This can lead to social aggression in the case of fear of a proximate threat (Booth et al., 2006; Honk et al., 2011). This may explain why boys who are challenged by school staff sometimes flee or respond aggressively. Other deep brain structures such as the hippocampus and amygdala are associated with experiential learning including avoidance of past negative experiences such as the guilt and anxiety of being in trouble or experiencing punishment (Carson, 2007; Zitzmann & Nieschlag, 2001).

## 2.6 Conclusion to Literature Review

Many factors influence the behaviour of individual boys (Figure 1.1). The literature review cited the influence of the school, societal and built environments, socioeconomic status, cultural background, ecosystemic variables, friendships and adult influences. In addition, biological influences on behaviour and psychosocial measures such as diet, exercise; genetic variance and inheritable traits; pubertal development, timing and tempo; endocrinological factors and even environmental influences such as toxins are well known and widely discussed in the literature. Upbringing, stressful life events and early childcare all influence later behaviour and mental health. Much of these diverse components are thought to act singly or in combination to exert an effect on brain development, structure and function, which manifests in psychosocial and behaviour outcomes.

As a consequence of this literature review, avenues of exploration have been determined that guide this dissertation towards the analysis of specific biological, psychosocial and behavioural elements linked to the research questions, that is: the relationships between pubertal stage and behaviour; testosterone, cortisol and behaviour (endocrinological measures); pubertal stage, endocrinological measures and psychosocial functioning; and finally, psychosocial function and behaviour.

It is commonly believed that the behaviour of adolescents deteriorates as they pass through puberty (Research Question (a)). Varying degrees of association was seen between the numerous measures of puberty. Such measures include the development of secondary sexual characteristics, accelerated growth  and structural changes within the brain, particularly the pre-frontal cortex (PFC). Internationally, the measure of puberty used by paediatricians is Tanner staging, where stage 1 is pre-puberty and stage 5 is adult development. The two main measures of Tanner staging in boys are testicular volume and pubic hair distribution. It is clear from the literature that the only accurate and appropriate method for determining pubertal stage in educational research is self- or parent-assessed measures. In line with this, the Pubertal Development Scale (Peterson et al.,1988) was the method used to determine participant pubertal stage in the ALSPAC dataset and included self- or parent-assessed pubic hair distribution, genital development, voice change and axillary (armpit) hair growth. Height and weight were also recorded. The details of this will be discussed in Chapter 3.

Although the literature review explored the biological/neurological development of boys, it is beyond the scope of this project to undertake measures of brain development during adolescence. All of these studies have shown changes in the structure of the PFC during childhood and adolescence and some that development continues into the early adulthood. These studies also provide associations between PFC development and aspects of executive function that influence behaviour including social cognition and the modulation of inhibition and impulsivity. Although it may be reasonable to assume, therefore, that puberty would be a time of deterioration in behaviour in the secondary school setting, no empirical evidence is evident from the literature that such associations exist. This gap in the literature justifies the inclusion of an analysis between pubertal development and adolescent behaviour in school, furthermore that pubertal stage should be determined by the sole measure of self- parent-assessed pubic hair development.

An even more commonly held, subjective believe is that increased androgen levels in adolescence is directly responsible in some way for the stereotypical behaviours associated with the so called *teenage condition*. Of particular interest to this project is evidence cited for associations between testosterone, aggression, dominance, other negative externalising behaviours and the potential attenuating effects on educational achievement. Likewise, evidence for the effects of high and low cortisol levels on general externalising behaviours was also presented in the literature. However, no evidence for direct associations between testosterone or cortisol and in-school behaviour resulted from the literature search. This presents an important opportunity for this project to contribute to empirical knowledge regarding supposed associations between these hormones and the behaviour of adolescents in school. The chapter also explored the literature about relationships between pubertal stage, endocrinological measures (as discussed above) and psychosocial functioning excluding in-school behaviour.

The literature provides a rich source of empirical evidence that links adolescence to psychosocial aspects of externalising and internalising behaviours, in particular for those who display atypical pubertal development (timing and tempo). However, examination of the literature revealed inconsistencies of findings when examining associations between pubertal development, psychosocial factors and challenging behaviour. These sometimes conflicting positive and negative factors associated with late and early puberty are shown in Table 2.1

and the advantages and disadvantages, particularly for early-maturing boys is discussed within the associated text. Outcome variability between early and late development was discussed in Section 2.5.3 and a number of important psychological theories relevant to psychosocial factors were introduced. Few of the articles cited used standard objective measures for psychosocial functioning in operational practice just as adolescent psychiatry clinics and schools most using assessment tools designed for research. The ALSPAC dataset includes two such measures, responses to the Strengths and Difficulties Questionnaire (SDQ) and the Social Communication Disorders Checklist (SCDC) (both to be discussed in Chapter 3). This gives justification for the need to analyse SDQ and SCDC data with biological variables to provide evidence towards answering the relevant research question as well as potentially closing gaps in the literature.

Psychosocial measures and the behaviour of adolescents in school is an under-researched area. It may seem obvious that psychosocial development or status would affect both internalised symptoms and externalising behaviour in any age group. However, little empirical evidence was presented in the literature that links predictive or diagnostic psychosocial measures such as the SDQ and SCDC to behaviour in school. Even fewer studies show how the education system responds to and supports challenging behaviour in school. Most of the studies undertaken focussed upon educational outcomes such as achievement, rather than behavioural challenges, although strong evidence suggest that the two are highly associated. For example, four papers link aspects of executive function to selective attention, decision-making, voluntary response inhibition and working memory. All of these affect achievement but it is posited they are also likely to influence behaviour in school, poor decision-making (especially in the presence of peers) and voluntary response inhibition (affecting impulsivity) in particular. In this project, therefore, an analysis will be undertaken between SDQ and SCDC measures and in-school behaviour reported principally by teachers, all of which form part of the ALSPAC dataset.

The methods for examining the data variables and themes discussed above are fully discussed in the next Chapter.

# Chapter 3: Research Methods

## 3.1 Introduction to Chapter 3

To conduct this project, I opted for a quantitative methods design involving the acquisition and analysis of selected data variables from the Avon Longitudinal Study of Parents and Children (ALSPAC), a resource provided by the University of Bristol. Having explored the ALSPAC website and variables list, I determined that the dataset was much respected with dozens of research papers having been published in peer-reviewed journals where ALSPAC data had been used. Other longitudinal secondary data sets were available, but they did not include all the variables of interest to my project.

In line with the research questions and theoretical framework presented in Figure 1.1, I focussed on the following ALSPAC variables:

- Those required to calculate a Tanner Stage, specifically determinants of the stage of puberty - genital development, pubic hair distribution, the presence of axillary hair, voice change and Body Mass Index (BMI) calculated from height and weight variables;
- Endocrinological values - testosterone and cortisol salivary assays;
- Psychosocial variables taken from the Strengths and Difficulties Questionnaire (SDQ) and the Social Communication Disorders Checklist (SCDC);
- In-school and out-of-school behaviour variables taken from one parental questionnaire and three teacher questionnaires.

As discussed in Chapter 1, the purpose of this study was to explore factors associated with the behaviour of adolescent boys in the context of the school setting. In particular, these include biological factors relating to the physical changes associated with puberty and psychological factors such as social cognition and challenging behaviour. In line with this objective, analysis of data will involve exploration for potential associations between the variables of interest: plasma testosterone and salivary cortisol concentrations, physical development stage, aspects of social cognition behaviour. This Chapter presents my decision-making process to develop the study.

## 3.2 Research Paradigm

I place my study within the research paradigm of post-positivism. Research paradigm is a series of subjective beliefs about the world and the methods that need to be employed when a subject is studied. There are several research paradigms that can be selected to form the basis of a study, which include interpretivism, constructivism, critical theory, positivism and, as is the case in this study, post-positivism, which is derived from positivism.

Positivists argue that there exists a true and objective reality to which scientific methods and enquiry can be applied. In this perspective, the fundamental basis is that, "the object of study is independent of researchers; knowledge is discovered and verified through direct observations or measurements of phenomena; facts are established by taking apart a phenomenon to examine its component parts" (Krauss, 2005, pp. 760–761). Bryman (2008), states that there are five principles of positivism:

- Phenomenalism, where the senses can confirm and be regarded as knowledge;
- Deductivism, where hypotheses are generated and can be tested;
- Inductivism, the gathering of facts to make laws and as the basis of knowledge;
- Objectivism, the belief that science should be factual and 'value free;'
- Scientific statements are made that are free from subjectivity.

Nonetheless, for instance, endocrinological factors are out of the control of young people, making the rationality of positivism questionable. To manage what was perceived by some as an inappropriate and unrealistic inflexibility of the positivist stance, the contemporary paradigm of post-positivism was developed (Krauss, 2005). Post-positivism is a model of scientific enquiry or a theoretical stance that develops and amends positivism to allow such flexibility. Post-positivists believe that a number of factors such as researcher bias and existing knowledge, theories and hypotheses can influence observations during data collection and recognise such biases (Phillips, 2000). In most aspects, the beliefs of both academic factions are the same. For example, they both believe in a single reality, but the post-positivists argue that, due to the limitations of scientific methods, the resources available and the intellectual and sensory limitations of scientists themselves, factual reality can never be known.

I chose the paradigm in order to be as objective and unbiased as possible during data analysis and interpretation of results. Due to the data analysed being solely from a secondary dataset, I did not have any direct contact with the research participants, therefore did not have the capacity to influence the primary data collection.

## 3.3 Linking Research Questions to Research Design

In this Section, the research questions are discussed in relation to the study design. I will explain each question and their pertinence. As a background note, the quantitative methods choice is consistent with research designs frequently used to advance knowledge in the disciplines of both biomedical science and psychology, the two principal themes of this study. The secondary dataset variables sourced from ALSPAC (Appendix 3) allow for all analyses relating to the research questions without the need for primary data to be collected. These variables are discussed in detail in the sections that follow.

The ALSPAC dataset includes variables relating to pubertal development between the ages of 9 and 17 and measures of participant behaviour in school at ages 10 to 11 and both in-school and out-of-school behaviour at ages 15 to 16. This set of variables allow the testing of the first research question, “Does the behaviour of adolescent boys change in school as pubertal development progresses?” Those variables selected to analyse this research question that are ordinal were analysed using ANOVA and Pearson’s chi square for the analysis of dichotomous variables.

Although more limited than pubertal stage data, plasma testosterone assay data and salivary cortisol concentration data is available in the dataset too. This information permits analyses relating to the second research question, “Are endocrinological factors, particularly plasma testosterone and cortisol concentrations, associated with adverse behaviour in the school setting?” Because cortisol data was collected only at age 8 and so may be more closely linked to behaviour at ages 10 to 11. The endocrinological variables are comprised of continuous data but as measures of behaviour are either ordinal or dichotomous. The analysis of continuous with ordinal data took place using ANOVA, with chi square analysis to test ordinal and dichotomous variables.

Finally, answers to the last research question, “Is there a relationship between psychosocial measures in adolescent boys and their behaviour?” was sought by analysing psychosocial measures with biological markers. The ALSPAC data includes two extra types of data, First, adult responses to the Social Communications Disorder Checklist (SCDC) on behalf of the child which were collected at ages 11, 13 and 16. It covers early-, mid- and late-adolescence. Second, Strengths and Difficulties Questionnaire (SDQ) Prosocial Score data was collected at ages 9, 11, 13 and 15. Combined, SDQ variables and SCDC scores offer a measure of social cognitive function. When analysed with the biological data variables stated above, the results allow for possible relationships between biological factors and psychosocial functioning to be explored. As all variables in this particular analysis are based on scales and are therefore ordinal, a simple ANOVA was employed. In all cases, where appropriate, descriptive analyses also took place.

The project is designed to allow the research questions to be considered in a logical order. The dataset was be ‘cleaned’ to remove variables that were not of interest that are automatically provided as part of the dataset (Section 3.5). In some cases, new variables needed for the analyses but not provided in the dataset were created. To exemplify, a new variable for BMI was created from participant height and weight data which were provided. All the variables of interest provided in the secondary dataset were then analysed with each other in order to determine which variables should be used in the final quantitative analyses (Chapter 4). The data relating to participants with either extreme biological, psychosocial or behavioural values were analysed using a case study approach in Chapter 5.

Before the data cleaning process and description of how the variables were manipulated is discussed, it is pertinent to describe the secondary dataset from which these variables were obtained.

## 3.4 The Secondary (ALSPAC) Dataset

ALSPAC is an ongoing prospective observational study considering biological, genetic, psychosocial and environmental exposures and influences on health and development across the life course of participants. It is a transgenerational project, involving 14,541 pregnant women and their offspring recruited in Bristol between the dates of 1st April 1991 and 31st December 1992 but increased to 15,247 pregnancies as participants were able to enrol their children up to the age of 18 years (Pembrey & ALSPAC Study Team, 2004). The data was generated using 59 questionnaires and 9 clinical assessment visits and the resource comprises phenotypic and environmental measures in addition to biological samples, including DNA sequencing. There are also links to educational and health records of the participants (Boyd et al., 2013). Initial sponsorship and support for ALSPAC came from a variety of sources including UK Government Departments, the UK Medical Research Council, the Wellcome Trust, the British Heart Foundation and several American sponsors. Data is held and administered by the University of Bristol.

Recruitment of participants was aimed at women in early pregnancy with contact made through media and by recruiters visiting community locations. Running in parallel, staff at antenatal and maternity services promoted the study and helped screen for participant eligibility. Prospective participants were asked to complete a card notifying researchers of their interest in the study, which was followed up within one week.

Frequent assessments took place between birth and 18 years of age. The data collected includes 34 child-completed questionnaires, 9 on pubertal development and 25 questionnaires about the child completed by their mother or main caregiver. Follow-up school-administered questionnaires were completed by each child’s teacher. All questionnaires can be downloaded from the ALSPAC website together with a catalogue of all available variables collected at each stage (Bristol, 2012).

The dataset is longitudinal, sampling taking place from the same participants at various junctures relating to either age or stage of schooling. Figure 3.1 illustrates when the various data sampling episodes took place. Continuous anthropometric and endocrinological data was collected during clinic visits. Pubertal stage data was reported by the parents of younger children and in the case of older respondents, the participants themselves. All other data was ordinal or dichotomous, coming from parent, teacher and school questionnaires. It is a requirement that all research conducted using the dataset is listed on the University of Bristol website. As all the variables of interest are available from ALSPAC, involving a large participant population and methodically reputable value, they represent the best source of secondary data for this project.

The ALSPAC dataset is a well-known and used resource. There have been over 700 peer reviewed articles published that have used ALSPAC data, the details of which can be viewed on the ALSPAC website with many notable examples of how the associated findings have influenced policy (Fraser et al., 2013). One study has examined executive function, impulsivity and adolescent behaviour (Stautz, Pechey, Couturier, Deary, & Marteau, 2016); another has explored girls’ pre-school age behaviour related to testosterone levels in utero (Bristol, 2012). Following a review of all of the paper titles and abstracts listed on the ALSPAC Website, no studies to date explore adolescent male behaviour from the perspective of endocrinology, social cognition and pubertal stage. Therefore, this study is unique in the use of this dataset.

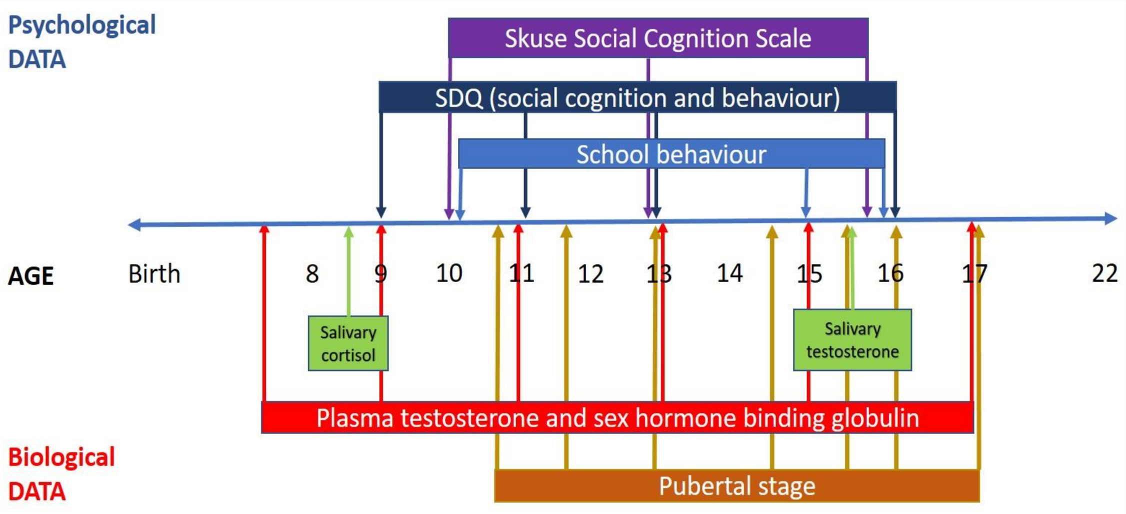



***Figure 3.1: Timing of events for data collection for all categories of variable from ALSPAC.***
***Note that the Skuse Social Cognition Scale is known throughout this project at the Social Communication Disorders Checklist (SCDC).***

Access to the data is gained via a project proposal form submitted during an online application process[24]. All proposals are allocated a unique identification number (in this case B2834) and are considered by a Committee of the University of Bristol. If approved, the study is included on the ALSPAC website and a 'Data Buddy' is allocated to assist with the identification and ordering of specific variables. These are selected from a downloadable catalogue and requested in an Excel spreadsheet sent to the Data Buddy (Appendix 3).

A University of Bristol ethics and confidentiality form was completed and endorsed by the project supervisor, requiring approval by the ALSPAC Team before data release. The data, in SPSS format (*.sav file) was supplied in a password protected, encrypted zipped folder, which was kept on a portable drive protected by Bitlocker[25].

In the sections that follow, a rationale is given for the cleaning, organisation, exclusion and creation of new variables from the ALSPAC dataset.

[24] http://www.bristol.ac.uk/alspac/
[25] Bitlocker is a proprietary security programme for Microsoft Windows® that allows an entire drive to be encrypted. Data is kept secret in the event of theft or loss.

## 3.5 Data 'cleaning', the organisation and creation of new variables and the reliability and validity of the variables.

*"The Dirty Data Theorem states that 'real world' data tends to come from bizarre and unspecifiable distributions of highly correlated variables and have unequal sample sizes, missing data points, non-independent observations, and an indeterminate number of inaccurately recorded values" (Unknown).*

The dataset acquired from ALSPAC includes data for all participants ever enrolled in the ALSPAC longitudinal study. It was necessary to remove variables that are automatically provided but not relevant to this study, for example, preferred birthweight, birth order of twins, the stage of the study at which the participant was recruited. Parental demographics was not provided, which would have been interesting to analyse, for instance, socioeconomic and education background. Although these variables may be important (Chapter 2), they are not essential for the purposes of this dissertation, which is, as a reminder, to examine biological, psychosocial and behavioural factors of male adolescents. Unfortunately, only 14,498 children were alive at one year so it was necessary to remove those who had died from the study since they would show as not participating and possibly affect the reliability of data analyses. As this project is focused on boys, girls were removed from the sample. This left a total sample of 7,635 boys for which at least some data existed. Unfortunately, there are significant gaps in the data. For example, testosterone data is only available for 197 boys and of those, psychosocial and behavioural values are only available for 108 participants (Table 3.1). As either the gender of the child was not recorded or the mother withdrew consent in 593 cases, these children could not be included in the study. Endocrinological data was collected by random sampling and so is not provided for every participant, however, full data has been provided for over 400 participants, which meets the statistical reliability requirements for the project (Section 3.6).

***Table 3.1: number of participants with complete data for each variable category***

| Androgen* | Cortisol | Pubertal stage | SDQ | SCDC | Year 6** behaviour | Year 11** behaviour |
|---|---|---|---|---|---|---|
| 197 | 474 | 1,105 | 2,274 | 745 | 3,804 | 2,671 |

*This is data relates to testosterone and sex hormone binding globulin.
** Year 6 is the final year of primary education and year 11 the final year of secondary education in the UK. Year 6 children are aged 10 to 11 and in year 11 they are 15 to 16.

ALSPAC researchers allocated an identifier number to each pregnancy, not individual children, so a unique identification number for each child was generated in Stata® (below) to take account of multiple births. This was needed to relate the data to individuals because the dataset includes 195 twins, three triplet and one quadruplet birth so the total data supplied relates to 15,450 children.

The creation or management of specific variables and variable groups are now discussed. The commercial statistical software package Stata® Version 15 IC was used exclusively for data cleaning, organisation and the creation of new variables analyses during this project. These processes are explained in the subsections that follow.

### 3.5.1 Participant age data

No variable for participant age was available in the acquired dataset so new variables for each age of independent variable data collection points were created in Stata® for the dataset in the wide format. As such, data relating to a single participant involves multiple variables for the same data at different time points. The variable ‘age’ was created when the dataset was converted to the long (stacked) format for analysis. Therefore, variables that measure the same thing are amalgamated to show variation according to different participants’ ages. In this case, the variables ‘Age9’, ‘Age11’, ‘Age13’, ‘Age14’, ‘Age15’, ‘Age16’ and ‘Age17’ were created with the dataset in the wide format as they correspond to the ages at which biological data was collected. The variable ‘age’ was necessary for reshaping the data to make the longitudinal analysis of variables possible. Further examples of variable creation and conversion between formats are given below (Table 3.2). Interrogation of the dataset showed that all 7,537 participants were represented in long format indicating an accurate conversion.

Additional variables were constructed to measure free testosterone, bioavailable testosterone and body mass index (BMI) percentile (explained below).

***Table 3.2: Independent variables relating to age, pubertal development, endocrinological and anthropometric data available in the ALSPAC dataset or constructed from it***

| Age | Pubertal Stage | Endocrine | Anthropometric |
|---|---|---|---|
| Age at which each measure was sampled* | • Development of penis, testes and scrotum<br>• Development stage of pubic hair<br>• Voice change<br>• Axillary hair development<br>• Tanner Stage* | • Sex Hormone Binding Globulin (SHBG)<br>• Serum (plasma) testosterone<br>• Mean exposure to testosterone over adolescence<br>• Bioavailable testosterone*<br>• Free testosterone*<br>• Cortisol | • Height (cm)<br>• Weight (kg)<br>• BMI*<br>• BMI percentile* |

*Variables that do not exist in the ALSPAC dataset that were created during this study

**3.5.2 Pubertal stage data**

Full explanations of pubertal measures were explained in Chapter 2, so what follows is an outline of the methods used to determine pubertal stage in this study. Important to this project is the accurate determination of the pubertal (Tanner) stage of each participant at the key ages where comprehensive and relevant data is available. Potential associations between Tanner stage and psychosocial measures is a key component of the aims of this study and needed to be explored.

Participants, or the parents of younger children, completed questionnaires based on the Pubertal Development Scale (Petersen et al., 1988). It consists of an eight item self-reported measure of physical development based on Tanner staging, an international standard of measure of pubertal development (Marshall & Tanner, 1970; Tanner, 1978). Male participants were asked to record details of their height, weight, genital development, pubic hair distribution, voice change and the presence of axillary (armpit) hair (Appendix 1). These were recorded as individual variables in the dataset, therefore a single measure of pubertal status was not recoded. This affords researchers several options to determine pubertal stage at each age of data collection, that is ages 11, 13, 14, 15, 16 and 17 bearing in mind that not all these individual indicators of pubertal stage are equally dependable. It was therefore important to decide on the most reliable indicators to determine pubertal status.  Evidence from several studies suggest that the only reliable self-report measure of pubertal stage is pubic hair distribution. In this study, the correlation at all ages between these variables was investigated in order to select the most reliable indicator of pubertal stage (Appendix 5).

Analysis of the ALSPAC data during this study showed that most boys identified a change of voice and the presence of axillary hair at Tanner stage 3 (mid-puberty). There is strong evidence to suggest that genital development is not a reliable self-measure of pubertal stage (Carskadon & Acebo, 1993; Desmangles et al., 2006). Pearson correlational analysis showed a statistically significant association between all variables at all ages(Appendix 5). At age 11, there was a significant, moderate association between self-evaluation of pubic hair and genital development, $r\ (2755) = .31$, $\rho < .001$; at age 13, $r\ (2085) = .65$, $\rho < .001$; at age 14, $r\ (1957) = .58$, $\rho < .001$; at age 16, $r\ (1661) = .43$, $\rho < .001$; and at age 17, $r\ (1517) = .43$, $\rho < .001$. It is interesting to note that accuracy between the two self-measures of pubertal stage is age dependent, with the best accuracy during mid-adolescence when most boys are ages 13 or 14, declining after this age (Appendix 5).

Given the nature of the data, peak height velocity (to be discussed below), would be arduous to calculate for many participants. Peak height velocity only signifies the onset of puberty and does not indicate a Tanner stage, which was required for this study. This led to the decision to use pubic hair development as the sole determinant of pubertal stage. This one variable, measured at eight points in time, corresponding to pubertal stage at each age, was used in the stacking of the dataset into the long format and collapsed into a new ‘Tanner’ variable according to the age at which sampling took place. Table 3.3 illustrates this transformation. Taking into consideration the high association between all the variables and that, as suggested in the literature, pubic hair distribution is the most reliable self-measure of pubertal stage, this was selected as the sole measure of pubertal stage during data analysis.

***Table 3.3: Illustration of the transformation between wide and long data format.***

**Data in wide format**

| Variable: | Pub355 | Pub455 | Pub555 | Pub655 | Pub755 | Pub855 | Pub955 |
|---|---|---|---|---|---|---|---|
| Age: | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Participant 11 | Tanner 1 | Tanner 2 | Tanner 3 | Tanner 4 | Tanner 4 | Tanner 5 | Tanner 5 |

**Same data in long (stacked) format**

| Participant | Age | Tanner |
|---|---|---|
| 11 | 11 | 1 |
| | 12 | 2 |
| | 13 | 3 |
| | 14 | 4 |
| | 15 | 4 |
| | 16 | 5 |
| | 17 | 6 |

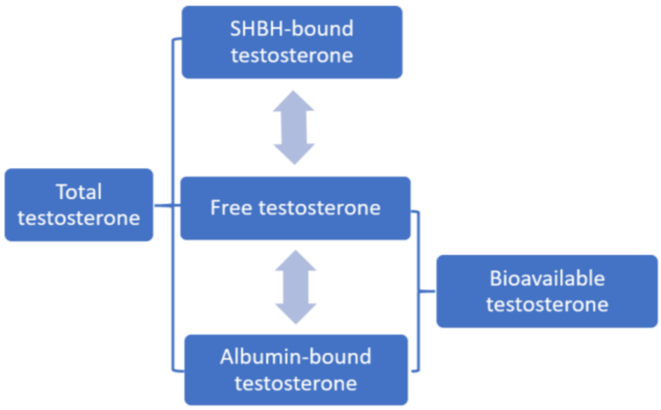
### 3.5.3 Endocrinological data (testosterone)

Endocrinological data measured during clinic visits were included in a set of variables under the domain ‘biological data.’ It included plasma testosterone and salivary cortisol concentrations recorded in $nmol^{-1}$. The dataset included a cumulative measure of testosterone exposure over adolescence, which may better explain the behaviour and psychosocial values of participants. Linked to the biological actions of testosterone is the plasma protein sex hormone binding globulin (SHBG) (Chapter 2) which was also available to this study. The stress hormone cortisol was sampled only at age 8.5 whereas testosterone sampling was at ages 9, 11, 13, 15 & 17. For clarity, the data for cortisol is discussed in the next Section.

Plasma testosterone and sex hormone binding globulin (SHBG) assays were collected in 2,216 samples from 513 boys at ages 9, 11, 13, 15 & 17 and given to the ALSPAC repository from a further study of brain structure using magnetic resonance imaging by Khairullah et al. in 2014. These researchers kindly gave permission for this endocrinological data to be used in this doctoral project mediated by Amanda Hill (Data Buddy) from the ALSPAC Team. Fasting blood samples were taken by intravenous venepuncture from participants in the morning (between 8:00 and 9:00) and were sent to a biomarker laboratory for analysis of sex steroid concentrations using commercially available enzyme-linked immunoassays.

There are potentially five measures of testosterone, the effects on the body of which have been considered by medical, biological and behavioural scientists (Figure 3.2). However, not all the testosterone identified in the plasma (total testosterone) is able to exert an influence on biological targets in the body. This is because testosterone binds strongly to SHBG (60-90%) and is not, in this bound form, available to exert a significant biopsychological influence. Some testosterone (approximately 53%) is also weakly bound to other plasma proteins, principally albumin. This weakly bound fraction is easily given up, thus making it active in effect. Depending on idiosyncratic variability, approximately 2-3% of testosterone circulates in an unbound state termed *free testosterone* (FT). That fraction which is biopsychologically active and available is known as *bioavailable testosterone* (BT). It is the sum of free testosterone and albumin-bound testosterone which constitutes 55% of all forms of testosterone (*Free & Bioavailable Testosterone Calculator*, 2018; Johnson & Everitt, 2000).

***Figure 3.2: The relationships and interchangeability between the five measures of testosterone.***




BT exerts an effect on a number of biological targets responsible not only for the development of secondary sexual characteristics during puberty, but also for the maturation of the adolescent brain (Burnett, Dahl, & Blakemore, 2010; Khairullah et al., 2014).

Serum concentrations of plasma proteins, including SHBG and albumin are highly variable in males and are dependent upon factors such as BMI, diet, age and insulin concentrations. In most healthy individuals, the plasma albumin concentration is approximately 4.3 g/dL, so this value was used as a constant when calculating $[FT]_{plasma}$ and $[BT]_{plasma.}$ Clinical endocrinologists consider that this pre-set gives a relatively accurate estimate of free testosterone so long as the patient does not have significant ill health which may alter serum albumin (Bhasin et al., 2010). Two new STATA® variables for $[FT]_{plasma}$ and $[BT]_{plasma}$ were created using the Vermeulen FT BT Model (Vermeulen et al., 1999). Using the general equation below (Equation 3.1), provided by this model, values were calculated into these new variables from the plasma testosterone concentration ($[testosterone]_{plasma}$) variable, the plasma SHBG ($[SHBG]_{plasma}$) variable and a plasma albumin concentration ($[albumin]_{plasma}$) constant value of 4.3 g/dL as stated above.

***Equation 3.1***

$$Testosterone_{total} = Testosterone_{free} + Testosterone_{SHBG-bound} + \mathrm{Testosterone}_{\mathrm{albumin-bound}}$$

Since bioavailable testosterone is the sum of free, SHBG-bound and albumin-bound testosterone, these can be combined and the equation rearranged to make bioavailable testosterone the subject (Equation 3.2).

***Equation 3.2***

$$Testosterone_{bioavailable} = Testosterone_{free} - Testosterone_{SHBG-bound}$$

As an exploration of $[BT]_{plasma}$ at different ages and pubertal stages is required, the data is stacked according to age, $[BT]_{plasma}$ and Tanner State for the analysis that follows.

Khairullah et al. (2014) devised a model that was applied to individuals' testosterone trajectory that calculated their average exposure to testosterone over adolescence. They pooled the data generated by their model alongside that of other studies in the literature to create a reference range of testosterone levels in males between the ages of 6 and 19 years. The variable for mean exposure over adolescence is already supplied in the ALSPAC dataset, the distribution for which is shown in Figure 3.3.

This data is pooled for all children for which testosterone levels were measured at ages 9, 11, 13, 15 and 17. The average exposure to testosterone can be employed in several investigations by any researcher or research team relating to associations between testosterone trajectories and pubertal dynamics, biopsychosocial development, behaviour and psychopathology as in this study.

***Figure 3.3: Histogram illustrating mean exposure to testosterone over adolescence. Source: ALSPAC.***

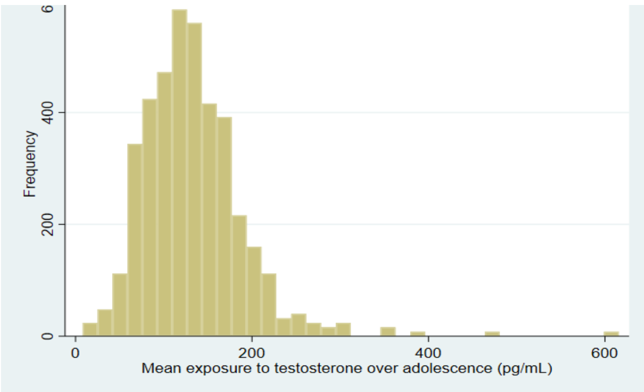
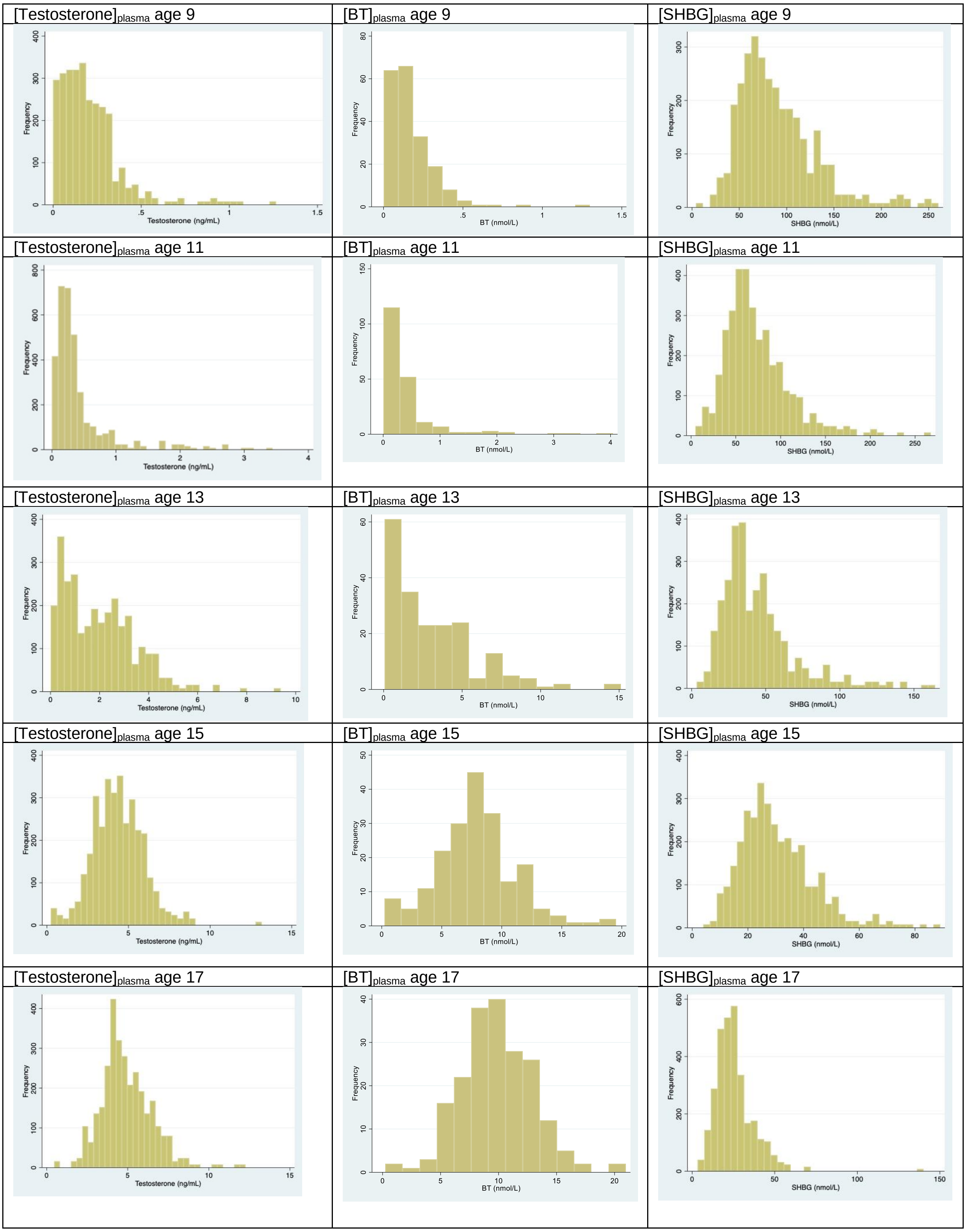



Figure 3.4 shows histograms for [Testosterone]$_{plasma}$ (plasma testosterone concentration), [BT]$_{plasma}$ (plasma bioavailable testosterone concentration) and [SHBG]$_{plasma}$ (plasma SHBG concentration) at these ages. The x-axes scales must be read carefully as these vary for each graph based on typical values for each age. As expected, at ages 9 and 11, [testosterone]$_{plasma}$ data is positively skewed showing that most participants have low plasma concentrations at these most commonly pre-pubertal ages. A value of 0.5 ng ml$^{-1}$ and above was chosen as the demarcation point for extreme outliers at age 9 (*n*=21) and a value of 1.5 ng ml$^{-1}$ at age 11 (*n*=23). At age 13, the [testosterone]$_{plasma}$ data is more widely distributed between 0.1 and 3.5 ng m$^{-1}$ with extreme values corresponding to 4.4 ng ml$^{-1}$ and above (*n*=19). By the age of 15, the [testosterone]$_{plasma}$ shows a normal distribution with small numbers of participants with very low and very high values being evident as at age 17. In this case, high values are 6.9 ng ml$^{-1}$ or above at age 15 (*n*=20) and 7.5 ng ml$^{-1}$ at age 17 (*n*=20).

***Figure 3.4: Histograms illustrating serum testosterone, SHBG & bioavailable testosterone plasma assays at ages 9, 11, 13, 15 & 17. Source: ALSPAC.***



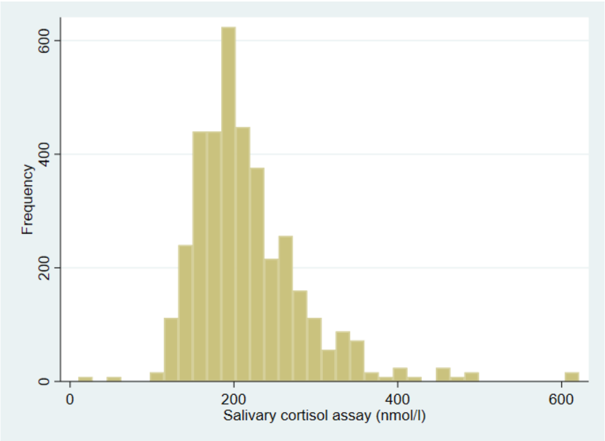
## 3.5.4 Endocrinological data (cortisol)

Cortisol (hydrocortisone) is a glucocorticoid steroid hormone released from the adrenal cortex in response to stress. Its normal plasma concentration range is between 85 and 618 nmol $l^{-1}$ (Stryer et al., 2002). Salivary cortisol concentrations ($[cortisol]_{saliva}$) are an accurate indicator of plasma concentrations (Grotzinger et al., 2018) and samples were easier to collect than intravenous blood during ALSPAC clinic data collection. Biological salivary samples were collected from participants by passive drool in controlled conditions using commercially available Salimetrics® kits. Samples were stored according to the manufacturer's instructions before being sent to an approved UK laboratory for analysis by assay. Analysis was only conducted with maternal consent. Results were documented electronically according to participant (pregnancy) number. It has been determined that salivary assays provide accurate results with a minimum detection limit at the picomolar concentration and a capture range of individual differences in boys of 99.09% (Granger, Scwartz, & Arentz, 1999).

Figure 3.5 shows a histogram for $[cortisol]_{saliva}$ (nmol $ml^{-1}$) taken at age 8, the only age for which this data is available. The data is normally distributed with a small number of extreme low and high outliers; the participants exhibiting these values are discussed in Chapter 5.

It should be noted that extreme $[cortisol]_{plasma}$ works as diagnostic indicators for Cushing's disease (high levels) or Addison's disease (low levels). These diseases are known to affect behaviour; both are associated with fatigue, cognitive dysfunction, anxiety, irritability and depression in children. They differ in terms of BMI changes in that Cushing's disease causes weight gain whereas Addison's disease causes weight loss (McCance & Heuther, 2018). These conditions are very rare in children, with an incidence of approximately 10-15/million. Where disease markers exist in the following study of extreme outliers, the possibility of disease will be stated. As their physical signs and symptoms are very debilitating and would be noticeable to parents and professionals, it is likely that participants would be medicated. Some problems exist in making inferences from

***Figure 3.5: Histogram illustrating salivary cortisol assay data at age 8 (nmol/ml).***



cortisol assay data aside from possible pathology. Cortisol levels follow a diurnal cycle, that is, they are usually higher in the early morning, decline during the day, and then undergo a nocturnal rise (Opstad, 1994; Sigman, 2011). Comparisons between participants can be made as samples were collected at the same time each day. *In utero* cortisol data from the ALSPAC study was used to measure *prenatal* stress and was associated with reduced resilience to anxiety during childhood (Fraser et al., 2013). Cortisol plasma concentration can also be altered by short-term responses to stress, anxiety and fear (Stryer et al., 2002). Aware of the influence of stress on cortisol levels, a final dilemma discussed in Chapter 5 in the context of extreme outliers is whether the abnormal $[\text{cortisol}]_{\text{saliva}}$ caused adverse behaviour and externalising symptoms, or if abnormal levels were, in fact, the result of it (Lenneke et al., 2008).

### 3.5.5 Anthropometric data

As part of the pubertal development questionnaire completed by parents and older children, instructions were given to measure height and weight accurately. Measurements for these two variables were available at ages 9, 11, 12, 13, 14, 16, and 17. There are three height-based markers of pubertal status: Age at Peak Height Velocity (APHV), Height Difference in Standard Deviations (HDSDS) and Percent Achieved of Adult Stature (PAAS). Khairullah et al. (2014) report that all these measures correlate strongly with each other and that PAAS correlates well with both testosterone levels and self-reported pubertal stage data. As ALSPAC testosterone levels and pubertal stage data is available, it was unnecessary to consider height variables to derive or verify pubertal state.

As the dataset did not include a variable for BMI, two new variables were created, BMI and BMI percentile. BMI is simply calculated using the standard equation:

***Equation 3.3***

$$\text{BMI} = \text{Weight(kg)}/\text{Height(m)}^2$$

However, for children and young people aged between 2 and 18, BMI is not an appropriate measure as it does not consider age and gender (NHS, 2018). For example, a tall, slim boy aged 14 would show an abnormally low BMI score for what is normal for this stage of development. Boys tend to grow in height initially then develop body mass, mostly due to muscle growth, at a later stage (Marshall & Tanner, 1970). For this reason, paediatric BMI is calculated and expressed as a centile.

Centile values indicate:

- Underweight – 2nd percentile or below
- Healthy weight – between 2nd and 91st centiles
- Overweight – 91st centile or above
- Obese – 98th centile or above.

Converting BMI to a centile score involves calculating the Z-score using equation 3.4 (‘Growth Charts Percentile Data Files with LMS Values’, 2017).

***Equation 3.4***

$$\mathrm{BMI}_{\mathrm{Z-score}} = \left[\left(\frac{\mathrm{BMI}}{\mathrm{M}}\right)^{\mathrm{L}} - 1\right] \div (\mathrm{L} \times \mathrm{S})$$

where: M is the median, S is the generalised coefficient of variation and L is the power in the Box Cox transformation.

It should be noted that at extreme values of >97th percentile or <3rd percentile, small differences in percentiles correspond to clinically significant differences in BMI. The z-score is therefore more precise in measuring how the individual measurement deviates from the mean (‘Body Mass Index (BMI) Percentiles for Boys Calculator’, 2018), which, combined with the discussion above, validates the choice of centile as the measure for the study analyses. Appendix 4 illustrates a typical growth chart for boys with percentiles for age. In Chapter 4 this variable was analysed with biopsychological and behavioural variables. In Chapter 5, possible associations between BMI centiles, psychosocial and behavioural variables was explored in cases of extreme outliers.

### 3.5.6 Psychosocial and behavioural variables

ALSPAC questionnaires yielding psychosocial and behavioural data were completed by the child’s principal caregiver and teachers. The Social Communication Disorder Checklist (SCDC) was completed by parents and Strengths and Difficulties Questionnaires (SDQ) were completed by parents, teachers and the children themselves. School behaviour questionnaires were completed by teachers for year 6 and year 11 pupils (Figure 3.1).

The SCDC questionnaire is comprised of 12 questions with three responses (Section 3.6) which provide a measure of social cognition and behaviour towards others. Responses in the ALSPAC dataset were coded 1 if the response was ‘not at all true’, 2 for ‘quite or sometimes true’ or 3 for ‘very or often true’ of the child. They result in a maximum score of 24, where scores of 8 and above are considered abnormal. It is considered clinically useful and is widely used as a screening tool for autistic spectrum disorder, ADHD, Tourette’s Syndrome, pragmatic language disorder and obsessive-compulsive disorder (Bölte et al., 2011a; Skuse et al., 2005). Two additional questions were added relating to other potential difficulties experienced by the participants. These gave a score of 14 for a typically developing child, but were not considered. The SCDC data for the 12 questions was recoded in the statistical software used for data analysis in this study, Stata®: ‘not at all true’ was recorded as zero, ‘quite or sometimes true’ as 1 and ‘very or often true’ as 2 to give a standardised score for the SCDC. These actions allowed for a total SCDC score at ages 11, 13 and 16 to be calculated as a new variable in Stata® (Table 3.4). In turn, this permitted an analysis for normally scoring boys to be compared with those who had abnormal scores and further analyses could take place between the SCDC score and biological variables or other psychosocial measures.

The SDQ is a well-known, widely published screening tool for behavioural and mental health issues in children aged 3 to 16 years old. It is widely used in over 100 countries in educational, clinical and research settings stated above (‘Youth in Mind: Information of researchers and professionals about the Strengths & Difficulties Questionnaire’, 2018). There are four components to the questionnaire, each with five items the scores for which can be added to give a total score. There is a fifth, prosocial behaviour component that measures empathy and kindness. Appendix 6 shows the components, questions and scoring matrix for the SDQ.

Table 3.4 lists the variables available in the ALSPC dataset in each of the categories. Some overlap in themes exists between these two main categories. For example, the Strengths & Difficulties Questionnaire (SDQ) conduct score involves questions relating to behaviour as do elements of the Social & Communications Disorder Checklist (SCDC) questionnaire.

For this study, 11 variables from an in-school behaviour questionnaire completed by year 6 teachers were acquired. Responses were coded as 1 for ‘not true’, 2 for ‘somewhat true’ and 3 for ‘certainly true.’ To allow a comparison of behaviour with psychosocial and biological variables, a new variable was created in Stata® which calculated the sum of these behaviour scores with 11 the lowest score and 33 the highest. As the year 6 total behaviour score was created for this study, there are no published references from which normal and abnormal scores can be determined. However, each participants' total score is a measure of their behaviour difficulties and allows statistical analyses with other variables.

***Table 3.4: Dependent variables relating to psychosocial and behavioural data available in the ALSPAC dataset or constructed from it. Source: ALSPAC.***

| Psychosocial variables | Behavioural variables |
|---|---|
| **Strengths & Difficulties Questionnaire (SDQ):**<br>▪ Emotional symptoms<br>▪ Hyperactivity<br>▪ Conduct problems<br>▪ Peer problems<br>▪ Prosocial score<br>▪ Total difficulties score<br>**Social & Communications Disorders Checklist (SCDC):**<br>▪ Awareness of others' feelings<br>▪ Realisation of others being upset or angry<br>▪ Realisation of the effect of their behaviour on others<br>▪ Noticing the effect of their behaviour on the family<br>▪ Disruption of behaviour to family life<br>▪ Demanding of other people's time<br>▪ Difficult to reason with when upset<br>▪ Doesn't understand social skills<br>▪ Does not pick up on body language<br>▪ Does not understand how to behaviour in public<br>▪ Realisation that they offend others with their behaviour<br>▪ Disobedient<br>▪ Only follows commands that are carefully worded<br>▪ Parents had other concerns in past six months<br>• SCDC total scores for ages 11, 13 & 16* | **Year 6 behaviour variables (in past year):**<br>▪ Has had temper tantrums<br>▪ Argued a lot with adults<br>▪ Disobedient<br>▪ Deliberately annoys others<br>▪ Annoyed by others<br>▪ Angry & resentful<br>▪ Spiteful<br>▪ Started fights<br>▪ Bullied others<br>▪ Physically cruel<br>▪ Showed unwanted sexual behaviour<br>• Year 6 behaviour total score*<br>**Age 16 parental behaviour report (in past six months):**<br>▪ Young person (YP) awkward/troublesome<br>▪ YP had temper outbursts<br>▪ YP often argued with adults<br>▪ YP often ignored rules or disobedient<br>▪ YP did things to deliberately annoy others<br>▪ YPs teachers complained of awkward behaviour/disruptiveness<br>▪ YP has played truant in past 12 months<br>**Year 11 behaviour variables (Teacher Questionnaire 1):**<br>▪ Frequency YP has arrived late to avoid part of lesson<br>▪ Frequency YP has gotten into physical fights in or out of school<br>▪ Frequency YP has been suspended or excluded from school<br>**Year 11 behaviour variables (Teacher Questionnaire 2):**<br>▪ Study child has had one detention<br>▪ Study child has had a number of detentions<br>▪ Study child has been fixed-term excluded<br>▪ Study child has been permanently excluded<br>▪ School has contacted parents with concerns about study child's behaviour<br>▪ School has contacted parents with concerns about study child's attitude towards school |

*Variables that do not exist in the ALSPAC dataset that were created during this project.

It was necessary to merge some year 11 teacher questionnaire variables for analyses in Chapter 4, described in the relevant sections. No other psychosocial variables required reorganisation or restructuring in order to be used during data analysis during this study.

Appendix 5 is principally a univariate with some multivariate analysis of individual and categories of variable. Not all variables are relevant to the study and this analysis provides justification for the inclusion of those variables selected for analysis in chapters 4 & 5. In addition to this Chapter, the analyses in Appendix 5 provide further evidence of the reliability and consistency of the dataset and original or constructed variables used in this project.

## 3.6 Methods and data analysis

Section 3.5 provided a detailed discussion of the methods used to sort and clean the data for this study, the organisation of existing variables and the creation of new variables necessary for data analysis. This section builds upon those discussions in explaining the methods used to analyse the data. It also introduces the analyses between individual variables performed to check for validity as a means to decide which variables should be analysed in order to provide evidence pertinent to the study's research questions. Four types of data were sought: psychosocial, pubertal, endocrinological (testosterone and cortisol).

As discussed above, this study used secondary data provided by the ALSPAC project. Psychosocial data was provided by teachers or parents completing questionnaires and was coded by the ALSPAC Team (SDQ and SCDC, as described in Section 3.5). ALSPAC also collected pubertal data by questionnaires answered by parents for younger children and the child themselves for older participants. The data was either continuous, with respect to height, and weight, dichotomous regarding axillary hair or voice change and ordinal regarding pubic hair development or development of the genitals (Appendix 1). *Plasma testosterone* samples were collected by venepuncture and *salivary cortisol* samples passive drool in controlled conditions using commercially available Salimetrics kits. Results were documented electronically according to participant (pregnancy) number. The summary of data is shown in Table 3.1.

Stata® Version 15 IC (StataCorp) was used for the pre-*viva voce* data analysis and Version 16 IC following the *viva* due to a StataCorp update. A power analysis was conducted using the software package, G*Power (V.3.1.9.2). The secondary (ALSPAC) dataset was comprised of ordinal, continuous and dichotomous variables. Ordinal data was analysed using one-way analysis of variance (ANOVA) and where significant differences were seen, a post hoc test (Tukey's HSD) was undertaken and reported. Continuous variable data was analysed using simple regression. As is convention, psychosocial and behaviour scales were treated as continuous as they exceeded five data points (Field, 2016). In analyses involving teacher questionnaire 2 data, a contingency table was constructed which included the Pearson's chi-square statistic for each combination of measures. As this does not automatically give a measure of association, the calculated Cramér's V coefficient was provided.

The alpha level used for the power analysis was $p < .05$ with a statistical power (1-β err prob) of *.80, both of which are considered appropriate for research in the field of biopsychology in education (Field, 2013). Analysis shows that the number of participants required to detect a: small effect size is 126; medium effect size is 106; and for a large effect size is 105. The ALSPAC data set, therefore, provides an appropriate number of participants to meet the power value required for the variables of interest. Once again, Table 3.1 shows the number of participants with complete data for each variable category. During the analyses that took place in Appendix 5, Spearman rho, Pearson correlation and Chi square were appropriate statistical methods (Bryman, 2008).

Table 3.5 shows the summary of the data analysis plan. In the Table, Parts 1 and 2 are retrospective of this thesis, given that cleaning and manipulation took place in Section 3.5. A full discussion of each analysis is provided at the appropriate juncture in Chapter 4.

***Table 3.5: Data analysis plan detailing statistical methods for each stage of the project.***

| Research question outline (if app.) | Variables used in analyses | Statistical testing method |
|---|---|---|
| Part 1: Data 'cleaning', the organisation and creation of new variables and the reliability and validity of the variables. | | |
| Creation of variable 'age' to allow rearrangement of data variables to stacked (long) format for comparison. | Points identified by pubertal stage and SDQ collection ages (e.g. pub355 collected age 11). | Not applicable. |
| Compare variables associated with the identification of pubertal stage and select that which is most reliable. Create new 'Tanner' variable for this at ages or interest. | Height, weight, genital development, pubic hair development, voice changes and axillary hair variables considered for creation of new variables, 'Tanner11', 'Tanner13', 'Tanner15' & 'Tanner17.' | Not applicable. See Section 3.5 and Appendix 5. |
| Create single variable as measure of testosterone for multivariate and case study analysis. Not applicable. See Section 3.5 and Appendix 5. | Plasma testosterone assay variables. Creation of new variables, "Testo11", 'Testo13', 'Testo15' & 'Testo17.' | Not applicable. See Section 3.5 and Appendix 5. |
| Assessment of cortisol as valid measure for multivariate and case study analyses. | Single salivary testosterone variable of data collected at age 8.5. | Descriptive analysis. Univariate analysis (Appendix 5). |
| Calculation of a BMI variables at ages 9, 11, 12, 13, 14, 16 & 17 for case study analyses (Chapter 5). | Height and body weight variables used to calculate BMI percentile values for all outlier participants in Chapter 5. | Equation 3.3 used to create BMI variable. From this Equation 3.4 used to convert BMI to centile score (Section 3.5). |
| Part 2: Univariate analysis to determine reliability of the data and to select variables for multivariate analysis (Appendix 5). | | |
| Psychological.<br>Social cognitive function.<br>Pubertal development.<br>Endocrinological variables. | All SDQ variables. Created SCDC score variable and SDQ prosocial score. Created Tanner stage variable. Created bioavailable testosterone variable. Cortisol variable. | Univariate analyses (Appendix 5): Pearson correlation (testosterone with cortisol), Spearman rho (SDQ, SCDC and pubertal stage and between these and testosterone and cortisol data). |
| Part 3: Multivariate analysis between biological, psychosocial and behavioural data. | | |
| The behaviour of adolescent boys changes as pubertal development progresses. | Year 6 teacher questionnaire variables. Parent questionnaire variables (ages 15 to 16).<br>Teacher questionnaire 1 & 2 variables (year 11).<br>Created Tanner variables all ages. | Ordinal year 6 teacher, parent and teacher questionnaire 1 with ordinal Tanner stage variables, ANOVA. Descriptive (scatter plots) where appropriate.<br>Dichotomous teacher questionnaire 2 with ordinal Tanner stage variables, Pearson's $X^2$ with Cramér's *V*. |
| Endocrinological measures are associated with challenging behaviour in the school setting. | Bioavailable testosterone variable at various ages. Single cortisol variable. Parental, year 6 teacher and first year 11 teacher questionnaires (treat each response as a variable). Merged teacher questionnaire 2 dichotomous variables into 'detentions', 'exclusions' and parental contact by school. | Bioavailable testosterone then cortisol (continuous data) with year 6 teacher, parental and first year 11 teacher questionnaire (ordinal) by regression analysis. Teacher 2 with testosterone then cortisol with Pearson's $X^2$ with Cramér's *V*.<br>Descriptive analysis (scatter plots) where appropriate. |

| | | |
|---|---|---|
| The relationship between biological changes during puberty and psychosocial functioning. | Bioavailable testosterone, cortisol and tanner stage variables at various ages. SCDC total score and SDQ hyperactivity, conduct and total scores. | All analysis by ANOVA as when Tanner stage involved. Regression analysis for continuous biological, psychosocial and behavioural scales. Descriptive analysis (scatter plots) where appropriate. |
| The relationship between psychosocial measures and the behaviour of boys. | SCDC score and SDQ hyperactivity, conduct and total scores. Parental, year 6 teacher and first year 11 teacher questionnaires (treat each response as a variable). Merged teacher questionnaire 2 dichotomous variables. | All variables except for teacher questionnaire 2 are ordinal so analysis by ANOVA. Teacher 2 questionnaire with all other variables by Pearson's $X^2$ with Cramér's *V*. Descriptive analysis (scatter plots) where appropriate. |
| Part 4: Case study analysis of participants with extreme outlier data values (the need for a case study analysis was determined by the multivariate analysis). | | |
| Atypical pubertal development with psychosocial problems and challenging behaviour. | Tanner stage variables at different ages. Created age variable. Parental, year 6 and year 11 behaviour questionnaire data. SCDC and all SDQ variables. | The values for all variables for each participant are tabulated then individually discussed as a case study. Descriptive analyses where appropriate. |
| Abnormal anthropometric values with psychosocial problems and challenging behaviour. | Body Mass Index centile variables at ages 11, 13 & 15. Created age variable. Parental, year 6 and year 11 behaviour questionnaire data. SCDC and all SDQ variables. | |
| Extreme endocrinological variables with psychosocial problems and challenging behaviour. | Bioavailable testosterone and cortisol variables. Parental, year 6 and year 11 behaviour questionnaire data. SCDC and all SDQ variables. | The data relating to individuals of concern are tabulated according to each participant. The biological, psychosocial and behavioural data summarised in the table is then discussed. No statistical analyses required. |
| Analysis of boys who are regularly excluded. | Tanner stage, bioavailable testosterone and cortisol variables. Parental, year 6 and year 11 behaviour questionnaire data. SCDC and all SDQ variables. Separate parent and teacher questionnaire variables specific for fixed-term and permanent exclusions. | |

Appendix 5 explains in detail the inclusion of data variables. Parts 3 and 4 will be introduced in the subsequent chapters. Chapter 4 is the bases of the quantitative analysis between these variables. The case studies of extreme physical and psychosocial outlier cases were discussed in Chapter 5 along with a comparison involving participants who did not meet the stated extreme criteria.

The aim of the analyses in Chapter 5 was to explore associations between variables in the context of the real world. A case study approach with a descriptive narrative around the biological, psychosocial and behavioural manifestations of boys exhibiting extreme values for one or more of these variables was appropriate. Gillham (2010, p. 1) defines a case study as "a unit of human activity embedded in the real world…which can only be studied or understood in context." In order to do this, a new method of data processing called 'qualitising' was used in the conversion and formatting of data for the case study analysis in Chapter 5. Whereas 'quantitising', an established method, involves converting qualitative data into numerical codes for statistical analysis (Leech & Onwuegbuzie, 2009; Miles & Huberman, 1994; Tashakkori et al., 2003), 'qualitising' is the opposite in that the technique involves the transformation of numerical data into a quantitative form, that is, obtaining narratives to explore the meaning of numerical data (Onwuegbuzie & Leech, in press). Technically, the term does not formally exist in the literature, with the first publications describing the technique still forthcoming. In this process, the quantitative data relating to participants in Chapter 4 was examined in Chapter 5 with more 'qualitative lenses.' Statistical analyses are not, therefore, indicated when following this approach. This case study method follows abductive inference where the data for individual boys is scrutinised, comparisons made with other variables and participants in order to seek possible explanations for the observations made (Burch, 2018). Finally, as case studies explore phenomena for a small number of individuals, much more can be revealed about these than in the case of the large number of contexts in the multivariate analysis (Gerring, 2006).

## 3.7 Research Ethics

Approval for this study was obtained from the University of Cambridge Faculty of Education and the ALSPAC Law & Ethics Committee. The Faculty of Education operates a streamlined system for ethics approval and both phases were approved by the Supervisors following the completion of a Research Ethics Review Checklist (Appendix 2) which was submitted prior to the registration *viva* in November 2016. This document confirms adherence to the ethical guidelines of the British Educational Research Association and was discussed during research supervisions with the decision that no further clearance was deemed necessary. A Faculty of Education Risk Assessment form for the project was also completed but it has been disregarded as the original plan to collect primary data from local participants was revised to a study that only used secondary data. The ALSPAC Committee meets every two months to consider applications for ALSPAC data usage. For the ALSPAC Study, parents were informed at the time of enrolment that their child's clinic records, parental, school and participant questionnaire data would be accessed for other research. Parents are nonetheless able to withdraw their consent to allow third party studies to use the data at any stage.

The rules regarding ALSPAC data storage are clear and contractual. Data is supplied in an encrypted, password protected file, which must be stored securely on a device such as a personal computer. Only the Principal Researcher and others named in the application may be given access to the data. The data set may only be used for the purposes stated in the application and must be destroyed at the point of project completion. All papers, monographs and book chapters for publication must be passed to the ALSPAC Executive for review and approval prior to submission to publishers. Re-approval must be sought if there are any significant changes to the paper after Executive approval. The construction of a thesis or dissertation during this project is permitted under the original proposal. Data from the ALSPAC Study is supplied in an anonymised format and appropriate participant consent is held and managed by the University of Bristol.

No special safeguarding concerns existed for this project since no primary data was to be collected and ALSPAC participants are anonymised and so cannot be contacted.

## 3.8 Conclusion

In this Chapter, the purpose of the study, the selected methods for data collection and analysis, the variables of interest and the context of the research were discussed. A justification for the choice of the post-positive research paradigm aimed to ensure objectivity and reduce bias but acknowledging the limitations of scientific methods was given. The quantitative methods design was justified including the acquisition and analysis of selected data variables from the Avon Longitudinal Study of Parents and Children (ALSPAC). When discussing the project design, reference was made to the research questions and an overview of all interrelated factors that could influence the study outcomes (Figure 1.1). Collections of variables relating to the physical development, endocrinology, psychosocial values and behavioural measures relating to participants were introduced.

An outline of the ALSPAC secondary dataset, solely used in the data analyses, was provided including how the dataset was accessed. This is a rich source of data including over 15,000 participants and hundreds of variables. The dataset has been used in over 700 peer reviewed publications and is of high repute internationally. This chapter also clarified the process for data cleaning and how the sample of approximately 7,500 boys remained. With this sample size, a high statistical power was identified. The reliability of the data was also established during this Chapter and Appendix 5, which is related to data analyses and internal validity. Variable collections in the dataset do not always follow the same sampling ages (Figure 3.1) but as the collection ages are close, this did not affect the reliability of analysis results.

It was explained that many variables were automatically provided in the ALSPAC dataset that were not relevant to this study (such as parent demographics) and that some variables such as age and a total score for the Social Communication Disorders Checklist had to be created. Variables such as age were created to allow the stacking of data into a longitudinal format so that patterns of data could be viewed for the same participants over a period of time. Data cleaning, the organisation and creation of new variables was achieved using the statistical analysis software Stata®, which was the programme used throughout the study. The justification for the inclusion and exclusion of some variables was explained in Section 3.5 and Appendix 5 with descriptions for the creation of new variables such as plasma testosterone, BMI and Tanner stage. As suggested in the Chapter, Appendix 5 is also an important source of information for those who are interested in the statistics of the study. These specialist analyses were purposely kept as an Appendix because the nature of the data discussed there would not be of interest to readers from a wider teaching background and would detract from the key messages of the study if included in the main text.

In Section 3.6, the methods and data analyses were described. All data analyses involved either regression analysis (continuous variables such as testosterone and cortisol); ANOVA (where analysis involved ordinal values such as Tanner stage or psychosocial scores); and chi-square with Cramér's *V*, where the dichotomous variables of teacher questionnaire 2 was involved. A data analysis plan was summarised in Table 3.5. The multivariate analyses of participant variables in Chapter 4 was justified with the rationale for a case study approach relating to participants with extreme data outliers in Chapter 5.

The discussion on research ethics was concise because this study solely involves a secondary dataset provided by another UK University, the University of Bristol. The ALSPAC project operates under a robust ethics approval process. Finally, this study was approved by following a Faculty of Education process based on British Educational Research Association Guidelines.

The chapters that follow will include a presentation of the results of the data analysis.

# Chapter 4: Quantitative Analysis of Biological, Psychosocial and Behavioural Data

## 4.1 Introduction to Chapter 4

This thesis departed from the argument that there are strong associations between age, pubertal stage and some endocrinological values in adolescents (Section 1.6 and Figure 1.1). Furthermore, it was suggested that some psychosocial and adolescent behaviour variables, both in and out of school, were associated. As such, boys with a high Social Communications Disorder Checklist score had much higher plasma testosterone levels than their peers. This Chapter will present the findings from the quantitative analysis in line with the study's research questions (Section 1.4).

This Chapter comprises of analyses between biological, psychosocial and behavioural variables: first, biological markers related to psychosocial outcomes (Section 4.2.1); then, biological markers and behavioural variables (Section 4.2.2); finally, an analysis of psychosocial with behaviour variables will take place (Section 4.3). A brief discussion of the key findings will take place with the data analysis in Sections 4.2 and 4.3. A detailed discussion of the Chapter findings will take place in the final Section (4.4).

Many of the scatterplots in this chapter are generated using data bins (binned scatterplots) which provide a clear way of observing relationships between variables, particularly when the dataset is large as in this case (Stepner, 2017) and where a traditional scatterplot would appear too crowded to allow accurate interpretation. Regular scatterplots are used where the opposite is the case and where it is useful to note the position of individual participants. No trend line will be applied to plots where extreme outliers would skew the gradient and give a misleading impression.

A statistical power analysis, with an alpha = .05 and power = 0.80, the projected sample needed with this effect size (GPower 3.1) is approximately $N$ = 303 for all analyses involving Tanner stage. In the analyses that follow, the number of extreme outlier participants is, therefore, inadequate. Where this is the case, a brief statement regarding a lack of statistical power will be made. These cases will be analysed in Chapter 5 using qualitative methods.

A full description of the ALSPAC secondary dataset and individual variables was included in Chapter 3, together with the rationale for the inclusion or exclusion of specific variables. As a reminder, endocrinological data, measured as continuous variables of testosterone and cortisol levels, were collected by ALSPAC researchers. A brief outline of each variable will take place in each section where they are initially analysed to provide clarity and to obviate the need to make inconvenient visits to the methods chapter.

## 4.2 Analysis of Biological Markers with Selected Psychosocial and Behavioural Variables

Analyses between the study's independent biological and dependent psychosocial and behavioural variables were conducted in order to determine possible relationships between these factors. They aimed to address the research question as to whether there are associations between endocrinological factors, pubertal stage, social cognition and the behaviour of adolescent boys in the school setting. As suggested in earlier chapters, it is likely that social communication and conduct disorders, hyperkinetic conditions and general psychosocial difficulties affect the achievement, mental wellbeing and inclusion of children in school. Data variables have therefore been selected that allow the testing of these factors with biological variables. As the ALSPAC dataset includes many variables, not all relevant to the research questions, it is not feasible to explore relationships between all of them.

### 4.2.1 Biological Markers Related to Psychosocial Outcomes

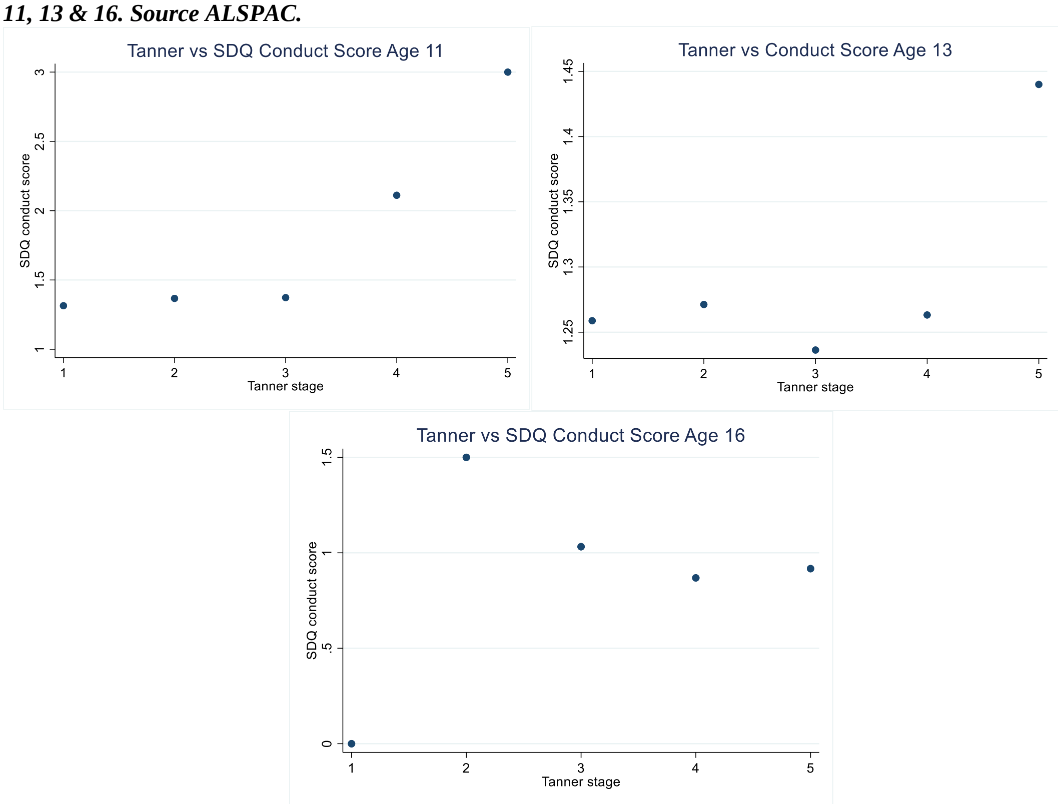
In this Section, an analysis of selected psychosocial variables will be undertaken with Tanner Stage (pubertal development), then with bioavailable testosterone (BT). During an examination of Strengths and Difficulties Questionnaire (SDQ) (see Chapter 3), it was determined that the Social and Communication Disorders Checklist (SCDC) scores, SDQ conduct, SDQ hyperactivity and SDQ total scores should be analysed with these biological measures at ages 11, 13 & 15.

#### 4.2.1.1 Tanner stages related to SDQ scores

It is suggested in the literature (Chapter 2) that children who physically develop much earlier or later than their peers experience psychosocial and behavioural difficulties in and out of school. Furthermore, it is implied that there are behavioural and psychological trends as puberty progresses. The ALSPAC dataset provides a measure of pubertal development using the internationally accepted clinical measure of puberty known as Tanner staging, and an equally robust measure of psychosocial development and functioning in the form of SDQ questionnaire scores (Chapter 3).

Figure 4.2.1 shows the analysis of Tanner stage with the SDQ conduct score performed at ages 11, 13 and 16. All participant data is included where both a Tanner stage and SDQ conduct score is available.

***Figure 4.2.1: Binned scatterplots of the relationship between Tanner stage and the SDQ conduct score at ages 11, 13 & 16. Source ALSPAC.***




***Notes: average scores displayed. Number of observations for Age 11 Tanner 1 (1724), Tanner 2 (660), Tanner 3 (106), Tanner 4 (9) and Tanner 5 (2). For Age 13, Tanner 1 (313), Tanner 2 (553), Tanner 3 (622), Tanner 4 (737) and Tanner 5 (150). For Age 16, Tanner 1 (3), Tanner 2 (18), Tanner 3 (94), Tanner 4 (830) and Tanner 5 (735).***

From the plots, participants with extreme pubertal development (i.e. Tanner stages 4 or 5 at age 11, or stages 1 or 2 at age 16), exhibit higher levels of conduct disorder. However, it should be noted that at age 11, only 11 participants were at Tanner stages 4 or 5, and only 21 were at Tanner stage 1 or 2 at age 15. A one-way analysis of variance (ANOVA) was conducted to evaluate the null hypothesis that there is no difference in conduct difficulties of boys aged 11 based on their Tanner stage. Results of the ANOVA indicated that there were not significant differences in the SDQ conduct score between Tanner stages at age 11 at the $p<.05$ level for the five conditions [$F(4, 2597) = 1.42$. $p = 0.225$][26]. The positive association between Tanner stage and high conduct score for the small number ($N$=2) of participants in the Tanner stage 5 extreme outlier category can be seen in Figure 4.2.1. Extreme pubertal outlier cases are analysed in Chapter 5 using qualitative methods.

[26] The sample size without the outliers was 2,490 at age 11 and 1,659 at age 15. No significant difference was seen in the outcomes of analysis conducted with or without the outliers in this case.

At age 13, where there is an even dispersion of Tanner stages (Chapter 3), a clear relationship is not evident. Only those at Tanner stage 5 appear to exhibit more conduct problems than their peers at that age. Furthermore, results of the ANOVA indicated that there were not significant differences in the SDQ conduct score between Tanner stages at age 13 at the $p<.05$ level for the five conditions [$F(4, 2370) = 0.62$. $p = 0.649$] in the general participant population. However, for extreme outlier cases, a more significant positive association was seen but not at the $p<0.5$ level [$F(2, 1506) = 1.21$. $p = 0.297$]. It should be noted that a Tanner Stage of 4 or 5 at age 13 is more commonplace than at age 11, which is considered highly atypical (Marshall & Tanner, 1970).

At age 16, the converse can be seen in that participants with an unusually low Tanner stage have a higher conduct score, but the result is not significant at the $p<0.05$ level [$F(4, 1675) = 1.81$. $p = 0.1253$]. Only 27 participants showed abnormal physical development at age 15, however, as at age 11, abnormal physical development, in this case, under-development in boys, may be associated with conduct problems (Chapter 5 and footnote 26).

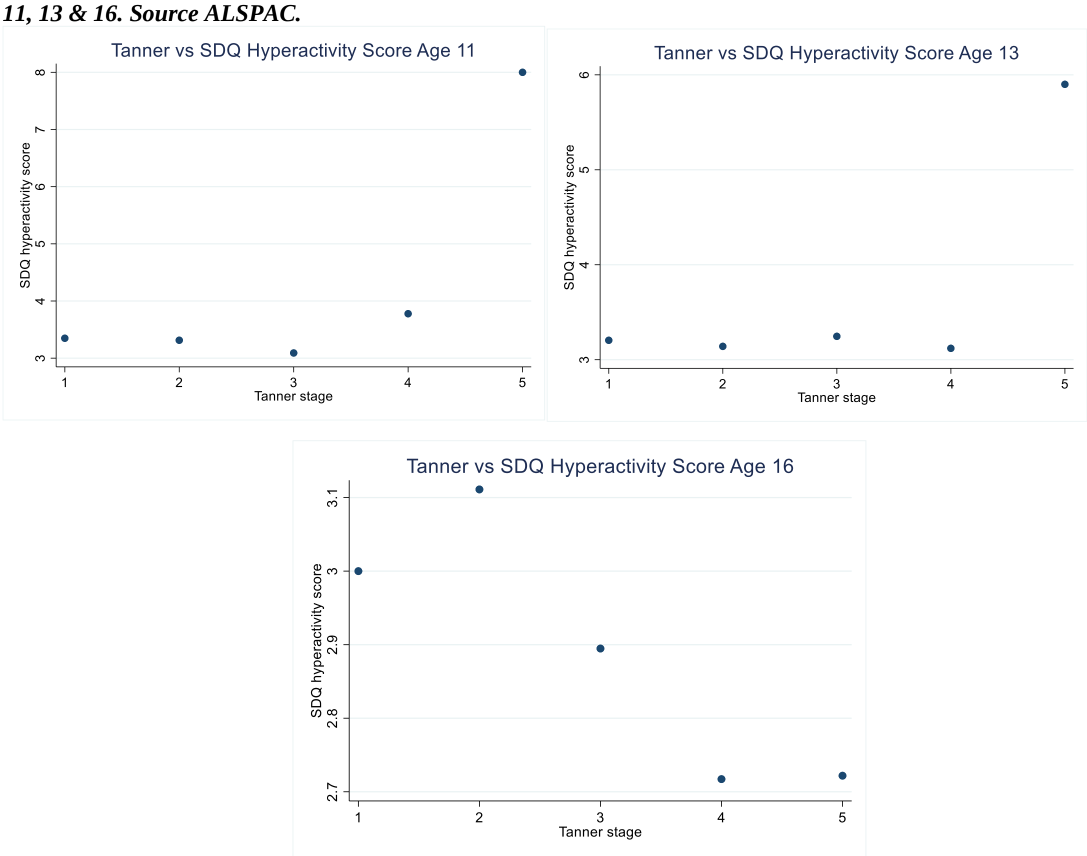
To explore potential associations between physical development (Tanner stage) and hyperkinetic disorders (SDQ hyperactivity score), a further series of binned scatterplots (Figure 4.2.2) were constructed from data collected as the same three ages as before.

At age 11, extreme outlier participants (Tanner stage 5, *n*=2) showed an abnormal hyperactivity score (≤ 6), whereas those at age normal Tanner stages generally scored within normal parameters. Those at Tanner stage 4 (*n*=9), also considered to be at an advanced stage of development at this age, did not show hyperactivity. In both cases, the number of extreme outlier participants is insufficient for statistical analysis.

At age 13, a more even distribution of Tanner stages is seen (Appendix 5), although a small number are at Tanner stage 5 (*n*=150), the most common stage being stage 4 (*n*=737). Results of the ANOVA indicated that there were not statistically significant differences in the SDQ hyperactivity score between Tanner stages at age 13 at the $p<.05$ level for the five conditions [$F(4, 2370) = 0.62$. $p = 0.645$]. Insufficient numbers of participants were available at Tanner stage 5 to perform statistical analysis.

For 15-year-olds, extreme outlier cases (Tanner stages 1 & 2) showed the highest scores. Hyperactivity appears to decline as puberty progresses towards normal in this age group. Results of ANOVA at the $p<.05$ level showed no significant differences for Tanner stage [$F(4, 1675) = 1.81$. $p = 0.125$]. Although boys at Tanner stage 5, which is the upper range of age normal, showed a similar pattern as the extreme outliers at Tanner stage 1 (≥ 8), the hyperactivity top scores were higher at age 11 than age 15 (8 vs. 3.1). Furthermore, ANOVA indicated a positive association between an abnormal pubertal stage (1 or 2) at age 15 with an abnormal SDQ hyperactivity score, which was not significant at the p<0.5 level [F(1, 19) = 3.62. p = 0.0729]. These findings indicate that boys at extreme pubertal stages (low and high) may show hyperkinetic symptoms during the final secondary school year (Year 11) (Chapter 5).

***Figure 4.2.2: Binned scatterplots of the relationship between Tanner stage and the SDQ hyperactivity score at ages 11, 13 & 16. Source ALSPAC.***

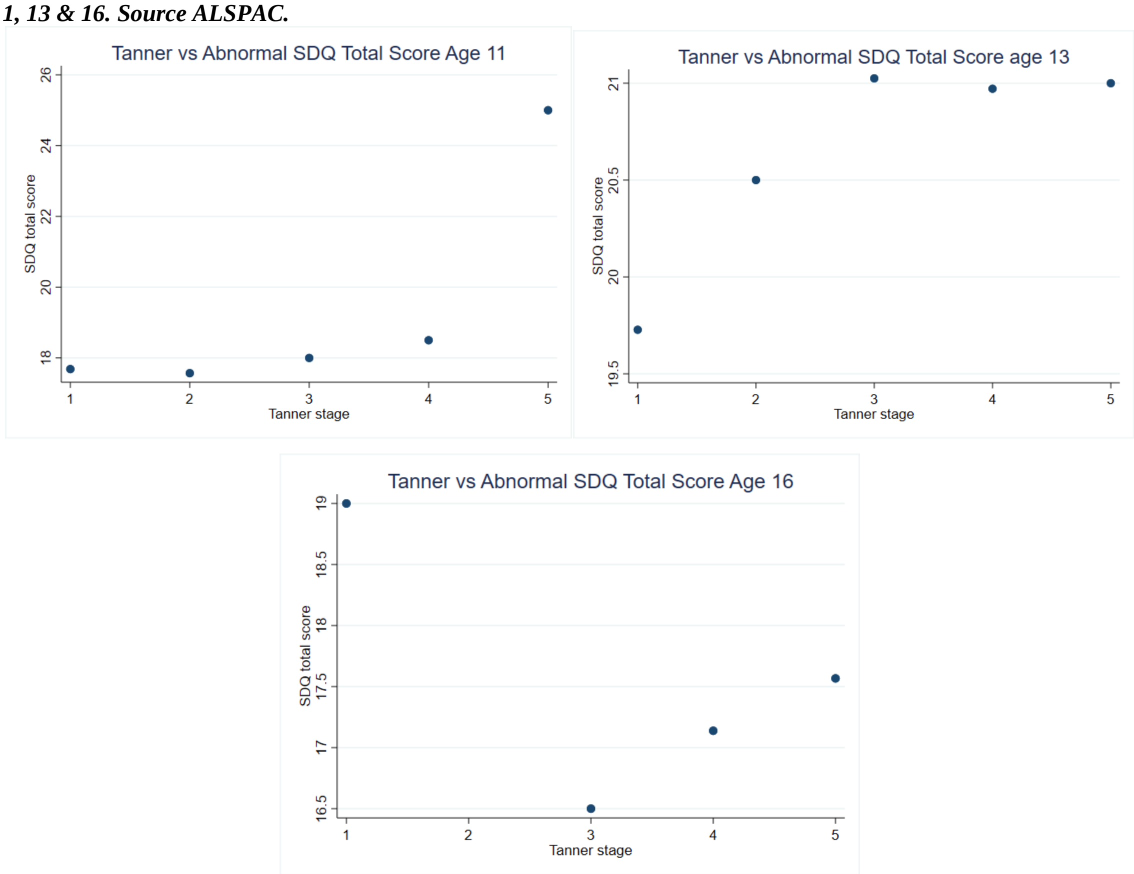



***Notes: average scores displayed. Number of observations for Age 11 Tanner 1 (1719), Tanner 2 (661), Tanner 3 (107), Tanner 4 (9) and Tanner 5 (2). For Age 13, Tanner 1 (313), Tanner 2 (553), Tanner 3 (624), Tanner 4 (738) and Tanner 5 (149). For Age 16, Tanner 1 (3), Tanner 2 (18), Tanner 3 (95), Tanner 4 (831) and Tanner 5 (737).***

The SDQ total difficulties score is a composite of all other constituent scores (emotional symptoms, hyperactivity, conduct problems and peer problems) and indicates the degree of difficulties a child experiences in and out of school at a given age (Chapter 3). SDQ total difficulties scores were plotted against Tanner stage to determine if relationships existed between general difficulties experienced by participants and their pubertal development.

The top left plot of Figure 4.2.3 shows the relationship for participants at age 11. As with conduct and hyperactivity scores, participants at Tanner stage 5 have the highest mean score (≤ 25 out of 40), however, results of the ANOVA indicated that there were not statistically significant differences in the SDQ total score between Tanner stages at age 11 at the $p<.05$ level for the five conditions [$F(4, 2578) = 0.84$. $p = 0.499$], with or without outliers included.

***Figure 4.2.3: Binned scatterplots of the relationship between Tanner stage and SDQ abnormal total scores at ages 11, 13 & 16. Source ALSPAC.***




***Notes: average scores displayed. Number of observations for Age 11 Tanner 1 (1712), Tanner 2 (659), Tanner 3 (106), Tanner 4 (9) and Tanner 5 (2). For Age 13, Tanner 1 (313), Tanner 2 (552), Tanner 3 (620), Tanner 4 (733) and Tanner 5 (149). For Age 16, Tanner 1 (3), Tanner 2 (18), Tanner 3 (93), Tanner 4 (824) and Tanner 5 (734).***

The pattern at age 13 shows a positive relationship between Tanner stages 1 to 3 and abnormal SDQ total scores after which a steady state is reached (Tanner stages 3 to 5) with a mean score of 21. ANOVA did not indicate significant differences in the SDQ total score between Tanner stages at age 13 at the $p<.05$ level [$F(4, 2362) = 0.86$. $p = 0.485$] at this age.

Again, at age 15, extreme outliers (Tanner stages 1 to 2) had the highest SDQ total scores for abnormal ranges. However, ANOVA showed a significant positive association between Tanner stage and SDQ total score when outliers were excluded [$F(3, 1667) = 3.20$. $p = 0.023$].

Only a small percentage of participants at an age-expected Tanner stage scored ≥ 3 (borderline or abnormal) on the SDQ Conduct Score. The percentage of boys with conduct difficulties increased from 24% at Tanner Stage 3 to 44% and 50% at Tanner Stages 4 and 5 respectively. At ages 11 and 15, there is a general trend between pubertal stage and conduct problems, but boys meeting the category of extreme outliers showed the most significant difficulties. The pattern relating to SDQ hyperactivity and SDQ total scores is similar. A relationship is seen with extreme pubertal outliers at ages 11 and 15. At age 13, where the distribution of Tanner stages is more even, the association is less marked. However, for children with abnormal SDQ hyperactivity and SDQ total scores, an even stronger association is seen with Tanner stage. Possible implications of these findings are discussed in Section 4.5. Such extreme outlier cases are the subject of Chapter 5.

### 4.2.1.2 Tanner stages related to SCDC scores

While SDQ is a measure of general strengths or difficulties, it does not capture to the same degree, social cognitive function and behaviours the way the SCDC does. The diagnostic role of the SCDC in identifying social and communication difficulties such as autistic spectrum disorder were discussed in Chapter 2. The SDQ component that measures social cognition is the prosocial score, which is the less reliable indicator (Chapter 3). Because one of the research questions involves pubertal development and social cognition, the SCDC data is examined here. Note that SCDC data were collected at age 16 rather than 15 as with SDQ and pubertal data.

Table 4.2.1 is a contingency table showing the SCDC score together with the percentage and participant numbers for each age and Tanner stage. Only those with a score associated with significant problematic behaviour (i.e. ≥ 8) are included.

***Table 4.2.1: SCDC (total) percentage and participant numbers for each age and Tanner stage for those with abnormal scores (≥ 8). Source: ALSPAC.***

| Age | *n | Tanner Stage 1 | | Tanner Stage 2 | | Tanner Stage 3 | | Tanner Stage 4 | | Tanner Stage 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *N* | % | *n* | % | *n* | % | *n* | % | *n* | % |
| 11 | 2,406 | 1,217 | 9 | 463 | 10 | 80 | 14 | 7 | 15 | 2 | 50 |
| 13 | 2,569 | 199 | 10 | 360 | 9 | 422 | 8 | 512 | 6 | 92 | 9 |
| 16 | 1,512 | 3 | 0 | 6 | 0 | 26 | 12 | 289 | 8 | 574 | 9 |

**n* = total number of participants for whom data was provided.

The data in Table 4.2.1 show that there may be an increasing association between SCDC with the developmental stage of puberty at age 11 and a decreasing association at age 16. When only abnormal SCDC scores were analysed with Tanner Stage at each age, results of the ANOVA indicated that there were statistically significant differences in the SDQ conduct score between Tanner stages at age 11 at the p<.05 level for the five conditions [F(4, 195) = 2.75. p = 0.0297]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the Tanner stage 5 vs stage 2 (*M* = 10.89, SD = 1.44) showed statistically significant differences to the other conditions (*M* = 0.75, SD = 1.38). Little difference was seen when extreme outliers (Tanner stages 4 & 5) were excluded from the analysis. Taken together, these results suggest that abnormally advanced pubertal stages have an effect on social cognitive function.

At age 13, with SCDC scores ≥ 8, ANOVA indicated a significant difference in the score between Tanner stage at age 13 at the p<.05 level [F(4, 146) = 2.96. p = 0.0218] at this age. Post hoc comparisons using the Tukey HSD test indicated that the mean score for the Tanner stage 2 vs stage 1 (*M* = 1.272, SD = 0.46) was significantly different than the other conditions (*M* = -0.40, SD = 0.68). As at age 11, taken together, these results suggest that an abnormal pubertal stage has an effect on social cognitive function, but in this case, delayed rather than advanced development. The majority of participants at age 13 have a Tanner score of 4 (Section 4.2.1.2).

For participants aged 16, with SCDC scores ≥ 8, results of the ANOVA did not show a significant difference between Tanner stage at age 16 at the p<.05 level [F(3, 87) = 1.03. p = 0.348]. However, it must be noted that children who have already developed by age 11 tend to experience greater social cognitive difficulties as indicated by the higher SCDC at age 11 for children at Tanner stage 5 (Chapter 2). Boys who have not yet reached Tanner Stage 4 by age 16 also tend to score higher on the SCDC than typically developing children of the same age. The statistical power analysis (Section 4.1) showed that the number of extreme outlier participants is insufficient for statistical analysis. The few children at these extreme developmental stages are considered qualitatively in Chapter 5.

**4.2.1.3 Bioavailable testosterone with SDQ scores**

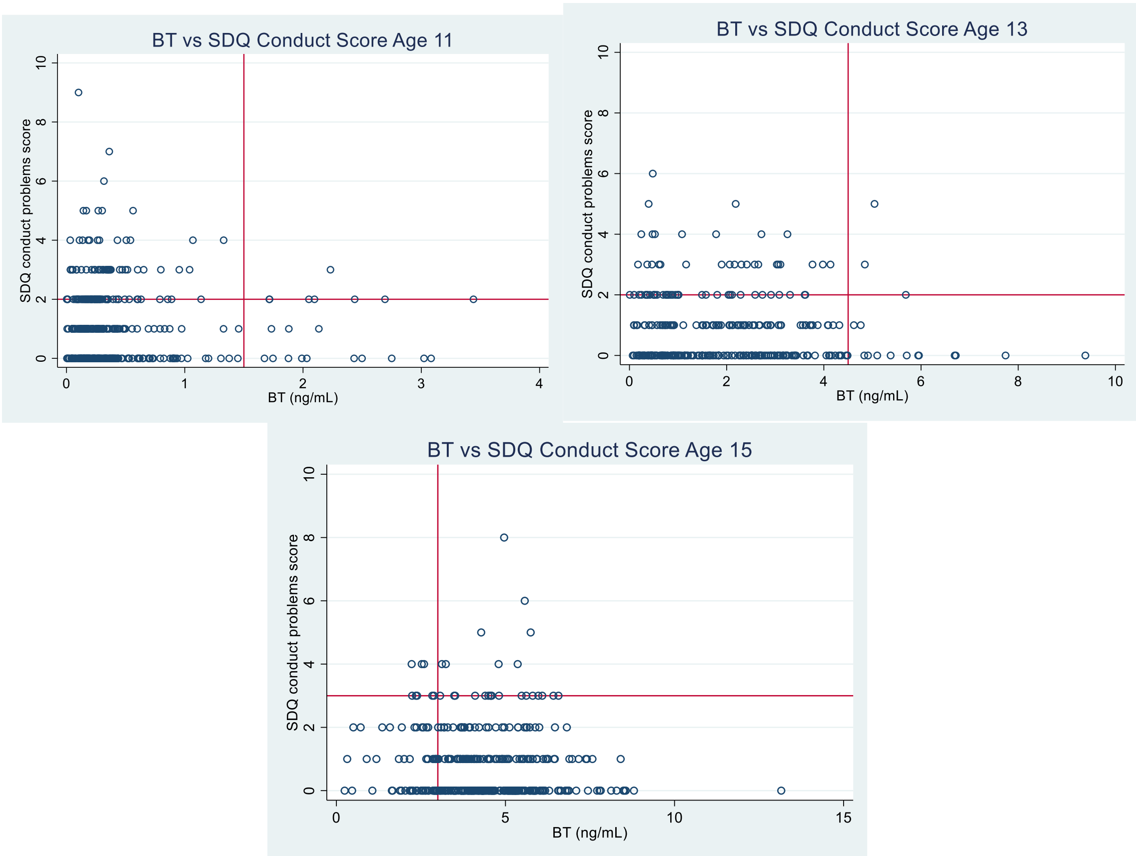
The concentration of bioavailable testosterone in the plasma, $[BT]_{plasma}$, is the fraction of testosterone in the body that is free to exert an influence on body systems and functions rather than inactive forms (Chapters 2 & 3). Although there is a high degree of positive correlation between age, Tanner stage and $[BT]_{plasma}$, in individual people there appears to be a significant variance in response to $[BT]_{plasma}$, so an analysis of psychosocial variables with this biological marker is justified. Of interest here is the variability of outcomes when comparing the findings of the previous section with this, which adds weight to this justification. Also of importance is that $[BT]_{plasma}$ data is not available for all the extreme cases represented in Chapter 5 although pubertal stage data is available for most and was included in the last two sections. Table 4.2.2 is a contingency table showing the number of participants for which testosterone data is available according to age. The number and percentage of extreme low and high outliers are shown together with the number and percentage of participants with typical values. Testosterone values and implications of these have been discussed fully in Chapters 2 and 3 and are recorded here in nanograms per millilitre of plasma (ng $ml^{-1}$). As it is typical for most boys to have negligible levels of $[BT]_{plasma}$ at age 11, no extreme low values are included for that age. Despite the deficit in endocrinological data, upon analysis, some interesting associations are evident between $[BT]_{plasma}$ and psychosocial data (SDQ and SCDC scores).

***Table 4.2.2: Number and percentage of participants for which testosterone data exists. See main text for explanation. All testosterone values are ng $ml^{-1}$. Source: ALSPAC.***

| Age | *n* | Extreme low | | | Typical | | | Extreme high | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $[BT]_{value}$ | *n* | % | $[BT]_{value}$ | *n* | % | $[BT]_{value}$ | *n* | % |
| 11 | 422 | | | | < 1.5 | 399 | 95 | ≥ 1.5 | 23 | 5 |
| 13 | 369 | ≤ 0.3 | 26 | 7 | 0.4 – 4.4 | 327 | 89 | ≥4.5 | 16 | 4 |
| 15 | 418 | ≤ 2.0 | 20 | 5 | 2.1 – 6.8 | 378 | 90 | ≥ 6.9 | 20 | 5 |

The two-way scatterplots in the next two sections allow for the position of individual participants to be seen rather than a binned mean as before (explained in Section 4.1). The x-axes indicate the concentration of bioavailable testosterone measured in ng $ml^{-1}$. The red vertical line shows the boundary of extreme outliers for $[BT]_{plasma.}$ The red horizontal line indicates the boundary above which are participants with abnormal SDQ scores. These vary between individual SDQ questionnaire components.

***Figure 4.2.4: Two-way scatterplots of the relationship between plasma bioavailable testosterone and SDQ conduct scores at ages 11, 13 & 15. Source ALSPAC.***




***Notes: Number of participants per quadrant from top left (Q1), clockwise to bottom left (Q4). At age 11, Q1=105, Q2=6, Q3=15, Q4=265. At age 13, Q1=98, Q2=3, Q3=13, Q4=220. At age 15, Q1=16, Q2=33, Q3=322, Q4=144.***

Figure 4.2.4 shows two-way scatterplots that compare $[BT]_{plasma}$ with SDQ conduct scores at ages 11, 13 & 15. The plots show that the abnormal score for SDQ conduct is 2 (horizontal red line) and that most participants fall within normal values. The extreme outlier boundary for boys aged 11 (top left plot) is 1.5 ng $ml^{-1}$, for boys aged 13 (top right plot) is 4.5 ng $ml^{-1}$ and below 3.0 ng $ml^{-1}$ for boys aged 15 (bottom plot). It must be remembered that older boys would be expected to be close to adult ranges for $[BT]_{plasma}$ which shows a normal distribution pattern with both extreme high and low outliers.

Even for extreme high values of $[BT]_{plasma,}$ most participants (*n*=13) were in the normal range of SDQ values so did not exhibit significantly poor conduct. Six participants with high $[BT]_{plasma}$ exhibited conduct problems. The highest value of these was 4 out of a maximum possible score of 10, which would not be considered very challenging in terms of behaviour.

A simple linear regression was calculated to evaluate SDQ conduct scores based on $[BT]_{plasma}$ values at age 11. Results of the linear regression indicated that there was no significant effect between the SDQ conduct score and $[BT]_{plasma}$ values at age 11, [F(1, 389) = 1.34, p = .248, $R^2$ = .0034]. A slightly more significant association was seen when extreme outliers were removed from the analysis [F(1, 368) = 2.73, p = .09, $R^2$ = .0074]. As only five participants were classified in the extreme outlier category at age 11, a lack of statistical power made analysis inappropriate as meaningful effects would not be detected, however, extreme outlier cases are discussed qualitatively in Chapter 5.

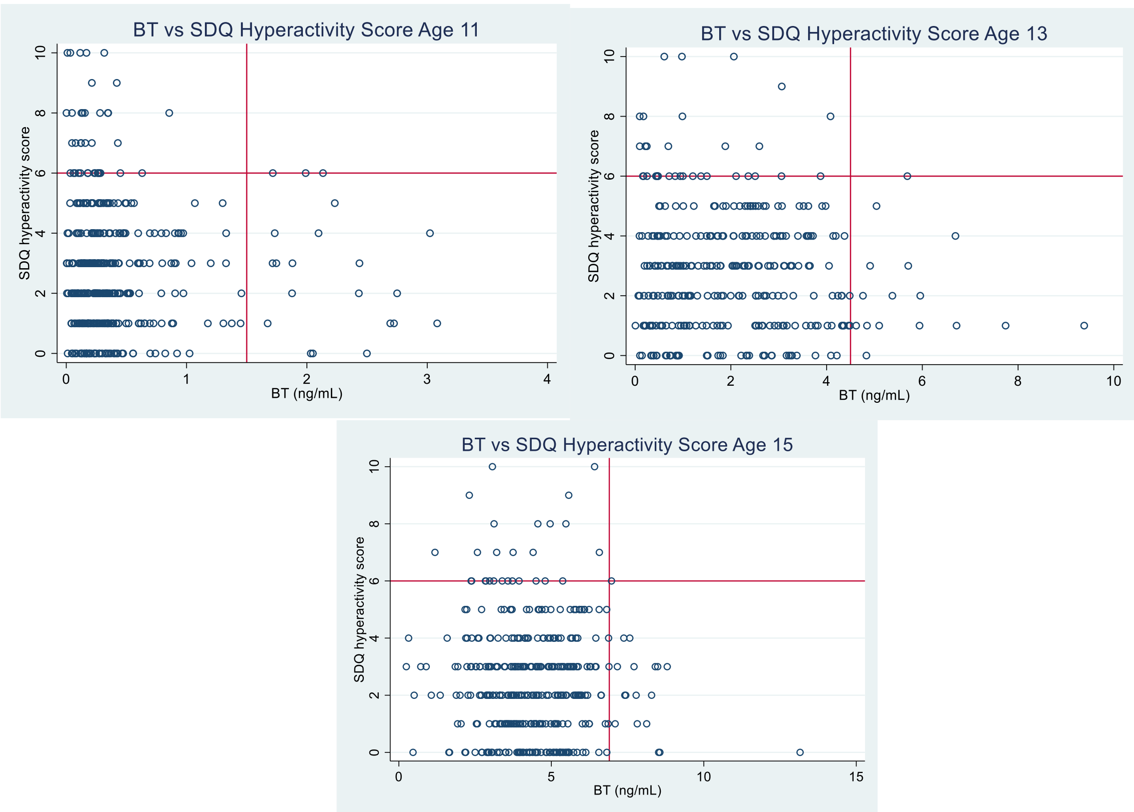
Descriptive analysis at age 13 also showed that a small number of participants with extreme high values of $[BT]_{plasma}$ with abnormal SDQ conduct scores (*n*=3) the highest score of which was 5. This contrasts with 16 participants who had high values of $[BT]_{plasma}$ without conduct problems. Results of the linear regression indicated that there was no significant effect between the SDQ conduct score and $[BT]_{plasma}$ values at age 13, [F(1, 332) = 1.07, p = .302, $R^2$ = .0032]. As with age 11, insufficient numbers on the extreme outlier category (*n*=14) made statistical analysis inappropriate.

For the oldest boys (bottom plot), descriptive analysis showed more significant findings. None of the participants with extreme high values of $[BT]_{plasma}$ (> 6.9 ng $ml^{-1}$) were identified as having conduct problems, unlike with Tanner stage (Figure 4.2.1). Of the boys with the most profound conduct problems (scores ≥ 5), 5 had a low $[BT]_{plasma}$ level. However, results of the linear regression indicated that there was no significant effect between conduct and $[BT]_{plasma}$ values, [F(1, 369) = 2.39, p = .123, $R^2$ = .0064] with or without the inclusion of outliers. These findings do not negate a relationship between significant conduct problems in boys with $[BT]_{plasma}$ levels, rather that there is a lack of testosterone data to support any reliable conclusions (see below).

As with conduct problems, there is a lack of testosterone data with SDQ hyperactivity scores, which was considered when this data analysis was conducted. A comparison between $[BT]_{plasma}$ and SDQ hyperactivity scores for participants with data relating to both variables at ages 11, 13 & 15 are shown in Figure 4.2.5. The abnormal score for SDQ hyperactivity is 6 and the extreme outlier boundaries for $[BT]_{plasma}$ values at all ages were given for Figure 4.2.4 above. As stated before, older boys can have extreme high and low testosterone values. The patterns of data are similar to that of $[BT]_{plasma}$ with SDQ conduct scores in that for all age groups, most participants fall into the normal range (bottom left quadrant of each plot).

At ages 11 and 13, only 3 and 1 participants respectively, exhibited abnormal hyperactivity scores and these were borderline. This shows that the higher hyperactivity scores are within the normal $[BT]_{plasma}$ range for boys in the 11 and 13 age groups. Because of the small number of participants with abnormal scores, statistical analysis was inappropriate. Linear regression analysis results indicated that there was no statistically significant effect between SDQ hyperactivity scores and $[BT]_{plasma}$ values in the general population (excluding outliers) at age 11, [$F(1, 390) = 2.16$, $p = .142$, $R^2 = .0055$] or at age 13 [$F(1, 332) = 3.12$, $p = .078$, $R^2 = .0093$].

***Figure 4.2.5: Two-way scatterplots of the relationship between plasma bioavailable testosterone and SDQ hyperactivity scores at ages 11, 13 & 15. Source ALSPAC.***



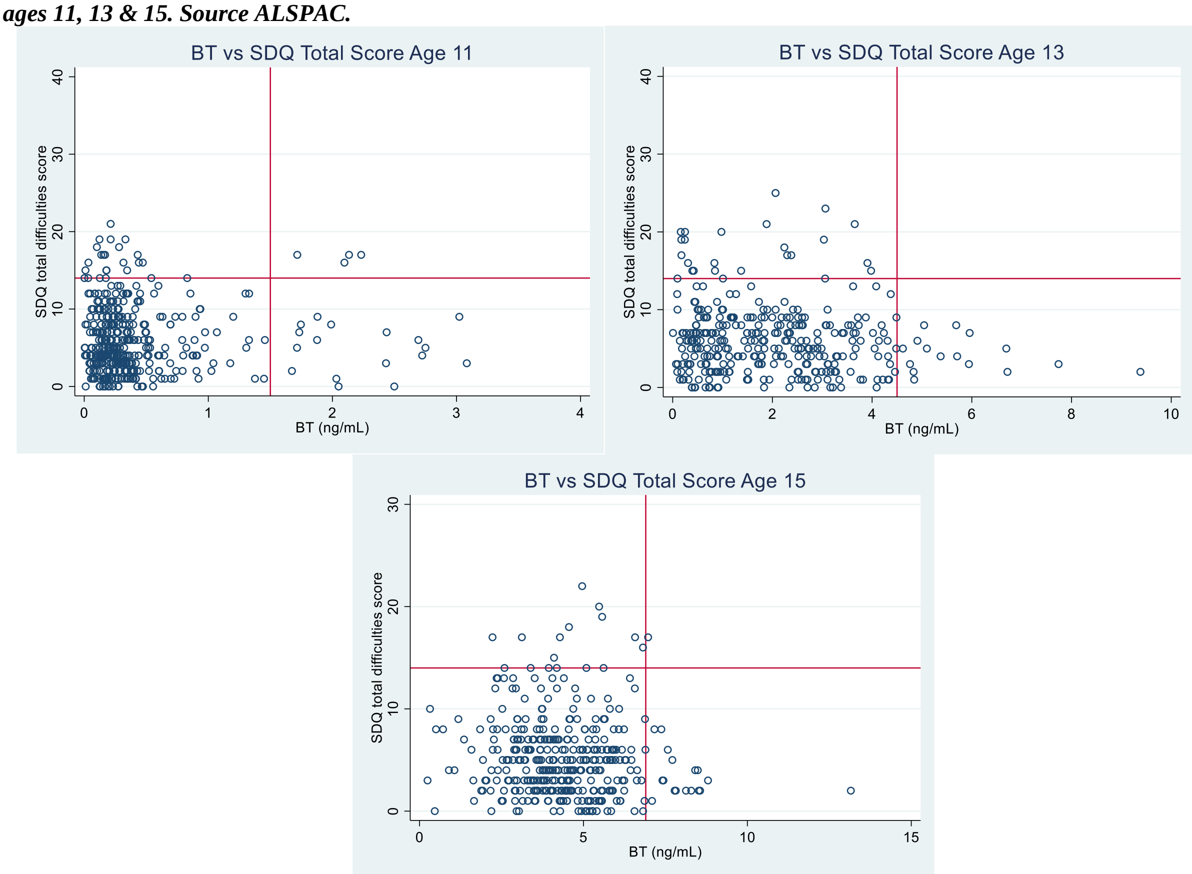

***Notes: Number of participants per quadrant from top left (Q1), clockwise to bottom left (Q4). At age 11, Q1=39, Q2=3, Q3=18, Q4=331. At age 13, Q1=35, Q2=1, Q3=15, Q4=283. At age 15, Q1=26, Q2=2, Q3=27, Q4=317.***

As stated above, the $[BT]_{plasma}$ at age 13 follows a normal distribution, therefore high and low values are likely. This is to say, a large proportion of boys at this age will have low and high $[BT]_{plasma}$ levels. If more observations existed, it is possible that a higher association would be seen between $[BT]_{plasma}$ levels and hyperactivity in extreme outlier cases and the general population.

At age 15, a different distribution of data is seen to that of younger ages in that boys with above mean $[BT]_{plasma}$ have normal range SDQ hyperactivity scores. This would be expected because in late adolescence, a low mean $[BT]_{plasma}$ would be abnormal with most boys of this age having above mean values. Nevertheless, although the majority (*n*=344) of those with lower mean $[BT]_{plasma}$ fall within the normal range of hyperactivity scores, 28 have borderline or above scores. Regression analysis indicated that no statistically significant association was seen between hyperactivity and $[BT]_{plasma}$ values in this general age range [$F(1, 370) = .65$, $p = .422$, $R^2 = .0017$]. Due to insufficient data, it is not possible to explore associations in those with abnormally low $[BT]_{plasma}$ values in this age group.

Figure 4.2.6 shows two-way scatterplots of the relationship between $[BT]_{plasma}$ and SDQ total scores at ages 11, 13 and 15.

***Figure 4.2.6: Two-way scatterplots of the relationship between plasma bioavailable testosterone and SDQ total scores at ages 11, 13 & 15. Source ALSPAC.***




***Notes: Number of participants per quadrant from top left (Q1), clockwise to bottom left (Q4). At age 11, Q1=29, Q2=4, Q3=17, Q4=341. At age 13, Q1=30, Q2=0, Q3=16, Q4=287. At age 15, Q1=15, Q2=1 Q3=17, Q4=333.***

At age 11, 4 participants with abnormally high $[BT]_{plasma}$ had abnormal SDQ total scores (17%) whereas 24 had scores in the borderline or normal range. Regression analysis showed that no statistically significant association was apparent in the general participant population [F(1, 389) = .10, p = .755, $R^2$ = .0003]. At age 13, there were no participants with an abnormally high $[BT]_{plasma}$ and abnormal SDQ total scores. However, regression analysis indicated a small negative association between the total difficulties score with $[BT]_{plasma}$ values at this age [F(1, 331) = 4.26, p = .039, $R^2$ = .0127]. This suggests that during mid-adolescence, boys who are endocrinologically more mature have fewer problems, which is also widely reported in the literature (Chapter 2). At age 15, one participant with borderline $[BT]_{plasma}$ had an abnormal total difficulty score (16 with lower $[BT]_{plasma}$) so statistical analysis was inappropriate.

Due to a lack of statistical power because of data limitations, associations between biological and SDQ data should be viewed with caution. Analysis of $[BT]_{plasma}$ with psychosocial data contrasts with that of the Tanner stage data, which shows a high level of association between the SDQ conduct, hyperactivity and total scores with the few participants at extremely high or low pubertal development stages. As stated above, a lack of testosterone assay data for these boys may account for the dearth of conclusive findings. However, as $[BT]_{plasma}$ and Tanner stage are highly correlated (Appendix 5), it is likely that had sufficient $[BT]_{plasma}$ data existed, similar associations would have been seen regarding extreme outliers of which the testosterone analysis partially supports.

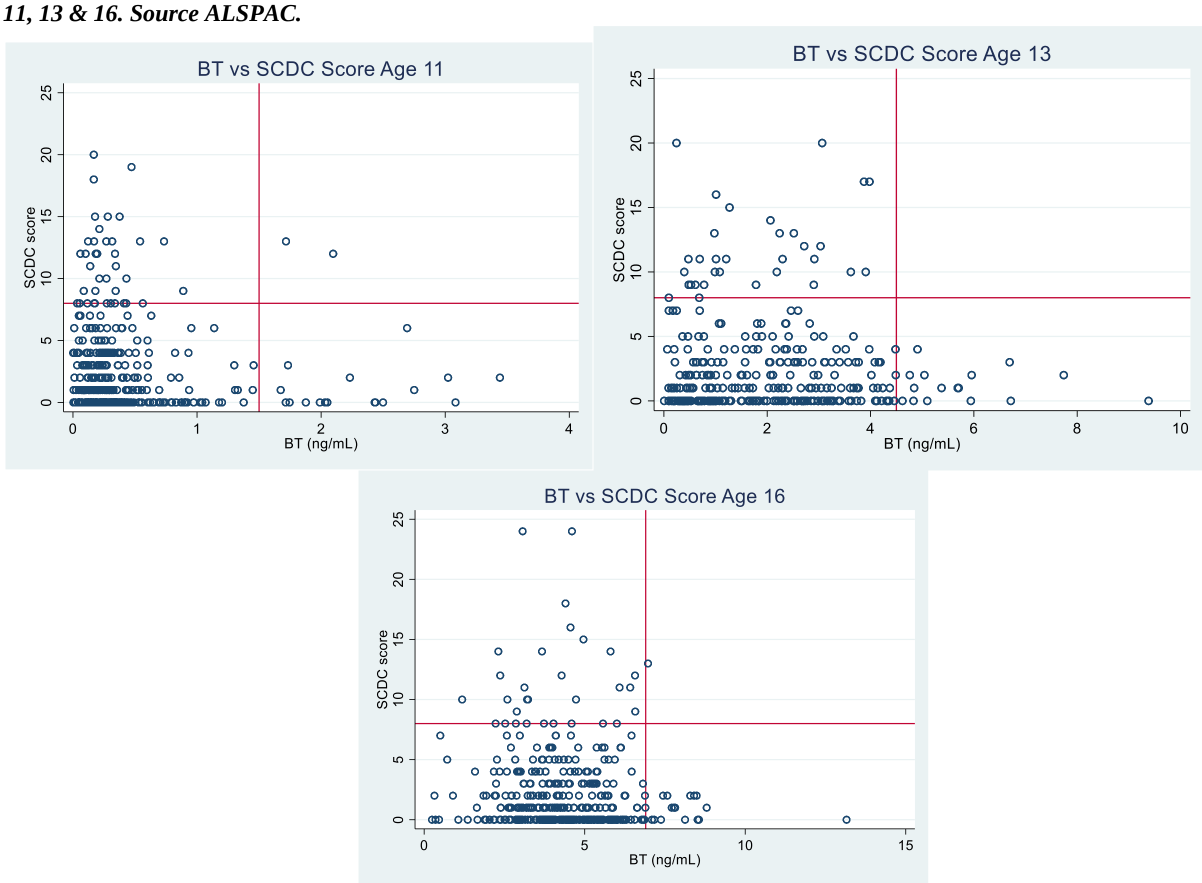
**4.2.1.4 Bioavailable testosterone with SCDC scores**

In Section 4.2.1.2, during an analysis of Tanner stage and SCDC scores, it was stated that the SCDC is not only a valuable measure of social cognitive function, but also a diagnostic tool for the identification of autism.

Figure 4.2.7 illustrates the comparison between participants $[BT]_{plasma}$ and their SCDC scores where data is available at ages 11, 13 & 16. The abnormal score for the SCDC is 8 or above. Typical (normal) and extreme outlier values for $[BT]_{plasma}$ for all ages are stated in Table 4.2.2 above. The data patterns are similar to that of $[BT]_{plasma}$ with SDQ score components. Most participants fall into the typical range (bottom left quadrant of each plot).

As shown in Table 4.2.2. only extreme high $[BT]_{plasma}$ outliers are relevant at age 11 and there were only 20 participants with these values and only 14 of these had both testosterone data and SCDC scores. Of these, only two boys had abnormal SCDC scores compared to 12 with normal scores and so could not be statically analysed. Of the 369 participants at age 13 for whom testosterone data is available, no participants exhibited abnormal SCDC scores with a high [BT]$_{plasma}$ whereas 13 had normal scores. Of those with unusually low [BT]$_{plasma}$ levels, two had abnormal SCDC scores and 15 had normal scores; only three participants did not have both SCDC and testosterone data variables.

***Figure 4.2.7: Two-way scatterplots of the relationship between plasma bioavailable testosterone and SCDC scores at ages 11, 13 & 16. Source ALSPAC.***




***Notes: Number of participants per quadrant from top left (Q1), clockwise to bottom left (Q4). At age 11, Q1=22, Q2=2, Q3=16, Q4=205. At age 13, Q1=25, Q2=0, Q3=17, Q4=224. At age 16, Q1=20, Q2=1 Q3=19, Q4=169.***

There were 418 participants for whom endocrinological data was available at age 15. Of these, 20 participants had extreme low [BT]$_{plasma}$ values, 8 with SCDC data; and the same number high [BT]$_{plasma}$ values, 13 with SCDC data. One participant had an abnormal SCDC score with low [BT]$_{plasma}$ and one had an abnormal SCDC score with high [BT]$_{plasma}$.

Although there is a lack of statistical power, other measures support the expected relationship which points towards the analysis of extreme values in the next Chapter. These findings are also interesting in that they agree with those of other researchers (Chapter 2), who make connections between high [BT]$_{plasma}$ levels and social and communication difficulties, such as autism. The converse may also be true of individuals with low [BT]$_{plasma}$ values and social and communication difficulties. However, no mid-adolescent decline in social cognition was evident, which has been widely reported (Erdley et al., 2010; Jones, Forster, & Skuse, 2007), thought to result from brain restructuring in the pre-frontal cortex during mid-puberty (Chapter 2).

**Summary of Section 4.2.1**

In this Section, analyses were conducted to ascertain if associations existed between biological markers and psychosocial outcomes. A small association was evident between pubertal stage, conduct problems, hyperactivity and general psychological difficulties at age 15. However, the association was strong for boys who physically developed early at age 11 or late at age 15, that is, extreme pubertal outliers. A similar pattern in the data was seen for social cognitive function in early and late developing boys whereas no significant association was seen for typically developing boys.

Testosterone data analyses with psychosocial values did not show the high associations as with that of pubertal stage data. The small number of participants for which both testosterone assay data and psychosocial measures exist may account for the lack of statistically measurable findings. However, $[BT]_{plasma}$ and pubertal stage are highly correlated so it is likely that similar associations of pubertal development measures would have been seen had more testosterone data been available.

Considering that the actual proportion of boys with such difficulties in the general population is likely to be much higher, these findings are valuable when considering school behaviour and inclusivity (Chapter 6). Behavioural and psychosocial variables for participants with extreme biological values are analysed and discussed in Chapter 5.

## 4.2.2 Biological Markers Related to Behavioural Outcomes

Biological data variables, that is pubertal (Tanner) staging, salivary cortisol concentration, $[cortisol]_{saliva}$ and biologically available plasma testosterone, $[BT]_{plasma}$, were analysed with behavioural data from questionnaires completed by adults involved with the participants. At ages 10 to 11, primary teachers completed a questionnaire (a measure of year 6 behaviour). At age 15, three questionnaires were completed, one by parents and two by teachers. The second teacher questionnaire required dichotomous responses, meaning that in analysis with psychosocial variables, Chi-squared with Cramér's *V* analysis was appropriate.

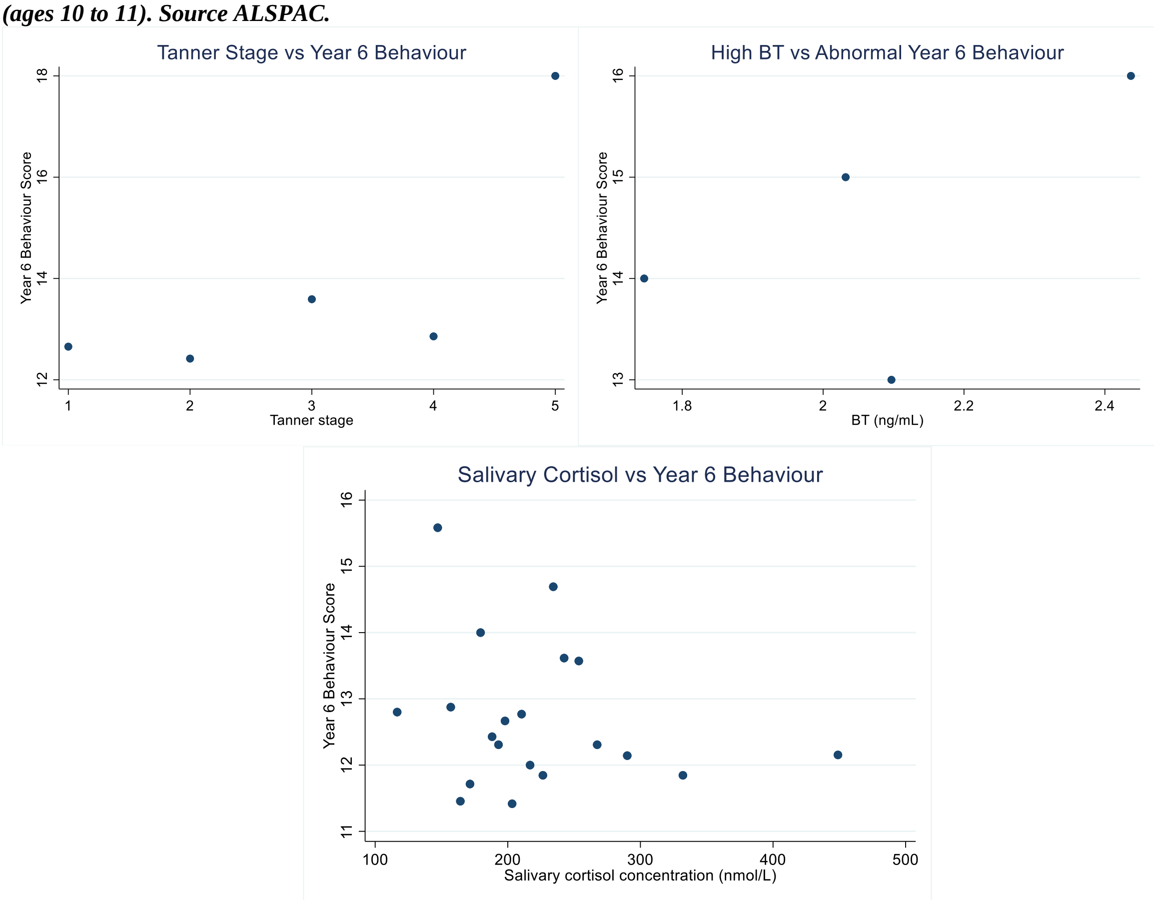
Where questionnaire data was ordinal, investigation by one-way analysis of variance took place. Where such data was continuous, regression analysis was conducted.

#### 4.2.2.1 Year 6 behaviour analysis with biological data

Teachers completed a questionnaire regarding the behaviour of participants during year 6 (children aged 10 and 11 in their final year of primary school). A total behaviour score was calculated from the questionnaire: the higher the score the more challenging an individual's behaviour. A score of zero represented no behavioural issues. Figure 4.2.8 shows the graphs for biological markers with the year 6 behaviour score. Only Tanner stage and the plasma concentration of testosterone at age 11, $[BT]_{plasma}$, were used in the analysis since these are pertinent to the age range covered by the year 6 teacher questionnaire data. The salivary cortisol data were collected at age 8. A description of cortisol is included in Chapters 2 & 3.

As with the psychosocial variables, only participants exhibiting extreme physical development at age 11 showed significant behavioural difficulties (top left plot). Furthermore, results of the ANOVA indicated that there were statistically significant differences in the year 6 behaviour score between Tanner stages at age 11 at the $p<.05$ level for the five conditions [$F(4, 1586) = 2.97$. $\rho = 0.018$]. Post hoc comparisons using the Tukey HSD test indicated that the mean score for year 6 behaviour at Tanner stage 5 ($M = 5.34$, $SD = 2.41$) was of statistically significant difference to that of Tanner stage 1 ($M = -.24$, $SD = .19$). This difference is based on two participants at the extreme end of the distribution (Tanner stage 5) and a small sample size ($n$=7) of other extreme outliers (Tanner stage 4), but even so, the outcome is significant. Taken together, these results suggest that advanced pubertal stage is associated with the in-school behaviour of boys aged between 10 & 11. Regarding individual components of the year 6 teacher questionnaire, ANOVA identified significant differences for boys at Tanner stages 4 or 5 (post hoc comparisons using the Tukey HSD test) in degree to which the child: had temper tantrums [$F(4, 1589) = 4.58$. $\rho < 0.001$]; was easily annoyed by others [$F(4, 1591) = 3.41$. $\rho < 0.01$]; was angry and resentful [$F(4, 1591) = 9.07$. $\rho < 0.001$]; started fights [$F(4, 1590) = 9.79$. $\rho < 0.001$]; was physically cruel [$F(4, 1591) = 3.95$. $\rho < 0.01$]; and showed unwanted sexual behaviour [$F(4, 1590) = 2.70$. $\rho = 0.03$]. These findings give an interesting picture of the behaviour of boys at an advanced pubertal stage in school.

***Figure 4.2.8: Binned scatterplots showing the relationship between biological variables and year 6 behaviour scores (ages 10 to 11). Source ALSPAC.***




***Notes: average scores displayed. Number of observations for Tanner Stage vs. Year 6 Behaviour, Tanner 1 (1098), Tanner 2 (418), Tanner 3 (66), Tanner 4 (9) and Tanner 5 (2). For BT vs. Abnormal & Year 6 Behaviour (left to right), 1535, 31, 17, 3. For salivary cortisol vs Year 6 Behaviour, n=269.***

The top right-hand plot of Figure 4.2.8 shows the relationship between high $[BT]_{plasma}$ levels and abnormal year 6 behaviour total scores. Only 245 participants were included for which endocrinological data and year 6 behaviour scores existed. Linear regression analysis indicated that there was not a significant effect between the year 6 behaviour score and $[BT]_{plasma}$ levels at age 11 [$F(1, 243) = 0.07$, $p = .790$, $R^2 = .0003$]. When adjusted to include only participants with abnormally high $[BT]_{plasma}$ levels (>= 2 ng $ml^{-1}$) as in the figure, regression analysis showed a stronger but not statistically significant association [$F(1, 8) = 3.96$, $p = .08$, $R^2 = .3313$], however, only 10 participants were included so the analysis lacked statistical power.

The bottom plot of Figure 4.2.8 shows the relationship between $[cortisol]_{saliva}$ levels and year 6 behaviour total scores for the whole sample of participants for which data existed. A simple linear regression was calculated to predict behaviour scores at age 11 based on $[cortisol]_{saliva}$ levels measured at age 8. Results of the linear regression indicated that there was no significant effect between the SDQ conduct score and $[cortisol]_{saliva}$ levels at age 11, [$F(1, 267) = 1.22$, $p = .271$, $R^2 = .0008$]. No statistically significant effect was seen for individual year 6 behaviour questionnaire components either for the typical population or high or low $[cortisol]_{saliva}$ outliers.

As discussed in Chapter 2, cortisol is a hormone released during times of stress and is subject to several pathologies with psychosocial and behavioural signs and symptoms. Its levels in the body can change as a result of internal and external factors as well as influencing behaviour (Chapter 3).

#### 4.2.2.2 Parental questionnaire analysis with biological data

Parents were asked to complete a parental questionnaire (PQ) of their child's behaviour at age 15. Testosterone and Tanner stage data collected at ages 15 and 17 were analysed with this behaviour data since children who were underdeveloped at age 17 would also have been so at age 16, so biological data is considered across the 15 to 17 age span. The questionnaire involved parents giving answers to seven questions, each one coded as a variable in the ALSPAC dataset. Responses varied according to each question but were coded as three increasing scale points, for instance, 'Young person is awkward/troublesome, compared to others of the same age', the responses were 'no more than others', 'little more than others or 'a lot more than others.'

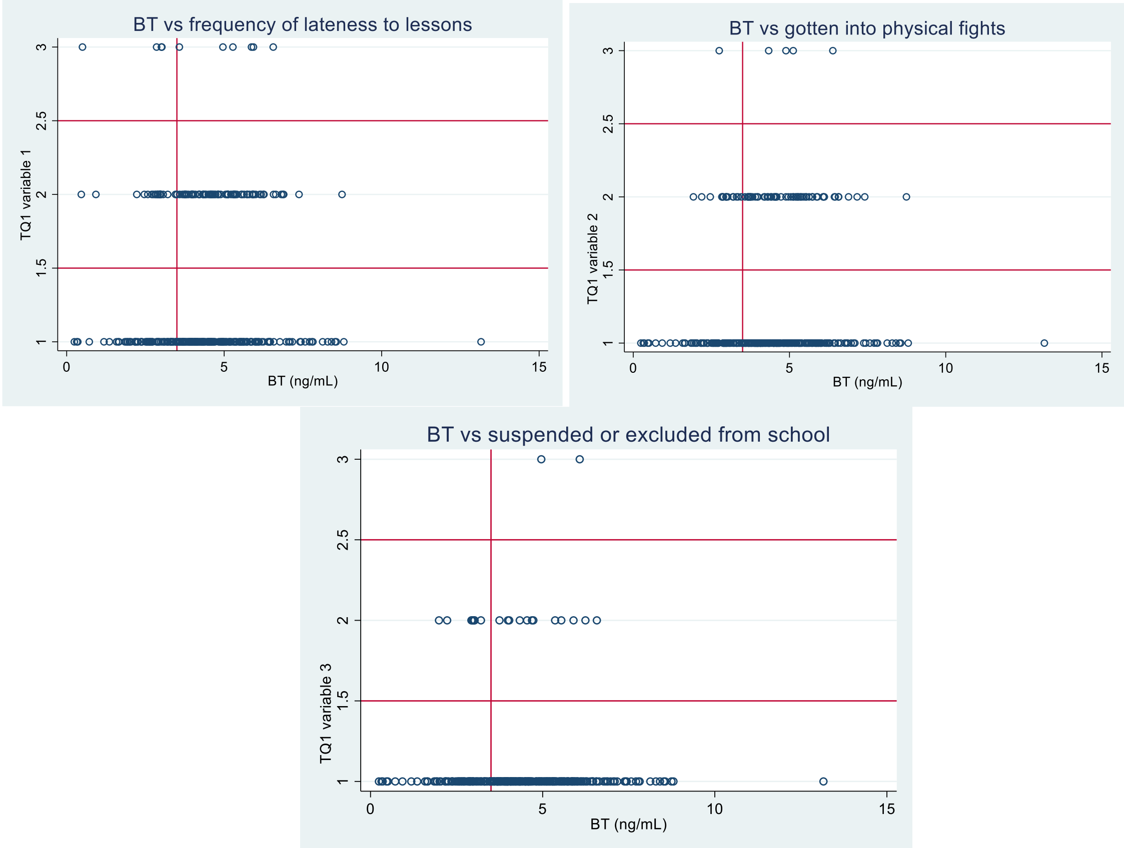
A one-way analysis of variance was conducted to evaluate the null hypothesis that there is no difference in parental concerns determined by PQ responses of boys aged 15 based on their Tanner stage. Results of the ANOVA indicated that there were not significant differences in the PQ scores between Tanner stages at age 15 at the $p<.05$ level for the five conditions [$F(4, 2597) = 1.42$. $p = 0.225$].

Neither descriptive data analysis nor analysis of variance showed statistically significant associations between PQ data and endocrinological values (cortisol and testosterone). This could be due to the limited data for these variables and because parents will have a different perspective on behaviour than other adults such as teachers. Having examined the data at the level of individual participants, there may an association between some aspects of challenging behaviour as reported by parents and atypical pubertal development. The small number of individuals considered to be extreme developmental outliers presented the greatest number of behavioural challenges and are discussed as individuals in the next chapter.

### 4.2.2.3 Teachers' first reporting of behaviour and boys' biological data

Since no relationship was evident between PQ and cortisol data, it was unlikely that descriptive analysis would yield remarkable findings with teacher questionnaire 1 (TQ1) in-school behaviour variables, which was the case. This is likely because teachers will have a different perspective on a child's behaviour and parents may not know about infractions such as punctuality to lessons and truancy from school. However, the most important consideration with regards to this study is how teachers and parents reflect their views on young peoples' behaviour and whether the young person's biological variances have anything to do with such behaviour.

***Figure 4.2.9: Two-way scatterplots showing the relationship between bioavailable testosterone and the three TQ1 variables (questionnaire completed during year 11). Source ALSPAC.***




***Notes: The red vertical lines indicate the low outlier threshold for testosterone of 3.0 ng $ml^{-1}$. The horizontal red lines separate the TQ1 responses, 1 is "never", 2 is "sometimes", 3 is "often".***
***Number of observations for frequency of lateness to lessons low outliers is "often" (3), "sometimes" (23), "never" (66). Number of observations for frequency of lateness to lessons normal BT values is "often" (7), "sometimes" (610), "never" (1421).***
***Number of observations for gotten into physical fights low outliers is "often" (1), "sometimes" (16), "never" (74). Number of observations for gotten into physical fights normal BT values is "often" (4), "sometimes" (460), "never" (1578).***
***Number of observations suspended of excluded from school low outliers is "often" (0), "sometimes" (10), "never" (135). Number of observations for suspended of excluded from school normal BT values is "often" (2), "sometimes" (13), "never" (1927).***

Figure 4.2.9 shows descriptive data analysis for plasma bioavailable testosterone, $[BT]_{plasma}$ and the three TQ1 variables. As these plots show categorical responses, red horizontal lines have been added to clearly separate them. TQ1 data was compiled by questionnaire during year 11 (the final year of secondary education in the UK for 15 to 16-year-olds).

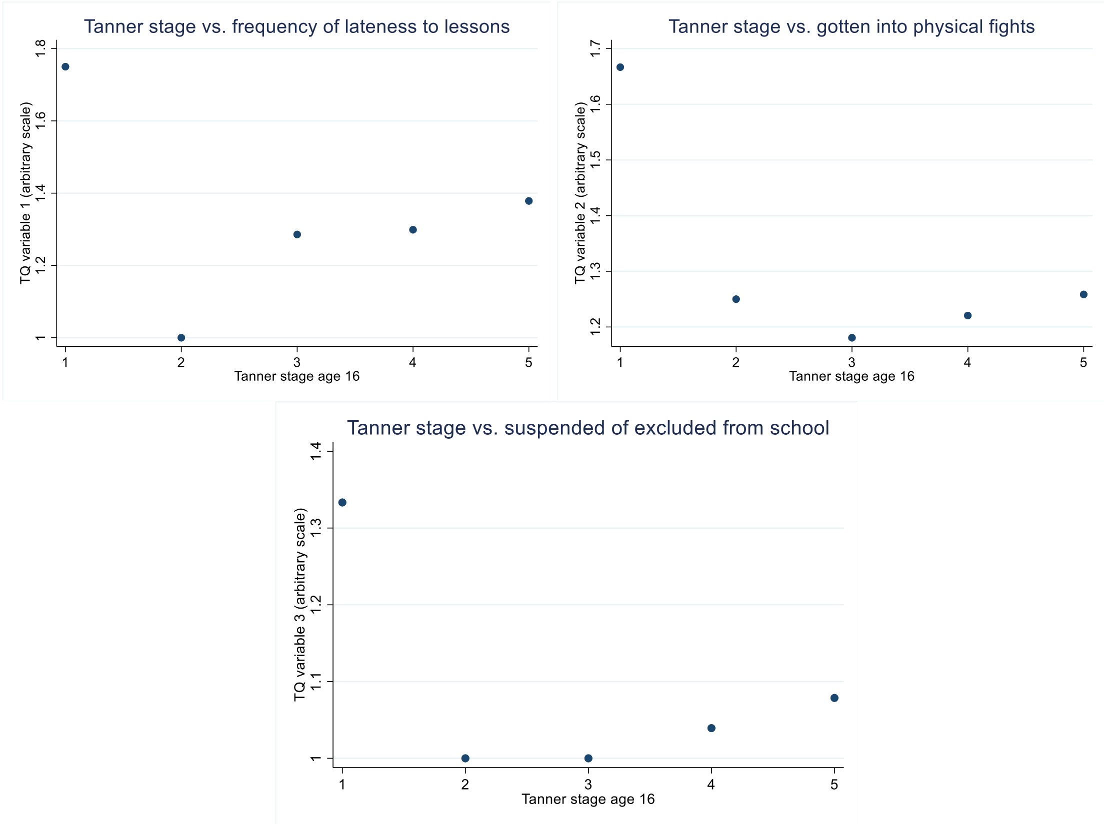
A simple linear regression was calculated to evaluate teacher TQ1 scores based on $[BT]_{plasma}$ values collected during year 11. Results of the linear regression indicated that there was not a significant effect between the TQ1 scores and $[BT]_{plasma}$ values during year 11, [$F(3, 321) = 0.62$, $p = .605$, $R^2 = .0036$].

Figure 4.2.10 shows descriptive data analysis for Tanner stage with the three TQ1 variables. The narrative that follows includes both [BT]plasma and Tanner stage analysis, referring to Figures 4.2.9 and 4.2.10.

Figure 4.2.10 indicates that extreme outlier participants, that is, those at Tanner stage 1 during year 11, are more often late to lessons, get into physical fights more frequently and are more often excluded from school than their typically developing peers. However, results of the ANOVA indicated that there were not significant differences in the TQ1 scores between Tanner stages at the $p<.05$ level for the five conditions [$F(4, 1492) = 1.42$. $p = 0.225$].

Figure 4.2.9 shows that 12 boys with low $[BT]_{plasma}$ out of 65 (23%) sometimes or often engaged in physical fights in and out of school as opposed to 4 high outliers. Insufficient data (Section 4.1) exists for participants with high data values to be statistically analysed. Regarding exclusion from school, no boys with low $[BT]_{plasma}$ were 'often' excluded and 5 were sometimes excluded as opposed to 61 low outliers who were never excluded (Figure 4.2.9). No boys with high $[BT]_{plasma}$ values were excluded. Figure 4.2.10, again, indicates that boys at Tanner stage 1 are more likely to be excluded than those with typical age-related development. Again, insufficient data exists for statistical analysis between Tanner stage 1 and exclusion to take place. Descriptive analysis shows that boys with low $[BT]_{plasma}$ values and those who are physically underdeveloped are more likely to be fixed-term or permanently excluded from school. Data limitations do not allow differentiation between the two nor for correlational analysis.

***Figure 4.2.10: Binned scatterplots showing the relationship between Tanner stage and the three TQ1 variables (questionnaire completed during year 11). Source ALSPAC.***




Notes: average scores displayed. Number of observations for ***Tanner stage vs. frequency late to lessons,*** Age 11 Tanner 1 (***3***), Tanner 2 (***16***), Tanner 3 (***83***), Tanner 4 (***746***) and Tanner 5 (***639***). For ***Tanner stage vs. gotten into physical fights,*** Tanner 1 (***3***), Tanner 2 (***16***), Tanner 3 (***83***), Tanner 4 (*748*) and Tanner 5 (***646***). For ***Tanner stage vs. suspended or excluded from school***, Tanner 1 (3), Tanner 2 (18), Tanner 3 (93), Tanner 4 (***750***) and Tanner 5 (***645***).

## 4.2.2.4 Teacher questionnaire two analysis with biological data

Similar to the first questionnaire, the teacher questionnaire 2 (TQ2) was completed by schools during year 11, yet it captured different information. This questionnaire was comprised of six questions, each coded as a separate dichotomous ('yes' or 'no') response variables in the ALSPAC dataset. These were analysed with two biological variables, collected between the ages of 15 and 16: Tanner stage and plasma concentration of bioavailable testosterone, $[BT]_{plasma.}$ Salivary cortisol concentration, $[cortisol]_{saliva}$, the third biological variable, collected at age 8 was also analysed with TQ2 variables. The relevance for analysing biological data collected years before with year 11 behaviour is fully discussed in Chapter 2, but a reminder is relevant as it is essentially due to a proposed longitudinal psychological effect of cortisol. As explained in the introduction to this Chapter, the $[BT]_{plasma}$ data were converted to categorical data to allow for appropriate analysis with the dichotomous variables of TQ2. Contingency tables were constructed to show the frequencies for crosstabulation of variables, Chi-square ($\chi^2$) and Cramér's *V* analysis. The methods used to convert these variables is fully explained in Chapter 3. These contingency tables and $\chi^2$ with Cramér's *V* analyses were merged to create Table 4.2.3.

***Table 4.2.3: Contingency tables with Chi-square (Chi2) and Cramér's V analysis of biological with TQ2 data. Source: ALSPAC.***

| | Tanner stage | | | | | | | Bioavailable testosterone | | | | | Cortisol level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Total | | Low | Normal | High | Total | | Low | Normal | High | Total |
| **Has received detentions** | **Yes** | 1 | 2 | 13 | 210 | 213 | 439 | **Yes** | 4 | 39 | 2 | 45 | **Yes** | 10 | 136 | 7 | 153 |
| | **%** | 25 | 8 | 13 | 20 | 23 | | **%** | 20 | 10 | 11 | | **%** | 34 | 33 | 22 | |
| | **No** | 3 | 22 | 105 | 861 | 730 | 1721 | **No** | 16 | 340 | 17 | 373 | **No** | 19 | 277 | 25 | 321 |
| | **%** | 75 | 92 | 88 | 80 | 77 | | **%** | 80 | 90 | 90 | | **%** | 66 | 67 | 78 | |
| | **Total** | 4 | 24 | 118 | 1071 | 943 | 2160 | **Total** | 20 | 379 | 19 | 418 | **Total** | 29 | 413 | 32 | 474 |
| | **Chi2** | 10.74 | Pr= | 0.03 | | | | **Chi2** | 1.866 | Pr= | 0.40 | | **Chi2** | 1.729 | Pr= | 0.40 | |
| | **Cramer's V** | 0.0705 | | | | | | **Cramer's V** | 0.067 | | | | **Cramer's V** | 0.060 | | | |

| | Tanner stage | | | | | | | Bioavailable testosterone | | | | | Cortisol level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Total | | Low | Normal | High | Total | | Low | Normal | High | Total |
| **Has been fixed term or permanently excluded from school** | **Yes** | 0 | 3 | 15 | 205 | 212 | 435 | **Yes** | 0 | 43 | 7 | 50 | **Yes** | 12 | 143 | 7 | 162 |
| | **%** | 0 | 13 | 13 | 19 | 22 | | **%** | 0 | 14 | 19 | | **%** | 41 | 35 | 22 | |
| | **No** | 3 | 21 | 105 | 866 | 731 | 1726 | **No** | 33 | 276 | 30 | 339 | **No** | 17 | 270 | 25 | 312 |
| | **%** | 100 | 88 | 88 | 81 | 78 | | **%** | 100 | 87 | 81 | | **%** | 59 | 65 | 78 | |
| | **Total** | 3 | 24 | 120 | 1071 | 943 | 2161 | **Total** | 33 | 319 | 37 | 389 | **Total** | 29 | 413 | 32 | 474 |
| | **Chi2** | 9.865 | Pr= | 0.04 | | | | **Chi2** | 6.194 | Pr= | 0.05 | | **Chi2** | 2.858 | Pr= | 0.20 | |
| | **Cramer's V** | 0.068 | | | | | | **Cramer's V** | 0.126 | | | | **Cramer's V** | 0.078 | | | |

| | Tanner stage | | | | | | | Bioavailable testosterone | | | | | Cortisol level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Total | | Low | Normal | High | Total | | Low | Normal | High | Total |
| **School concerns about attitude** | **Yes** | 0 | 2 | 21 | 149 | 149 | 321 | **Yes** | 2 | 51 | 1 | 54 | **Yes** | 2 | 60 | 4 | 66 |
| | **%** | 0 | 9 | 20 | 17 | 20 | | **%** | 11 | 15 | 6 | | **%** | 11 | 22 | 15 | |
| | **No** | 3 | 20 | 82 | 723 | 593 | 1421 | **No** | 16 | 292 | 16 | 324 | **No** | 17 | 213 | 22 | 252 |
| | **%** | 100 | 91 | 80 | 83 | 80 | | **%** | 89 | 85 | 94 | | **%** | 89 | 78 | 85 | |
| | **Total** | 3 | 22 | 103 | 872 | 742 | 1742 | **Total** | 18 | 343 | 17 | 378 | **Total** | 19 | 273 | 26 | 318 |
| | **Chi2** | 9.62 | Pr= | 0.05 | | | | **Chi2** | 2.466 | Pr= | 0.30 | | **Chi2** | 1.191 | Pr= | 0.40 | |
| | **Cramer's V** | 0.051 | | | | | | **Cramer's V** | 0.085 | | | | **Cramer's V** | 0.078 | | | |

| | Tanner stage | | | | | | | Bioavailable testosterone | | | | | Cortisol level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Total | | Low | Normal | High | Total | | Low | Normal | High | Total |
| **School concerns about behaviour** | **Yes** | 0 | 3 | 29 | 231 | 214 | 477 | **Yes** | 7 | 76 | 4 | 87 | **Yes** | 4 | 76 | 8 | 88 |
| | **%** | 0 | 14 | 28 | 27 | 29 | | **%** | 39 | 22 | 24 | | **%** | 21 | 28 | 31 | |
| | **No** | 3 | 19 | 73 | 639 | 526 | 1260 | **No** | 11 | 268 | 13 | 292 | **No** | 15 | 194 | 18 | 227 |
| | **%** | 100 | 86 | 72 | 73 | 71 | | **%** | 61 | 78 | 76 | | **%** | 79 | 72 | 69 | |
| | **Total** | 3 | 22 | 102 | 870 | 740 | 1737 | **Total** | 18 | 344 | 17 | 379 | **Total** | 19 | 270 | 26 | 315 |
| | **Chi2** | 4.445 | Pr= | 0.30 | | | | **Chi2** | 2.732 | Pr= | 0.03 | | **Chi2** | 0.557 | Pr= | 0.80 | |
| | **Cramer's V** | 0.506 | | | | | | **Cramer's V** | 0.085 | | | | **Cramer's V** | 0.042 | | | |

Due to the lack of participant numbers, the variables 'one detention' and 'multiple detentions' were merged into a new variable 'has received detentions.' Likewise, the two variables relating to fixed term and permanent exclusions were merged into 'has been fixed term or permanently excluded from school.' As the merged outcomes are very similar, this was appropriate.

No significant associations were seen between any of the variables with the exception of a small association between Tanner stage and detentions, $\chi^2$ (4, *N* = 2160) = 10.74, ρ=.03 V=.0705; exclusions, $\chi^2$ (4, *N* = 2161) = 9.865, ρ=.04 V=.068; and the school contacting parents about concerns regarding the participants' attitude, $\chi^2$ (4, *N* = 1742) = 9.62, ρ=.05 V=.0781. An association was also evident between $[BT]_{plasma}$ and exclusions, $\chi^2$ (2, *N* = 389)

= 6.194, ρ=.05 V=.126. The links between biological factors and misbehaviour at ages 15 for the general population may, therefore, be considered weak. However, when pubertal low extreme outliers (Tanner stage 1 or 2) and extreme low $[BT]_{plasma}$ values were analysed with individual TQ2 responses, a significant moderate association was evident with detentions, $\chi^2$ (2, *N* = 16) = 15.24, ρ=.05 V=.35. Also, a moderate association was seen between those individuals at Tanner stage 1 or 2 and exclusion during year 11, $\chi^2$ (2, *N* = 16) = 1.406, ρ=.20 V=.40 but this was not significant at the alpha level of 0.05. No significant associations were seen between behaviour variables with cortisol outlier cases. Despite the latter finding, overall, the data suggests that late maturing boys during year 11 are given disciplinary sanctions more often than their typically developing peers.

**Summary of Section 4.2.2**

In this Section, biological markers were analysed with behavioural questionnaire data provided by teachers and parents. No significant association was seen between pubertal stage and challenging behaviour during year 6 for typically developing boys. However, for the small number of individuals exhibiting advanced pubertal stage, a significant association was seen. A linear relationship was seen between boys with abnormally high plasma testosterone levels and challenging behaviour during year 6. No significant association was seen between cortisol levels and challenging year 6 behaviour. Again, those with extreme low or high values exhibited behaviours such as being disobedient, bad tempered, spiteful, aggressive and resentful.

During year 11, one parental questionnaire was completed and two by teachers. No significant associations were seen between parental questionnaire data and endocrinological values. However, boys with atypical underdevelopment exhibited troublesome behaviour, were disobedient and had temper outbursts like those with deranged cortisol levels during year 6. Surprisingly, those who were underdeveloped were more often late to lessons, got into fights more frequently, were given more detentions and were more frequently suspended or excluded from school than typically developing boys. A moderate association was seen between detentions and exclusions with testosterone concentrations. There were no significant associations evident between behavioural variables and cortisol levels.

## 4.3: Analysis of Selected Psychosocial Measures with Behaviour Variables

Analysis between the ALSPAC psychosocial and behavioural variables was conducted to discover potential associations between these factors. The intention was that these analyses provide outcomes relevant to the study research question, ‘Is there a relationship between psychosocial measures in adolescent boys and their behaviour?’ A full description of the variables and the rationale for their inclusion in these analyses were given in Chapter 3.

First, selected Strengths and Difficulties Questionnaire (SDQ) variables (hyperactivity, conduct and total score) and the Social Communications Disorders Checklist (SCDC) total score (psychosocial variables) were analysed with year 6 behaviour variables. The same psychosocial variables were then analysed with parental questionnaire (PQ) data, teacher questionnaire 1 (TQ1) and teacher questionnaire 2 (TQ2) variables all collected during year 11. The same statistical analyses as discussed in previous sections was completed according to the types of the variable being analysed.

### 4.3.1 Analysis of Year 6 Behaviour with Psychosocial Variables

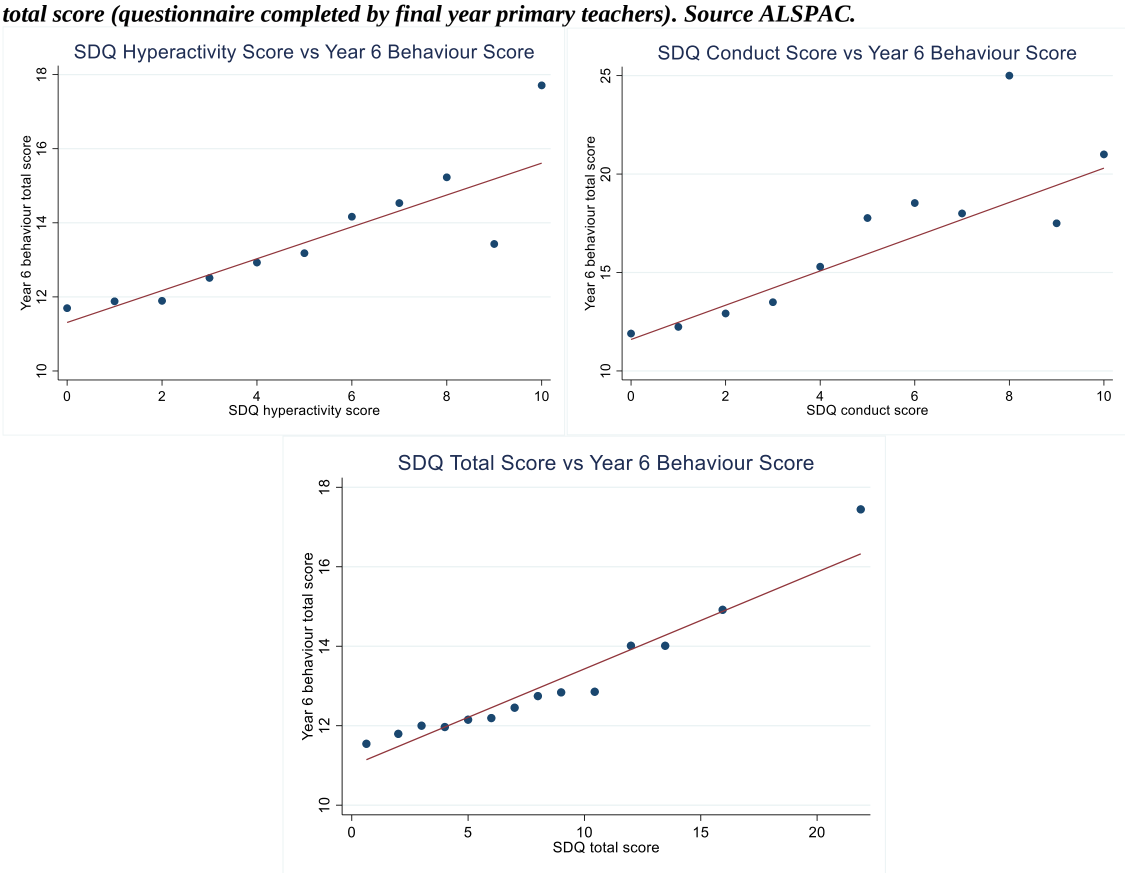
As discussed in Chapter 3, all year 6 behaviour variables are highly associated with each other, therefore for these analyses the year 6 behaviour total score will be used. This is a variable derived from the addition of all the individual component scores in the questionnaire and gives an impression of the participants' general behaviour during the final year of primary schooling. First, the year 6 total score was analysed with SDQ components and then with the SCDC total score, for which the binned scatter plots are shown in Figure 4.3.1.

The descriptive analysis shows clear linear relationships between the year 6 total behaviour score and all psychosocial variables. The hyperactivity and conduct scores show outliers in the high range, that is, boys with potential hyperkinetic and conduct disorders exhibit the most challenging behaviour during year 6. These are less marked for the SDQ total and SCDC scores.

A linear regression was calculated to evaluate the year 6 behaviour total score based on SDQ hyperactivity, conduct and total difficulties scores for boys aged 11. Results of the linear regression indicated that there was a significant effect between the behaviour total score and all SDQ scores at age 11: SDQ hyperactivity score [$F(1, 2020 = 187.40$. $p < .001$]; SDQ conduct score [$F(1, 2028) = 324.25$. $p <.001$]; and SDQ total score [$F(1, 2009) = 305.00$. $p < 0.001$].

These findings indicate that boys with psychosocial difficulties at ages 10 and 11, particularly those who have high scores for psychosocial measures, often exhibit challenging behaviour in school.

***Figure 4.3.1: Binned scatterplots showing the relationship between psychosocial variables and the year 6 behaviour total score (questionnaire completed by final year primary teachers). Source ALSPAC.***




***Notes: actual scores displayed. Number of observations for each plot, top left n=2022, top right n=2030, bottom n=2011.***

## 4.3.2 Analysis of Parental Questionnaire Data with Psychosocial Variables

The seven parental questionnaire (PQ) variables were analysed with the three SDQ variables of interest collected at ages 15 to 16 and with the SCDC total score collected at age 16. The scale for each SDQ and SCDC score is stated above. Bar charts representing these analyses are shown together in Figure 4.3.2. The wide dispersion indicated by the standard error bars should be noted. PQ responses were individualised by ALSPAC for each question and are clearly stated in each chart.

The pattern of data shown in the graphs is very similar for each PQ variable and is generally indicative of an increase in the mean scores for SDQ and SCDC with an increase in the scale of each problematic behaviour stated by the parent.

***Figure 4.3.2: Bar charts with standard error bars (95% CI) showing the relationships between psychosocial and parental questionnaire (PQ) variables at ages 15 to 16.***
***In all cases the y axes are mean scores for each PQ variable indicated in individual chart titles. Source ALSPAC.***

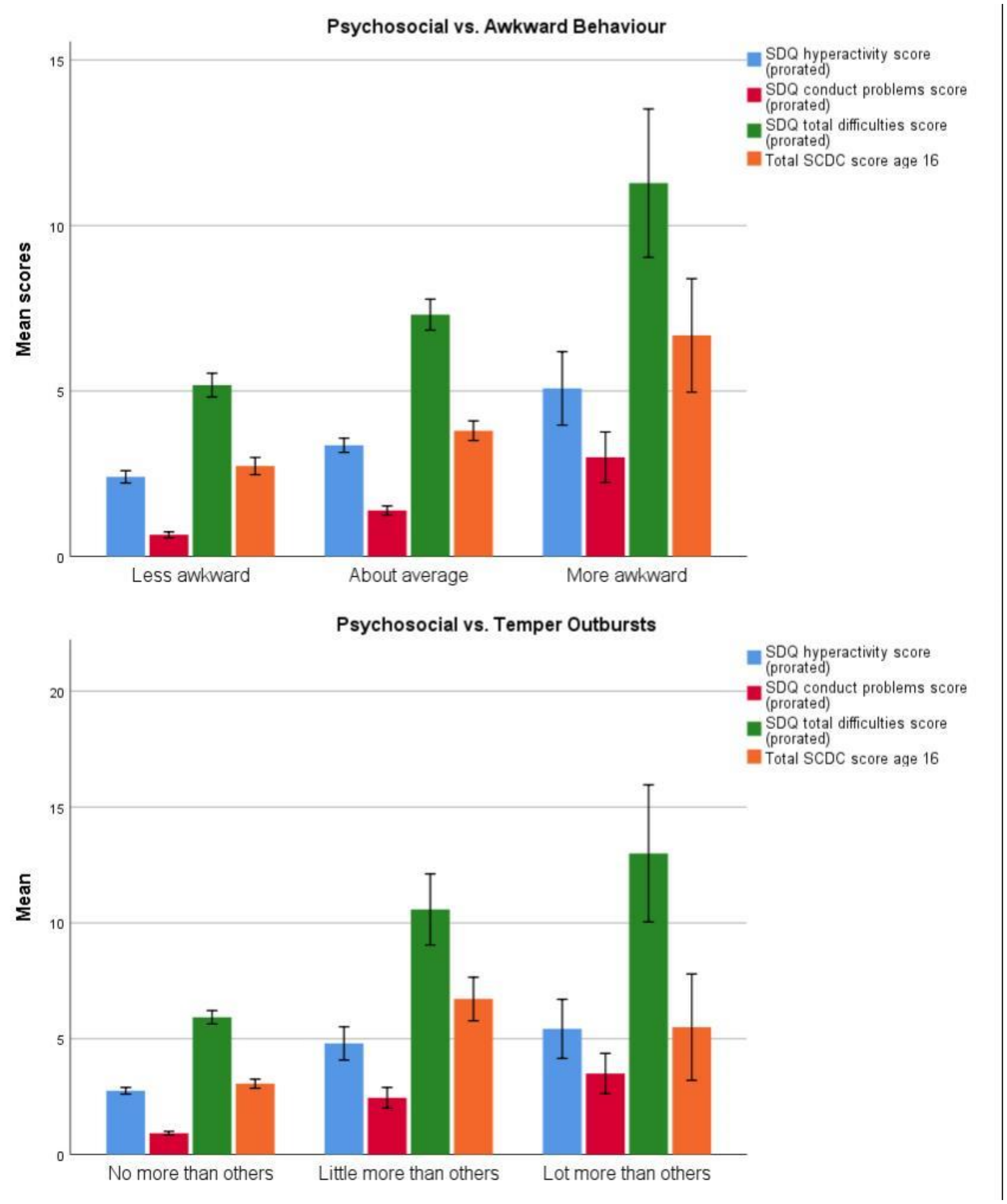
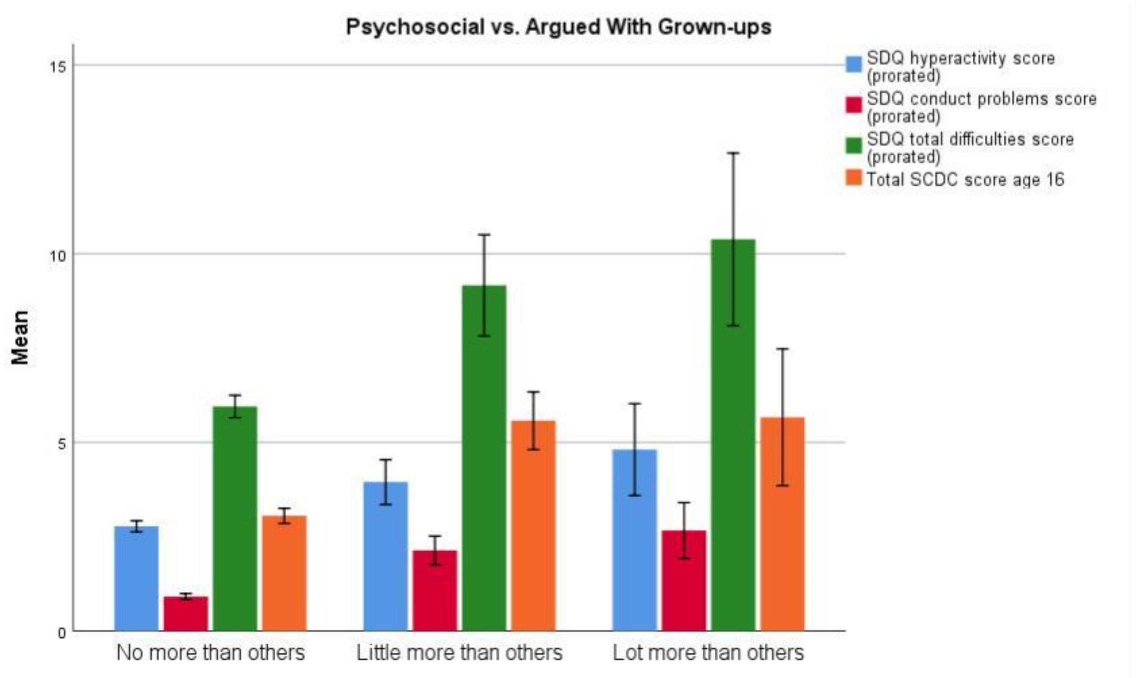


***Figure 4.3.2 continued.***



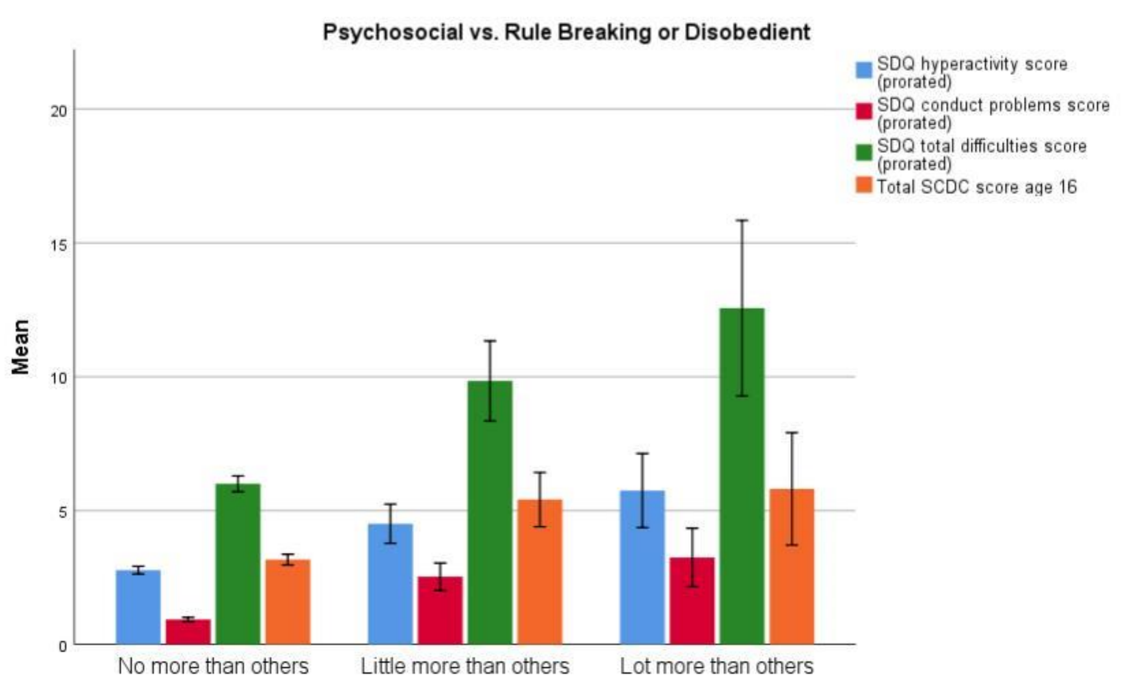
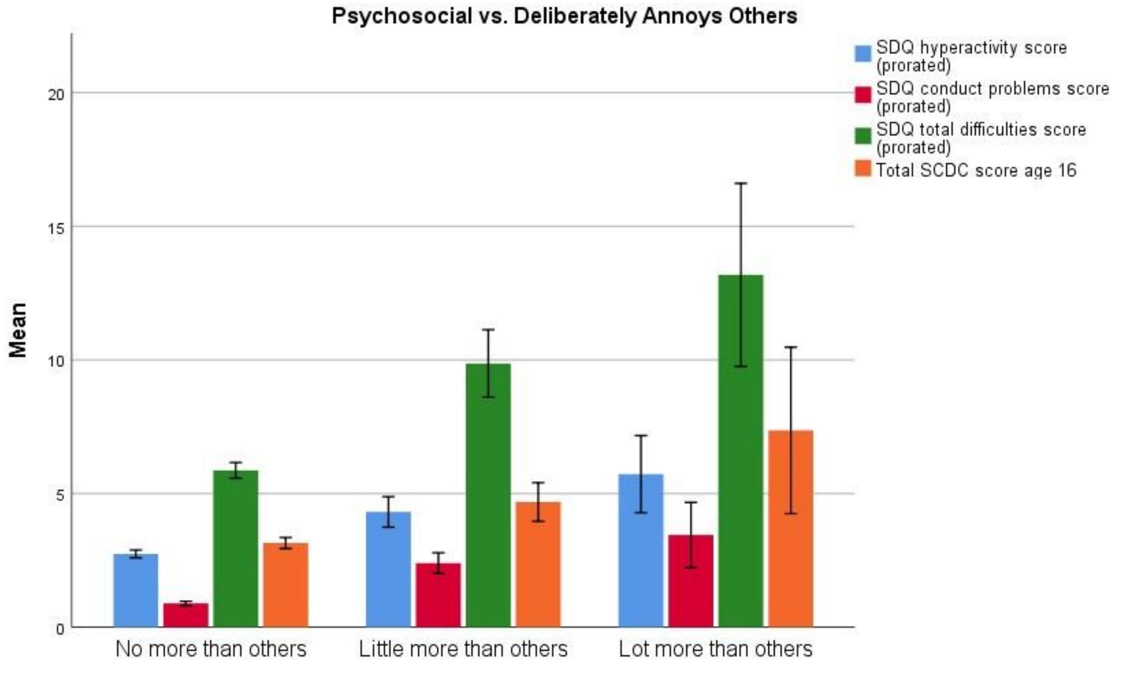



***Figure 4.3.2 continued.***



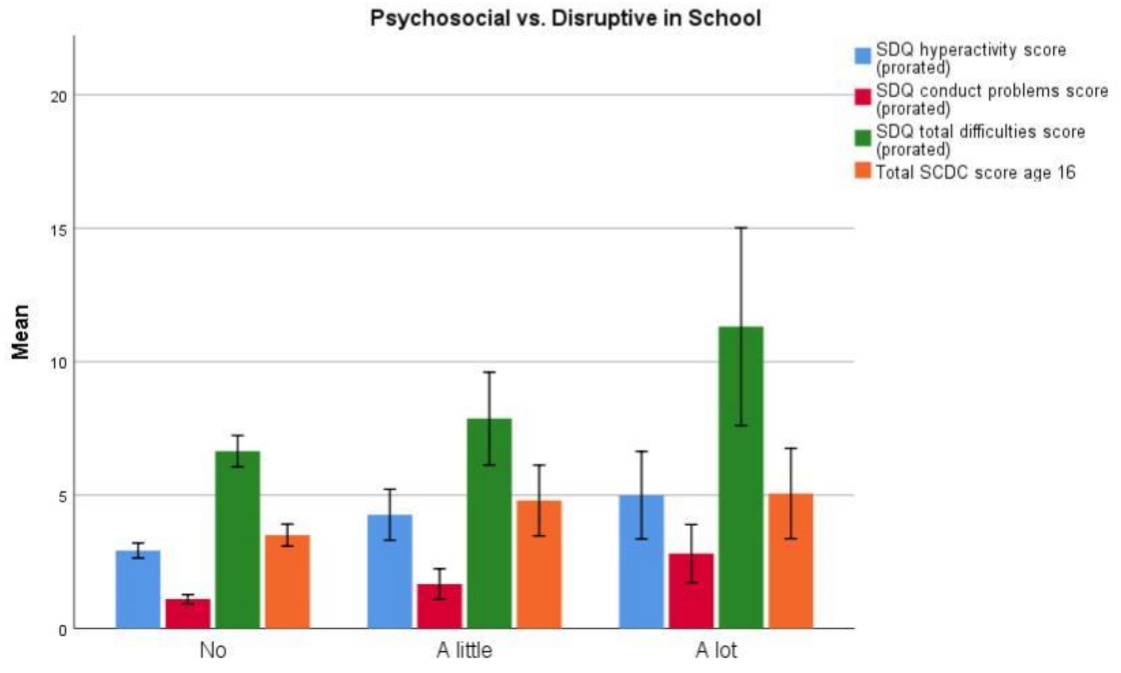
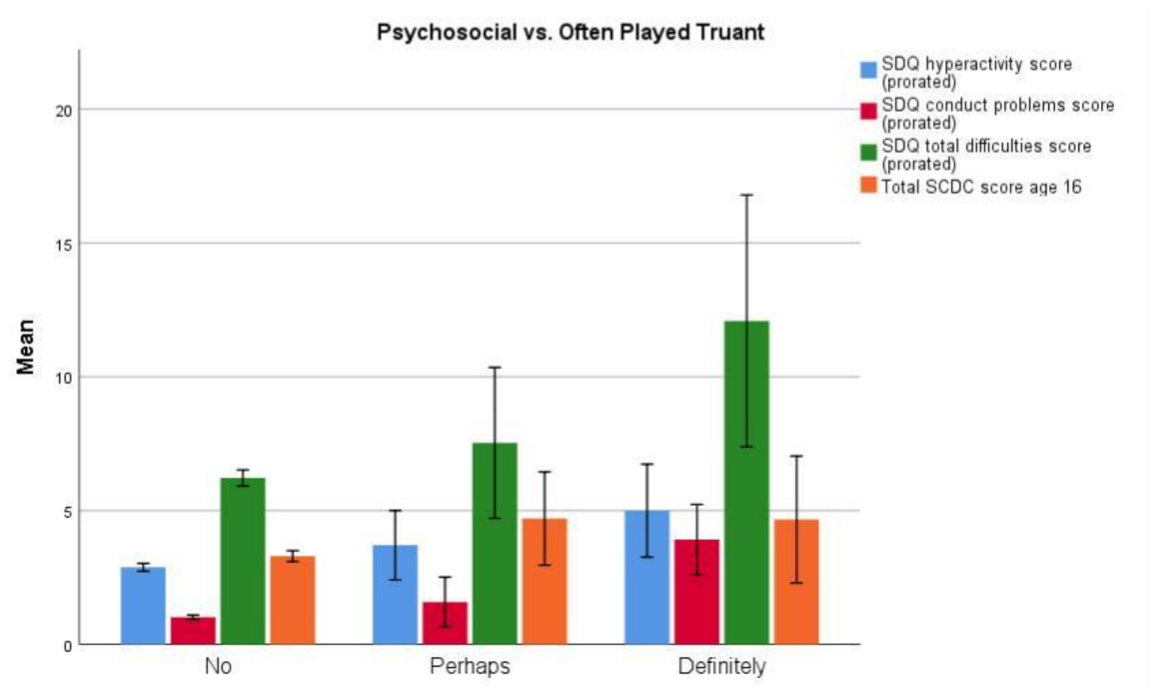



***Figure 4.3.2 continued.***




For example, there is an increase in the mean SDQ hyperactivity score between ‘no more than others’, ‘little more than others’ and ‘a lot more than others’ for the questions about temper, argumentativeness, disobedience and being annoying. The difference between the hyperactivity and conduct scores which are both on a scale from 0 to 10, is due to the abnormal scores for each variable being different, 6/10 and 3/10 respectively. The total SDQ scores are higher than the individual scores as they are the sum of these (a score of 0 to 40, therefore). The only analyses which did not show an increasing pattern across the PQ scales were: temper outbursts where the SCDC score for ‘little more…’ was higher than ‘lot more…’; and hyperactivity with disruptive in school where there was no difference between ‘a little’ and ‘a lot.’ Some increments were small or negligible.

A one-way analysis of variance was conducted for all combinations of psychosocial variable and PQ responses. For clarity, the results of the ANOVA have been collated into Table 4.3.1a. For the SCDC component, the first number in each row is the F value, the second is the degree of freedom and the third is the ρ value. For all SDQ variables, the number shown is the F values. In all cases the df (10, 1732) and $\rho < 0.001$.

***Table 4.3.1a: Results of the ANOVA between SCDC & SDQ variables at age 16 and PQ variables. The first-row number for the SCDC component is the F value, the second df and the third is the ρ value. For all SDQ variables the number shown is the F value, df (10, 1732) and ρ < 0.001. Source: ALSPAC.***

| **SCDC variables age 16** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Awkward behaviour | Temper outbursts | Often argues… | Disobedient | Annoys others | Disruptive in school | Often truant |
| SCDC score | 31.84 | 52.55 | 35.41 | 20.12 | 22.91 | 4.40 | 4.12 |
| | (2, 996) | (2, 968) | (2, 969) | (2, 959) | (2, 958) | (2, 283) | (2, 960) |
| | p<.001 | p<.001 | p<.001 | p<.001 | p<.001 | p=.013 | p=.017 |
| **SDQ variables age 16** | | | | | | | |
| Hyperactivity | 102.06 | 67.42 | 74.01 | 72.04 | 63.64 | 67.71 | 18.27 |
| Conduct | 216.54 | 174.54 | 168.20 | 143.75 | 115.98 | 45.59 | 35.87 |
| SDQ total score | 122.78 | 121.46 | 110.18 | 89.29 | 94.93 | 35.00 | 18.86 |

It can be seen from Table 4.3.1a. that the results of the ANOVA indicated that there were significant differences in all psychosocial (SCDC & SDQ) scores between PQ responses. Post hoc comparisons using the Tukey HSD test are shown in Table 4.3.1b. Where the confidence interval is <95%, the text is shown in red.

An association was evident between SCDC scores and all PQ variables. However, during the post hoc comparisons, it was identified that some associations were not significantly different. With the exception of those variables outside the 95% CI, these results show that psychosocial difficulties including those that are indicative of attention deficit hyperactivity disorder (ADHD) and autistic spectrum disorder (ASD) have an effect on the behaviour of boys aged 15 and 16. In all cases were the confidence interval exceeded 95%, the condition involved was, ‘A lot more’ vs. ‘a little more.’ This indicates a similarity between the two conditions in terms of the views of respondents. The contrast between, ‘More so’ vs. ‘no more than others’ and ‘a lot more’ vs. ‘no more than others’ was more clearly defined.

It is interesting to note that the association between ‘awkward behaviour’ and all psychosocial variables was strong. This gives the impression of boys with psychosocial problems being, according to adults, ‘awkward and troublesome compared to others of the same age’ (exact wording of questionnaire statement). Likewise, adults consider them to have often, ‘had temper outbursts’, ‘argued with grown-ups’, ‘ignored rules or refused to do at they were told’ and ‘often did things to annoy others on purpose.’ Unsurprisingly, the teachers of these boys had complained about their awkward behaviour and disruptiveness in school. In particular, this would be expected for boys with symptoms of ADHD or conduct disorder. Potential disciplinary outcomes are considered in the next Section.

***Table 4.3.1b: Post hoc comparisons of the ANOVA between SCDC & SDQ variables at age 16 and PQ variables, ρ < 0.001. Red text denotes < 95% CI. Source: ALSPAC.***

| SCDC variables age 16 | Awkward behaviour | Temper outbursts | Often argues… | Disobedient | Annoys others | Disruptive in school | Often truant |
|---|---|---|---|---|---|---|---|
| SCDC score | Average vs less *M*=1.12, *SD*= 0.195 | More vs no more than others *M*=3.73, *SD*= 0.378 | More vs no more than others *M*=2.50, *SD*= 0.343 | Little more vs no more than others *M*=2.06, *SD*= 0.427 | Little more vs no more than others *M*=1.71, *SD*= 0.331 | Little vs not *M*=1.19, *SD*= 0.607 | Perhaps vs no *M*=1.03, *SD*= 0.699 |
| | More vs less *M*=3.93, *SD*=0.616 | Lot more vs no more than others *M*=2.42, *SD*=0.793 | Lot more vs no more than others *M*=2.92, *SD*=0.654 | Lot more vs no more than others *M*=3.08, *SD*=0.724 | Lot more vs no more than others *M*=4.21, *SD*=0.921 | A lot vs not *M*=1.79, *SD*= 0.750 | Definitely vs no *M*=1.93, *SD*= 0.779 |
| | More vs ave. *M*=2.82, *SD*=0.617 | **Lot more vs little more. *M*=-1.31, *SD*=0.867, 95% CI [-3.50, 0.72]** | **Lot more vs little more. *M*=-0.41, *SD*=0.717, 95% CI [-0.92, 2.96]** | Lot more vs little more. *M*=-1.01, *SD*=0.829 | Lot more vs little more. *M*=-2.50, *SD*=0.969 | **A lot vs a little *M*=0.60, *SD*= 0.919, 95% CI [-1.56, 2.76]** | **Definitely vs perhaps *M*=0.90, *SD*= 0.103, 95% CI [-1.53, 3.33]** |
| **SDQ variables age 16** | | | | | | | |
| Hyperactivity | Average vs less *M*=1.02, *SD*= 0.103 | More vs no more than others *M*=1.92, *SD*= 0.199 | Little more vs no more than others *M*=1.62, *SD*= 0.177 | Little more vs no more than others *M*=1.87, *SD*= 0.201 | Little more vs no more than others *M*=1.61, *SD*= 0.171 | Little vs not *M*=2.57, *SD*= 0.289 | Perhaps vs no *M*=1.44, *SD*= 0.351 |
| | More vs less *M*=3.50, *SD*=0.297 | Lot more vs no more than others *M*=2.39, *SD*=0.430 | Lot more vs no more than others *M*=2.75, *SD*=0.326 | Lot more vs no more than others *M*=2.74, *SD*=0.345 | Lot more vs no more than others *M*=2.85, *SD*=0.431 | A lot vs not *M*=2.69, *SD*= 0.355 | Definitely vs no *M*=1.80, *SD*= 0.397 |
| | More vs ave. *M*=2.47, *SD*=0.298 | **Lot more vs little more. *M*=-1.01, *SD*=0.468, 95% CI [-0.08, 2.11]** | Lot more vs little more. *M*=-1.12, *SD*=0.363 | **Lot more vs little more. *M*=-8.866, *SD*=0..392, 95% CI [-0.55, 1.78]** | Lot more vs little more. *M*=-1.24, *SD*=0.457 | **A lot vs a little *M*=0.123, *SD*= 0.433, 95% CI [-0.89, 1.14]** | **Definitely vs perhaps *M*=0.35, *SD*= 0.525, 95% CI [-0.87, 1.59]** |
| Conduct | Average vs less *M*=0.72, *SD*= 0.056 | Little more vs no more than others *M*=1.51, *SD*= 0.111 | Little more vs no more than others *M*=1.19, *SD*= 0.099 | Little more vs no more than others *M*=1.23, *SD*= 0.113 | Little more vs no more than others *M*=1.03, *SD*= 0.097 | Little vs not *M*=1.29, *SD*= 0.200 | Perhaps vs no *M*=1.44, *SD*= 0.351 |
| | More vs less *M*=3.03, *SD*=0.165 | Lot more vs no more than others *M*=3.14, *SD*=0.238 | Lot more vs no more than others *M*=2.61, *SD*=0.181 | Lot more vs no more than others *M*=2.60, *SD*=0.193 | Lot more vs no more than others *M*=2.74, *SD*=0.243 | A lot vs not *M*=1.84, *SD*= 0.248 | Definitely vs no *M*=1.80, *SD*= 0.397 |
| | More vs ave. *M*=2.31, *SD*=0.165 | Lot more vs little more. *M*=-1.62, *SD*=0.259 | Lot more vs little more. *M*=-1.41, *SD*=0.202 | Lot more vs little more. *M*=-1.37, *SD*=0.220 | Lot more vs little more. *M*=-1.70, *SD*=0.259 | **A lot vs a little *M*=0.55, *SD*= 0.302, 95% CI [-0.15, 1.27]** | Definitely vs perhaps *M*=0.35, *SD*= 0.525 |
| SDQ total score | Average vs less *M*=1.85, *SD*= 0.205 | Little more vs no more than others *M*=4.69, *SD*= 0.395 | Little more vs no more than others *M*=1.23, *SD*= 0.113 | Little more vs no more than others *M*=3.53, *SD*= 0.404 | Little more vs no more than others *M*=3.15, *SD*= 0.342 | Little vs not *M*=4.35, *SD*= 0.653 | Perhaps vs no *M*=2.79, *SD*= 0.713 |
| | More vs less *M*=8.63, *SD*=0.611 | Lot more vs no more than others *M*=9.25, *SD*=0.881 | Lot more vs no more than others *M*=2.60, *SD*=0.193 | Lot more vs no more than others *M*=7.48, *SD*=0.715 | Lot more vs no more than others *M*=9.05, *SD*=0.853 | A lot vs not *M*=4.75, *SD*= 0.831 | Definitely vs no *M*=3.90, *SD*= 0.811 |
| | More vs ave. *M*=6.78, *SD*=0.612 | Lot more vs little more. *M*=-4.56, *SD*=0.954 | Lot more vs little more. *M*=-1.37, *SD*=0.220 | Lot more vs little more. *M*=-3.95, *SD*=0.807 | Lot more vs little more. *M*=-5.89, *SD*=0.906 | **A lot vs a little *M*=0.39, *SD*= 1.00, 95% CI [-1.95, 2.75]** | **Definitely vs perhaps *M*=1.11, *SD*= 1.07, 95% CI [-1.39, 3.62]** |

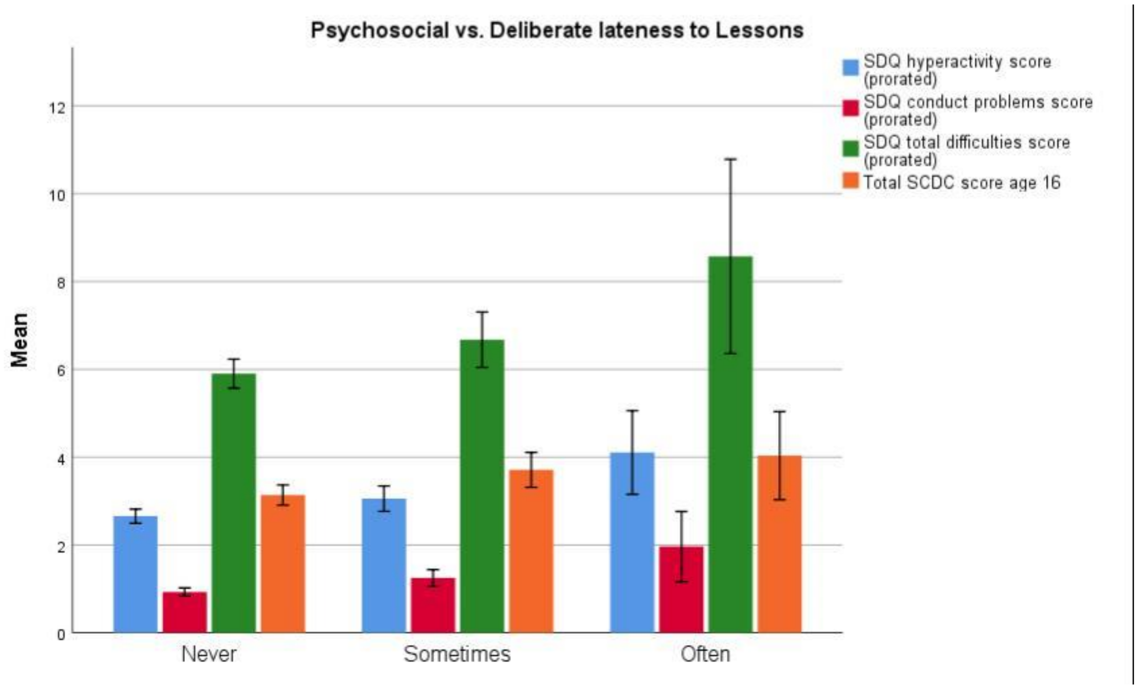
It was noted in Chapter 2 that boys with psychosocial difficulties often refuse school, especially ASD. There is no evidence that supports or refutes if parents identify school refusal as truancy, which may obviously affect the context of the data provided for that variable. It should also be noted that the number of participants with a high SCDC score and challenging behaviour in school during year 6, had declined by year 11. There are a number of possible reasons for this including exclusion from mainstream school between years 6 and 11 or the provision of support for different needs due to an autistic spectrum disorder for which the SCDC is a diagnostic indicator (Section 4.4).

### 4.3.3 Analysis of Teacher Questionnaire One Data with Psychosocial Variables

Psychosocial variables (SDQ as stated above and the SCDC score) were analysed with the three behaviour variables taken from teacher questionnaire 1 (TQ1) to identify potential associations. The TQ1 was undertaken when the participants were in year 11 and responses were either ‘never’, ‘sometimes’ or ‘often.’ Each question is shown in the chart legend. The descriptive analyses of the data are illustrated in Figure 4.3.3.

A remarkably similar pattern is seen in the TQ1 data as for the parental questionnaire (PQ), which included the same psychosocial variables with similar question response categories (i.e. three possible responses ranked from ‘never’ to ‘often’). This consistency of responses and, therefore, the pattern of data between parental and teacher views of the behaviour of year 11 boys, provides internal validity of the data. Although the overall frequency of each category of response is lower for ‘lateness to lessons’ compared to ‘often played truant’ which measure a similar behaviour, the pattern of data is the same in that the conduct mean response has the lowest frequency and the SCDC score the highest (the SDQ total score uses a different scale). Boys with the highest levels of SDQ and SCDC rated difficulties are most often late and most often play truant. A similar pattern is seen between the other two TQ1 variables and similar PQ ones: boys who engage in physical fights are disruptive in school and show aggressive behaviour (‘temper outbursts’). Exclusion is associated with disruptive behaviour in school, SCDC, hyperactivity and poor conduct. As stated before, the SCDC score is an indicator of autism and the SDQ hyperactivity score a sign of a potential hyperkinetic disorder.

***Figure 4.3.3: Bar charts with standard error bars (95% CI) showing the relationships between psychosocial and teacher questionnaire 1 (TQ1) variables at ages 15 to 16.***
***In all cases the y axes are mean scores for each TQ1 variable indicated in individual chart titles. Source ALSPAC.***



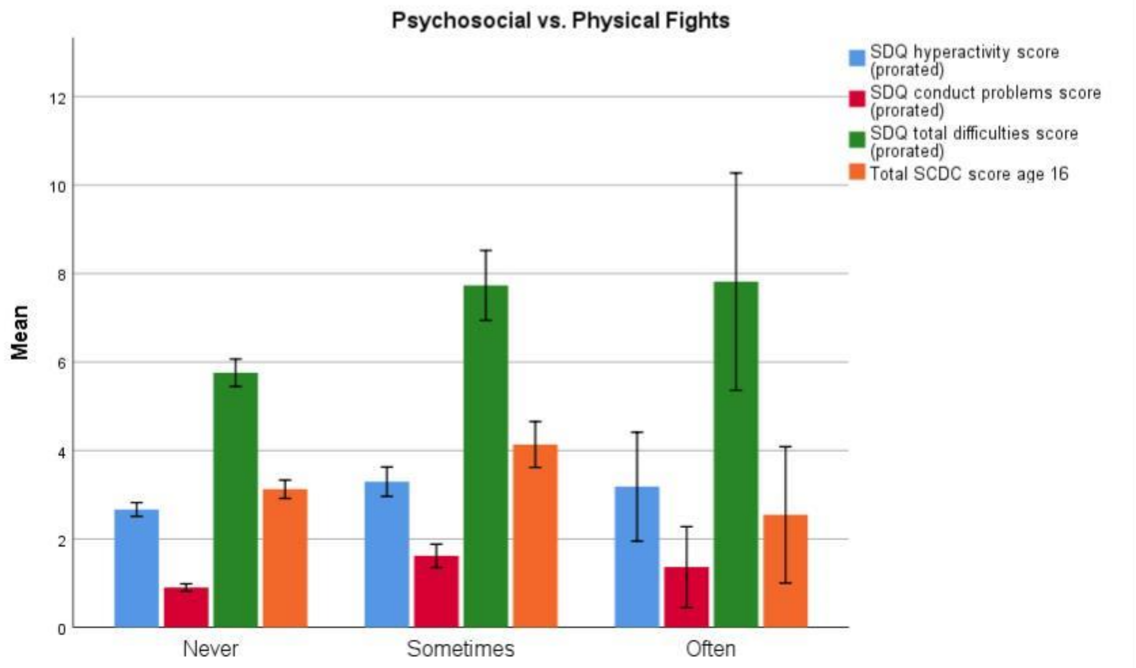
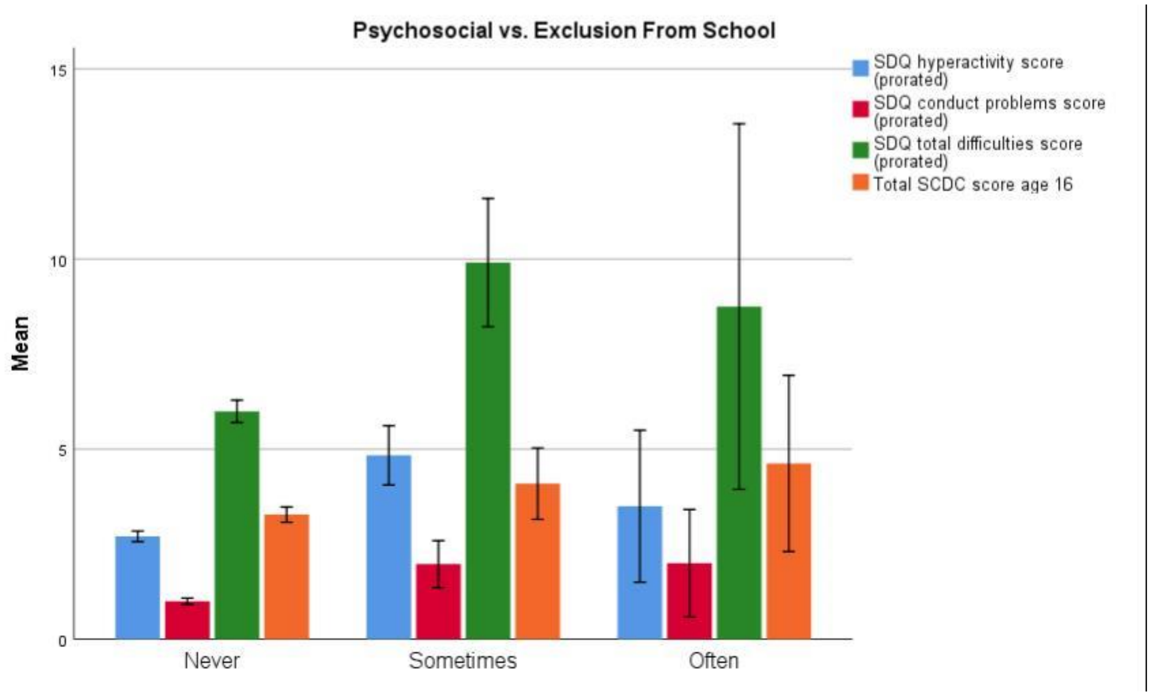



***Figure 4.3.3 continued.***




Descriptive analyses showed marked differences between all of the variables with the exception of those relating to behaviour and SCDC values. A one-way analysis of variance was conducted to evaluate the null hypothesis that there was no difference in behaviour outcomes as measured by the TQ1 based on the psychosocial variables. Results of the ANOVA indicated that there were significant differences in TQ1 responses between psychosocial variables, the F values for which are shown in Table 4.3.2. In all but two cases, 'physical fights' and 'exclusion' relating to the SCDC score, the df (10, 1776) and $\rho < 0.001$. Post hoc comparisons using the Tukey HSD test indicated that the mean scores of the SCDC 'lateness to lessons' and 'physical fights' scores were significantly different between the TQ1 responses with the exception of the conditions 'often' vs. 'never' ($M = 1.05$, $SD = 0.55$) and 'often' vs. 'sometimes' ($M = -0.48$, $SD = 0.56$), which were significantly different than that of 'sometimes' vs. 'never' ($M = -0.57$, $SD = 0.21$). There were no significant differences in the conditions for 'exclusions.'

***Table 4.3.2: Results of the ANOVA between SCDC & SDQ variables at age 16 and PQ variables. The number shown is the F value, df (10, 1776) and $\rho < 0.001$. Source: ALSPAC.***

| | Lateness to lessons | Physical fights | Exclusions |
|---|---|---|---|
| **SCDC score** | 3.29 | **1.60 $\rho < 0.09$** | 2.11 $\rho < 0.01$ |
| **Hyperactivity** | 5.75 | 10.84 | 17.33 |
| **Conduct** | 7.32 | 10.34 | 12.67 |
| **SDQ total score** | 2.19 | 3.62 | 5.72 |

With regards to SDQ variables, post hoc comparisons indicated that the mean scores were significantly different between all conditions of the TQ1 with the following exceptions: hyperactivity and physical fights, ‘often’ vs. ‘sometimes’ ($M$ = 0.59, $SD$ = 0.41) and SDQ total score and physical fights, ‘often’ vs. ‘sometimes’ ($M$ = 0.35, $SD$ = 0.88).

As stated previously, boys with an autistic spectrum disorder with significantly challenging behaviour may have been diagnosed earlier in their schooling which may account for the smaller association between TQ1 variables and the SCDC score. Boys exhibiting hyperactivity, those with potential conduct disorders and those with general difficulties appear to be less punctual than their peers, engage in physical fighting and are more frequently excluded.

### 4.3.4 Analysis of Teacher Questionnaire Two Data with Psychosocial Variables

An analysis of the SDQ and SCDC psychosocial variables with TQ2 variables took place to identify potential associations. The ordinal psychosocial scores were grouped into ‘normal’, ‘borderline’ and ‘abnormal’ SDQ scores and ‘normal’ and ‘abnormal’ scores for the SDCD to explore if differences existed between these categories. In brief, an SCDC score $\geq 8$ is considered abnormal, whereas SDQ scores are placed in the categories above and differ between components (Appendix 6). Considering the nature of the psychosocial variables with that of the dichotomous, ‘yes’ or ‘no’, TQ2 responses, all analyses were undertaken using the Pearson’s Chi-square ($\chi^2$) statistic with the Cramér’s $V$ coefficient, Table 4.3.3 being a contingency table of these analyses. Cumulative psychosocial scores, for example, those scores greater or equal to 1, 2, 3, etc. were later analysed to explore potential patterns in the data (Figure 4.3.4). The analysis summarised in Table 4.3.3 only includes those participants for whom SDQ, SCDC and TQ2 data exists.

When comparing only those who received detentions, it should be noted that although boys with borderline and abnormal psychosocial scores who did not receive detentions significantly outnumbered those who did, those experiencing psychosocial problems were more highly represented. For example, 257 of those with borderline or abnormal hyperactivity scores did not receive detentions (68%) whereas 88 did. Only comparisons between those given detentions will follow in this narrative.

Of those who received detentions, 21% had borderline or abnormal hyperactivity scores, statistically significant although with a weak association, $\chi^2$ (2, $N$ = 2743) = 14.45, ρ=.001 V=.07. In the analysis between the SDQ conduct score and detentions, a smaller proportion of participants with abnormal and borderline scores received detentions (2%) than with hyperactivity and these findings were not statistically significant at the α = 5 level, $\chi^2$ (2, $N$ = 2736) = 1.72, ρ=.40 V=.025. When the relationship between the total difficulties experienced by year 11 boys and being given detentions is considered, more boys with borderline and abnormal scores (256) received detentions compared with those who did not (238). However, when differences in the population are analysed, a significant weak positive association is seen between the SDQ total difficulties score and detentions given, $\chi^2$ (2, $N$ = 2714) = 41.49, ρ=.001 V=.073. Finally, a small negative association was seen between detentions and the SCDC score, $\chi^2$ (2, $N$ = 16) = 15.24, ρ=.05 V=.35 with 16% of those receiving detentions having abnormal scores.

Bearing in mind that the statistical analyses take all values in the entire population into account, it is unsurprising that only statistically weak associations were evident in the analysis. However, when only considering those who receive detentions, the results above show that boys with psychosocial difficulties are highly represented in those being punished in this way.

***Table 4.3.3: Contingency tables with Chi-square (Chi2) and Cramér's V analysis of psychosocial variables with TQ2 data. Nrm=normal, Brder=borderline, Ab=abnormal. Source: ALSPAC.***

**Has received detention**

| SDQ hyperactivity score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 411 | 38 | 50 | 499 |
| % | 17 | 27 | 25 | |
| No | 1987 | 104 | 153 | 2244 |
| % | 83 | 73 | 75 | |
| Total | 2398 | 142 | 203 | 2743 |
| Chi2 | 14.446 | | Pr= | 0.001 |
| Cramer's V | 0.073 | | | |

| SDQ conduct score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 490 | 5 | 5 | 500 |
| % | 18 | 25 | 28 | |
| No | 2208 | 15 | 13 | 2236 |
| % | 82 | 75 | 72 | |
| Total | 2698 | 20 | 18 | 2736 |
| Chi2 | 1.717 | | Pr= | 0.40 |
| Cramer's V | 0.025 | | | |

| SDQ total score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 238 | 42 | 214 | 494 |
| % | 16 | 17 | 22 | |
| No | 1258 | 200 | 762 | 2220 |
| % | 84 | 83 | 78 | |
| Total | 1496 | 242 | 976 | 2714 |
| Chi2 | 14.491 | | Pr= | 0.01 |
| Cramer's V | 0.073 | | | |

| SCDC score | Nrm | Ab | Tot |
|---|---|---|---|
| Yes | 240 | 38 | 278 |
| % | 18 | 26 | |
| No | 1127 | 107 | 1234 |
| % | 82 | 74 | |
| Total | 1367 | 145 | 1512 |
| Chi2 | 6.537 | Pr= | 0.01 |
| Cramer's V | -0.066 | | |

**Has been fixed term or permane-ntly excluded from school**

| SDQ hyperactivity score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 409 | 42 | 45 | 496 |
| % | 17 | 30 | 22 | |
| No | 1989 | 100 | 158 | 2247 |
| % | 83 | 70 | 78 | |
| Total | 2398 | 142 | 203 | 2743 |
| Chi2 | 16.660 | | Pr= | 0.001 |
| Cramer's V | 0.078 | | | |

| SDQ conduct score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 486 | 4 | 7 | 497 |
| % | 18 | 20 | 39 | |
| No | 2212 | 16 | 11 | 2239 |
| % | 82 | 80 | 61 | |
| Total | 2698 | 20 | 18 | 2736 |
| Chi2 | 5.287 | | Pr= | 0.07 |
| Cramer's V | 0.044 | | | |

| SDQ total score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 242 | 43 | 204 | 489 |
| % | 16 | 18 | 21 | |
| No | 1254 | 199 | 772 | 2225 |
| % | 1496 | 242 | 976 | |
| Total | 1496 | 242 | 976 | 2714 |
| Chi2 | 8.939 | | Pr= | 0.01 |
| Cramer's V | 0.057 | | | |

| SCDC score | Nrm | Ab | Tot |
|---|---|---|---|
| Yes | 236 | 35 | 271 |
| % | 17 | 24 | |
| No | 1131 | 110 | 1241 |
| % | 83 | 76 | |
| Total | 1367 | 145 | 1512 |
| Chi2 | 4.211 | Pr= | 0.04 |
| Cramer's V | - 0.053 | | |

**School concerns about attitude**

| SDQ hyperactivity score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 507 | 52 | 96 | 655 |
| % | 25 | 50 | 60 | |
| No | 1491 | 52 | 65 | 1608 |
| % | 75 | 50 | 40 | |
| Total | 1998 | 104 | 161 | 2263 |
| Chi2 | 108.492 | | Pr= | 0.001 |
| Cramer's V | 0.219 | | | |

| SDQ conduct score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 625 | 11 | 11 | 647 |
| % | 28 | 69 | 92 | |
| No | 1602 | 5 | 1 | 1608 |
| % | 72 | 31 | 8 | |
| Total | 2227 | 16 | 12 | 2255 |
| Chi2 | 36.238 | | Pr= | 0.001 |
| Cramer's V | 0.127 | | | |

| SDQ total score | Nrm | Brder | Ab | Tot |
|---|---|---|---|---|
| Yes | 249 | 64 | 330 | 643 |
| % | 20 | 31 | 42 | |
| No | 1008 | 141 | 448 | 1597 |
| % | 80 | 69 | 58 | |
| Total | 1257 | 205 | 778 | 2240 |
| Chi2 | 120.711 | | Pr= | 0.001 |
| Cramer's V | 0.232 | | | |

| SCDC score | Nrm | Ab | Tot |
|---|---|---|---|
| Yes | 299 | 41 | 340 |
| % | 26 | 38 | |
| No | 835 | 68 | 903 |
| % | 74 | 62 | |
| Total | 1134 | 109 | 1243 |
| Chi2 | 6.331 | Pr= | 0.01 |
| Cramer's V | -0.071 | | |

***Table 4.3.3 (continued).***

| | **SDQ hyperactivity score** | | | | |
|---|---|---|---|---|---|
| | | **Nrm** | **Brder** | **Ab** | **Tot** |
| **School concerns about behaviour** | **Yes** | 295 | 37 | 82 | 414 |
| | **%** | 15 | 35 | 51 | |
| | **No** | 1704 | 68 | 79 | 1851 |
| | **%** | 85 | 65 | 49 | |
| | **Total** | 1999 | 105 | 161 | 2265 |
| | **Chi2** | 151.734 | | Pr= | 0.001 |
| | **Cramer's V** | 0.259 | | | |

| | **SDQ conduct score** | | | | |
|---|---|---|---|---|---|
| | | **Nrm** | **Brder** | **Ab** | **Tot** |
| **School concerns about behaviour** | **Yes** | 388 | 9 | 11 | 408 |
| | **%** | 17 | 56 | 92 | |
| | **No** | 1841 | 7 | 1 | 1849 |
| | **%** | 83 | 44 | 8 | |
| | **Total** | 2229 | 16 | 12 | 2257 |
| | **Chi2** | 60.301 | | Pr= | 0.001 |
| | **Cramer's V** | 0.164 | | | |

| | **SDQ total score** | | | | |
|---|---|---|---|---|---|
| | | **Nrm** | **Brder** | **Ab** | **Tot** |
| **School concerns about behaviour** | **Yes** | 131 | 44 | 228 | 403 |
| | **%** | 10 | 21 | 29 | |
| | **No** | 1125 | 161 | 552 | 1838 |
| | **%** | 90 | 79 | 71 | |
| | **Total** | 1256 | 205 | 780 | 2241 |
| | **Chi2** | 117.170 | | Pr= | 0.001 |
| | **Cramer's V** | 0.229 | | | |

| | **SCDC score** | | | |
|---|---|---|---|---|
| | | **Nrm** | **Ab** | **Tot** |
| **School concerns about behaviour** | **Yes** | 176 | 32 | 208 |
| | **%** | 15 | 29 | |
| | **No** | 961 | 78 | 1039 |
| | **%** | 85 | 71 | |
| | **Total** | 1137 | 110 | 1247 |
| | **Chi2** | 6.331 | Pr= | 0.01 |
| | **Cramer's V** | -0.071 | | |

The ALSPAC dataset shows that only a small number of boys in the general population, 6 of the 2772 for whom data exists (0.22%), were permanently excluded during year 11, compared with 153 (7%) who were fixed-term excluded, and 18 (~1%) of whom were often excluded. Of those permanently excluded: 1 or 5 had a borderline hyperactivity score, 1 of 3 had an abnormal conduct score, 3 or 4 had an abnormal SDQ total score and 2 of 3 had an abnormal SCDC score. Of those often fixed-term excluded, 1 of 19 had a borderline score and 9 of 19 had an abnormal score. This proportion was less prominent for those who were sometimes excluded: 5 of 94 with abnormal hyperactivity scores and 21 of 94 with abnormal scores. Statistical analysis indicated a small positive association between hyperactivity and receiving detentions in the general sample, $\chi^2$ (2, $N$ = 2743) = 14.45, ρ=.001 V=.073.

The number of boys with potential conduct disorders who were sometimes fixed-term excluded during year 11 is much lower: 2 of 94 with borderline scores and none with abnormal scores. Two of the 18 often excluded having an abnormal conduct score. The statistical analysis showed a similar small association to that of hyperactivity, $\chi^2$ (2, $N$ = 2743) = 16.60, ρ=.001 V=.078. It could be that boys with severely challenging behaviour are often moved to specialist schools before they reach year 11. In fact, the data supports this idea; in the dataset, there are only 38 boys out of 2,736 with borderline or abnormal SDQ conduct scores whereas during year 6, 331 boys had borderline and 321 had abnormal scores.

There is a stark difference between the findings of statistical analyses of exclusion in the general population and the proportion of those excluded with borderline and abnormal SDQ total scores, a sign of general difficulties and potential mental illness. During year 11, 1 of 4 of those permanently excluded suffered general difficulties with 6 of 97 (6%) being fixed-term excluded. The sample size is insufficient for statistical analysis (Section 4.1) to take place for permanent exclusions. For fixed-term exclusions, a small, significant positive association was seen, $\chi^2$ (2, $N$ = 2216) = 41.12, ρ=.001 V=.140.

It is interesting to note that, overall, the number of boys with abnormal and borderline difficulties varies across age groups. During year 6, there were 200 participants with borderline SDQ total scores and 278 with abnormal scores. By year 11, the number of borderline cases had risen to 242 and to 976 of abnormal. This suggests that general difficulties, as determined by the SDQ, develop during adolescence or are identified at later stages of schooling. Remarkably, despite a similar sample size, at age 13 (year 9), the SDQ total score dips to 97 for borderline scores and 140 for abnormal scores. The anxiety of transition from primary to secondary education could account for this at age 11 and the stress of terminal examinations and leaving secondary school at age 16.

Of those permanently excluded during year 11, 2 of 3 had an abnormal SCDC score and 6 of 49 of those with an abnormal SCDC score were fixed-term excluded. There were 101 participants in the sample that had an abnormal SDCD score and were not excluded out of a sample size of 1,236. The total number of participants with an abnormal SCDC score at age 11 was 278 and at age 13 it was 267. This shows a significant decline in the number of participants with social and communication difficulties throughout the secondary phase of education. Exclusion data is only available for year 11, so it is not certain if these boys were moved to alternative provision, became school refusers (relatively common in those with autism) or were permanently excluded.

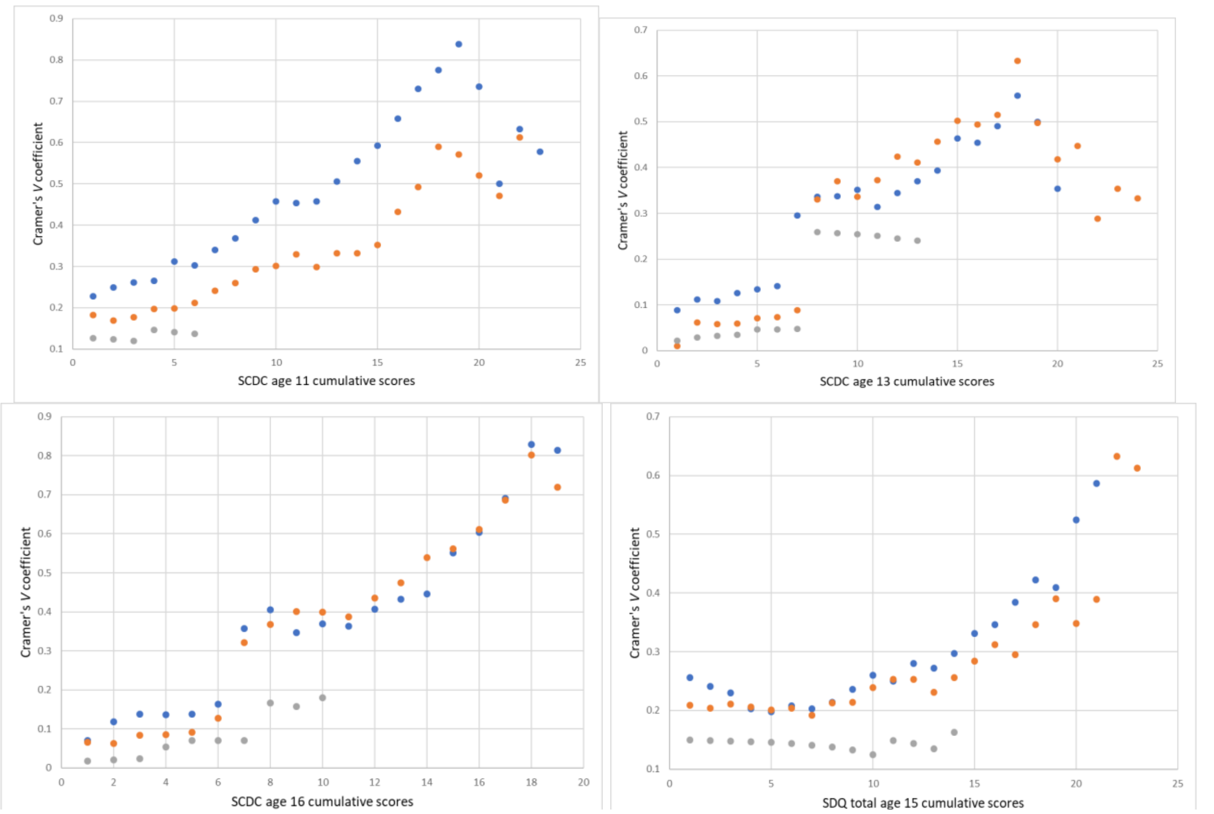
Teachers were specifically asked to state if their school had contacted parents with concerns about the young person's attitude towards school, their behaviour or both. The sample size was roughly the same ($N$=~2,200) for each analysis and all analyses were statistically significant ($\rho < .01$). Regarding the hyperactivity score, 29% of those whose parents were contacted about attitude concerns had borderline or abnormal scores and 40% concerning behaviour concerns for which a moderate positive association was seen, $\chi^2$ (2, $N$ = 2263) = 151.73, ρ=.001 V=.259. The parents of approximately the same proportion of students with borderline and abnormal conduct scores were contacted by schools regarding both attitude and behaviour; 22 participants of 28 (79%). Only 28% of boys with a normal conduct score had communications about their attitude and 17% for behaviour. Statistical analysis indicated a significant small positive association between the population conduct score with concerns about attitude, $\chi^2$ (2, $N$ = 2255) = 36.23, ρ=.001 V=.127; and with behaviour, $\chi^2$ (2, $N$ = 2257) = 60.30, ρ=.001 V=.164.

A moderate association was seen between the SDQ total score and both school parental contact variables: for attitude, $\chi^2$ (2, $N$ = 2240) = 120.71, ρ=.001 V=.232; and for behaviour $\chi^2$ (2, $N$ = 2241) = 117.17, ρ=.001 V=.229. However, there were far more parental contacts regarding attitude for boys with borderline or abnormal SDQ scores than those with normal scores (394 vs. 249). For parental contacts regarding behaviour, 272 of the boys had borderline or abnormal scores whereas only 131 had normal scores. A different distribution was seen for parental contact and SCDC scores. For concerns regarding attitude, 14% had abnormal scores and for behaviour, 18% had abnormal scores. A small negative association was seen between SCDC scores with concerns regarding attitude, $\chi^2$ (2, $N$ = 1243) = 6.33, ρ=.01 V=-.07; and concerns regarding behaviour, $\chi^2$ (2, $N$ = 1247) = 6.33, ρ=.01 V=-.07.

It may be expected that schools would communicate more with the parents of children who exhibit psychosocial difficulties. Of the boys exhibiting hyperactivity, 40% had contacts concerning behaviour and 79% for those with conduct problems. There were substantially more parental contacts regarding both attitude and behaviour for boys with an abnormal total difficulties score. Potential reasons for the small negative association between SCDC scores and psychosocial variables were discussed in various sections above.

To see if a pattern existed in the data for the strength of association with cumulative psychosocial variables scores, individual scores for the SCDC at ages 11, 13 and 16 and the SDQ total score at age 15 were plotted with their Cramer's V coefficients for multiple detentions, fixed-term exclusions and permanent exclusions. These plots are grouped together in Figure 4.3.4.

***Figure 4.3.4: Strength of association between Cramer's V coefficient and cumulative psychosocial variable scores for SCDC at ages 11, 13 and16 and the SDQ total score at age 15.***
***Datapoints: blue=multiple detentions; orange =fixed-term exclusions; grey=permanent exclusions.***



As a result, a significant linear relationship can be seen between psychosocial variables with multiple detentions and fixed-term exclusions. Figure 4.3.4 shows a particularly high relationship between SCDC scores above 13 at ages 11 and 13, and 15 and above at age 16. A similarly high relationship is seen between multiple detentions and an SDQ total score of 14 or above at age 15 (the threshold for an abnormal score).

It must be noted that the graphs show psychosocial data at the ages stated and the outcome is TQ2 data representing year 11. No significant association was shown between psychosocial scores at age 11 with permanent exclusion during year 11 and so should not be considered predictive. However, the plot indicates that an abnormal SCDC score (8 or above) at age 13 is associated with exclusion during year 11. This indicates that children with a probable learning disability are later excluded from school and that an early SCDC scoring may be predictive. A small association is seen between the SCDC score at 16 and exclusion.

In conclusion, a high SCDC score at age 11 is predictive of fixed-term exclusion and multiple detentions at age 15 but not permanent exclusion. As no school behaviour data exists between years 6 and 11, ongoing school sanctions cannot be determined. By age 13, the SCDC score is predictive of all three sanctions at year 11 (including permanent exclusion) over the abnormal threshold of 8. All three sanctions (multiple detentions, fixed-term and permanent exclusion) are associated with an abnormal SCDC score at age 16. A linear relationship is seen between borderline and abnormal SDQ total scores (equal to and greater than 14) at age 15 with multiple detentions and fixed-term exclusions. However, there is no apparent relationship between SDQ scores and permanent exclusion except for a high conduct problems score at age 15.

**<u>Summary of Section 4.3</u>**

This section involved analyses between psychosocial measures with behaviour variables. A significant association was evident between year 6 behaviour scores and all psychosocial variables, particularly those relating to hyperactivity and conduct problems. The findings were statistically significant. Small but significant positive associations were seen between challenging behaviour in and out of school as reported by parents and all psychological scores, including general difficulties, hyperactivity and conduct problems. Similar associations were seen with measures of social cognition indicating that boys with poor social cognitive function exhibit more challenging behaviour than their peers. These were identified by high SCDC scores, an indicator of an autistic spectrum disorder (ASD).

For reasons unknown, the number of boys in mainstream school with a potential ASD declined between years 6 and 11.

As with the parental questionnaire data, an increase in mean psychosocial scores was seen with negative teacher responses such as sometimes or often late, fights or exclusions. Boys with abnormally high or borderline psychosocial scores are also more likely to be aggressive and disruptive in school. It was evident that boys with psychosocial difficulties are unfairly represented amongst those being punished with detentions.

Differences between parent and teacher responses to similar questions could be due to their differing perspectives. However, in most cases, the responses were similar indicating internal validity of the data. It appears that boys who exhibit challenging behaviour in school also do so at home.

## 4.4 Chapter 4 Summary of Findings

In this Section, the outcomes of the quantitative data analysis will be summarised into key findings cross-referenced to each of the chapter subsections and linked to the study research questions.

There is no evidence to suggest that challenging behaviour in school is associated with pubertal development *per se*. However, strong associations were seen with the small number of participants exhibiting extreme age-atypical pubertal stages. That means to say, those at age 11 showing adult pubertal development (Tanner stages 4 or 5) and those at pre-adolescent or delayed pubertal development (Tanner stages 1 or 2) at age 15. Boys at extreme stages of physical development for their age exhibit hyperactivity, poor conduct and a high degree of behavioural and psychological difficulties as determined by the SDQ total score (the sum of the hyperactivity, conduct problems, peer relationship problems and emotional symptom scores). A high hyperactivity score can indicate a hyperkinetic disorder such as Attention Deficit Hyperactivity Disorder (ADHD) and a high conduct problems score may be indicative of conduct disorder. Physical underdevelopment at ages 15 to 17 was also associated with challenging behaviour at home and disruptive behaviour in school as reported by parents.

Endocrinological data with psychological or behavioural data only existed for a small number of participants, so care was taken when considering potential inferences. No relationships were evident between plasma testosterone concentrations and adverse behaviour in school for the general population. Neither were associations identified between testosterone levels and psychological difficulties. As stated above, there is a high level of association between plasma testosterone levels and pubertal stage, so similar findings would be expected to that of the analysis of pubertal stage with behavioural and psychological variables. Had the testosterone sample size been larger, that may have been the case. However, as with pubertal stage, age-atypical extreme outlier values were associated with challenging behaviour in school such as poor punctuality, fighting and being fixed-term excluded more often.

Abnormally low or high salivary cortisol concentrations were not associated with behaviour difficulties during the final year of primary education.

Using the Social and Communication Disorders Checklist (SCDC) data as a measure of social cognitive functioning, potential associations with pubertal stage, testosterone and cortisol levels were examined. In common with previously stated findings, atypical pubertal development at ages 11 and 15 was highly associated with social cognitive difficulties, particularly for early developing boys. No relationship was seen between SCDC scores and normal pubertal development. Similarly, boys with abnormally high levels of testosterone at ages 9 and 11 exhibited significantly more social cognitive difficulties. The converse was also true in that those with abnormally low levels of testosterone in mid- and late-adolescence had fewer social cognitive problems although the evidence for this was weak. This confirms the work of others (Chapter 2), which links early pubertal development and high testosterone levels with social communication disorders such as autism. Several studies also suggest a mid-adolescent decline in social cognitive functioning due to a restructuring of the brain prefrontal cortex, a function of which is social cognition. No such mid-adolescent decline in social cognitive functioning was apparent upon analysis of the ALSPAC dataset. Considering that the actual number of boys with social cognitive difficulties in the general population is likely to be much higher, these findings are valuable when considering the potential need for revised school behaviour management strategies, policies and inclusivity (Chapter 6).

Clear relationships were seen between psychosocial measures in adolescent boys and their behaviour. Significant associations were seen between year 6 behaviour problems and all of the psychosocial variables. Similar findings were evident during year 11. In fact, challenging behaviour and psychosocial difficulties in year 6 were a good predictor of challenging behaviour during year 11, leading to sanctions such as detentions and exclusion. These findings indicate the potential benefits of early support and intervention (Chapter 6). It may be considered that repeated punishments are ineffective in the management of boys with the most challenging of behaviour in schools. Findings suggest that a significant number of these boys have a learning disability or mental health problem, the moral dimension of which should be considered.

In conclusion, there is strong evidence to suggest that boys presenting as extreme biological and psychosocial outliers also have challenging behaviour both in and out of school. Therefore, it is argued they have unmet additional needs requiring support. The small number of boys presenting with severe behavioural challenges are discussed in the next Chapter.

# Chapter 5: Analysis of Extreme Developmental Cases

## 5.1 Introduction to Chapter 5

In previous chapters, it was suggested that associations exist between pubertal stage, endocrinological factors, psychosocial variables and adolescent behaviour. However, trends in these factors are mainly represented in data relating to outliers, that is, participants with extreme physical, endocrinological, behavioural and psychosocial data values. This chapter concerns the detailed analysis and discussion of such extreme cases. By way of comparison, 10 randomly selected participants in the normal range of pubertal development are described in the same way so that it is possible to have an informed opinion regarding how different the outlier cases are from the typical population relating to the variables considered.

Of the ~1900 participants for which pubertal data exists, only 15 underwent early physical development and another 15 late physical development. In Chapter 4 it was determined that 60% of those who underwent early physical development suffered psychosocial or behavioural difficulties. However, due to the small number of observations, the statistic is not reliable. Therefore, these 15 cases will be investigated in detail using all the relevant behavioural and psychosocial data at different ages available from ALSPAC.

The Conceptual Framework (Section 1.6) shows multiple, interrelated factors that could influence a child's behaviour in school. The literature (Chapter 2) and quantitative analysis of ALSPAC data variables (Chapter 4) suggest several biological factors associated with puberty that affect executive function. Social cognitive function, as measured by the Social Communications Disorders Checklist (SCDC), is a domain of executive function. Biopsychological measures collected as Strengths and Difficulties Questionnaire (SDQ) data are also implicated in behaviour and social functioning.

In this Chapter, an examination of the pubertal stage distribution in the dataset will take place followed by an in-depth analysis of data relating to anthropometric, pubertal stage, pubertal trajectory, psychosocial and behavioural variables for each of the atypical maturing participants. Ten typically maturing participants are also considered for comparison. It was done using the methodological approach of *qualitising*, which involves viewing quantitative data through the lenses of a qualitative researcher (Chapter 3). An analysis of participant data linked to extreme or unusual endocrinological values (testosterone and cortisol) will be also conducted. Finally, an analysis of anthropometric, endocrine, psychosocial and behavioural variables will take place for boys who are often fixed-term or permanently excluded from school.

## 5.2 Participants and Age-related Tanner Staging

Tanner stage is a pubertal development scale where stage 1 is pre-puberty and stage 5 is that of an adult (Tanner, 1978). The ALSPAC dataset was interrogated using the statistical analysis software STATA 15 IC (StataCorp) to identify the number of participants at each stage of pubertal development at age 11 and at age 15. Fifteen boys in the ALSPAC dataset showed uncommonly early maturity, that is a Tanner stage of 4 (*n*=13) or 5 (*n*=2) at age 11. Age-related norms are Tanner stages 1 to 3 at these ages, with most boys being at Tanner stage 1 or 2 at age 11 (*n*=1,981) (Table 5.2.1).

***Table 5.2.1: Table indicating the number and percentage of boys at each pubertal stage at age 11. Source: ALSPAC.***

| Tanner stage | Frequency | Percent | Cumulative |
|---|---|---|---|
| **1** | 1,981 | 68.95 | 68.95 |
| **2** | 759 | 26.42 | 95.37 |
| **3** | 118 | 4.11 | 99.48 |
| **4** | 13 | 0.45 | 99.93 |
| **5** | 2 | 0.07 | 100.00 |
| **Total** | **2,873** | **100.00** | |

At age 13, there is an approximately even dispersion of Tanner stages with the highest frequency at Tanner stage 4 (*n*=751). At age 15, it is expected that most boys would be at Tanner Stage 4 or 5 with a still significant number at Tanner Stage 3 (Johnson & Everitt, 2000; Monteilh et al., 2011; Tanner, 1978). The ALSPAC data shows such a negatively skewed distribution, with 1,868 participants at Tanner Stages 3 to 5. Table 5.2.2 shows the numbers of participants at each Tanner stage at age 15. There were 16 participants reported as late-developers, that is, being at Tanner stage 1 (*n*=6) or Tanner stage 2 (*n*=10) at age 16. However, there is evidence that one participant (id = 5243) was actually at Tanner stage 5, not 1 as reported for age 15 for which Table 5.2.2 has been corrected (he had already reported passing Tanner stages 3 & 4 at earlier ages).

***Table 5.2.2: Table indicating the number and percentage of boys at each pubertal stage at age 15. Source: ALSPAC.***

| Tanner stage | Frequency | Percent | Cumulative |
|---|---|---|---|
| **1** | 5 | 0.27 | 0.27 |
| **2** | 10 | 0.53 | 0.80 |
| **3** | 56 | 2.97 | 3.77 |
| **4** | 612 | 32.50 | 36.27 |
| **5** | 1200 | 63.73 | 100.00 |
| **Total** | **1,883** | **100.00** | |

A further STATA interrogation provided the identification numbers of the boys with typical physical development at ages 11 (Tanner stages 1 or 2) and 15 (Tanner stages 4 or 5), early physical development (Tanner stages 4 or 5 at age 11) and delayed physical development (Tanner stages 1 or two at age 15). Participants were not selected on the basis of pubertal stage at age 13 as the distribution of such at this age is wide. Only those with complete biological (in some cases body weight was missing so BMI could not be calculated), psychosocial and behavioural data were entered for possible selection. Any psychosocial or behaviour difficulties were noted. Participants with psychosocial difficulties were identified as having abnormal scores, that is 8 and above on the SCDC or 14 or above on the SDQ total score. Challenging behaviour at school during years 6 (final year of primary education for children aged 10 to 11) and year 11 (final year of secondary education for young people aged 15 to 16) were classified according to questionnaire variables completed by school staff. Parents completed questionnaires relating to behaviour at ages 11, 13 & 15. For the purposes of commentary, typically-developing participants were given pseudonyms beginning with the letter 'A', early-developing participants, the letter 'J' and late-developing participants, the letter 'D'.

***Table 5.2.3: Participant pseudonyms for age-typical, early and late developers for analysis.***
***Those exhibiting psychosocial difficulties are identified according to their SCDC and SDQ scores. Those exhibiting challenging behaviour during years 6 (Y6) and 11 (Y11) are also identified.***

| | **Tanner Stage 1** | | **Tanner Stage 2** | | **Tanner Stage 4** | | **Tanner Stage 5** | |
|---|---|---|---|---|---|---|---|---|
| **Ages 10 & 11 (Year 6)** | Alex | No psychosocial or behaviour difficulties | Aaron | No psychosocial or behaviour difficulties | Jacob | Y11 | Joseph | SCDC, SDQ, Y6, Y11 |
| | Ant | | Adam | | Josh | Y11 | Jack | Y6, Y11 |
| | Andrew | | | | James | SCDC, Y11 | Jay | SCDC, SDQ |
| | | | | | Jonny | SCDC, Y11 | Jasper | SCDC, SDQ, Y6, Y11 |
| | | | | | Jess | SCDC, SDQ, Y6, Y11 | Jared | Y6, Y11 |
| **Ages 15 & 16 (Year 11)** | Dominic | SCDC, SDQ, Y6, Y11 | Daniel | SCDC, SDQ, Y6, Y11 | Antony | No psychosocial or behaviour difficulties | Antoine | Y6, Y11 |
| | Danny | SDQ | Damien | SDQ | Artur | | Alan | SDQ |
| | Denzel | SCDC, SDQ, Y6 | Doug | SCDC, Y6 | Ali | | | |
| | Dion | Y11 | Drew | Y6, Y11 | | | | |

It is important to take into consideration that the ALSPAC data is longitudinal and that sampling took place at various ages for the same participants. Chapter 3 includes a discussion of the sampling distribution for all groups of variables across the age range. It would be expected that early maturing participants would exhibit psychosocial difficulties during early adolescence and that these would decline as they became older and within the boundaries of age normal values. Likewise, late-maturing participants would be expected to show normal psychosocial values during early adolescence, when their physical and endocrinological values were similar to peers but develop problems as they lagged behind normally developing peers (Chapter 2). The findings presented in this dissertation are interesting for they only partially support these assumptions.

Of the 15 participants who underwent extreme early pubertal development, 10 of them (67%) experienced either psychosocial and/or behavioural difficulties: 6 with poor social cognition (high SCDC score); 4 with psychological difficulties (high SDQ score); 5 with challenging year 6 behaviour; and 9 with behaviour difficulties during year 11. Participants Joseph, Jasper and Jess experienced difficulties according to all four measures. Only 2 participants in the ALSPAC dataset had a recorded Tanner Stage of 5 at age 11 and both experienced a combination of issues. Of the 13 at Tanner Stage 4 at age 11, 7 of them experienced psychosocial or behaviour difficulties.

Data relating to the 15 participants who physically matured late showed that 8 of them (53%) experienced psychosocial or behavioural difficulties: 4 with high SCDC scores; 5 with high SDQ scores; 5 having had exhibited challenging behaviour during year 6; 4 during year 11; and 3 with difficulties relating to all four measures. Of the 10 randomly selected typically maturing participants, only two exhibited psychosocial or behavioural difficulties.

Psychosocial and biological data relating to the individual early- and late-maturing participants is summarised in Tables 5.4.1 and 5.5.1 and fully discussed in the narratives that follow. The data for typically developing participants is summarised in Table 5.3.1 and discussed in Section 5.3. Only variables pertinent to the study research questions have been included: those relating to age, pubertal (Tanner) stage, psychological profiling (SDQ total score, SCDC total score, SDQ prosocial score) and school behaviour variables in year 6 and year 11. Parental responses to behaviour questionnaires at ages 11, 13 and 15 are recorded in the behaviour positive variables column along with school responses. Endocrinological data is not available for any of the atypically developing participants.

The Tanner stage for each participant was taken directly from the variable ‘Development stage of pubic hair’ at each age since most studies involving self- or parental reporting of pubertal stage indicates that this is the most reliable measure (Chapter 2).

During an examination of all variables for each participant, it was identified that some participants exhibiting psychosocial or behavioural difficulties had atypical heights and weights for their age. From these two variables, a Body Mass Index (BMI) percentile was calculated and evaluated according to the National Health Service recommended norms. In paediatrics, as introduced in Chapter 3, percentiles are calculated instead of the integers that result from adult calculations because normal BMI values differ according to age and gender in children.

## 5.3 Typically Developing Participants

The 10 participants in this section showed typical physical development at ages 11 and 15. By chance, as the participants were randomly selected, two exhibited psychosocial difficulties or challenging behaviour during year 11 (ages 15 and 16). Their pubertal, endocrinological, anthropometric, psychosocial and measures of their behaviour are summarised in Table 5.3.1. Abnormal psychological profiling scores and significant challenging behaviour variables are shown in red. SDQ scores are E (emotional symptoms), C (conduct), H (hyperactivity), PP (peer problems), PS (prosocial). The Body Mass Index (BMI) percentile profile, where available, is coded red=obese, orange=overweight, green=normal, blue=underweight.

***Table 5.3.1: Summary of variables relating to participants undergoing typical pubertal development.***

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Alex | 11 | 1 | 48 | 1 | 0 | 3 | 0 | 4 | 10 | 2 | Y6 – occasional temper tantrums. |
| | 13 | 1 | - | 0 | 0 | 2 | 0 | 2 | 9 | 1 | No parental concerns. No school behaviour variables available. |
| | 16 | 4 | - | 4 | 1 | 2 | 1 | 8 | 9 | 2 | No school or parental concerns regarding behaviour. No school behaviour sanctions during Y11. Lower than normal testosterone levels at age 17, Tanner stage 4 and height 175cm. |
| Ant | 11 | 1 | 88 | 0 | 0 | 3 | 2 | 3 | 9 | 3 | Sometimes didn't realise effects of behaviour on family members. |
| | 13 | 4 | - | 1 | 0 | 3 | 0 | 4 | 7 | 2 | Sometimes didn't understand body language. No school behaviour variables available. |
| | 16 | 5 | 40 | 1 | 0 | 3 | 1 | 5 | 9 | 2 | High testosterone levels at age 15. Sometimes disobedient. |
| Andrew | 11 | 1 | 21 | 0 | 0 | 1 | 0 | 1 | 9 | 1 | All Y6 behaviour variables 'not true.' |
| | 13 | 2 | 24 | 0 | 0 | 2 | 0 | 2 | 9 | 1 | No parental concerns. No school behaviour variables available. |
| | 16 | 4 | 16 | 0 | 0 | 0 | 0 | 0 | 9 | 1 | No school or parental concerns regarding behaviour. No school behaviour sanctions during Y11. |

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Aaron | 11 | 2 | - | 3 | 1 | 0 | 0 | 4 | 9 | 2 | All Y6 variables 'not true'. Difficult to reason with when upset. |
| | 13 | 2 | 15 | 3 | 0 | 3 | 0 | 6 | 9 | 2 | Difficult to reason with when upset. |
| | 16 | 4 | 62 | 3 | 0 | 3 | 0 | 6 | 9 | 3 | Difficult to reason with when upset. Sometimes disobedient. |
| Adam | 11 | 1 | 58 | 1 | 1 | 3 | 2 | 7 | 9 | 3 | All Y6 behaviour variables 'not true.' Difficult to reason with when upset. Sometimes disobedient. |
| | 13 | 3 | - | 0 | 0 | 3 | 0 | 3 | 7 | 3 | Difficult to reason with when upset. Sometimes disobedient. No school behaviour variables available. |
| | 16 | 4 | 43 | 0 | 0 | 3 | 0 | 3 | 5 | 1 | Had one detention during Y11. School contacted parents about child's attitude towards school. |
| Antony | 11 | 1 | 88 | 0 | 0 | 3 | 0 | 3 | 7 | 3 | All Y6 behaviour variables 'not true.' Sometimes didn't understand body language. Sometimes didn't realise effects of behaviour on family members. |
| | 13 | 4 | - | 1 | 0 | 3 | 0 | 4 | 7 | 2 | Sometimes didn't understand body language. No school behaviour variables available. |
| | 16 | 5 | - | 1 | 0 | 3 | 1 | 5 | 9 | 2 | Sometimes disobedient. Higher than normal testosterone levels at age 15. |
| Artur | 11 | 2 | 58 | 1 | 1 | 3 | 2 | 7 | 9 | 3 | All Y6 behaviour variables 'not true.' Difficult to reason with when upset. Sometimes disobedient. |
| | 13 | 3 | 67 | 0 | 0 | 3 | 0 | 3 | 7 | 3 | Difficult to reason with when upset. Sometimes disobedient. |
| | 16 | 4 | 43 | 0 | 1 | 2 | 0 | 3 | 5 | 1 | Had one detention during Y11. School contacted parents about child's attitude towards school. |
| Ali | 11 | 1 | 10 | 0 | 0 | 2 | 2 | 4 | 10 | 1 | Y6 – sometimes deliberately annoyed others, sometimes easily annoyed by others. |
| | 13 | 2 | - | 0 | 0 | 5 | 1 | 6 | 8 | 1 | No parental concerns. No school behaviour variables available. |
| | 16 | 4 | 38 | 0 | 1 | 1 | 0 | 2 | 9 | 1 | Sometimes deliberately late to lessons. |
| Antoine | 11 | 2 | - | 0 | 0 | 0 | 1 | 1 | 10 | 1 | Y6 – occasional temper tantrums, argumentative with adults, easily annoyed by others, angry and resentful. |
| | 13 | 4 | 82 | 0 | 1 | 1 | 1 | 3 | 10 | 1 | No parental concerns. No school behaviour variables available. |
| | 16 | 5 | 69 | 1 | 1 | 3 | 1 | 6 | 10 | 2 | Sometimes didn't realise effects of behaviour on family members. Sometimes deliberately late to lessons. Had gotten into physical fights. Sometimes: had temper outbursts; was argumentative; ignored rules and was disobedient. |
| Alan | 11 | 1 | 5 | 1 | 1 | 2 | 2 | 5 | 6 | 5 | Y6 – easily annoyed by others, angry and resentful. Sometimes: not aware of others feelings, didn't realise when others are angry or upset, very demanding of others' time, didn't understand body language, did not know how to behave in public. |
| | 13 | 3 | 7 | 2 | 3 | 1 | 2 | 8 | 5 | 6 | Sometimes: not aware of others feelings, very demanding of others' time, didn't understand body language, did not know how to behave in public, didn't realise effects of his behaviour on family members, behaviour often affected family life, difficult to reason with when upset. |
| | 16 | 5 | 64 | 2 | 1 | 3 | 1 | 7 | 8 | 3 | Sometimes: didn't realise effects of his behaviour on family members, very demanding of others' time. |

### 5.3.1: Discussion of typically-maturing participants

The ALSPAC dataset has data relating to approximately 7,500 boys of which Tanner staging is recorded for 2,873 at age 11 and 1,883 at age 15. At each of these ages, 15 showed atypical pubertal development. The 10 typically-maturing participants were selected from the participants (*n*=2,624) for which complete data was available (see above) who displayed an age-typical pubertal stage. Caution must, therefore, be observed when making inferences from this group. A quantitative analysis of all variables relating to typically developing participants took place in Chapter 4. The narrative that follows takes a qualitative approach relating to individual participants summarised in Table 5.3.1.

**Alex**

Between the ages of 11 and 13, Alex was at Tanner stage 1. He had developed to Tanner stage 4 by age 15 and remained so at age 17. Some young men remain at Tanner stage 4 into early adulthood (Tanner 1978). This indicates that at ages 11 and 15, his pubertal development was normal but at age 13, was delayed (Appendix 5). Complete anthropometric data was only available at age 11 allowing a normal body mass index (BMI) to be calculated, his height being 175 cm at age 15. Interestingly, lower than normal testosterone levels were recorded at age 17, which correspond with the Tanner stage of 4 at ages 15 and 17. All other endocrinological values were age-normal.

During year 6, Alex had occasional temper tantrums. Apart from this, no other behaviour concerns were noted at home or in school. His SDQ and SCDC scores were all normal. He had the highest possible SDQ prosocial score fulfilling all of the following statements: was considerate of others; shared readily with other children; was helpful if someone was hurt, upset or feeling ill; was kinder to younger children; and often volunteered to help others.

**Ant**

Ant showed a typical progression through puberty (normal pubertal tempo), being Tanner stage 1 at age 11, 4 at age 13 and 5 at age 15. Values for testosterone and cortisol were within normal limits at ages 11 and 13. At age 15, his testosterone level was recorded as high. He had a normal BMI at ages 11 and 15 (data missing at age 13).

At age 11, his parents noted that he sometimes didn't realise how his behaviour affected other members of the family. At age 13, they commented that he found it difficult to interpret body language. At age 15, he was described as being disobedient sometimes. There were no behavioural concerns in school during year 6 and year 11. His SDQ and SCDC scores were within normal boundaries at all ages. It should be noted that the few behaviour concerns were not significant and not representative of challenging behaviour. Despite having an atypically high plasma testosterone concentration at age 15, he did not exhibit psychosocial or behavioural difficulties.

**Andrew**

Andrew slowed slightly below average pubertal development at age 13, that is Tanner Stage 2. At ages 11 and 15, these were normal, Tanner stages 1 and 4 respectively. As stated with Alex, some young men remain at Tanner stage 4. His endocrinological data was unremarkable and his BMI normal at all ages.

Impressively, all behaviour variables collected during years 6 and 11 were recorded as being unproblematic. He had a prosocial score of 9/10 and negative or low scores for SDQ and SCDC variables.

Only 55 boys in the dataset, including Andrew, have completely negative responses to school sanctions, behaviour issues or parental concerns. This does not include those for whom data is missing.

**Aaron**

Aaron was at Tanner stage 2 at age 11 and did not reach Tanner stage 5 until age 17, so his pubertal tempo was slow. His endocrinological data values were all within normal boundaries. His BMI was not obtainable for age 11 but was normal for ages 13 and 15. He would have been relatively tall and thin at age 13 (BMI of 15 with height of 170cm) but had a normal BMI at age 15 (62$^{nd}$ percentile). This change from low BMI to normal often occurs as boys traverse puberty since many increase their muscle mass during the later stages (Tanner, 1978).

In terms of psychosocial problems, Aaron remained 'difficult to reason with when upset' at all ages. At age 16, he was reported as being 'sometimes disobedient.' He was given a high prosocial score (9/10) which indicates kindness and empathy. Some hyperactivity was recorded for ages 13 and 15, but scores were within the normal range. No behaviour difficulties were recorded by his teachers during year 6 or year 11.

Although minor psychosocial and behaviour problems were recorded, it could be argued that these specific concerns regarding Aaron are normal for adolescents (Chapter 2).

**Adam**

Adam showed a normal pubertal progression and tempo being Tanner stage 1 at age 11, 3 at age 13 and 4 at age 15. His endocrinological values were all normal as was his BMI at ages 11 and 15 (data was missing at age 13).

SDQ data shows some hyperactivity at all three ages, but within normal parameters. He also appeared to have some peer problems at age 11, but again, the score was within the normal range of values. There was a steady decline in his prosocial score through puberty but again, the scores were normal as were his SCDC scores. It was reported that he was sometimes difficult to reason with when upset and was sometimes disobedient at ages 11 and 13. All year 6 behaviour values were recorded as 'not true' meaning that he did not show challenging behaviour in school at ages 10 to 11. During year 11, he received one detention and the school contacted his parents with concerns about his attitude towards school.

Although Adam displayed some psychosocial and behavioural difficulties, these could be considered as normal for a school-age child (Chapter 2) and were not recorded as significant.

**Antony**

Antony showed typical pubertal progression and tempo being Tanner stage 1 at age 11, stage 4 at age 13 and stage 5 at 15. His endocrinological values were normal at ages 11 and 13 but his plasma testosterone concentration was recorded as high at age 15. It was only possible to calculate a BMI at age 11 due to missing data at other ages. This was normal (88$^{th}$ percentile).

His SDQ and SCDC scores were normal throughout adolescence but there was evidence of some hyperactivity. His prosocial score was 7/10 improving to 9/10 at age 16 illustrating kindness and empathy towards others. At age 11, it was recorded that he 'sometimes didn't appear to understand body language' (repeated at age 13) and 'sometimes didn't realise the effect of his behaviour on family members.' At age 15, it was stated that he was 'sometimes disobedient and broke rules.'  All behavioural responses at years 6 and 11 were recorded as 'no' or 'not true' so he did not exhibit any behaviour challenges in school.

As with Adam, it is acknowledged that adolescent boys engage in rule breaking and defiant behaviour as they progress through puberty (Chapter 2), which in his case would be considered normal particularly as the incidence was 'sometimes.'

**Artur**

Artur progressed through puberty as a slow tempo progressing from Tanner stage 2 at age 11 to stage 4 at age 15. All of his endocrinological values were recorded as normal as were his BMI at all ages.

All of his psychosocial scores were normal, although there were some markers for hyperactivity and at age 11, peer problems such as being bullied, being solitary or unliked. These were not, however, recorded as being problematic (low scores). There was a steady decline in his SDQ prosocial score through adolescence, with the score at age 15 as being borderline abnormal. It is widely reported in the literature (Chapter 2) that a decline in social cognition is common as puberty progresses, the prosocial score being a partial measure of this.

In terms of behaviour, Artur was 'difficult to reason with when upset' and 'sometimes disobedient' at ages 11 and 13. He did not exhibit challenging behaviour during year 6. During year 11,  he received one detention and the school contacted his parents due to concerns about his attitude towards school.

**Ali**

At age 11, Ali was at Tanner stage 1, at age 13 was stage 2 and stage 4 at age 15. This indicates a slow pubertal tempo. His BMI was 10 at age 13 and 38 at age 15, his height of 151cm placing him in the 95$^{th}$ centile. This would make him tall for his age, but of a slight build and by age 15 he was 185cm tall. His endocrinological values were all within normal boundaries.

Ali appeared to exhibit a small degree of hyperactivity, especially at age 13 and suffered some peer problems at age 11. His prosocial score was 10/10 at age 11 indicating a high degree of kindness and empathy declining only slightly with age (8 at age 13 and 9 at age 15).

During year 6, his teacher noted that he sometimes deliberately annoyed others and was annoyed by others. During year 11, he was sometimes deliberately late for lessons but did not receive detentions.

In terms of psychosocial and behavioural factors, no significant concerns were evident relating to Ali.

**Antoine**

Antoine showed normal pubertal progression and tempo, being Tanner stage 2 at age 11, stage 4 at 13 and 5 at age 15. His endocrinological values were all normal as were his BMI at ages 13 and 15. The height value was missing for age 11 so his BMI could not be calculated, although his weight was 36kg, that is, age-normal (75$^{th}$ percentile).

He experienced very minimal peer problems at all ages and seemed to develop a degree of hyperactivity (SDQ score 3/10) at age 15, and with minor emotional, conduct and peer problems, raised his total SDQ score to 6. Antoine's prosocial score was recorded as the highest at all ages indicating that he was kind and helpful.

In terms of in-school behaviour, during year 6 his teacher noted that he had occasional temper tantrums, was argumentative with adults, was easily annoyed by others and was sometimes angry and resentful. At age 16, he didn't realise the effects of his behaviour on family (contradicts his prosocial score), which could be said of many adolescents (Chapter 2). In school, he was sometimes deliberately late to lessons, and got into physical fights in or out of school. His parents reported that he had temper outbursts, was argumentative, ignored rules and was disobedient at home.

Antoine appeared to develop worsening behaviour and, although within normal parameters, developed an increase in difficulties measured as an increase in the SDQ total score at age 16. No sanctions were recorded during year 11 indicating that apart from his punctuality, his behaviour was probably acceptable in school and that the fights may have taken place out of school. It could also be that sanctions were given but that they were not documented. His behaviour at home appeared to also have been challenging.

Antoine appears to have exhibited challenging behaviour in and out of school with normal biopsychological development despite being kind, empathetic, considerate and being helpful to adults (all components of the prosocial score for which he scored 10/10).

**Alan**

Of the typically-developing participants included in this analysis, Alan appeared to have the most difficulties in terms of psychosocial functioning and behaviour. His pubertal development and tempo was typical, being Tanner stage 1 at age 11, stage 3 at 13 and stage 5 at 15. His plasma testosterone levels were all age-normal. No cortisol data was recorded. Although not clinically underweight, his BMI was 5$^{th}$ percentile at age 11 and 7$^{th}$ at age 13 and by age 15 had increased to 64$^{th}$ percentile. His height was 139cm at age 11 and 152cm at age 13, indicating that he was tall and thin.

Alan had some social cognitive difficulties at ages 11 and 13, which had declined by age 16, although his SCDC was normal to borderline at all ages. His parents recorded that when he was age 11, he was sometimes: not aware of others' feelings; didn't realise when others were angry or upset; was very demanding of others' time; didn't understand body language; and did not know how to behave in public. At age 13, he also didn't realise the effects of his behaviour on family members, that his behaviour affected family life, and was difficult to reason with when upset. By age 16, he sometimes didn't realise the effects of his behaviour on family members and was very demanding of others' time. Interestingly, Alan's SDQ prosocial score improved with his SCDC score. During the analysis in Appendix 5, only a small association was seen between prosocial and SCDC scores, which was unexpected since they are both measures of social cognition. At age 13, he exhibited emotional symptoms, such as psychosomatic illness, anxiety, tearfulness, etc., conduct problems and hyperactivity (Appendix 6). This resulted in his SDQ total difficulties score being the highest out of the 10 boys in this section. It must be stressed that all of the scores were within normal parameters, however.

During year 6, his teacher recorded that he was easily annoyed by others and was angry and resentful. No challenging behaviour or sanctions were reported by the school during year 11. As with other participants, this could be due to a lack of recording by the school.

It is interesting to note that Alan's social cognitive function improved with age and pubertal development. Although below the screening threshold of an SCDC score of ≥8, there are some indicators of autistic spectrum disorder (ASD). His low BMI, normal pubertal development and testosterone values contrast with those values in others who meet the criteria for an ASD (Section 5.4).

### 5.3.2: Themes relating to typically-maturating participant case studies

When comparing the boys in this sample to those who were early-maturing (Section 5.4) and those who were late-maturing (Section 5.5), some interesting comparisons can be made between physical development, endocrinological and anthropometric values, psychosocial and behavioural difficulties.

Unlike early and late-maturing participants, the boys in this sample are those who have matured typically and do not appear to have extreme endocrinological values at ages where these would affect pubertal development and perhaps psychosocial or behaviour outcomes. For example, Ant had a high testosterone plasma concentration at age 15 when he was at the age expected Tanner stage of 5 and Alex a lower than normal value at age 17 with a Tanner stage of 4. It was explained above that Tanner stage 4 can be normal in young adult men. It was interesting to note that in this random sample of typically-developing boys, none of them had an abnormal BMI. During the literature review (Chapter 2) it was discovered that many children in special needs classes or those exhibiting behaviour problems had abnormal, particularly high, BMIs. Several of the boys in Sections 5.4 and 5.5 had an abnormal BMI.

None of the boys in this sample had borderline or abnormal SDQ hyperactivity, conduct or total difficulties scores. This is in contrast to early and late maturing participants, a significant number of whom did have borderline or abnormal scores. Only Alan had a borderline SCDC score at age 13 with markers for an ASD. The prosocial scores were high for all but two of these boys and, again, only Alan had a borderline score indicating poor social functioning. ASD is often associated with an advanced Tanner at an early age, which was not evident in the case of Alan. The SCDC and prosocial scores correspond well with each other in this sample but do not for early or late maturing participants. In some cases, a mid-adolescent decline in social cognition was seen, which links with the findings stated in much of the literature (Chapter 2).

Although not completely void of psychosocial or behavioural problems, the boys in this random sample of those undergoing typical pubertal development did not exhibit to the same extent the difficulties of the early and late maturing participants discussed in the next two sections.

## 5.4 Early Maturing Participants

The 10 participants in this section showed advanced physical development at age 11 with psychosocial difficulties or challenging behaviour at one or more stages of adolescence (summarised in Table 5.4.1). Abnormal psychological profiling scores and significant challenging behaviour variables are shown in red. SDQ scores are E (emotional symptoms), C (conduct), H (hyperactivity), PP (peer problems), PS (prosocial). The Body Mass Index (BMI) percentile profile, where available, is coded red=obese, orange=overweight, green=normal, blue=underweight.

*Table 5.4.1: Summary of variables relating to participants undergoing early puberty.*

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Jacob | 11 | 4 | - | 0 | 0 | 1 | 0 | 4 | 9 | 1 | No Y6 behaviour data. |
| | 13 | 4 | - | 2 | 0 | 3 | 0 | 5 | 9 | 1 | No parental concerns. No school behaviour variables. |
| | 16 | 5 | 92 | 0 | 1 | 3 | 0 | 4 | 8 | 0 | School contacted parents with behaviour concerns. School contacted parents with concerns regarding attitude towards school. Several detentions given. Has been fixed-term excluded. Parental report: unaware of others' feelings; behaviour affects family life. |
| Joseph | 11 | 5 | 59 | 6 | 5 | 10 | 4 | 25 | 5 | 22 | Has temper tantrums. Easily annoyed by others. Angry & resentful. Starts fights. |
| | 13 | 5 | 77 | 7 | 5 | 10 | 4 | 26 | 4 | 22 | Parental behaviour report indicative of poor social cognition. |
| | 16 | 5 | 79 | 5 | 6 | 10 | 1 | 22 | 0 | 22 | School contacted parents with behaviour concerns. School contacted parents with concerns regarding attitude towards school. Several detentions given. |
| Jack | 11 | 4 | 1 | 0 | 0 | 6 | 1 | 7 | 10 | 3 | Has temper tantrums. Deliberately annoys others. Easily annoyed by others. Angry & resentful. Starts fights. |
| | 13 | 4 | 1 | 0 | 0 | 4 | 1 | 5 | 10 | 1 | No parental concerns. No school behaviour variables. |
| | 16 | 4 | - | - | - | - | - | - | - | - | Has had one detention. School contacted parents with concerns regarding attitude towards school. |
| Josh | 11 | 4 | 94 | 1 | 3 | 5 | 1 | 10 | 6 | 4 | All Y6 variables 'not true'. Parental report: difficult to reason with; does not understand body language; disobedient. |
| | 13 | 4 | 93 | 4 | 2 | 6 | 0 | 12 | 8 | 3 | No school behaviour variables. Parental report: behaviour affects family life; difficult to reason with; disobedient. |
| | 16 | 5 | 69 | 0 | 2 | 7 | 0 | 9 | 7 | 2 | Physical fights in and out of school. Deliberately late for lessons. School contacted parents with behaviour concerns. School contacted parents with concerns regarding attitude towards school. Has had one detention. Parental report: difficult to reason with. |

| ID | | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | E | C | H | PP | Tot | PS | | |
| James | | 11 | 4 | 72 | 1 | 0 | 1 | 0 | 2 | 9 | 14 | All Y6 behaviour variables 'not true' |
| | | 13 | 5 | 91 | 1 | 0 | 2 | 1 | 4 | 10 | 15 | No school behaviour variables. Parental report: disobedient. |
| | | 16 | 5 | - | 3 | 0 | 0 | 1 | 4 | 10 | 15 | Had one detention. School contacted parents with concerns regarding attitude towards school. Parental report: disobedient. |
| Jay | | 11 | 4 | 1 | 3 | 4 | 6 | 4 | 17 | 4 | 23 | Has temper tantrums. Disobedient. Deliberately annoys others. Spiteful. Angry & resentful. Starts fights. Bullies others. Physically cruel. Parental report indicative of high SCDC score. |
| | | 13 | 4 | 83 | 2 | 4 | 6 | 6 | 18 | 5 | 22 | Parental report: unaware of others' feelings; behaviour disrupts family life; difficult to reason with; poor understanding of social skills; poor understanding how to behave when out of home; doesn't notice effect of behaviour on others; disobedient. |
| | | 16 | 4 | 55 | 3 | - | 4 | 3 | - | 6 | 19 | School contacted parents with behaviour concerns. School contacted parents with concerns regarding attitude towards school. Several detentions given. Has been fixed-term excluded. |
| Jonny | | 11 | 4 | 99 | 3 | 4 | 1 | 2 | 6 | 6 | 5 | Parental report: demanding of others' time; difficult to reason with; poor understanding of social skills; disobedient. |
| | | 13 | 5 | 97 | 0 | 3 | 3 | 5 | 11 | 8 | 8 | Parental report: unaware of others' feelings; unaware others angry or upset; doesn't notice effect of behaviour on others; demanding of others' time; poor understanding of social skills. |
| | | 16 | 5 | 97 | 1 | 0 | 1 | 1 | 3 | 10 | 2 | Parental report: unaware of others' feelings; doesn't notice effect of behaviour on others. Deliberately arrives late for lessons. |
| Jasper | | 11 | 3 | **65** | 1 | 5 | 8 | 2 | 12 | 7 | 8 | Highest possible score (33/33) for challenging behaviour during year 6. |
| | | 13 | 4 | **63** | 0 | 5 | 6 | 1 | 12 | 6 | 7 | Parental report: unaware of others' feelings; unaware others angry or upset; doesn't notice effect of behaviour on others; behaviour affects family life; difficult to reason with when upset; poor understanding of social skills; disobedient. No school behaviour report available. |
| | | 16 | - | **59** | 0 | 5 | 7 | 0 | 12 | 8 | 6 | Has had several detentions. Often fixed term excluded. Deliberately arrives late for lessons. School has contacted parents with behaviour concerns and regarding attitude to school. |
| Jess | | 11 | 3 | **79** | 1 | 5 | 7 | 6 | 19 | 4 | 8 | Year 6 teacher report: Argues with adults. Disobedient. Deliberately annoys others and is annoyed by them. Spiteful towards others. |
| | | 13 | 4 | **53** | 0 | 5 | 5 | 4 | 14 | 3 | - | No parental or school behaviour report. |
| | | 16 | 5 | **38** | 2 | 3 | 4 | 3 | 12 | 1 | 8 | Has had several detentions. Often fixed term excluded. School has contacted parents with behaviour concerns and regarding attitude to school. |

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Jared | 11 | 2 | **12** | 1 | 0 | 0 | 1 | 2 | 10 | 0 | Year 6 teacher report: Often has temper tantrums. Argues with adults. Disobedient. Deliberately annoys others and is annoyed by them. Angry and resentful. |
| | 13 | 4 | **37** | 0 | 0 | 2 | 1 | 3 | 10 | 0 | Parents report no issues. No school behaviour report. |
| | 16 | 5 | **22** | 1 | 0 | 4 | 2 | 7 | 9 | - | Teachers complain of disruptiveness. Argues with adults. Plays truant. Arrives late to lessons. Often fixed-term excluded. School has contacted parents with behaviour concerns and regarding attitude to school. |

### 5.3.1: Discussion of early-maturing participants

What follows is an analysis and narrative relating to the data of early-maturing individual participants as summarised in Table 5.4.1, that is, who demonstrated significant difficulties associated with one or more data variables.

**Jacob**

Between the ages of 11 and 15, Jacob was at Tanner stage 4 completing pubertal development at age 16 giving at least a 5-year pubertal tempo. The prolonged period of pubertal development may account for the emergence of challenging behaviour at home and in school during year 11 due to this maturational gap (see Section 2.5 'Maturational Gap Theory'). No teacher-reported behaviour data exists for year 6 but his parents reported no concerns at ages 11 and 13. At age 16, Jacob was given several detentions and was fixed-term excluded at least once. The school contacted his parents with concerns regarding his behaviour and attitude towards school. His parents reported that he seemed unaware of other peoples' feelings and that his behaviour affected family life. However, he had a low SCDC score and his SDQ prosocial scored was highly suggestive of normal social cognitive function. Although within normal parameters, his parents scored a degree of hyperactivity at ages 13 and 16 but not age 11. Jacob only scored 1 on the SDQ conduct score which is not indicative of pathopsychological behaviour difficulties such as conduct disorder. No anthropometric data were available for Jacob until age 16 when he was identified as being obese. The data shows that Jacob's BMI had fallen to the 81st percentile (normal range) at age 17. It is interesting to note that his behaviour was challenging during the known period of obesity. As he did not score above zero for peer problems, issues with others such as bullying are not apparent or were not disclosed.

**Joseph**

Joseph was already at Tanner stage 5 (adult) at age 11. His precise pubertal tempo cannot be determined as there is no Tanner stage data for him prior to this, but puberty would have commenced during his primary schooling. An analysis of his height and body mass trajectory shows that physical development continued throughout adolescence until he was 16. According to the World Health Organisation (2018) data, the 50% centile for boy's height at age 10 is ~135cm and body mass is ~30kg. Joseph's height was 144cm (98$^{th}$ percentile) and his body mass 38kg (95$^{th}$ percentile) at age 10.

Brain development is known to occur with growth into late adolescence (Choudhury et al., 2008) and a mid-adolescent decline in social cognitive ability commonly occurs as a neurological restructuring of the teenage brain continues, although this was not evident during general analyses of the ALSPAC data (Chapter 4). It is widely reported that exposure to steroid hormones during early puberty masculinises the adolescent brain and may be associated with social communication disorders such as autism (Baron-Cohen, 2004; Schulz et al., 2009) although the effects at an early age are not reported. As discussed in Section 5.1, early maturing boys are more at risk of developing psychosocial disorders. Joseph's high score in the SCDC and his low SDQ prosocial score are signs of poor social cognitive function, the latter worsening with age with him having a borderline score of 5 at age 11 becoming 0 by age 16, the lowest possible level.

Joseph's hyperactivity score was at the maximum (10/10). He was given a high SDQ score for conduct problems at ages 11, 13 and 16, which was congruent with both teacher and parent behaviour questionnaire responses. Although school behaviour data at age 13 is not available, parental responses to the SCDC questionnaire indicated probable social cognitive dysfunction.

Joseph also exhibited significant emotional symptoms throughout adolescence but did not suffer peer problems, which may have been linked to his behaviour. Together with his large body size, he may have been perceived as intimidating by his peers. Because of his unusually advanced physical development at age 11, further interrogation of the dataset was undertaken. It was revealed that at age 9 Joseph's SDQ scores were: emotional symptoms 1/10; hyperactivity 9/10; conduct problems 5/10; peer problems 3/10; and a prosocial score of 3/10). This shows that emotional symptoms developed during early adolescence. Peer problems were borderline at age 9 which may provide additional evidence relating to lesser peer problems with increasing body size.

Although it is not documented, poor social cognition and evidence of a hyperkinetic disorder are complementary to the discussion in Section 5.1, where early maturing boys often present with psychosocial dysfunction and ADHD. In this case, there is evidence to suggest that Joseph was suffering from an autistic spectrum disorder. Tordjman, Ferrari, Sulmont, Duyme, & Roubertoux (1997) report that androgenic activity in precocious puberty can lead to aggressive and socially dysfunctional behaviour in autistic children and several studies have shown a link between autism and psychotic behaviours during puberty (Bölte et al., 2011a; Gillberg, 2008; Rutter, 1989, 1997). Furthermore, it is understood that early exposure to testosterone, the hormone responsible for genital development and secondary sexual characteristics in males, may result in a masculinisation of the brain and in some cases, autism. The data relating to Joseph confirms such an association between early physical development and poor social cognitive function or an autistic spectrum disorder.

It is not known whether Joseph had a Statement of Special Educational Needs (now known as an Education and Health Care Plan) or any form of in-school support. He was given several detentions during year 11 and his parents were contacted by the school regarding behaviour concerns, however, he was not excluded. It could be argued that if he had a learning disability, as the data suggests, the sanctions applied during year 11 were punishing him for his externalising behaviour rather than providing positive support for his condition.

**Jack**

Jack was at Tanner stage 4 throughout his secondary schooling and no data is recorded for his pubertal stage at age 9 or 17, so it is not possible to ascertain pubertal tempo. During year 6, his teachers reported that he had temper tantrums, deliberately annoyed other children and was easily annoyed by the actions of others, often starting fights. He was often angry and resentful. In contrast to this, at ages 11 and 13, his SDQ peer problems score was 0 as was his SDQ conduct score. This could be due to a number of factors. The improvement in behaviour between year 6 and year 7 could be due to ecosystemic variables (Section 2.2) such as the change of geographical setting, classes, teachers and environment. His peer group would have been different and much larger in a secondary setting (‘big fish in a small pond become small fish in a big pond’), a well-reported phenomenon of primary to secondary transition with mixed effects on behaviour (Chapter 2). He may have been less well equipped in terms of social cognitive maturity to cope with conflict during year 6. During year 11, he was given only one detention, which is not a sign of significant behavioural issues and the school only had cause to contact his parents about his attitude towards school, not behaviour. A Tanner stage of 4 meant that his pubertal development was normal during year 11. Unfortunately, no SDQ or SCDC data is available for age 16, however, Jack had a high prosocial score and low SCDC score at ages 11 and 13 indicating no significant social cognitive dysfunction.

Anthropometric data at ages 11 and 13 show that Jack was significantly underweight with a BMI in the 1st percentile; data is not available after this.

**Josh**

The data shows that Josh was at Tanner stage 4 between the ages of 10 and 14 years 7 months when he developed to Tanner stage 5. He also gained 15cm in height between 13 and 14 years of age. His BMI was above normal at ages 11 (94th percentile) and 13 (93rd percentile) but was normal by age 16. Although this shows early physical maturation, it does not indicate a rapid pubertal tempo.

During year 6, his teachers reported no problematic behaviours, however, his parents reported that he was difficult to reason with when upset, did not understand body language and was disobedient. Together with an SDCD score of 4, this is indicative of some problems with social cognitive ability. No SCDC scores were recorded at ages 13 and 16, although his parents reported worsening social cognitive function at age 13 stating that his behaviour was now affecting family life. Despite this, he maintained a normal SDQ prosocial score, an indicator of normal social cognitive function. No school behaviour variables are available for age 13. With advancing physical development, his SDQ hyperactivity score increased from normal at ages 9 and 11 to borderline at age 13 and abnormal at age 16. It is unknown if Josh had a diagnosis of ADHD and, if so, he was medicated. Poulton et al. (2013) found that stimulant ADHD medication was associated with a slower physical development tempo and recommend lower doses during puberty. However, Josh's pubertal tempo was not unusual. It has been known for some time that children with ADHD may develop mental health issues, including manic symptoms and externalising symptoms during progression through adolescence (Ge et al., 2006; Geller et al., 1998).

In terms of his behaviour during year 11, there were significant teacher concerns. He got into physical fights in and out of school, was deliberately late to avoid the first part of his lessons and the school had to contact his parents with concerns regarding his behaviour and attitude towards school. Remarkably, he was only given one detention with no reported exclusions. His parents once again noted that he was difficult to reason with when upset.

In summary, in terms of Josh's social cognitive function, the parental reports, SCDC (age 11) and SDQ prosocial score data were conflicting, so no inference should be made. In common with other early-maturing boys, his hyperactivity increased with age and physical development. Similarly to the ages 11 and 13, his parents stated that he was difficult to reason with at age 16. This corresponded with a decline in his behaviour with pubertal progression, a known phenomenon with early maturing boys. It is not known what support was given to him in school, but the data shows that responses to his challenging behaviour were not disproportionate.

**James**

James was of normal BMI at age 11 and was overweight at the age of 13 (91$^{st}$ percentile) which corresponds to a Tanner stage of 4 at age 11 and Tanner stage 5 by age 13. It is known that the body mass of some boys increases during mid-adolescence. Apart from parental reports of him being disobedient at ages 13 and 16 and having one year 11 detention, no other remarkable behaviour issues are evident. During year 11 the school reported that his attitude towards school had become negative. This could have been due to the pressures placed upon students during their final year at secondary school and the associated GCSE examinations. His SDQ total score was normal indicating that he did not have emotional, conduct or peer problems and did not exhibit a hyperkinetic abnormality.

Of interest and in common with five other early-maturing boys, James had a high SCDC score (14 or 15) throughout adolescence indicating poor social cognition but in contrast, his SDQ prosocial score indicated the converse. This may indicate that the prosocial score is not an indicator of social cognitive function. In fact, the SDQ prosocial score has five questions that measure how helpful, kind and considerate a child is towards others rather than their understanding of conspecifics' behaviour and their theory of mind (Chapter 2). James' high SCDC score is suggestive of an autistic spectrum disorder and so he may have been given support in school. Being on the autistic spectrum does not preclude an individual from being kind and helpful which may be the case here.

**Jay**

Jay's anthropological data indicates that he was significantly underweight at age 11 (1$^{st}$ percentile) with a normal BMI by age 13. His Tanner stage remained at 4 throughout adolescence. No physical development data exists for Jay before age 11 or after 16 so pubertal tempo cannot be established. It is possible that Jay would not progress past pubic hair stage 4 as some adult men do not develop pubic hair that meets the fold of the groin, the criterion for stage 5. However, at age 16, Jay's voice had not changed, showing that puberty was not yet complete. His maximum height velocity, a reliable measure of the passage through puberty, was between ages 13 and 14 years 7 months. At age 16, his height was 188 cm making him tall for his age. Taking these factors into consideration, it is likely that Jay was close to pubertal completion during year 11.

The psychosocial data shows that Jay was very likely to have had a social development disorder (very high SCDC scores) with poor empathy towards others (low SDQ prosocial scores). This is confirmed by year 6 teacher reports that he was spiteful, physically cruel, bullied others and started fights. Year 6 behaviour issues also included temper tantrums, disobedience, deliberately annoying others, angry and resentful behaviour. Parental reports indicate poor social cognitive function. Between the ages of 11 and 13, Jay showed an abnormal level of hyperactivity, which had resolved by the age of 16. At age 13, Jay had problems with his peers, the causes of which could be related to his behaviour. For example, being socially isolated, having no or few friends or being unliked by other children. At age 13, his behaviour was of serious concern to his parents and reinforce the likelihood of an autistic spectrum disorder, such as being unaware of other peoples' feelings and the effects of his behaviour on them, his behaviour being disruptive to family life, being difficult to reason with, having poor social skills and defiance to parental instructions. This corresponds to a high SCDC score (22/24).

During year 11, there was a slight improvement in his social cognitive function, still having a high SCDC score (19) but lower than before, and SDQ prosocial and hyperactivity scores within normal parameters of 6 and 4 respectively. However, his behaviour was of serious concern to his school who contacted his parents regarding his behaviour and despondency towards school. He was also given several detentions and was fixed-term excluded at least once. Bearing in mind his behaviour difficulties and the significant likelihood of a learning disability, it is feasible that Jay would have had a Statement of Special Educational Needs and in-school support, however, this cannot be determined from the data. In any case, the evidence suggests that punishments such as exclusion and detentions would not be productive nor ethical.

**Jonny**

The anthropometric data shows that Jonny was clinically obese at age 11 (99th percentile) and significantly overweight at ages 13 and 16 (97th percentile). He was at Tanner stage 4 at age 11 and at stage 5 by age 13. Because pubertal data before age 11 was not recorded, pubertal tempo cannot be ascertained. Jonny exhibited abnormal conduct at age 11 such as bullying others, was disobedient and had temper tantrums. In terms of social cognition, his parents reported that he was demanding of other peoples' time, was difficult to reason with when upset and had a poor understanding of social skills. However, throughout adolescence, his SDQ prosocial score improved to within normal boundaries indicating that his behaviour towards other children became appropriate, with him only having continuing issues with adult authority. He developed problems with his peers at age 13, which corresponds with a decline in his social cognition to an abnormal level (SCDC score of 8). There were no teacher reports of in-school behaviour during year 6. At year 11, the only behaviour concern raised by his school was that he deliberately arrived late for lessons. This links with a significant improvement in social cognition (highest SDC prosocial score of 10/10 and low SCDC score of 2), with no other psychosocial concerns (SDQ total score of 3). His parents reported that age 16 only occasionally did he not notice the effect of his behaviour on others and sometimes was unaware of others' feelings.

Interestingly, Jonny shows a typical high-lower-higher pattern of social cognitive function in adolescence, which corresponds to synaptic pruning in the pre-frontal cortex that occurs in mid-adolescence (Chapter 2) (Blakemore, 2010; Choudhury et al., 2008). Jay, Josh and Jack show an expected improvement in social cognition with age but not this mid-adolescent dip.

**Jasper, Jess and Jared**

The final three early-maturing participants were at Tanner Stage 4 at age 12. They represent early maturation but not the extreme physical development of those in Section 5.3. All three exhibited some degree of psychosocial difficulties and significantly challenging behaviour during year 6, plus frequent exclusions during year 11 and so are worth discussing here. The analysis of the data shows that of 13 participants for which both year 6 and year 11 data is available, 11 were often excluded from school and 9 of the 11 had strong indicators of an autistic spectrum disorder. This evidence is supported in studies by Eccles (1991) and Schultz et al. (2009) which provide compelling evidence that challenging behaviour during pre- and early-adolescence is a reliable indicator of severe behaviour problems during later school years, often leading to fixed-term and permanent exclusion. This indicates the need for early behaviour improvement interventions and support in school. My previous research also provides evidence that early intervention during years 7 & 8 supports the inclusion of boys identified during primary education as having challenging behaviour (Butler, 2010). It cannot be ascertained if such positive management strategies were put in place to support improvement in these boys' behaviour and lessen the risk of their exclusion from school.

Jared was unusual in that he did not suffer psychosocial difficulties during adolescence (all SDQ variables were normal and he had a zero score for SCDC). It is likely that Jasper and Jess both had a social development disorder both having abnormal SCDC scores. Jess also had low SDQ prosocial scores showing a lack of empathy and unkindness towards others. Jasper exhibited extreme behavioural difficulties during year 6, scoring 33/33 in the teacher behaviour questionnaire. Both Jasper and Jess showed signs of a borderline hyperkinetic disorder with abnormal or borderline SDQ hyperactivity scores together with SDQ conduct difficulties as well as challenging school behaviour. Again, hyperactivity can be a predictor of poor educational outcomes and inclusion (Section 5.2).

### 5.4.2: Themes relating to early maturating participant case studies

The heterogeneity of all the cases discussed above is very interesting: they are not the same in terms of the complexity of psychosocial and behavioural outcomes of early pubertal development. Of the 15 early maturing participants, 10 exhibited some form of psychosocial difficulty or challenging behaviour. The analysis showed that there may be an anthropometric association between these factors in early maturing boys given that 8 of the 10 had an abnormal BMI during at least one stage of adolescence. Of the early maturing boys who did not exhibit psychosocial difficulties or challenging behaviour and for whom anthropometric data were available, none had an abnormal BMI. Our findings concur with those of Aksglaede et al. (2009) who showed a relationship between pre-pubertal body mass and the age at which children entered puberty (Chapter 4). Obesity has also been linked to mental health problems and increased odds of psychosocial dysfunction such as ADHD and other learning disabilities (Halfon et al., 2013). Several studies over the past twenty-five years have reported a significant trend between childhood obesity and abnormal psychosocial and behavioural profiles. Tershakovec, Weller & Gallagher (1994) identified abnormal scores on the Child

Behaviour Checklist and the hyperactivity subscale of the Conner Parental Questionnaire (standardised test for Attention Deficit Hyperactivity Disorder) for overweight individuals. They also found that the proportion of children in special education classes who were clinically obese was twice that for children with a normal BMI. This project findings also correspond with those of Halfon, Larson and Slusser (2013) in that school-related problems are associated with obesity and advanced pubertal stage. However, the data analysis did not show the increased emotional symptoms or global conduct disorders they cite in their paper (only Joseph displayed these symptoms).

This analysis shows that a high proportion of early developing boys have high SDQ hyperactivity scores indicating a probable hyperkinetic disorder such as ADHD. Hyperkinetic disorders are associated with poor academic achievement and less formal schooling which result in lower ranking employment. However, there is also strong evidence to suggest that it is not the hyperkinetic component of ADHD that is associated with poor academic outcomes, but the deficit in attention. In a large study (*n*=2000) of Canadian children, assessed separately for both inattention and hyperactivity between the ages of 6 and 12, inattention predicted the likelihood of later high school graduation (Pingault et al., 2011). In terms of other outcomes in adulthood, a study conducted by Mannuzza, Klein, Bessler, Malloy, & LaPadula (1993) provided evidence that children with ADHD are greater than 7 times more likely to suffer drug abuse problems, criminality or an antisocial personality disorder in adulthood. However, in contrast, a more recent large sample size (*n*=2741) longitudinal study of participants diagnosed with ADHD in an early years setting with follow up at ages 6, 12 and 25, determined that this condition on its own is not a reliable predictor of adult criminality (Pingault et al., 2013). The study also monitored physical aggression and family adversity for these participants which were potential indicators of the need for crime prevention intervention.

For several of the boys, a prolonged period of adolescence may be linked to the emergence of challenging behaviour due to the maturational gap hypothesis (Chapter 2). Jacob, Joseph and Josh, in particular, show the symptoms of challenging behaviour in late adolescence that may be linked to prolonged pubertal tempo including aggressive behaviour towards others, but only Joseph showed psychological effects during a lengthened period of adolescence. As stated in Chapter 2, brain restructuring occurs throughout adolescence with a mid-adolescent decline in social cognitive function and other forms of executive function linked to pubertal stage. In cases of early maturation, it was not possible to make inferences from the data available: only Jonny showed a decline in social cognitive function in mid-adolescence. This lack of a trend similar to that reported in the literature could be due to the fact that the participants discussed so far have all been early-maturing. No pre-pubertal SCDC data exists for these participants that would make such an analysis possible.

The ALSPAC data only shows a weak to moderate negative correlation between the SDC prosocial and SCDC scores (as detailed in Appendix 5). A stronger negative correlation would be expected if the two variables showed a strong relationship. It is likely that the SDQ prosocial and SCDC questionnaires do not both indicate a deficit in social cognitive function, rather the SDQ scale focusses on kindness and empathy. Having an autistic spectrum disorder (ASD) does not preclude an individual from being helpful, supportive and sympathetic towards others, however, both Jay and Joseph had low pro-social scores with a high SCDC score which is suggestive of an ASD. Both were repeatedly punished during year 11. In an epidemiological study involving the ALSPAC data, Russell, Ford, Steer, & Golding (2010) performed a logic regression analysis to determine possible unmet educational needs of children with autistic traits. They identified that 55% of such children had not been identified by schools as needing additional support from educational providers and health services. Only 37.5% of those with autistic traits had a formal diagnosis of ASD and 57% of those with probable Asperger's syndrome had no special provision at school. The data relating to Jay and Joseph, indicating punishment for behaviour that is likely to be linked to a disability, thus adds additional evidence to these findings.

## 5.5 Late Maturing Participants

The participants in this section showed delayed physical development at age 15, that is, a Tanner stage of either 1 or 2. There were 15 participants with delayed development in the ALSPAC cohort of the 1,883 for which data was available. Of these 15 participants, 8 exhibited psychosocial or behavioural concerns at one or more stages of adolescence (summarised in Table 5.5.1). As in the preceding sections, abnormal psychological profiling scores and significant challenging behaviour variables are shown in red. SDQ scores are E (emotional symptoms), C (conduct), H (hyperactivity), PP (peer problems), PS (prosocial). The Body Mass Index (BMI) percentile profile, where available, is coded red=obese, orange=overweight, green=normal, blue=underweight.

***Table 5.5.1: Summary of variables relating to participants undergoing late puberty.***

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Dominic | 11 | 1 | - | - | 2 | - | - | 2 | 5 | 3 | Deliberately annoys others. Angry and resentful. Parental report: behaviour affects family life; difficult to reason with. |
| | 13 | 1 | - | 1 | 3 | 5 | 0 | 9 | 6 | 1 | Parental report: disobedient. |
| | 16 | 2 | - | - | - | 5 | - | 5 | 6 | 8 | Parental report: unaware of others' feelings; behaviour affects family life; difficult to reason with; poor understanding of how to behave when out of home; disobedient; only follows command if carefully worded. School contacted parents with concerns regarding attitude towards school. Several detentions given. |
| Daniel | 11 | 1 | 95 | 0 | 0 | 3 | 0 | 3 | 10 | 0 | Disobedient. Easily annoyed by others. |
| | 13 | 1 | 98 | 1 | 1 | 3 | 2 | 7 | 9 | 5 | Parental report: behaviour disrupts family life; difficult to reason with; poor understanding of social skills; doesn't realise when behaviour offends others; disobedient. No school behaviour variables. |
| | 16 | 1 | 93 | 3 | 4 | 8 | 4 | 19 | 7 | 7 | Parental report: doesn't notice effect of behaviour on others; very demanding of others' time; difficult to reason with; doesn't realise when behaviour offends others; disobedient; only follows command if carefully worded. Deliberately late for lessons. Physical fights in and out of school. |
| Danny | 11 | 1 | 50 | 5 | 2 | 8 | 2 | 17 | 9 | 8 | No Y6 behaviour data. Parental report: unaware of others' feelings; doesn't notice effect of behaviour on others; behaviour disrupts family life; very demanding of others' time; difficult to reason with; poor understanding of social skills; does not understand body language; disobedient. |
| | 13 | 2 | 29 | 2 | 1 | 5 | 3 | 11 | 8 | 2 | Parental report: disobedient; only follows command if carefully worded. No school behaviour variables. |
| | 16 | 2 | 67 | 1 | 0 | 7 | 1 | 9 | 9 | 3 | Parental report: very demanding of others' time; difficult to reason with; disobedient. Has had one detention. |
| Damien | 11 | 1 | 95 | 7 | 2 | 3 | 4 | 16 | 9 | 5 | No Y6 behaviour data. Parental report: doesn't notice effect of behaviour on others; behaviour disrupts family life; very demanding of others' time; difficult to reason with; poor understanding of social skills. |
| | 13 | - | 99 | 8 | 2 | 6 | 6 | 22 | 10 | - | No parental concern data. No school behaviour variables. |
| | 16 | 2 | 99 | 4 | 0 | 3 | 5 | 12 | 10 | 1 | All Y11 behaviour variables 'not true'. Parental report: does not understand body language. |

| ID | Age | Tanner | BMI | SDQ | | | | | | SCDC | Behaviour positive variables |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | E | C | H | PP | Tot | PS | | |
| Dion | 11 | 1 | 44 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | All Y6 behaviour variables 'not true'. No parental concerns. |
| | 13 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | No parental concerns. No school behaviour variables. |
| | 16 | 2 | 44 | 3 | 1 | 0 | 1 | 5 | 9 | 0 | Has had one detention. School contacted parents with concerns regarding attitude towards school. Argumentative with adults. Ignores rules and disobedient. Awkward and disruptive. |
| Drew | 11 | 1 | 1 | 1 | 0 | 1 | 0 | 2 | 9 | 1 | Deliberately annoys others. Easily annoyed by others. Bullies others. |
| | 13 | 1 | 12 | 0 | 0 | 1 | 1 | 2 | 7 | - | No parental concerns. No school behaviour variables. |
| | 16 | 2 | 34 | 1 | 0 | 1 | 1 | 3 | 9 | 1 | Physical fights in and out of school. |
| Denzel | 11 | - | - | - | - | - | - | - | - | - | Has temper tantrums. Argues with adults. Disobedient. Easily annoyed by others. Angry & resentful. Spiteful. Starts fights. Bullies others. |
| | 13 | 1 | 81 | 0 | 1 | 6 | 1 | 9 | 9 | - | No social difficulties data recorded. No school behaviour variables. |
| | 16 | 2 | 87 | 3 | 2 | 5 | 3 | 5 | 9 | 6 | Parental report: unaware of others' feelings; doesn't notice effect of behaviour on others; behaviour disrupts family life; difficult to reason with; disobedient. |
| Doug | 11 | 1 | 1 | 3 | 0 | 3 | 5 | 8 | 6 | 3 | Parental report: unaware of others' feelings; difficult to reason with. Has temper tantrums. Argues with adults. Disobedient. Easily annoyed by others. Angry & resentful. Spiteful. Physically cruel. Starts fights. Bullies others. Shows unwanted sexual behaviour. |
| | 13 | 1 | 9 | 0 | 2 | 4 | 2 | 8 | 10 | 2 | Parental report: unaware of others' feelings; doesn't notice effect of behaviour on others. No school behaviour variables. |
| | 16 | 2 | 70 | 0 | 1 | 1 | 0 | 2 | 7 | 0 | All Y11 behaviour variables 'not true'. |

### 5.5.1: Discussion of late-maturing participants

The following analysis and narrative relate to the data of late-maturing individual participants as summarised in Table 5.5.1, that is, who demonstrated significant difficulties associated with one or more data variables. Unless data is available at age 17 that shows age-normal pubertal staging (i.e. Tanner stages 4 or 5) it will not be possible to comment on pubertal tempo.

**Dominic**

Dominic was at Tanner stage 1 at ages 11 and 13 and stage 2 at age 16. By age 17 he showed mature physical development, that is, 183cm height (was 180 at age 16), Tanner Stage 4, axillary hair and complete voice change. Some individuals never reach the Stage 5 pubic hair distribution, even in adulthood, which must be remembered in the context of this study. Unfortunately, Dominic's body mass was not recorded at any age so a BMI could not be calculated.

Dominic lacked empathy and may have been unkind or unhelpful at age 11, having a borderline SDQ prosocial score of 5 and an SCDC score of 3. His year 6 teachers stated that he deliberately annoyed others and was often angry and resentful. These factors showed that he had some difficulties with social cognitive function, but not to the extent of psychopathology such as an autistic spectrum disorder. By age 13, Dominic displayed normal social cognition (SCDC score of 1 and SDQ prosocial score of 6), his parents' only concern being his disobedience. No teacher reports are available for this age.

By age 16, although his SDQ prosocial was within normal parameters, Dominic's social cognitive function had declined to the extent at which his SCDC score was abnormal (8). His parents reported that he was unaware of others' feelings; his behaviour affected family life; he was difficult to reason with when upset; he had a poor understanding of how to behave when he was out of home, for example in shops or other peoples' houses; he was disobedient; and only followed commands if they were carefully worded. All of these are signs of a potential social communication development disorder. Dominic also exhibited challenging behaviour in school during year 11, being given several detentions and the school having to contact his parents regarding his attitude towards school. Paradoxically, his SDQ scores were normal for ages 13 and 16, although his hyperactivity score was at the upper end of the normal parameter indicating some hyperkinetic tendencies.

As stated previously, testosterone is associated with brain masculinisation and autistic spectrum disorders (ASD). Unfortunately, testosterone assay data is not available for Dominic, but as a surge in plasma testosterone is associated with the initiation of puberty it would be reasonable to expect that this would be higher than before as he showed increased pubertal tempo between ages 16 and 17. A rapid pubertal tempo is associated with externalising symptoms and psychopathology (Chapter 2). Had the data been available, it would be interesting to discover if Dominic was diagnosed with an ASD and the deterioration in his behaviour led to support being provided in school. This may not be the case since the response of teachers to his behaviour appeared to be punitive.

**Daniel**

Daniel was at Tanner stage 1 according to pubic hair distribution throughout adolescence with Tanner stage 2 genital development stated at age 17. At all ages, no change in voice or appearance of axillary hair was reported. He appears to have reached peak height growth velocity between ages 14 years 7 months to age 16 (155cm to 170cm). These factors mean that at age 16, Daniel had only just entered puberty and although plasma testosterone data is not available for him, an increase in this value could correspond to the acceleration in growth. Anthropometric data shows that he was overweight throughout this period (between 93rd and 98th percentile) but was of normal weight at age 17 (82nd percentile), again providing evidence of endocrinological and pubertal development between the ages of 16 and 17.

Except for an SDQ hyperactivity score (8/10) at age 16, all other psychosocial variables were within the normal range.  However, Daniel showed a decline in social cognitive function between the ages of 13 and 16 (SDQ prosocial score declined from 10/10 to 7/10 and SCDC score from 0 to 7), which does not indicate severe difficulties but those reported by parents included several indicators of poor social development including that he: didn't notice the effect of his behaviour on others; was very demanding of others' time; was difficult to reason with when upset; didn't realise when his behaviour offended others; was disobedient; and only followed instructions that were carefully worded. His behaviour also affected family life and he had poor social skills, for example, constantly interrupting conversations.

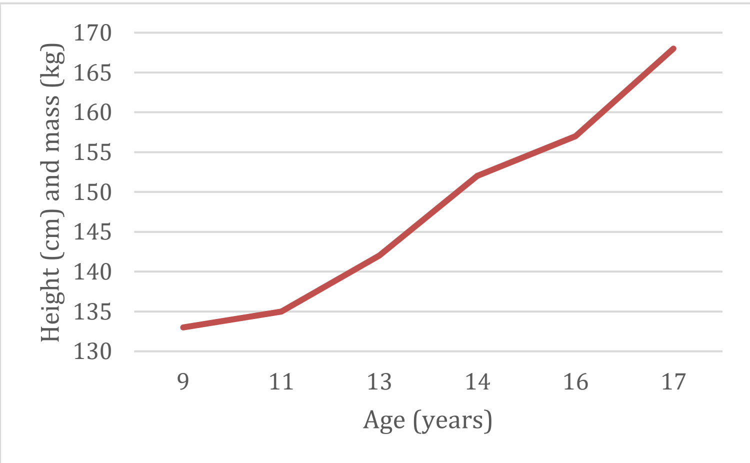
Regarding school behaviour, during year 6 Daniel was disobedient and was easily annoyed by others but did not bully or commit offences against other children. He was clinically obese at this age, which may indicate a reason for him being targeted and annoyed by others. Teachers did not report any behaviour issues that would indicate poor social cognition. At this age, neither did his parents (SCDC score of 0). During year 11, Daniel was deliberately late for lessons and got involved in fights in and out of school. This deterioration in behaviour was represented in his psychosocial assessment: there was a decline in his conduct (SDQ score of 4), an increase in hyperactivity (SDQ score of 8) and he began to experience peer problems (SDQ score of 4) giving an abnormal SDQ total difficulties score of 19. Although his SCDC score was not indicative of a social development disorder, his social cognitive function had declined as adolescence progressed (0 at age 11, 5 at age 13 and 7 at age 16), which may be associated with plasma testosterone concentrations.

**Danny**

Danny developed from Tanner stage 1 to 2 between the ages of 11 and 13 and his BMI was normal until the age of 17 when he was underweight (4$^{th}$ percentile). He appears to have experienced two periods of accelerated growth (Figure 5.5.1), one between the ages of 13 and 14 (15cm) and one between the ages of 16 and 17 (11cm). The first is may have involved the largest testosterone surge corresponding with physical development from Tanner Stage 1 to 2.

Unusually, as Danny entered puberty, his social cognitive function appears to have improved, which is contrary to theories stated in the literature (Chapter 2) and the experiences of other ALSPAC participants (at age 11 his SCDC score was 8, then 2 at age 13 and 3 at age 16). At age 11, his parents reported that he was unaware of others' feelings; did not notice the effect of his behaviour on others; that his behaviour disrupted family life; he was very demanding of others' time; was difficult to reason with when upset; had a poor understanding of social skills; did not understand body language; and was disobedient. By age 13, his social behaviour had improved but he was disobedient and only followed commands if they were carefully worded. At age 16, his social behaviour parental report was the same as at age 13 but he began to be demanding of others' time again. However, throughout this time, his SDQ prosocial score remained normal.

***Figure 5.5.1: Height chart for participant Danny***



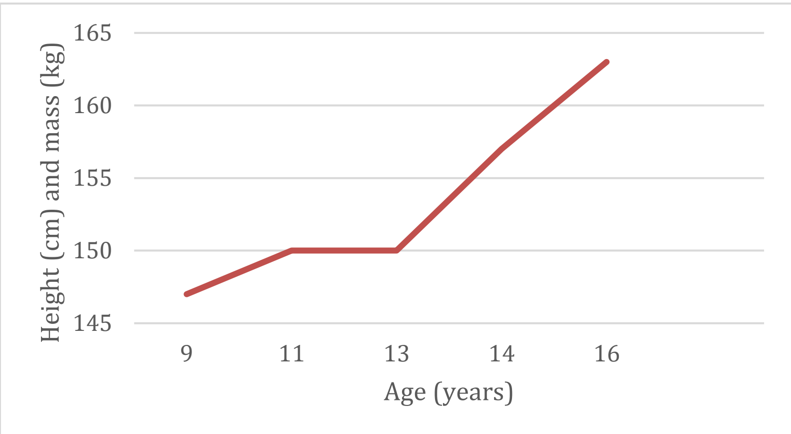

In common with other late and early maturing boys, Danny exhibited abnormal hyperactivity at ages 11, 13 and 16 (SDQ scores of 8, 5 and 7 respectively). He exhibited emotional symptoms at age 11 (SDQ score of 5). His SDQ total difficulties scores were abnormal also (age 11 = 17, age 13 = 11 and age 16 = 9) although these show improvement as adolescence progressed.

Despite his social behaviour difficulties, Danny did not experience significant behaviour issues in school at age 11 except for being given one detention. Unfortunately, no year 6 behaviour exists for Danny.

**Damien**

Damien was reported as being at Tanner stage 1 at age 11 and stage 2 at age 16. Although the data is incomplete, has was at stage 1 at age 12 and stage 2 at age 15. From Figure 5.5.2, it can be seen that Damien's peak height velocity was between the ages of 13 and 16. It is likely, therefore that at age 13, his Tanner Stage was still 1. A surge of testosterone was also likely between these two ages. Damien was clinically obese throughout adolescence (95$^{th}$ percentile at age 11 then 99$^{th}$ percentile at ages 13 and 16). Obesity is associated with delayed puberty in boys but not girls (Villamor & Jansen, 2016). It is also associated with mental health disorders and bullying behaviours (Janssen et al., 2004). Unfortunately, no behaviour data is available for this participant at ages 11 and 13. All year 11 behaviour variables are recorded as 'not true' so he did not present with challenging behaviour in school at age 16.

***Figure 5.5.2: Height chart for participant Damien***




At ages 11 and 13, Damien was reported as experiencing emotional symptoms such as having many fears and worries, being unhappy and lacking in confidence (SDQ score of 7 and 8 respectively). Peer problems were not reported in the SDQ questionnaire until ages 13 (6) and 16 (5). Hyperactivity was only reported at age 13 (SDQ score of 6). His SDQ total difficulties were reported at their worse in mid-adolescence (22), being 16 at age 11 and 12 at age 16, the peak being due to increased hyperactivity and peer problems scores.

Whilst Damien's SDQ prosocial score was high throughout adolescence showing that he was helpful and had empathy towards others. He had some social behaviour difficulties at age 11 but insufficient to evidence a social development disorder (SCDC score of 5) and just one positive indicator at age 16. No data relating to social cognition is available for age 13. His parents reported that at age 11 he did not notice the effect of behaviour on others; his behaviour disrupted family life; he was very demanding of others' time; was difficult to reason with when upset; and had a poor understanding of social skills. The one adverse variable reported at age 16 was that he did not seem to understand body language.

**Dion**

Dion was at Tanner stage 1 until the age of 14, when Tanner stage 2 was recorded. Between the ages of 13 and 16, he had grown by 10cm, but as pubertal and anthropometric data is not available at age 17, pubertal tempo and peak height growth velocity cannot be established. It is likely that he entered puberty between the ages of 13 and 14 according to the data but as his genital development was Tanner stage 1 and his voice had not changed and no axillary hair was evident at age 16, indicating delayed pubertal development. In most cases, axillary hair development and voice change occur at Tanner stage 3 (Appendix 5). He was recorded as being underweight at age 13 ($6^{th}$ percentile) but this does not appear to have any relevance to his behaviour and psychosocial values but may be associated with physical underdevelopment. Interestingly, his BMI returned to the same percentile at age 16 as it was at age 11 ($44^{th}$) but the reason for the weight loss in mid-adolescence cannot be determined.

Dion is one of the few participants for which cortisol assay data is available. At age 8, he had a normal plasma cortisol level of 279.04 nmol $l^{-1}$ (normal range 85 to 618 nmol $l^{-1}$) (Appendix 5). This is a likely indicator of an absence of childhood stress at that time and possibly hypopituitarism, which could lead to delayed puberty (Susman et al., 2010).

His psychosocial profile was unremarkable for year 6 and age 13 with no parental concerns. Although school behaviour data is not available for age 13, all year 6 behaviour variables were recorded at 'not true' so it can be assumed his behaviour was good. There were no questionnaire responses that might indicate a social development disorder as his SCDC scores was zero and he had SDQ prosocial scores of 9/10 throughout adolescence. However, by age 16, he had developed an SDQ total score of 5, relating to emotional symptoms (3), peer problems (1) and conduct (1). Although within the normal range, Dion appears to have developed some difficulties, particularly school behaviour with advancing physical development. His teachers reported that he had one detention, was argumentative with staff, ignored rules and was disobedient, awkward and disruptive to the extent that the school had to contact his parents. Although the data does not provide direct evidence for this increase in psychological difficulties and decline in school behaviour, there are a number of possible associations. Externalising behaviours can be due to increased testosterone and cortisol levels corresponding to initiation of puberty (Grotzinger et al., 2018) as can the pressures associated with the final year of secondary schooling and the assessments that take place during this period together with stressors such as impending transition from school to further education or work (Kimmel & Weiner, 1995; Rutter, 1989). These factors are likely to be even more pronounced in a boy who is significantly physically and neuropsychologically underdeveloped compared with his age-normal peers (Chapter 2).

**Drew**

Drew was at Tanner stage 1 at ages 11 and 13, Tanner stage 2 at age 16 and was only Tanner stage 3 at age 17. He was significantly underweight at age 11 and 13 (1$^{st}$ percentile) and was within normal parameters by age 16 (41$^{st}$ percentile). All psychosocial parameters were normal. Three adverse behaviour variables were recorded during year 6: that he deliberately annoyed others, was easily annoyed by others and was responsible for bullying other children. There were no parental concerns reported at age 13 and only one adverse behaviour variable was recorded at age 16 in that he got into physical fights. His SDQ prosocial score, although normal, declined during mid-adolescence, which is widely reported in the literature (Chapter 2). As the parent-reported variables at all sampling periods were recorded as ‘not true’ that is, not problematic, Drew’s challenging behaviour only manifested in school. It could be that his behaviour was not appropriately managed in that setting or that the ecosystemic microsystem of school (Chapter 2) was not conducive to his needs. It cannot be seen if he exhibited challenging behaviour throughout his schooling as no school behaviour variables exist for age 13. It is unlikely that Drew had a special educational need as his SDQ and SCDC reports were normal. His challenging behaviour in years 6 & 11 was limited to aggression towards others.

**Denzel**

No pubertal, anthropometric or psychosocial data is available for Denzel at age 11. During year 6, his teachers expressed concerns regarding his behaviour, namely: he had temper tantrums, was easily annoyed by others, was angry and resentful, was spiteful and bullied other children, started fights, argued with adults and was disobedient. Combined, these factors indicate that Denzel exhibited significantly challenging behaviour. It would have been interesting to know his height and body mass at age 11 as at ages 13 and 16, he was a large child, which may explain how his victimizing behaviour may go unchallenged by other year 6 children.

Denzel was Tanner stage 1 at age 13 and stage 2 by age 16, confirmed by his unchanged voice. Psychosocial variables at these ages suggest problematic relationships with his peers. By age 16, his ability to empathise with others had declined significantly from a high to borderline SDQ prosocial score. His parents reported difficulties associated with a poor social cognitive function, that is: him being unaware of other peoples' feelings; not noticing the effect of his behaviour on others; his behaviour disrupting family life; being difficult to reason with when upset; and general disobedience. These all coincide with the commencement of puberty and a peak height growth velocity of 11cm.

Unfortunately, no data relating to social communication difficulties are available for Denzel at ages 11 and 13 and so, although it is not certain that his social cognitive decline was due to the initiation of puberty, previous peer problems at age 13 provide some evidence for this. No school behaviour data is provided for year 11 nor age 13. As his parents reported challenging behaviour at age 16 and his behaviour was difficult for his teachers to manage during year 6, it is likely that Denzel would have exhibited challenging behaviour throughout his secondary schooling.

**Doug**

Doug was Tanner stage 1 at age 13 and by the age of 16 was at stage 2. No pubertal data is available between the ages of 13 and 16 as is often the case with the ALSPAC dataset. In the year between the ages of 16 and 17, he had developed to Tanner stage 4 with axillary hair development and complete voice change, this suggesting a rapid pubertal tempo between these ages and possible pubertal completion. Unfortunately, no data relating to potential difficulties he may have faced during this transition is available. No height data is available between ages 12 and 16 so peak height growth velocity cannot be calculated as a second measure of his pubertal trajectory.

The onset of puberty occurred at a time when Doug's behaviour in school was unproblematic, presumed 'good' and his social cognitive function was good (SCDC score of zero). His parents state two social cognitive difficulty traits at age 13 in that he was unaware of other's feelings and didn't notice the effect of his behaviour on others. At age 11, they reported the same traits adding that he was difficult to reason with when upset. This is in stark contrast to his year 6 behaviour when his teachers reported that Doug had temper tantrums, argued with adults, was disobedient, easily annoyed by others, angry, resentful, spiteful, physically cruel, started fights and bullied other children. Unusually, he was one of only 40 boys in the dataset who showed unwanted sexual behaviour towards other children. This should be considered within the context of his small stature (BMI in 1st percentile) for which aggressive and abusive behaviour towards others is not instinctual.

There is a discontinuity between the psychosocial data relating to Doug and his behaviour during year 6. His SDQ conduct score was zero, indicating a lack of challenging behaviour at home, yet his year 6 (in-school) behaviour was recorded as extremely challenging. Other factors outside of the dataset must always be considered even when strong associations are shown between data variables. For example, children who are abused often show age-inappropriate sexualised behaviour (Bentovim & Williams, 1998) and externalising behaviours such as aggression (Tong et al., 1987) and challenging behaviour outside of the home. A quick analysis of the ALSPAC dataset showed that 48 boys at Tanner Stage 2 exhibited sexualised behaviour as opposed to 3,304 who did not (1.5%). At Tanner Stage 1, 24 showed sexualised behaviour whereas 8,784 did not (0.3%). None of the boys at Tanner Stages 3 to 5 at age 11 showed such behaviour, not expected if sexualised behaviour were due to sexual maturity and therefore plasma testosterone concentrations. It may be speculated that this behaviour was due to other factors and would be interesting to know if, upon teacher identification of age-inappropriate sexualised behaviours, safeguarding concerns were raised, especially when considering, “In contrast [with girls], ‘acting out’ responses, believed to be more typical of boys, may be less likely to attract concern and more likely to be condemned as bad behaviour” (Spataro, Moss, & Wells, 2001. p.579). As with participants Jack and Drew, ecosystemic issues can come into play in the school setting which precipitates problematic behaviour. It is interesting to note that Doug’s psychosocial data is normal and does not correspond to the challenging behaviour he exhibited in early adolescence. This should be considered when attempting to make inferences between psychosocial and behavioural data.

### 5.4.2: Themes relating to late maturating participant case studies

Of the 15 late-maturing participants, 10 exhibited psychosocial or behavioural difficulties at one or more stages of adolescence. As with early maturing participants, an anthropometric association is evident, that is, of the 10 participants exhibiting the aforementioned difficulties, 5 were either clinically obese or significantly underweight at some stage in their development (data was missing in two cases). As discussed in Section 5.3, childhood and adolescent obesity is linked to mental health problems. In addition, underweight and overweight children are more likely to be bullied and to become bullies, the result of psychosocial dysfunction (Janssen et al., 2004). A significant number of obese children suffer from eating disorders especially binge eating, resulting in poor self-esteem and self-image.

The dataset is incomplete regarding some variables relating to pubertal development, so it is not possible to reliably explore pubertal tempo for all late physically maturing participants. Only Dominic and Doug showed rapid pubertal tempo, but this was between the ages of 16 and 17 when psychosocial and behavioural data is unavailable. Dominic but not Doug showed behavioural difficulties during year 11.

As discussed in Chapter 2, the maturational-deviance hypothesis suggests a relationship between early and late pubertal development and heightened emotional distress. Only Danny and Damien had borderline or abnormal SDQ emotional symptoms scores. Neither Dominic nor Doug had an abnormal SDQ emotional symptoms score at age 16 despite their rapid pubertal tempo at that age.

A lesser proportion of late-maturing boys in the study sample (4 of 10) have high SDQ hyperactivity scores compared with early maturing boys (5 of 10) indicating a probable hyperkinetic disorder such as ADHD.

Unlike early maturing participants, none of the late-maturers showed a mid-adolescent decline in social cognitive function, although four participants had high SCDC scores at one or more ages: Dominic and Daniel showed an unexpected decline in SCDC with age (incongruent with the literature) whereas Danny and Doug showed improvement with age, comparable with much of the literature that widely reports enhanced social cognitive function with pubertal development. Of the others, three had missing data and one showed no discernible change with pubertal stage or age. In Section 5.4, the weak to moderate correlation between SDQ prosocial and SCDC scores were discussed. None of the late-maturing participants showed significant autistic spectrum disorder markers, unlike early maturing participants, giving further evidence to the involvement of testosterone in brain masculinisation. These participants would be expected to score low on the SDQ prosocial score and high on the SCDC scale with feelings of social rejection and inferiority. If peer relationships were inharmonious, they would have faced poor mental health especially depressive illness and behaviour problems relating to others. This is supported by this study in that only Dion was not recorded as having significant relationship difficulties with others amongst the late-maturing cohort whereas four boys, Jacob, James, Jeremy and Jason in the early-maturing cohort showed such problems.

The data for late-maturing participants shows a different pattern of challenging behaviour to those who matured early. Only Dominic was given sanctions in year 11 despite problematic behaviour which could be due to a number of reasons, including the fact that he may have had a statement of special educational needs. The late-maturing participants appeared to suffer fewer challenging behaviours than early-maturers but had more psychosocial issues. Of the nine late-maturing participants, seven had psychosocial or exhibited challenging behaviour during year 6 or at age 11. Late-maturers exhibited more spiteful, cruel and bullying behaviours than early-maturers, the reason for which is not apparent but could be due to the mental immaturity evident in young children. Delinquent behaviour was not evident amongst late-maturers by age 16 except for Daniel and Drew, who were engaged in fighting in and out of school. However, Drew shows evidence of a learning disability rather than delinquency *per se*. The dataset does not include variables for criminal activity, antisocial behaviour, recreational drug use or sexual behaviour. Only Doug was amongst the 48 participants in the dataset who exhibited unwanted sexualised behaviour towards others; his case analysis outlines the significance of this and his extreme externalising behaviour.

In many of the cases in the dataset, there appears to be a mismatch between externalised behaviour, pubertal onset and endocrinological factors. In cases where no challenging behaviour was reported, some were reported as having ‘normal’ behaviour and for many, behavioural data was missing. In these cases, it is obviously not possible to determine whether their behaviour and psychosocial values were normal so the prevalence of children with problems could be higher. It is also important to consider that some children can adjust to physical and psychosocial stresses and they would not show significant externalising symptoms. Those who were unable to adjust are the extreme cases who exhibited complex behavioural issues represented in Sections 5.4 to 5.5.

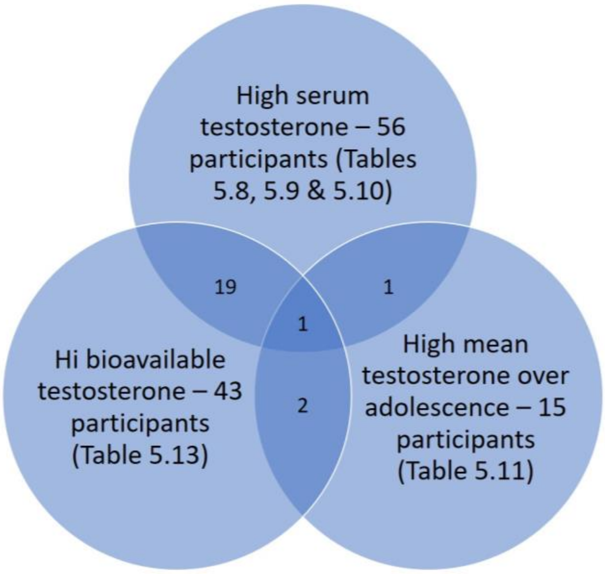
The next section is an exploration of this apparent misalliance but focussing on possible associations between endocrinological and these other factors.

## 5.6 Participants with Extreme Endocrinological Values

The ALSPAC dataset contains measurements of plasma testosterone and sex hormone binding globulin in 2,216 samples obtained from 513 males (9 to 17 years of age); and a single salivary cortisol measurement from 3,792 males at age 8. Individual and longitudinal measures of testosterone can be collapsed into a measure of average exposure and then related to other outcomes such as the effect of testosterone dynamics on shaping the adolescent brain and the relationships between testosterone and risk of psychopathology. Previous analyses showed that a high positive correlation exists between pubertal stage and testosterone levels.

Furthermore, there is an inverse correlation between plasma testosterone and sex hormone binding globulin (SHBG) levels, a protein to which testosterone is strongly bound. When bound, testosterone is not available to exert a biopsychological influence on body systems. Any associations between biopsychosocial and behavioural factors are explained in Chapter 2. However, in short, the bioavailable fraction of testosterone, $[BT]_{plasma}$, is known to exert an effect on a number of biological targets responsible not only for the development of secondary sexual characteristics during puberty, but also those responsible for the development and maturation of the adolescent brain (Burnett et al., 2010; Khairullah et al., 2014). Testosterone has, therefore, been implicated in psychopathology, especially depression and the risk of psychosis, variances in executive function including social cognition and decision-making linked to behaviour in males such as risk-taking, impulsivity and aggression (Grotzinger et al., 2018; Susman et al., 1987). It should also be noted that high and low testosterone levels can be indicative of pathology, mostly in adults. Low testosterone in late-adolescence may indicate hypopituitarism whereas high levels is associated with precocious puberty in pre-adolescence (Emadi-Konjin et al., 2003). None of the participants in this analysis showed signs of either pathology since Tanner staging was normal for all extreme endocrinological outliers. This is unexpected as there is a high linear correlation between testosterone assay data and that of Tanner staging (Appendix 5). Despite this, participants who present with psychosocial issues or challenging behaviour that have extreme values of testosterone according to one measure are, in the main, not represented according to another (Figure 5.6.1). It can be seen that only one participant was represented by all three measures, one by both high mean testosterone and high serum testosterone and two by high bioavailable testosterone and high mean testosterone. The most significant comparison was high serum and high bioavailable values where 19 participants are represented out of 99.

*Figure 5.6.1: Venn diagram showing participant numbers with extreme values of different measures of testosterone.*




The analysis of data relating to individuals who meet the criteria for extreme values according to individual measures of testosterone is, therefore, justified.

In this Section, a cohort (group) analysis approach is taken of participants with unusual endocrinological variables. There are a number of reasons for changing the methodological approach from the extensive reporting of individual cases to that of grouped themes. The previous sections were interesting partly because we explored in detail the data relating to individual boys and their journey through adolescence. This allowed a degree of insight into their lives and the construction of a narrative outlining factors such as probable personal experiences of education and the outcomes of having a psychosocial problem. The narrative included key themes such as obesity, externalising behaviour and difficulties of daily living. It was also important in terms of the contrasting that needed to be done between early- and late-maturing participants. There is no requirement to follow this methodological approach during the analysis of data relating to participants with extreme endocrinological values (this Section) nor for participants who were often or permanently excluded from school (Section 5.7). For the purposes of coherence, clarity and conciseness, these cases are explored thematically.

First, participants with high values for salivary cortisol assays recorded at age 8 and high plasma testosterone assays and bioavailable testosterone concentrations at ages 9, 11, 13, 15 & 17 are discussed. It is likely that the dynamics of testosterone may be associated with biopsychological factors that were previously associated with pubertal timing and tempo (Khairullah et al., 2014). Finally, the effects of low plasma testosterone concentrations across puberty are briefly outlined. In Chapter 3, the distribution of endocrinological values were fully outlined but here it is sufficient to understand that at age 11, most participants have low plasma concentrations of testosterone with values increasing throughout puberty with a normal distribution pattern at mid-puberty. As testosterone and SHBG data is not available for age 16 (only ages 15 and 17), an analysis of extreme outliers at age 17 is also considered since high testosterone and SHBG levels at this age are likely to indicate high levels towards the end of year 11, for which behavioural and psychosocial data is available. Many of these participants also exhibit high plasma concentrations of these biological factors.

### 5.6.1 Participant group with high plasma testosterone at ages 9 or 11

Data were extracted for participants at age 9 with a $[BT]_{plasma}$ of 0.5 ng $ml^{-1}$ or above and those aged 11 with $[BT]_{plasma}$ of 1.5 ng $ml^{-1}$ - both values being the threshold representing high levels. Table 5.6.1 was constructed from this data extraction and captured the top 21 and 23 extreme outliers respectively. Interestingly, only two participants, from those with problems had high recorded $[BT]_{plasma}$ values at both ages 9 and 11. For others, high values were recorded at only one age, either at ages 13, 15 or 17. None showed a high mean plasma testosterone exposure over adolescence (Section 5.6.4). These findings are contrary to those in the literature which state that continued high $[BT]_{plasma}$ values in males from the point at which these are first recorded. Khairullah et al. (2014) report that testosterone levels remain high once they increase, meaning that if a large increase occurs at an early age, then the individual experiences a greater exposure over adolescence.

Of the 21 outlier participants at age 9, 12 (57%) experienced difficulties and of the 23 participants at age 11, 11 (48%) experienced difficulties at a variety of ages. This suggests that a high $[testosterone]_{plasma}$ value at age 9 exerts an influence on psychosocial and behavioural elements downstream. In fact, many of this group exhibited a higher degree of challenging behaviour at age 16 than at any other age, including the most proximal (age 11). Of most significance is that all but one of these participants (13503) showed some level of social cognitive dysfunction during adolescence. Four age 9 extreme outlier participants later demonstrated the mid-adolescent decline in social cognition that is associated with cerebral reorganisation at this stage of development, as hypothesised by several researchers notably Blakemore & Choudhury (2006), Gilbert and Burgess (2008), Baron-Cohen (2004) and Skuse et al. (2005) (Chapter 2).

Furthermore, social cognitive dysfunction is often the consequence of an autistic spectrum disorder, thought to partly result from brain masculinisation, the result of high *in utero* concentrations of testosterone (Baron-Cohen, 2004; Skuse et al., 2005). Only one study (Tordjman et al., 1997) has explored a potential association between androgenic activity and autism in children rather than prenatally. They observed precocious secondary sexual characteristics in several pre-pubertal autistic children attending an in-patient child psychiatry unit. This, with the fact that there are four times more male individuals diagnosed with autism than females, suggested a link between testosterone and social cognitive dysfunction. They found that three of nine autistic 'subjects' had abnormally high $[BT]_{plasma}$ levels, over 2 SDs above the mean for non-autistic participants with more aggressive externalising symptoms, a known influence of testosterone on behaviour in boys (Archer, 1991).

***Table 5.6.1: Participants with high $[BT]_{plasma}$ at ages 9 or 11 and psychosocial or challenging behaviour.***

| **High $[BT]_{plasma}$ age 9** | | **$[BT]_{plasma}$ age 11** | |
|---|---|---|---|
| **Case** | **Problems/difficulties** | **Case** | **Problems/difficulties** |
| 1 | Borderline poor social cognitive function age 13. Deliberately arrived late to lessons during Y11. Fights in and out of school at age 16. | 13 | Increasing hyperactivity with adolescence. Abnormal SDQ total score age 16 due to poor conduct and hyperactivity. Challenging Y6 behaviour. Awkward & disruptive & deliberately arrived late to lessons during Y11. |
| 2 | Some social cognitive difficulties age 11. No Y6 behaviour data. | 14 | Some social cognitive difficulties at all ages. Argumentative, disobedient and deliberately arrived late to lessons during Y11. |
| 3 | Mid-adolescent decline in social cognition. | 15 | Social cognitive difficulties, emotional symptoms and peer problems all ages. Some challenging Y6 behaviour. |
| 4 | Borderline SCDC score age 16. Deliberately arrived late to lessons during Y11. Fights in and out of school at age 16. | 16 | Challenging Y6 behaviour: deliberately annoys others, is annoyed by others, spiteful. |
| 5 | Mid-adolescent decline in social cognition. Out of school behaviour age 16: temper outbursts, argumentative, disobedient, deliberately annoys others. | 17 | Abnormal SDQ total scores ages 13 & 16 due to hyperactivity and peer problems. Deliberately arrived late to lessons during Y11. Fights in and out of school at age 16. |
| 6 | Some social cognitive difficulties age 11. | 18 | Recorded at age 9 also. |
| 7 | Some mid-adolescent social cognitive difficulties. | 19 | Detentions and excluded during Y11. |
| 8 | Social cognitive difficulties worsening significantly at age 11. Deliberately arrived late to lessons during Y11. | 20 | Recorded at age 9 also. |
| 9 | Some social cognitive difficulties ages 11 & 13. Argumentative and deliberately arrived late to lessons during Y11. | 21 | Abnormal SDQ total scores relating to conduct and peer problems. Significant mid-adolescent decline in social cognition. |
| 10 | Some social cognitive difficulties age 11. | 22 | Significant decline in social cognition at age 16 from normal at age 13. |
| 11 | Some mid-adolescent social cognitive difficulties. Detentions and excluded during Y11. | 23 | High SDQ total & high SCDC score at ages 9, 11 & 16. Age 9 abnormal: emotional symptoms, 7/10; hyperactivity, 8/10; peer problems 6/10. Age 11 abnormal: hyperactivity, 6/10; peer problems, 8/10; prosocial 3/10. Age 16 abnormal: hyperactivity, 6/10; peer problems, 7/10. |
| 12 | Challenging Y6 behaviour. | | |

High $[BT]_{plasma}$ at age 11 was also associated with social cognitive dysfunction but not as profoundly as at age 9. The most common associations at age 11 were borderline or abnormal SDQ scores including hyperactivity. Downstream challenging behaviour at age 16 was also evident in five cases. In both groups, being deliberately late to avoid part of lessons and fighting in and out of school was a key theme apparent in eight cases. Upon analysis of the data, this appears to be restricted to participants undergoing early physical maturation (Section 5.4) as well as those with high $[testosterone]_{plasma}$. Conversely, a strong correlation between these variables was not seen across the population upon statistical analysis (Chapter 4). This may be due to gaps in the data: of the 548 participants in the dataset where the data is complete, 318 were at Tanner Stage 4 or 5, which is associated with a higher $[BT]_{plasma}$ than other pubertal stages. A disproportionate number of late-maturing participants was also represented (Section 5.5), that is 179 of 548.

### 5.6.2 Participant group with high plasma testosterone at ages 13 or 15

The data extraction method used in Section 5.6.1 was repeated for participants at age 13 with a $[BT]_{plasma}$ of 4.4 ng $ml^{-1}$ or above of which there were 19 top extreme outliers and those aged 15 with $[BT]_{plasma}$ of 6.9 ng $ml^{-1}$ or above (20 top extreme outliers) from which Table 5.6.2 was constructed. None of the participants showed a high mean plasma testosterone exposure over adolescence nor was represented as high at other age.

***Table 5.6.2: Participants with high $[BT]_{plasma}$ at ages 13 & 15 and psychosocial problems at both ages or challenging behaviour during year 11 (no behaviour data available for mid-adolescence).***

| High $[BT]_{plasma}$ age 13 | | $[BT]_{plasma}$ age 15 | |
|---|---|---|---|
| **Case** | **Problems/difficulties** | **Case** | **Problems/difficulties** |
| 1 | Frequently truanted Y11. | 11 | Challenging behaviour during Y6. |
| 2 | Fights in and out of school at age 16. | 12 | Borderline SDQ prosocial & SCDC scores at age 13. Fights in and out of school at age 16. |
| 3 | Fights in and out of school at age 16. | 13 | Age 9: high SDQ hyperactivity age 11 (7/10), borderline peer problems (6/10). Borderline social cognitive function ages 11 & 13. |
| 4 | Challenging Y11 behaviour. | 14 | SDQ peer problems at age 11. Fights in and out of school at age 16. |
| 5 | Decline in social cognition at age 16. | 15 | Abnormal SDQ prosocial scores all ages (no SCDC data). Abnormal SDQ total scores at ages 13 & 15 (peer problems and hyperactivity) with high plasma testosterone age 15. Arrived late to lessons during Y11; fights in and out of school at age 16. |
| 6 | Recorded at age 9 also. | 16 | Slight decline in social cognition at age 13. |
| 7 | Decline in social cognition at age 13. | 17 | Mid-adolescent decline in social cognition. Deliberately arrived late to lessons during Y11; often truanted; parents contacted regarding poor behaviour and attitude towards school; frequent detentions. |
| 8 | Slight decline in social cognition at age 13. | 18 | Evidence of social cognitive difficulties age 9. |
| 9 | Decline in social cognition at age 16; fights in and out of school at age 16. | 19 | Mid-adolescent decline in social cognition. |
| 10 | Recorded at ages 11 & 17 also. | 20 | Mid-adolescent decline in social cognition. |

Of the 19 participants showing high $[BT]_{plasma}$ at age 13, nine exhibited psychosocial or challenging behaviour (47%) at some stage of adolescence. Unfortunately, as stated before, the ALSPAC dataset does not contain school behaviour variables covering age 13, therefore an interpretation must be made of SDQ/SCDC data and the parental questionnaire recorded at this age. Eleven of the 20 participants (55%) with a high $[BT]_{plasma}$ at age 15 were recorded as having psychosocial or behavioural difficulties at one or more stages of adolescence.

As with participants having high $[BT]_{plasma}$ at ages 9 and 11, aggressive behaviour such as fighting in an out of school is a common theme. It is widely reported that high testosterone levels are a risk factor contributing to risk-taking and impulsive behaviours, aggression and criminality. In school, such behaviours lead to disruption, psychological harm to staff and other students and often results in exclusion (Archer, 1991; Olweus et al., 1988; Tremblay et al., 1998; van Bokhoven et al., 2006).

Truancy, including being deliberately late to lessons is also a recurrent theme. In a study of truancy involving secondary school children in four local authority areas, most truancy was internal (missing parts of lessons) manifested by pretending to run errands for other teachers, faking illness and deceiving supply teachers (Malcolm et al., 2003). Incidentally, several connected the use of supply teachers to disliking lessons, many saying that teacher substitutes make 'school boring.' Other common themes were problems with teachers, lessons or subject content, the complexity of secondary school, opportunism, being bullied particularly due to being overweight, peer pressure and social isolation. (The consequences of obesity for pubertal development and peer problems was discussed in Section 5.2.) Some children avoided lessons because of unmanaged disruptive class behaviour. Individual factors stated by children included laziness (not wanting to get out of bed and lacking the energy or will to work), curiosity and daring (e.g. I get a thrill from the risks of being caught, being daring and wanted to know what truancy feels like), mental health problems and fear of the consequences of anger (with the relationship between testosterone and aggression discussed above).

A change in circadian rhythm in adolescence is widely reported (Carskadon et al., 1998; Valdez et al., 2014). This has led some schools to improve attendance and educational performance by shifting the school day towards later start and finish times. Relevant to this study of endocrinological severe outliers, it is widely reported that serum androgen exposure affects sleep-wake patterns in both sexes but that these effects are more pronounced in adolescent boys and young men with energy deficiency (perceived as laziness).

Psychological stress including high cortisone levels exacerbate these factors (Opstad, 1994). Poor mental health is associated with psychological stress and is also a feature of abnormal pubertal timing and tempo, which in turn is a consequence of atypical plasma testosterone concentrations (Chapter 2). Risk-taking and thrill-seeking are well-known features of adolescence and it is supposed that brain reorganisation, partly modulated by testosterone, are connected to such behaviour (Busso, 2014). The adolescent need for peer approval and testosterone as a social hormone is discussed in Chapter 2. All these factors may contribute to the high levels of truancy reported in extreme pubertal and testosterone outliers.

There is evidence to show that several participants exhibit a mid- to late-adolescent decline in social cognitive function, which is congruent with much of the literature (Chapter 2). This is more common in participants with a high $[BT]_{plasma}$ at age 15 rather than 13, the age at which most participants are at mid-adolescence. Abnormal scores for the SDQ questionnaires appear to be most common in the 11 and 15 age-group.

### 5.6.3 Participant group with high plasma testosterone at age 17

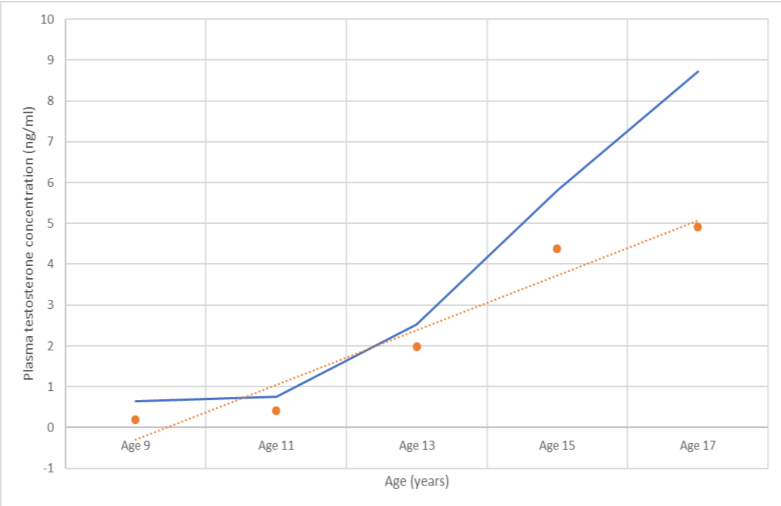
The same data extraction method used in the above sections was repeated for participants aged 17 years with a $[BT]_{plasma}$ of 7.5 ng ml$^{-1}$ or above of which there were 20 extreme outliers. Table 5.6.3 summarises an analysis of the data relating to these participants.

***Table 5.6.3: Participants with high $[BT]_{plasma}$ at age 17 and psychosocial or challenging behaviour during year 11.***

| **High $[BT]_{plasma}$ age 17** | | | |
|---|---|---|---|
| **ID** | **Problems/difficulties** | **ID** | **Problems/difficulties** |
| 1 | Recorded at age 9 also. | 8 | Recorded at age 9 also. |
| 2 | Deliberately arrived late to lessons during Y11. | 9 | Social cognitive difficulties at ages 13 & 16. Fights in and out of school at age 16. |
| 3 | Borderline SCDC score age 9. Fights in and out of school at age 16. | 10 | Poor behaviour Y6. Poor social cognition ages 11 to 16. Several detentions Y11 & school contacted parents regarding attitude. |
| 4 | Recorded at age 9 also. | 11 | Poor social cognition ages 11 to 16. Deliberately arrived late to lessons during Y11 & school contacted parents regarding attitude. |
| 5 | Recorded at ages 9 & 13 also. | 12 | Low SDQ prosocial and high hyperactivity scores all ages. Deliberately arrived late to lessons during Y11. |
| 6 | Low SDQ prosocial and high hyperactivity scores all ages. Deliberately arrived late to lessons during Y11. Fights in and out of school at age 16. | 13 | Recorded at ages 11 & 15 also. |
| 7 | Recorded at age 15 also. | | |

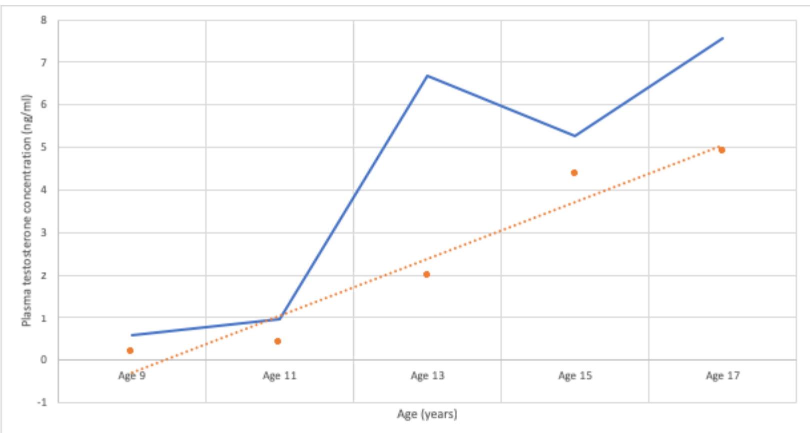
None of the participants showed a high mean plasma testosterone exposure over adolescence, although several also showed high $[BT]_{plasma}$ at other ages: 5 at age 9 or 11 and 3 at age 13 or 15. This shows an unexpected trend as most commonly, $[BT]_{plasma}$ shows a linear trajectory with age (Appendix 5) and it has been widely reported that once a child has a $[BT]_{plasma}$ this continues to adulthood. However, Figure 5.6.2 shows that the median pattern of data for these outliers differs from the linear trajectory shown by the median all participants in the ALSPAC dataset, as calculated by Khairullah et al. (2014) pooled with reference data reported in the literature.

***Figure 5.6.2: Median values of extreme outliers (blue) plotted against pooled mean values (orange) described in Khiarullah et al. (2014).***




Of the 20 participants with a recorded high $[BT]_{plasma}$ at age 17, thirteen (65%) had psychosocial problems or exhibited challenging behaviour during Year 11. From Figure 5.6.3, it can be seen that the testosterone trajectory for outlier participants increases significantly above the normal reference range beyond age 13. Year 11 students are aged 15 or 16 and although endocrinological data is not available for age 16, the deviance above normal, extrapolated from Figure 5.6.2, is substantial. Interestingly, in most cases of high $[BT]_{plasma}$ at age 9, a dip below the normal range follows between the ages of 11 rising to normal at age 13. This is possibly due to negative feedback systems coming into effect, where androgen levels are monitored by the pituitary gland and inhibition of their production occurs when a biological set point is reached. It is probable that these mechanisms become overwhelmed in severe outlier cases (Johnson & Everitt, 2000).

***Figure 5.6.3: Testosterone assay values for participant 5 (blue) plotted against pooled mean values (orange) described in Khiarullah et al. (2014).***

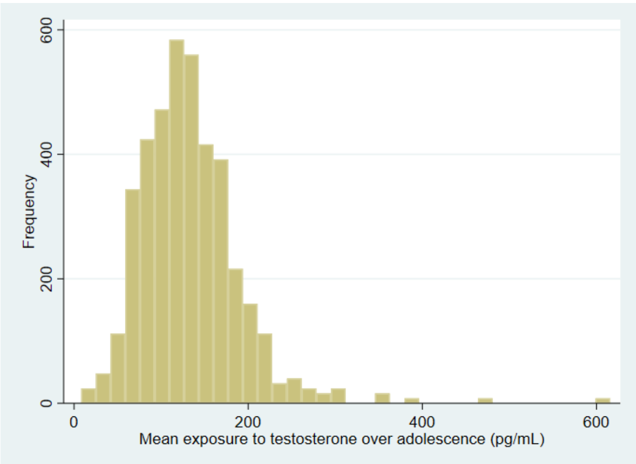


Another possibility for this decline in $[BT]_{plasma}$ is an increase in SHBG, which sequesters free plasma testosterone and rises in response to testosterone levels. Plasma albumin also binds free testosterone to reduce its free plasma levels (Chapters 2 and 3) although the binding is weak, so the testosterone is easily given up becoming free under the right conditions. Participant 5 (Table 5.6.3) did not fit the pattern shown in Figure 5.6.2 having a substantial plasma testosterone spike (6.697 ng $ml^{-1}$) at age 13 (Figure 5.6.3). At other ages, the levels were high except for a normal value at age 11. Unfortunately, behaviour data is not available for age 13 but this participant did exhibit borderline social cognitive difficulties at ages 13 and 16. He was sanctioned for truancy and aggressive behaviour during Year 11.

### 5.6.4 Participant group with high plasma testosterone exposure over adolescence

Khairullah et al. (2014) devised a model that was applied to individuals' testosterone trajectory that calculated their average exposure to testosterone over adolescence. This data was then pooled alongside that of other studies in the literature to create a reference range of testosterone levels in males between the ages of 6 and 19 years. As stated in the introduction to this section, the average exposure to testosterone can be employed in a number of investigations by any researcher or research team relating to associations between testosterone trajectories and pubertal dynamics, biopsychosocial development, behaviour and psychopathology as in this study. With a variation in $[BT]_{plasma}$ at different ages, not all participants have prolonged high exposure over adolescence. In fact, the data shows 22 participants with such extreme high mean $[BT]_{plasma}$ values.

***Figure 5.6.4: Histogram illustrating mean exposure to testosterone over adolescence. Source: ALSPAC.***




As outlined in Section 5.6.1, these findings contradict much of those in the literature which state that high $[BT]_{plasma}$ values in males continue from the point at which such high levels are first recorded. In one such study, Khairullah et al. (2014) report that testosterone levels remain high one they increase and that a large increase occurring at an early age results in an individual experiencing a greater exposure over adolescence.

A histogram was constructed (Figure 5.6.4) to identify these potential outliers and a value of 225 pg $ml^{-1}$ was selected to identify the top 22 extreme outliers (Table 5.6.4). Where participants had high $[BT]_{plasma}$ values at specified ages with psychosocial or behavioural difficulties, these are identified. The table outlines the difficulties exhibited by the 15 participants (68%) of the 22 extreme outliers. The following number of participants had a high plasma testosterone concentration at each age and an overall mean plasma testosterone concentration of greater or equal to 225 pg $ml^{-1}$: 26 $\geq$ 0.5 ng $ml^{-1}$ at age 9; 33 $\geq$ 1.5 ng $ml^{-1}$ at age 11; 27 $\geq$ 4.4 ng $ml^{-1}$ at age 13; 29 $\geq$ 6.9 ng $ml^{-1}$) at age 15; 28 $\geq$ 7.4 ng $ml^{-1}$ at age 17.

When crosschecking this data with ALSPAC questionnaires, it is revealed that much of the challenging behaviour for participants with mean high $[BT]_{plasma}$ occurred during year 11 or at age 16. Ten of the 15 participants were reported by teachers as exhibiting challenging behaviours including truancy including being deliberately late for lessons (Section 5.6.2); disrupting lessons and poor attitude resulting in detentions and in one case, exclusion from school. Parents also expressed concerns such as participants being disobedient, quarrelsome and belligerent at this age. As testosterone has been associated with aggression in numerous studies (Chapter 2), it is unsurprising that five participants also exhibited aggressive behaviours such as fighting and temper tantrums.

***Table 5.6.4: Participants with high mean $[BT]_{plasma}$ taken from all ages. Source: ALSPAC.***

| **High mean $[BT]_{plasma}$** | | | |
|---|---|---|---|
| **ID** | **Problems/difficulties** | **ID** | **Problems/difficulties** |
| 1 | Borderline hyperkinetic disorder. Social cognitive dysfunction all ages. | 9 | Social cognitive dysfunction all ages. Mid-adolescent hyperactivity. |
| 2 | Social cognitive dysfunction all ages. | 10 | Social cognitive dysfunction all ages. Challenging behaviour Y6 & Y11 |
| 3 | Deliberately arrived late to lessons during Y11. | 11 | Social cognitive dysfunction all ages. Age 16 behaviour: awkward, temper outbursts, argumentative, disobedient. Year 11 behaviour: disruptive, often arrived late for lessons, excluded. |
| 4 | Borderline hyperactivity. Fights in and out of school at age 16. Mid-adolescent borderline decline in social cognition. | 12 | Mid-adolescent borderline decline in social cognition. School concerned with attitude during Y11. |
| 5 | Borderline social cognitive difficulties all ages. | 13 | Mid-adolescence slight decline in SDQ prosocial score indicative of empathy and helpfulness towards others. |
| 6 | Parents had non-disclosed concerns regarding the child at age 13. Borderline hyperactivity age 13. Fights in and out of school at age 16. | 14 | Several detentions during Y11 and deliberately arrived late for lessons. School concerned with attitude during Y11. |
| 7 | School contacted parents regarding poor behaviour during Y11. Several detentions during Y11. | 15 | Often arrived late for lessons during Y11, several detentions given and school concerned with attitude. |
| 8 | Often played truant and arrived late for lessons during Y11. Fights in and out of school at age 16. | | |

Across all ages, five had high SDQ hyperactivity scores, in one case indicative of a probable hyperkinetic disorder. Two participants, 1 and 9 (Table 5.6.4), had the highest levels, 475 and 616 pg $ml^{-1}$ respectively. Both suffered a social cognitive dysfunction and a possible hyperkinetic disorder at all ages, scoring particularly high on the SDQ hyperactivity score. Nine of the participants exhibited social cognitive difficulties at some stage or more during adolescence: in Chapter 2 the role of testosterone as a social hormone was discussed, which relates to findings of this study regarding an association between it and the features of autistic spectrum disorder (Chapter 4).

### 5.6.5 Participant group with high bioavailable plasma testosterone

As explained in Chapter 3, not all plasma testosterone is bioactive and thus able to exert a biopsychological influence. The concentration of this bioavailable testosterone (BT) fraction for each participant was calculated where SHBG and plasma testosterone levels were available in the dataset. BT was then used for analysis with biopsychosocial and behaviour variables. Histograms for plasma concentrations of testosterone, BT and SHBG are shown in Chapter 3. Khairullah (2014, p.2) included ranges for SHBG and bioavailable fractions of testosterone in their study as “these are of interest when studying the effect of testosterone on the brain and body”. Data in the histograms for BT and extreme ranges outlined in the aforementioned paper were used to identify extreme outliers for BT at different ages. The ranges selected, the number of participants identified and the number and percentage of students with psychosocial or behaviour problems are shown in Table 5.6.5.

***Table 5.6.5: Range of values for BT identified as extreme in nmol/l, the number of participants with extreme values and the number of those with psychosocial problems & challenging behaviour.***

| Age | Range high BT | Part | Prob | % |
|---|---|---|---|---|
| 9 | 0.30 – 0.64 | 30 | 22 | 73% |
| 11 | 0.55 – 3.98 | 32 | 23 | 72% |
| 13 | 6.00 – 11.96 | 28 | 19 | 68% |
| 15 | 11.0 – 13.11 | 32 | 15 | 47% |
| 17 | 13.0 – 16.04 | 28 | 12 | 43% |

Table 5.6.6 was constructed from Table 5.6.5 and following the interrogation of STATA® for details of problems encountered by specific participants using the same method as discussed above. Of note is that only 17 of the participants were previously identified as having high $[BT]_{plasma.}$ In addition, 35 participants were identified as having high $[BT]_{plasma}$ that was not previously represented within the high $[BT]_{plasma}$ cohort.

Five participants with high testosterone levels at ages 9, 17, 11, 11 & 17 had missing psychosocial and behavioural data. These were excluded from Table 5.6.6 and were not included in Table 5.6.5. In 31 of 43 cases of those with high $[BT]_{plasma}$ (72%) at any age, challenging behaviour or a decline in social cognition manifested at age 16. A significant proportion (45%) of these cases exhibited aggressive behaviours such as temper outbursts and fighting.

As referenced in 5.6.2, there is evidence that testosterone, particularly the bioavailable fraction is associated with aggression towards others. Analysis of the study data shows that high $[BT]_{plasma}$ exposure during early adolescence, that is, ages 9 & 11, exerts an influence on social cognition during mid- and late adolescence and externalising symptoms in the form of challenging behaviour during late adolescence. This corresponds with the findings of Gray et al. (2017), Zehr et al. (2007), Nottelmann et al. (1987) who reported that prolonged exposure to high levels of testosterone affects later behaviour. Tordjman et al. (1997) noted that 4 of 12 pre-pubertal autistic children (6 to 10 years old) attending a clinic had precocious puberty and linked this observation to earlier studies where *in utero* testosterone was implicated. They then compared the $[BT]_{plasma}$ of these participants with a control group. In the 1997 study, three of the 9 autistic participants had $[BT]_{plasma}$ over two standard deviations above the mean compared with controls. The behaviour of these children included ‘explosive aggression,’ violence towards others and self-mutilation. An interesting aside is that the sole female participant also had an unusually high $[BT]_{plasma}$ of 0.5 ng $ml^{-1}$. In this research, early maturing participant Joseph was discussed in Section 5.4 due to his extreme behaviour. Although no endocrinological data was available for him, it is likely that he would have an extreme $[BT]_{plasma}$ as he was at Tanner Stage 5 at age 11 (the high correlation between $[BT]_{plasma}$ and Tanner Stage were discussed in Chapter 3). Possible effects of androgenic activity on left hemisphere brain development and associated brain masculinisation including cognitive dysfunction were discussed in Chapter 2.

Truancy, including being deliberately late for lessons during year 11, was common (33%) for participants with high $[BT]_{plasma}$ as well as in early maturing participants and those with high with $[cortisol]_{saliva}$ (discussed fully in Section 5.6.2). This may indicate a need for schools to look deeper for causality in cases of truancy and poor punctuality, providing support where a need exists.

***Table 5.6.6: Participants with a high $[BT]_{plasma}$ and identified as experiencing significant psychosocial difficulties or challenging behaviour at ages 11, 13, 15 & 17. Age(s) at which $[BT]_{plasma}$ was extreme are shaded yellow.***

| ID | Age | Summary of problems/difficulties | ID | Age | Summary of problems/difficulties |
|---|---|---|---|---|---|
| 1 | **9** 11<br>13 15<br>17 | Age 16: Physical fights in and out of school | 13 | **9** 11<br>**13** 15<br>17 | Age 16: Significant truancy and temper outbursts. |
| 2 | **9** **11**<br>13 15<br>17 | Age 8: High salivary cortisol level.<br>Age 16: Temper outbursts, argumentative, disobedient, truant, fights. | 14 | **9** 11<br>13 15<br>17 | Ages 9 & 11: High SDQ hyperactivity scores.<br>All ages: Diagnostic indicators for social cognitive disorder such as autism. |
| 3 | 9 11<br>**13** 15<br>**17** | Age 13: Borderline poor social cognitive function.<br>Age 16: Physical fights in and out of school. Deliberately arrived late to lessons during Y11. | 15 | **9** 11<br>13 15<br>17 | Age 16: Deliberately arrived late to lessons during Y11. |
| 4 | 9 **11**<br>**13** **15**<br>17 | Age 13: Mid-adolescent decline in social cognition. | 16 | 9 **11**<br>13 15<br>17 | Age 16: Significant truancy. Several detentions. |
| 5 | **9** 11<br>13 15<br>17 | Age 16: Physical fights in and out of school. | 17 | 9 **11**<br>13 15<br>17 | Age 16: Late-adolescent decline in social cognition. |
| 6 | **9** **11**<br>**13** **15**<br>**17** | Age 16: Borderline poor social cognitive function. Deliberately arrived late to lessons during Y11. Physical fights in and out of school. | 18 | 9 **11**<br>13 15<br>17 | Age 16: Borderline poor social cognitive function. |
| 7 | **9** **11**<br>**13** 15<br>17 | Age 13: Mid-adolescent decline in social cognition.<br>Age 16: Challenging out of school behaviour, temper outbursts, argumentative, disobedient, deliberately annoys others. | 19 | 9 **11**<br>13 15<br>**17** | Age 13: Mid-adolescent decline in social cognition. |
| 8 | **9** **11**<br>13 **15**<br>**17** | Age 13: Mid-adolescent decline in social cognition. | 20 | 9 **11**<br>**13** 15<br>**17** | Year 6: Challenging behaviour.<br>All ages: Social cognitive difficulties, emotional symptoms and peer problems. |
| 9 | **9** 11<br>13 15<br>17 | Age 16: Deliberately arrived late to lessons during Y11. | 21 | 9 **11**<br>**13** 15<br>17 | Age 16: Physical fights in and out of school. |
| 10 | **9** 11<br>13 15<br>17 | Age 16: Borderline poor social cognitive function. | 22 | 9 **11**<br>**13** 15<br>**17** | Age 16: Physical fights in and out of school. |
| 11 | **9** 11<br>13 15<br>17 | Age 13: Mid-adolescent decline in social cognition. | 23 | 9 **11**<br>13 15<br>17 | Age 16: Late-adolescent decline in social cognition. |
| 12 | **9** 11<br>13 15<br>17 | All ages: Diagnostic indicators for social cognitive disorder such as autism. | 24 | **9** **11**<br>**13** **15**<br>**17** | Age 16: Fixed-term excluded from school during year 11. |

***Table 5.6.6: Continued***

| ID | Age | Summary of problems/difficulties |
|---|---|---|
| 25 | 9 **11**<br>**13** **15**<br>17 | Age 16: Deliberately arrived late to lessons during Y11. |
| 26 | 9 **11**<br>13 **15**<br>17 | All ages: Diagnostic indicators for social cognitive disorder such as autism. Age 16: School concerns about attitude and disruptiveness. |
| 27 | 9 11<br>**13** 15<br>17 | Age 16: Several detentions and fixed-term exclusions during year 11. School concerns about behaviour and attitude. |
| 28 | 9 11<br>**13** **15**<br>17 | Age 16: Physical fights in and out of school. |
| 29 | 9 11<br>**13** **15**<br>17 | Age 16: Deliberately arrived late to lessons during Y11. |
| 30 | **9** **11**<br>**13** **15**<br>**17** | Age 13: Mid-adolescent decline in social cognition with corresponding decline in empathy towards others. |
| 31 | 9 11<br>**13** 15<br>17 | Age 16: Physical fights in and out of school. |
| 32 | 9 11<br>**13** 15<br>17 | All ages: Borderline poor social cognitive function. |
| 33 | 9 11<br>**13** **15**<br>17 | Age 16: Late-adolescent decline in social cognition. Physical fights in and out of school. |
| 34 | 9 11<br>13 15<br>**17** | All ages: Poor empathy with others (social cognition) and high hyperactivity scores.<br>Age 16: Deliberately arrived late to lessons during Y11. |
| 35 | 9 11<br>13 **15**<br>**17** | Age 16: Deliberately arrived late to lessons during Y11. |
| 36 | 9 11<br>13 **15**<br>**17** | Age 16: Deliberately arrived late to lessons during Y11. |
| 37 | 9 11<br>13 **15**<br>17 | Age 13: Mid-adolescent decline in social cognition.<br>Age 16: Significantly disruptive behaviour in school and deliberately arrived late to lessons during year 11. Often fixed-term excluded during year 11. |
| 38 | 9 11<br>13 **15**<br>**17** | Ages 11 & 13: High SDQ hyperactivity score.<br>Age 16: Deliberately arrived late to lessons and several detentions during Y11. |
| 39 | 9 11<br>13 **15**<br>**17** | Age 16: Late-adolescent decline in social cognition. |
| 40 | 9 11<br>13 **15**<br>**17** | Age 16: Deliberately arrived late to lessons and several fixed-term exclusions during year 11. |
| 41 | 9 11<br>13 15<br>**17** | Age 16: Deliberately arrived late to lessons during Y11. |
| 42 | 9 11<br>13 15<br>**17** | Age 11: Challenging behaviour during year 6.<br>Ages 11 to 16: Poor social cognition.<br>Age 16. Several detentions during year 11 & school concerns regarding attitude. |
| 43 | 9 11<br>13 15<br>**17** | Age 11: Challenging behaviour during year 6.<br>Age 16: Age 16: Deliberately arrived late to lessons during Y11. Late-adolescent decline in empathy with others (social cognition). |

### 5.5.6 Participant group with extreme salivary cortisol concentrations

Cortisol is often referred to as a ‘stress hormone,’ its normal plasma concentration range being between 85 and high as 618 nmol $l^{-1}$ during times of severe stress (Stryer et al., 2002). The properties and actions of cortisol were already discussed in chapters 3 & 4 and as stated there, high cortisol levels can be an indicator of an endocrine disorder. However, analysis of the BMI data did not indicate any abnormal values for participants with psychosocial problems or challenging behaviour and a low $[cortisol]_{saliva}$ that might indicate Addison’s disease. Of those with high $[cortisol]_{saliva,}$ two had evidence of a significant hyperkinetic disorder and a further two had a low BMI, both of which might indicate an endocrine pathology. Only participant had a low BMI and borderline hyperactivity during early adolescence. Finally, a ‘chicken and egg’ scenario is a possibility in that did abnormal $[cortisol]_{saliva}$ cause adverse behaviour and externalising symptoms or were abnormal levels the result of these? The outcome of intrinsic and extrinsic stressors is associated with cortisol release in the general population and higher levels in susceptible individuals. Nevertheless, despite these possible confounding variables, data analysis shows that associations exist that could indicate that some schoolchildren are at risk of sanctions and exclusionary practices due to biopsychological abnormalities.

A value of 140 nmol $l^{-1}$ and below was selected as the classification point for extreme low outliers ($n$=29) and a value of 330 nmol $l^{-1}$ for extreme high outliers ($n$=30), that rationale for which is outlined in Appendix 5. Four participants were excluded from the low outliers due to missing data and 45 from the high outliers. Table 5.6.7 lists those participants with low $[cortisol]_{saliva}$ exhibiting psychosocial problems or challenging behaviour (18) and Table 5.6.8 for those with high cortisol levels exhibiting such problems (13). Excluding those with missing data gives the percentage values of 62% (low cortisol) and 52% (high).

***Table 5.6.7: Participants with extreme low [cortisol]$_{saliva}$ age 8.***

| High mean [BT]$_{plasma}$ | | | |
|---|---|---|---|
| **ID** | **Problems/difficulties** | **ID** | **Problems/difficulties** |
| 1 | Mid-adolescent decline in social cognition. | 10 | Insufficient data to perform analysis. |
| 2 | Challenging year 6 behaviour. Evidence for social cognitive dysfunction (low SCDC all ages). High SDQ hyperactivity score ages 11 & 13. | 11 | Borderline mid-adolescent decline in social cognition. |
| 3 | Challenging year 6 behaviour. Strong diagnostic indicators for autistic spectrum disorder. Significant hyperactivity and peer problems (bullied, solitary, unliked). | 12 | Challenging year 11 behaviour including detentions given, school concerned regarding attitude and behaviour. |
| 4 | Deliberately arrived late to lessons during Y11. Several detentions given. | 13 | Detentions given during year 11. |
| 5 | SDQ emotional symptoms age 11 such as worried, unhappy, nervous, tearful, faked illnesses. Deliberately arrived late to lessons during year 11. Several detentions given. | 14 | Insufficient data to perform analysis. |
| 6 | Often excluded during year 11. | 15 | Deliberately arrived late to lessons during year 11. Several detentions given. |
| 7 | Insufficient data to perform analysis. | 16 | Insufficient data to perform analysis. |
| 8 | Borderline social cognitive difficulties all ages. | 17 | Insufficient data to perform analysis. |
| 9 | Challenging year 6 behaviour. | 18 | Challenging year 6 behaviour. Social cognitive difficulties all ages. Year 11 behaviour: detentions given, fixed-term excluded, school concerned regarding attitude and behaviour. |

When considering participants with a high [cortisol]$_{saliva}$, there are a number of factors discussed in the literature (Chapter 2). Boys who go through puberty late have been found to have higher levels of cortisol than early or normal developing peers (Susman et al., 2010). Also, several researchers have found that aggression in boys and young males with high testosterone levels is moderated by high cortisone levels (Dabbs et al., 1991; Grotzinger et al., 2018; Mendle & Ferrero, 2012).

***Table 5.6.8: Participants with extreme high [cortisol]$_{saliva}$ age 8.***

| High mean [BT]$_{plasma}$ | | | |
|---|---|---|---|
| **ID** | **Problems/difficulties** | **ID** | **Problems/difficulties** |
| 1 | Behaviour during Y6: temper tantrums, argumentative, easily annoyed by others, angry & resentful. Behaviour at age 16: temper outbursts, argumentative, disobedient, fights in and out of school. Y11 behaviour: sometimes arrived late for lessons. | 8 | Borderline hyperactivity ages 9 and 11. Social cognitive dysfunction at all ages. Temper outbursts, argumentative and disobedient age 16. Y11 behaviour: sometimes arrived late for lessons. Low BMI until age 16. |
| 2 | Y11 behaviour: sometimes arrived late for lessons. | 9 | Poor social cognition and behaviour during Y6. |
| 3 | Borderline social cognitive dysfunction at age 16. | 10 | Hyperactivity ages 9 & 11. Social cognitive dysfunction age 11. Y11 behaviour: sometimes arrived late for lessons. |
| 4 | Borderline social cognitive dysfunction at age 16. School contacted parents regarding poor attitude during Y11. | 11 | Borderline social cognitive dysfunction at ages 13 & 16. School contacted parents regarding poor attitude during Y11. |
| 5 | Y11 behaviour: sometimes arrived late for lessons & excluded from school. | 12 | Several detentions during Y11 and deliberately arrived late for lessons. School concerned with attitude during Y11. |
| 6 | Y11 behaviour: several detentions, school contacted parents about behaviour and attitude, sometimes arrived late for lessons & excluded from school. Low BMI age 11 & 16. | 13 | Hyperactive ages 9 & 11. Y11 behaviour: sometimes arrived late for lessons, given detentions, school contacted parents about behaviour and attitude. Disobedient and deliberately annoys others. |
| 7 | Y11 behaviour: awkward and disruptive; school contacted parents about behaviour and attitude, sometimes arrived late for lessons. | | |

In addition, chronic stress occurring during puberty could precipitate adrenal gland development and, therefore, increased secretion of stress hormones such as cortisol. These are known to contribute to psychosocial adjustment problems and challenging behaviour (Susman et al., 1987). This is a common theme for participants in Table 5.6.8.

It is surprising to note that of the 26 participants with extreme $[cortisol]_{saliva}$ levels (high and low outliers) for which other data variables exist, most psychosocial problems and challenging behaviour manifested during late adolescence. Four of the low $[cortisol]_{saliva}$ cohort exhibited challenging behaviour during pre- and early adolescence and two in the high $[cortisol]_{saliva}$ cohort. In contrast, 16 (7 low and 9 high cohort) exhibited challenging behaviour during late adolescence. Two participants from each cohort were excluded from school during year 11. School behaviour is not available for mid-adolescence.

According to Social and Communication Disorders Checklist (SCDC) data, participants in the low $[cortisol]_{saliva}$ cohort showed a typical mid-adolescent decline in social cognition but none in the high $[cortisol]_{saliva}$ cohort. Four participants with low cortisol exhibited poor social cognitive function at all ages. Of the participants with high cortisol, two showed signs of poor social cognition at all ages and one during early adolescence. In only two cases did the SDQ prosocial score data support these findings, but, as stated before, these appear to be an indicator of empathy and kindness rather than social cognition.

Two participants with low $[cortisol]_{saliva}$ and three with high $[cortisol]_{saliva}$ had high SDQ hyperactivity scores indicating a possible hyperkinetic disorder. One participant with a low $[cortisol]_{saliva}$ exhibited SDQ emotional symptoms such as being worried, unhappy, nervous, tearful and faking illness and another suffered peer problems including being bullied and socially isolated. No other psychosocial problems were reported for either cohort.

It is difficult to make assertions about these findings other than that a large proportion of individuals with extreme outlier plasma cortisol concentrations exhibit psychosocial and behavioural difficulties, but this mostly manifests in late adolescence. Of the 26 participants with psychosocial or behavioural difficulties for which comprehensive data exists, 13 of them (50%) were punished by schools facing detentions or exclusion. This point is explored further in Chapter 6. Further research is needed especially regarding the effects of hormones on psychosocial factors and school behaviour variables. To facilitate this, complete $[BT]_{plasma}$ and $[cortisol]_{saliva}$ data would be essential together with SDQ, SCDC, Development and Well-Being Assessment (DAWBA) and school behaviour data collected at specific junctures during pre- early- mid- and late adolescence.

## 5.7 Analysis of Often Excluded Participants

The 24 participants in this section were described in the one of the two year 11 teacher questionnaires as being 'often excluded.' Of these participants, 16 (67%) exhibited psychosocial problems (Table 5.7.1). It must be noted that all the participants in Table 5.7.1 exhibited in-school challenging behaviour, so school behaviour variables are not included or discussed in the following narrative.

***Table 5.7.1: Participants who were 'often' excluded during year 11 with biopsychosocial difficulties or challenging behaviour.***

| ID | Problems/difficulties | ID | Problems/difficulties |
|---|---|---|---|
| 1 | Strong diagnostic indicators for autistic spectrum disorder. Low testosterone values throughout adolescence but normal pubertal progression. Significant truancy. BMI normal. | 9 | All other data normal. Missing endocrinological data. BMI normal. |
| 2 | Study name Jess (early pubertal timing). Challenging year 6 behaviour. Poor social cognition and low prosocial scores all ages. Parental concerns regarding out of school behaviour at age 16. Missing endocrinological data. BMI normal. | 10 | Study name Jared (early pubertal timing). Challenging year 6 behaviour. Parental concerns regarding out of school behaviour at age 16. Missing endocrinological data. BMI normal. |
| 3 | Challenging year 6 behaviour. Strong diagnostic indicators for autistic spectrum disorder. Missing endocrinological data. BMI normal. | 11 | Challenging year 6 behaviour. Strong diagnostic indicators for autistic spectrum disorder. Missing endocrinological data. BMI normal. |
| 4 | Borderline SDQ hyperactivity scores. Low testosterone values throughout adolescence but normal pubertal progression. BMI low. | 12 | Challenging year 6 behaviour. Missing endocrinological and BMI data. |
| 5 | Missing year 6 behaviour data. Borderline SDQ prosocial scores and some evidence for poor social cognition. BMI normal. Missing endocrinological data. | 13 | Year 6 behaviour normal. Missing endocrinological and BMI data. Some evidence of poor social cognition at age 13 (other data missing). Borderline prosocial score age 16. |
| 6 | Strong diagnostic indicators for autistic spectrum disorder. Missing year 6 behaviour, endocrinological and BMI normal. | 14 | Challenging year 6 behaviour. Diagnostic indicators for autistic spectrum disorder. Parental concerns regarding out of school behaviour at age 16. Missing endocrinological data. BMI normal. |
| 7 | Some evidence for poor social cognition. Missing endocrinological data. BMI normal. | 15 | Some evidence for poor social cognition. High SDQ hyperactivity score age 11. No year 6 behaviour data. Missing endocrinological data. BMI normal. |
| 8 | Challenging year 6 behaviour. Borderline SDQ prosocial scores and some evidence for poor social cognition. Missing endocrinological data. BMI normal. | 16 | Strong diagnostic indicators for autistic spectrum disorder. High SDQ hyperactivity score suggestive of hyperkinetic disorder. Missing endocrinological data. Low BMI. |

Of the 16 participants with challenging behaviour in year 11 leading to exclusion, 8 exhibited challenging behaviour during year 6 (missing year 6 behaviour data for one participant). This shows that challenging behaviour during year 6 is often a predictor of future exclusion and, therefore, an indicator of the need for early, meaningful interventions. Two participants, Jess and Jared, were represented in an earlier discussion, being in the early maturing participant group. Both boys exhibited challenging year 6 behaviour and both of their parents had concerns regarding their out of school behaviour. Jess showed strong indicators of an autistic spectrum disorder.

Three of the participants showed evidence for a hyperkinetic disorder such as ADHD. Throughout these analyses, borderline and abnormal SDQ hyperactivity scores are associated with poor outcomes in terms of school behaviour and out of school behaviour at age 16.

Finally, 12 of the 16 participants showed some degree of poor social cognitive function with seven exhibiting strong diagnostic indicators for an autistic spectrum disorder, among them Participant 1 (Table 5.7.1) who had low plasma testosterone values throughout adolescence but a normal pubertal progression. This is unusual in that pubertal development is strongly associated with testosterone levels (Appendix 5), providing further evidence for either increased androgen receptor sensitivity or for the relevance of considering bioavailable or free testosterone levels.

These data show that a large proportion of those who are often or permanently excluded from school have a learning disability or some other psychosocial problem, some of which are apparent during year 6. It is almost certain that psychosocial data is not available to schools when deciding sanctions and exclusion for students with challenging behaviour. This gives further evidence for the need for screening tests to be undertaken and early intervention to be provided for children with challenging behaviour. Indeed, some schools subscribe to online SDQ testing for all year 7 students, but do not always act in response to the findings (Chapter 6).

## 5.8 Chapter 5 Conclusions

In this chapter, the psychosocial and behavioural data relating to participants who exhibited extreme physical and endocrinological values at one or more ages have been considered using an individualised and cohort study methodology. The emerging methodology of ‘qualitising’ was used in Chapter 5, which is the conversion of quantitative data into a qualitative format to allow a narrative relating to research participants.

In Table 2.1 (Chapter 2), a number of positive and negative outcomes associated with early and late pubertal maturity was summarised, not all of which could be considered within this study due to a deficit in the data available and time constraints. However, themes in the table such as peer popularity and family problems, emotional symptoms, early sexualised behaviour, behaviour in school and some aspects of deviant behaviour could be analysed along with other biological, behavioural and psychosocial variables. This Chapter analysed in depth three groups: typically-developing participants, extreme early developers and extreme late developers.

Fifteen participants in the ALSPAC cohort of 1,883 males for which complete pubertal data was available, showed advanced physical development at age 11, of which 10 exhibited psychosocial difficulties or challenging behaviour during adolescence. A strong association between an abnormal body mass index (BMI) and externalising symptoms in early-maturing boys was found, which supports the findings of other researchers in terms of psychological problems and early pubertal onset in boys with a high pre-pubertal BMI. An association has also been reported between obesity and learning disabilities. None of the typically-developing boys had abnormal BMI percentiles. It was found that a high proportion of early developing boys had high SDQ hyperactivity scores possibly indicating ADHD and also evidence of challenging behaviour in school. Three boys, in particular, had a prolonged period of adolescence (pubertal tempo) with associated challenging and aggressive behaviour in later adolescence as cited in several studies. Only one of the typically-developing boys exhibited psychosocial and behavioural problems but these were not close to the severity of many of the late and early maturing participants.

In terms of test compatibility (Chapter 3 and Appendix 5), we found only a weak to moderate correlation between the SDC prosocial score and SCDC scores and so the former is not a reliable indicator of a possible autistic spectrum disorder (ASD) in isolation, rather a measure of kindness and empathy. Several individuals with strong diagnostic markers for an ASD were punished during year 11 (repeated detentions and exclusion), which agrees with the findings of several authors that many children with behavioural difficulties have an undiagnosed or unmet learning disability. This was also true of boys who were borderline early-maturing (late puberty at age 12). Challenging behaviour during year 6 is a reliable indicator of challenging behaviour during year 11 and exclusion from school, especially for early maturing boys with evidence of a hyperkinetic or ASD. These findings concur with those of others including those of this study and signpost the need for positive behaviour improvement interventions and support, particularly during the first two years of secondary education (Chapter 6).

There were 15 participants with delayed development in the cohort of 1,883 for which complete data was available, 10 of whom exhibited psychosocial difficulties or challenging behaviour at one or more stages of adolescence. As with early-maturing participants, an anthropometric association is evident with 5 of the 10 being clinically obese or significantly underweight. Of these 5, 4 experienced peer problems such as being bullied and unliked by peers. The Maturational-Deviance Hypothesis (Chapter 2) suggests a relationship between late pubertal development and heightened emotional distress. However, only two participants were found with borderline SDQ emotional symptoms scores. A lesser proportion of late-maturing boys (4 or 10) had high SDQ hyperactivity scores compared to early-maturers (5 of 10), indicative of a hyperkinetic disorder. None of the late-maturers, unlike those who matured early, showed the mid-adolescent decline in social cognitive function widely reported in the literature. Also, incongruent with the literature, two showed a decline in SDCD scores with age. None of the late-maturing participants had significant markers for an ASD unlike early-maturers, which supports the hypothesis that early maturation is associated with autism. Only one participant in the late-maturing group did not have significant relationship difficulties with others whereas four boys had significant problems. In terms of challenging behaviour, late-maturers showed a different pattern to early-maturers who appear to have exhibited less challenging behaviour than early-maturers. However, a significant majority displayed psychosocial difficulties or challenging behaviour including being cruel, spiteful and bullying others; possibly due to mental immaturity linked to late brain development. Delinquent behaviour was not evident with the late-maturers except for two participants who engaged in fighting. However, one of these participants showed evidence of a learning disability rather than delinquency *per se*. The data available to this study does not include other variables relating to delinquent behaviour.

The dataset available to this study contains relevant androgen samples from 513 male participants, including sex hormone binding globulin (SHBG), plasma testosterone and cortisol assay data. Three measures of testosterone were analysed and unexpectedly revealed three different groups of participants with minimal overlap (Figure 5.6.1). Of those participants with an extreme plasma concentration of testosterone in pre- or early adolescence, 53% experienced psychosocial difficulties or challenging behaviour during adolescence and 47% of those with an extreme testosterone concentration at age 13. As plasma testosterone data were available for both ages 15 & 17, both values were compared with psychosocial variables at age 16 and year 11 behaviour. At age 15, 55% of participants experienced such difficulties and at age 17, 65% did. Psychosocial and behavioural variables were also analysed for participants with prolonged exposure to high testosterone levels throughout adolescence ($n$=20) and those at any age with extreme bioavailable testosterone concentrations (*n*=43), 72% of which exhibited challenging behaviour or a late-adolescent decline in social cognition and 45% aggressive behaviour.

Although the participants affected by high mean testosterone exposure differed (except for two), psychosocial and behavioural themes for these two groups were similar. For example, our findings agreed with the literature in that participants with prolonged exposure experienced problems at a later age. Also, extreme testosterone values during pre- or early adolescence exerts a strong influence of psychosocial and behavioural factors ‘downstream’ with many participants in this group exhibiting a higher degree of challenging behaviour at age 16 and during year 11 than at any other age. Reports in the literature, particularly that of Marceau et al. (2011) suggest that individuals with extremely early adrenarche are often withdrawn and depressed and display higher levels of aggression, acting out and peer problems whereas lower levels in late adolescence/early adulthood and associated with depression and anxiety. Their findings are in agreement with other key themes we identified including hyperactivity, truancy and other behaviour problems at age 16.

A significant decline in social cognitive function was seen in mid-adolescence for participants with high testosterone levels at an early age and a late-adolescent decline in those with a high mean testosterone value. The findings of this study show strong associations between high testosterone values in any group and indicators for social and communication disorders such as autism, but especially early exposure. They are supported by the work of Tordjman et al. (1997) who report that androgenic activity in precocious puberty in boys is associated with autism.

Several participants with high testosterone exposure were shown to have high SDQ hyperactivity scores indicative of a hyperkinetic disorder, which also corresponds with data relating to early puberty.

Truancy, including deliberately missing parts of lessons, is a concurrent theme for all participant groups with high plasma testosterone concentrations, but again, particularly prominent for early extreme exposure and high mean values. Several papers report energy deficiency and poor sleep in boys and young men with high serum androgen exposure together with depression, risk-taking and thrill-seeking, which the literature suggests may all lead to truancy. Those with a mean high testosterone concentration were also more likely to be described as quarrelsome, belligerent, disobedient disruptive in lessons and having a poor attitude to school resulting in sanctions, including exclusion. These findings agree with those of Mendle and Ferro (2012) and Schulzt, Molenda-Figueira & Sisk (2009) who provide evidence that it is the timing of puberty or adrenarche that are associated with emotional and behaviour change risks as brain sensitivity to androgen hormones decreases with age, so the earlier the children experience hormone increase, the greater the impact. Their findings also suggest that self-regulatory skills are the last neural capacities to develop leading to the behavioural difficulties we have described. As stated in Section 5.6 relating to high bioavailable testosterone, there is an indication of the need for schools to look deeper for causality in cases of truancy and poor punctuality, providing support where a biopsychological need exists.

Evidence from two papers suggest that the association between testosterone and aggression may be moderated by cortisol levels, that is, high cortisol moderates the effects of high testosterone (Dabbs, Jurkovic & Frady, 1991; Popma et al., 2007). As much of the cortisol data is missing from the ALSPAC dataset and it was only collected at age 8, drawing firm conclusions about the influence of this hormone on behaviour and psychosocial difficulties are problematic. Where data does exist, it is impossible to determine if the abnormal cortisol concentrations are the cause or result of the difficulties exhibited by participants. However, the literature shows an association between high cortisol levels at an early age and late puberty: data analysis indicated psychosocial adjustment problems and challenging behaviour to be common to both, mostly during late adolescence. Those with extremely low cortisol levels also exhibited challenging behaviour during adolescence. Those with low cortisol levels showed the typical mid-adolescent decline in social cognition but none of those in the high cortisol cohort did. Five participants in both groups had high SDQ hyperactivity scores, one had a high SDQ emotional symptoms score and another suffered peer problems such as being bullied and socially isolated. It is conceivable that these factors could result in high cortisol levels due to the stress they are likely to cause.

In Chapter 4, a quantitative analysis was undertaken that indicated mostly weak associations between some biological, psychosocial and behavioural variables. However, compelling evidence for associations between these variable groups was shown during the analysis of extreme cases in this Chapter. This supports a positive outcome in relation to the study research questions linked to physical development, endocrinological values, psychosocial and behaviour variables.

# Chapter 6: Conclusions and Recommendations

## 6.1 Introduction to Chapter 6

> *"So the first step out of childhood is made all at once, without looking before or behind, without caution, and nothing held in reserve."*
> Ursula k Le Guin. *The Farthest Shore.*

The aim of this project was to justify, by empirical evidence, the consideration by school leaders and teachers of the biological and psychosocial factors involved in adolescence behaviour when deciding behaviour support strategies. This was in order to improve the inclusion and wellbeing of adolescent boys identified with challenging behaviour. The project research questions were devised to find if evidence existed that supported the idea that some boys require special considerations and supportive interventions to achieve better behaviour outcomes. The research questions provided a framework with which to analyse: whether there is a change in the behaviour of adolescent boys as puberty progresses; if there are any hormonal correlates with the adverse behaviour of boys in school; if any relationships exist between pubertal development, hormone levels and psychosocial functioning; and whether associations exist between psychosocial measures in adolescent boys and their behaviour.

In this final chapter, the findings of the quantitative and case study analyses of this study will be reviewed. Although a full discussion was included at the various points of analysis in Chapters 4 and 5, the importance of these findings are now be discussed in terms of policy at the national and local level. On a policy context, this research hopes to inform policies and practices that support the inclusion of children in mainstream school or, when beneficial to them, a move to a specialist placement with expert provision. As such, potential implications of the suggested policy changes for children in schools will also be discussed. This is followed by a fuller dialogue regarding the implications to the practice of teachers and potential benefits to all pupils, not just those exhibiting challenging behaviour or with psychosocial problems. Aware of the relevance of sharing practitioner research, Section 6.5 proposes methods of dissemination of the findings of this project. Discussing the results in the school context, it is hoped that the findings will be particularly interesting to secondary school teachers in terms of their practice and school leaders who have a responsibility for providing positive support for pupil behaviour in secondary settings, although many of the findings will also be useful to staff in primary settings. Finally, recommendations are made with a view of possible future horizons for research following the publication of this study.

## 6.2 Review of Findings

In this dissertation, I explored the relationships between pubertal stage and behaviour; testosterone, cortisol and behaviour (endocrinological measures); pubertal stage, endocrinological measures and psychosocial functioning; and finally, psychosocial function and behaviour. I adopted a post-positivist approach to look for relationships between many variables. The main source of data was selected variables from the ALSPAC dataset, collected by researchers of the University of Bristol.

The dissertation builds on the literature review (Chapter 2), which determined avenues of exploration towards the analysis of specific biological, psychosocial and behavioural elements linked to the research questions.

The literature provided a rich source of empirical evidence that linked adolescence to psychosocial aspects of externalising and internalising behaviours, in particular for those who display atypical pubertal development (timing and tempo). However, examination of the literature revealed inconsistencies of findings when examining associations between pubertal development, psychosocial factors and challenging behaviour. To fill this gap, I cross checked the analysis of behaviour data with biological and psychosocial variables, looking to provide evidence towards potentially closing this gap in the literature.

Psychosocial measures and the behaviour of adolescents in school is an under-researched area. It may seem obvious that psychosocial development or status would affect both internalised symptoms and externalising behaviour in any age group. However, little empirical evidence was presented in the literature that links diagnostic psychosocial measures such as the SCDC and those that are predictive, such as the SDQ, to behaviour in school. Even fewer studies show how the education system responds to and supports those with challenging behaviour in school. Most of the studies undertaken focussed upon educational outcomes such as achievement, rather than behavioural challenges, although strong evidence suggests that the two are highly associated.

Within the limitations of the dataset, particularly with respect of variables to which access is available, conclusions have been reached relating to the research questions laid out above and other findings as a consequence of these analyses. The data analysis plan, relevant to the study research questions, was provided in Chapter 3. The results that follow from the data analysis are presented in line with the research questions.

A comparison was made between various measures of Tanner (pubertal) stage available in the dataset, these being parent or participant reporting of pubic hair distribution, genital development, height, weight, the presence of axillary (armpit) hair and whether voice change (deepening) had taken place. Analysis showed that pubic hair distribution was the most reliable self- or parent-measure of pubertal stage. Voice change and the presence of axillary hair was associated with Tanner stage 3, or mid-puberty. These findings were consistent with those the literature review (Chapter 2), although clinically, boys are considered to have entered puberty when testicular volume exceeds 4ml, which can only be determined by a paediatrician. However, for the purposes of this study, it is the progression through puberty with potential associations with psychosocial and behavioural measures that are relevant and so defining participant entry into puberty in not of interest. Plasma testosterone concentrations, Tanner stage, age and anthropometric variables such as height, weight and therefore BMI were all highly correlated with each other, which also confirms what is well known regarding associations between these biological factors (Appendix 5).

No direct, significant association was seen between the behaviour of boys at any age and salivary cortisol levels measured at age 8.5. However, during year 6, low cortisol levels at age 8.5 was strongly associated with defiance but placidity whereas high levels were strongly associated with starting fights and aggression. Boys with both extremes of cortisol levels exhibited spiteful, angry and resentful behaviour. The finding that atypical extremes of cortisol levels are associated with challenging behaviour in the school setting is novel. It is, however, difficult to determine whether adverse life experiences in and out of school cause both elevated cortisol levels and behaviour changes or whether these variables are distinct from each other. For example, could elevated cortisol levels result in adverse behaviour or could adverse behaviour, or the consequences of such, cause cortisol levels to be elevated? Evidence from other studies suggest that elevated salivary cortisol levels during pre-adolescence cause greater externalising behaviours in response to stress (Grotzinger et al., 2018; Lenneke et al., 2008; Roisman G, 2009; Shoal et al., 2003). Also, early stress is associated with early puberty, which is shown in this study to result in challenging behaviour.

The first two research questions imply an association between biological measures, that is, Tanner stage, testosterone, cortisol levels and challenging behaviour in boys. The findings of this study are that no evidence exists for an association between pubertal progression, or endocrinological values and challenging behaviour except for extreme outlier cases. Outlier cases, explored in depth in Chapter 5, were boys with advanced Tanner stage at age 11 and delayed Tanner stage at age 16. Although testosterone data was limited in the dataset, the strong correlation between Tanner stage and testosterone levels, allowed an impression to be formed that extreme high levels of testosterone at ages 9 & 11 is associated with challenging behaviour during year 6. Advanced Tanner stage and high testosterone levels at ages 9 & 11 was particularly associated with behaviours indicative of autistic spectrum disorder. Several studies have found an association between *in vivo* testosterone and later social communication disorders, however, only one publication (Bölte et al., 2011a) makes mention of autism and advanced pubertal stage and high testosterone levels in primary and early secondary-age boys, so the findings of this study add evidence to the latter.

The third research question required an investigation of biological changes during puberty and psychosocial functioning rather than challenging behaviour in school, which may be connected (see below). Analysis of the ALSPAC dataset did not show an associative trend between the biological variables stated above and social cognitive function as measured by Strengths and Difficulties Questionnaire (SDQ) Prosocial and Social Communication Disorders Checklist (SCDC) scores. The SDQ prosocial score is a measure of kindness towards and empathy with others and the SCDC score is a measure of social cognitive functioning. This does not confirm what is widely reported in the literature that a mid-adolescent decline is seen in executive functioning (EF). Such a decline is associated with lowered cognitive functioning and thus learning ability and also social cognition, a component of EF. Evidence shows that brain restructuring during adolescence, particularly that of the pre-frontal cortex, is responsible for this decline (Chapter 2). Classroom performance was not measured in this project and only the SCDC score was deemed relevant as a measure of social cognitive functioning. The lack of a mid-adolescent decline in social cognition in this study when compared with others could be due to the variables available in the secondary dataset used, however, as the SCDC is a robust measure of social cognitive function, the opposite findings could challenge the field. As with other biological measures and as stated above, only those at an advanced pubertal stage at ages 9 & 11 (consistent with high testosterone values at these ages) exhibited poor social cognitive function that was indicative of autism.

Regarding other measures of psychological difficulties, an association was only seen between the conduct, hyperactivity and total difficulties scores and pubertal development and thus testosterone levels. At age 11, there was a slight increase in the conduct score for participants at normal pubertal stages, however, boys at advanced pubertal stages showed abnormally high conduct scores, indicative of potential childhood conduct disorder. These high scores indicate significantly higher instances of challenging behaviour in and out of school. At age 16, there was a small, statistically insignificant association between delayed puberty and conduct disorder but only for boys just entering puberty. No significant association was evident between hyperactivity and pubertal stage at ages 11 and 13, except for boys with advanced puberty.

A very interesting relationship was seen between these two variables at age 16 in that a clear linear relationship was apparent between pubertal stage and hyperactivity with pre-pubertal stage sharing the same value as those at an adult pubertal stage. A similar pattern was seen between biological variables and overall psychological difficulties as determined by the SDQ total score in that early maturing boys at age 11 and late maturing boys at age 16, were reported as having more psychosocial problems than their typically developing peers. At age 13, an interesting linear increase in total problems between low to mid-pubertal stages was identified which then levelled off. This shows that at age 13, difficulties increase as pubertal development increases, but only up to what would be considered a normal pubertal stage for this age. Those below this pubertal stage experience less problems than their peers.

The final research question involved potential associations between psychosocial measures and the behaviour of boys in the school setting. The psychosocial variables SDQ hyperactivity, SDQ conduct, SDQ total scores were individually analysed with variables relating to participants' behaviour during year 6 reported in a primary teacher questionnaire, a parental questionnaire conducted at age 15 and two teacher questionnaires completed during year 11.

Results indicate a clear linear relationship between behaviour during year 6 and all psychosocial variables. A particularly strong association was evident between a high year 6 behaviour score and high SDQ hyperkinetic, conduct and SCDC scores. This indicates that boys with hyperkinetic, conduct disorders and autistic spectrum disorders exhibit the most challenging behaviour during the final year in primary school.

Relationships were evident between all elements of the parental questionnaire with psychosocial variables with the exception of truancy, however, this relies on parents knowing that their child played truant, which would not always be the case. Evidence from teacher questionnaires and school data differs in this respect (below). Boys exhibiting the signs of autism at age 15 were not considered by parents to be disruptive in school. However, this would only be determined by teacher reports home which could, again, be considered unreliable. The strongest association between disruptive behaviour in school was for boys with possible hyperkinetic disorders such as ADHD and to a lesser extent, those with a potential conduct disorder. Regarding behaviour at home, relationships were seen between all psychosocial values and awkwardness, temper outbursts, being argumentative and disobedient.

When comparing parental questionnaire data with that provided by teachers, boys who engaged in physical fights also showed aggressive behaviour at home and were disruptive in school. Boys experiencing the highest levels of difficulties and social cognitive problems were more often late to lessons and were more likely to play truant from school. Fixed-term exclusion from school was unsurprisingly associated with disruptive behaviour; however, it was also strongly associated with high SCDC scores and a high SDQ hyperactivity in school, indicators of an autistic spectrum disorder and ADHD respectively. There was a much smaller association between the SCDC score and teacher questionnaire variables at age 16 than at age 11, mainly due to a significantly smaller number of boys with high SCDC scores represented in the school data at age 16. Reasons for this could include exclusion before year 11, them receiving additional support or a specialist placement. Interestingly, boys with evidence of an autistic spectrum disorder at age 11 were more likely to be given multiple detentions and to be fixed-term excluded at age 16 than their peers. At age 16, multiple detentions and fixed-term exclusions were more evident in boys exhibiting signs of autism and a high degree of general difficulties. This is not true of permanent exclusion where the only association at age 16 was seen with significant conduct problems.

Evidence gained during the multivariate analyses between all groups of variables conducted in Chapter 4 justified the need for a case study approach focussing upon participants with extreme outlier values, which was the theme of Chapter 5. Associations between psychosocial problems and challenging behaviour of the participants with extreme biological values were explored.

In the ALSPAC dataset, 18 boys showed atypical pubertal development, 10 with advanced pubertal development at age 11 and 8 with late physical development at age 16. Psychosocial and behaviour variables for these boys with atypical pubertal development were analysed. Of those with advanced pubertal development, 6 of them experienced either psychosocial or behavioural difficulties and three had both psychosocial and behavioural difficulties including up to five years later during year 11. Of those with delayed pubertal development, 5 experienced psychosocial or behavioural difficulties. One had challenging behaviour during year 6 and year 11 which is aligned to the general trend stated above that challenging behaviour during year 6 is a predictor of poor outcomes during secondary schooling. Three of the early maturing participants showed significantly challenging behaviour during year 6 and were frequently excluded during year 11. Four of the 8 late developing students displayed both challenging behaviour and psychosocial difficulties. A high proportion of early developing boys also showed traits suggestive of hyperkinetic disorders such as ADHD, associated with less formal schooling and poor academic attainment. Most parental concerns regarding early developing boys were related to behaviours suggestive of autistic spectrum disorder and, as with hyperkinetic disorders, there was evidence of exclusionary practices towards these boys which in turn is linked to low grade employment. Children with ADHD are greater than 7 times more likely to suffer drug abuse problems or an antisocial personality disorder in adulthood (Section 5.4).

During the literature review, several papers identified associations between anthropometric values such as height, weight and body mass index (BMI) with measures of psychosocial functioning and behaviour. Obesity is linked to mental health problems and increased odds of psychosocial dysfunction, ADHD and learning difficulties. Tershkovec, Weller and Gallagher (1994) found that over half of the children in special needs classes were clinically obese. Generally speaking, girls with a higher BMI tend to go through puberty early and boys with a high BMI later, although the findings of this study did not show this trend in that none of the early maturing boys with psychosocial problems or challenging behaviour had an abnormal BMI, however, the sample size was small. Of the late maturing participants with psychosocial and behavioural difficulties, 5 of the 8 had an abnormal BMI at some stage of adolescence. Interestingly, of the randomly selected 10 typically-developing participants, all had a normal BMI.

Potential associations were explored between psychosocial and behaviour measures for boys with high testosterone and cortisol values. Of those with a high testosterone value at ages 9 or 11, over half experienced psychosocial and behavioural difficulties at age 11 and ‘downstream’ at age 16. All but one showed social cognitive dysfunction at some stage during adolescence providing further evidence that high pre-pubertal testosterone levels are associated with social communication disorders such as autism. Atypical cortisol levels in pre- or early-adolescence can have longitudinal effects with 16 of the 26 participants with abnormally high or low levels exhibiting challenging behaviour in school during late adolescence. Low cortisol levels were associated with emotional symptoms such as being worried, tearful, nervous and with peer problems such as being bullied or socially isolated.

Exclusion is the most significant sanction handed down by schools and, with multiple detentions, is a sign of significant challenging behaviour. Schools identified 24 students as being 'often excluded' with all of them exhibiting challenging behaviour. Of those excluded during year 11, half exhibited challenging behaviour during year 6 indicating the predictive value of earlier behaviour profiling and the need for meaningful early intervention and support. Of those showing some degree of social cognitive dysfunction indicative of autism, roughly half were excluded during year 11. So, the findings of this study show that a large proportion of those who are excluded from school have a learning disability or difficulty or a psychosocial problem, many of which are apparent during year 6.

In conclusion, analysis of the ALSPAC dataset showed no statistically significant evidence that the general behaviour of adolescent boys changes as pubertal development progresses. Likewise, neither plasma testosterone or cortisol concentrations are associated with adverse behaviour in or out of the school setting for the general population of adolescent boys. These biological factors are not associated with psychosocial functioning. However, those individuals who are at an abnormally advanced pubertal stage at age 11 or delayed puberty at age 16 also show extremes of behaviour and psychosocial problems. The same is true of those with abnormally high or low testosterone and cortisol values. There is, therefore, a relationship between psychosocial measures in adolescent boys and their behaviour, particularly high Social and Communication Difficulties Checklist scores and high Strengths and Difficulties Questionnaire scores that relate to behaviour and total difficulties. It must be noted that a high Social and Communication Difficulties Checklist score is a diagnostic indicator of autistic spectrum disorder and the Strengths and Difficulties Questionnaire score of hyperkinetic and childhood conduct disorder along with potential or developing mental health problems. It must be borne in mind that despite being diagnostic indicators and valid measures of the difficulties that children experience, the measures arising from these questionnaires have limitations and are not diagnostic in themselves. Psychiatric evaluation or assessment by an educational psychologist is usually required for a diagnosis to take place (Wearmouth, 2009). In many settings, a diagnosis is required before additional learning or behavioural support will be provided by schools. The importance of these research findings, especially when considering the possibility of learning disabilities and mental health problems, are discussed in the next Section, however, limitations in the data may have an effect on the strength of an impressions stated in the narrative that follows.

## 6.3 Limitations of the Study

Although these findings are compelling, it may be problematic making general inferences to all schools in the UK. The custodians of the ALSPAC dataset and the many researchers who have used the data in various projects highlight that the data were collected in mostly affluent areas in the Avon geographical area. In addition, Avon and Somerset are not counties renowned for being ethnically and culturally diverse. As stated in Chapter 2, socioeconomic status and family culture, in particular, are associated with the psychosocial and behavioural profiles of participants. The practices of schools in different localities will also influence behaviour outcomes. Areas in which schools are well funded are more likely to be able to afford transition programmes, expert help, in-classroom support and specialist teachers. As discussed in the sections that follow, exclusionary practices in some areas differ and will also have differed in relation to practices over time. For example, it has been established that the recently formed academies are more exclusionary than schools under local authority control and that exclusions are far more prevalent now than they were when the ALSPAC data used in this study was collected (Sections 6.4 & 6.6). It may also be true that schools provide better screening and support than before but there is little evidence to support this assertion (Lindsay, 2018).

As well as limitations in terms of the socioeconomic, cultural and ethnicities of participants, there are significant gaps in the dataset. Utopia would be a situation where biological, psychosocial and behavioural data existed at every stage of adolescence for a large and diverse population sampled from all areas of the UK. However, endocrinological data only existed for around 300 or the 7,500 boys involved in the study and pubertal data for less than 2,000. School behaviour data was only available for participants during the last year of primary and the last year of secondary schooling. Likewise, psychosocial data was not available for every participant.

Due to limitations in the ALSPAC dataset and because time and resources are finite, especially to a sole researcher undertaking a doctoral study, it was not be possible to contribute evidence to refute or support all of the empirical studies discussed above, however fascinating or compelling. This was unfortunate as not all of the findings of these studies are complementary. For instance, data was not available to this project regarding the mental health of participants. Some studies attribute poorer mental health to early maturation whereas some attribute it to late pubertal development. However, the Strengths and Difficulties Questionnaire (SDQ) data can be used to predict future mental health problems in both groups of participants and was available to this project. In addition, evidence may be added to these theories and studies through the analysis of pubertal timing, psychosocial difficulties and challenging behaviour, the variables for which were also available.

A strength of this study is that these limitations were, to a significant degree, overcome and new variables were created from existing data to aid both quantitative and case study analysis (Chapter 3). Had more time and resources been available, it would have been interesting to follow the original plan of running a two-phase investigation. ALSPAC data could have been used to approximate biological values based in non-invasive indicators such as changes in height and a focussed questionnaire to elicit specific findings of interest completed locally. The outcomes of this study could be used as phase one of a future study (Section 6.7). A doctoral journey involves explorations of themes that may end as ‘blind alleys’ and with hindsight, a strong focus on themes specifically relating to the research questions would have made the project more time efficient.

## 6.4 Importance of the Findings: Who Benefits and Implications for Policy & Practice

At the forefront of the professional researcher’s mind should be the question, “Who is really ‘empowered’ by the research and who really benefits?” This may not always involve findings specifically linked to research questions. On occasions, a project may contribute to knowledge in other ways such as new methods for analysis or novel research methods. This project was one of the first to use the emerging practice of ‘qualitising’ (Onwuegbuzie & Leech, in press) and is discussed below and in Chapter 3.

Although this project did not involve the implementation and evaluation of behaviour management strategies, speculatively, the findings alongside other recent results in developmental cognitive neuroscience research, may have beneficial implications for education across the period of puberty and adolescence (Burnett et al., 2011). It is hoped that an understanding of how children with additional psychosocial needs can be included in mainstream schools will be facilitated and the number of exclusions reduced. A possible result of such understanding is the formation of a number of interventions that may improve the behaviour and inclusion of boys with challenging behaviour, since their life chances are often poor (Pallett, 2016):

- <1% of children are in care but 40% of prisoners under 21 have been in care, many of whom have social, emotional and behavioural difficulties;
- 25% of those in the youth justice system have a special educational need or disability and 46% are or were rated as underachieving at school;
- 52% of young offenders have been permanently excluded from school.

As stated previously, the principal aim of this study was to use arguments based on the quantitative and case study analysis of biological, psychosocial and behavioural variables to help inform policies and practices that support the inclusion of children in mainstream school or, when beneficial to them, a move to a specialist placement with expert provision. This is desirable for a number of reasons that may be grouped into three key themes: beneficence and non-maleficence towards the child with challenging behaviour; providing an environment where all children feel safe and are able to achieve to their full potential; and a workplace where the wellbeing of staff is considered as important as that of the children. These themes are relevant to both policy and practice.

In the introduction, I discussed a few cases of individual boys exhibiting challenging behaviour. Although identified as being 'bad' by a number of professional staff and other students, worthy of harsh punishment and exclusion, there were a number of circumstances that made their behaviour understandable and attributable to the intrinsic factors and extrinsic difficulties they faced (outlined here using pseudonyms). At the time he entered puberty, one boy's behaviour changed drastically. He went from being a pleasant and caring boy to one who exhibited challenging behaviour in school, engaged in antisocial behaviour out of school and was arrested twice for criminal offences including theft and criminal damage. As abruptly as his behaviour changed for the worse, it resolved, and his character and behaviour returned to 'normal.' In terms of beneficence, I used my professional learning and influence, being in the process of undertaking research into challenging behaviour in boys, to support his inclusion and provide mechanisms for support during the difficult stage of his schooling. I was in the privileged position of having the appreciation, knowledge and skills to be able to, in the definition of beneficence, to 'do or produce good' for him, part of the code of practice for many professional groups. The findings of this study justify my actions in ensuring his inclusion in the mainstream setting and provide potential explanations for his behaviour.

Non-maleficence is not engaging in professional ‘acts of committing harm or evil’ which is of particular import for those engaging in research involving human participants but can also be related to practices by educational professionals. It could be robustly argued that teachers and school leaders engaging in vengeful punishments and exclusionary practices exemplifies maleficence at worse and unethical practice at least, especially considering the findings of this study, which highlights exclusionary practices with regard to children with ADHD and autism in particular. In fact, over the past year (2018/19), broadsheet newspapers, particularly the Guardian, have published several articles about unethical, harsh and in some cases illegal exclusionary practices, adopted by secondary schools, particularly multi-academy trusts. In one article, based on a report from the National Audit Office, it was noted that children with special educational needs or disabilities (SEND) were more likely to be permanently excluded or ‘off-rolled’ than those without special needs. Despite representing only 20% of the school population, children with SEND accounted for 45% of permanent exclusions and 43% of fixed-term exclusions. ‘Off-rolling’ is a situation where schools encourage parents to remove a child for the school’s benefit only, a practice which is described as ‘exclusion by the back door’ and is illegal (Adams, 2019).

The findings of this study are as equally valid when informing potential improvements to local and national policies, the need for which is evidenced by the above discussion of negative practices. For example, internal exclusions could come under the same legal framework as fixed-term exclusions where schools have to report the number of times individual children are placed in isolation, for how long and for what reasons. Mandatory tests for psychosocial problems could be implemented for children who are internally, or fixed-term excluded more than twice in one school term, for example. If a learning disability or difficulty is identified, the child should be offered support rather than punishment where the adverse behaviour is likely to be linked to the child’s biopsychosocial condition. Specialist provision should be considered either in a specialist unit attached to the school or a specialist placement that caters for children with alternative needs. Placement in specialist units attached to schools can be considered as an alternative to exclusion and this has been successfully employed by some schools (Price, 2008; Sproson, 2004; Sproson, 2010). The Department for Education should consider banning zero tolerance (assertive discipline) policies (Canter and Canter, 1992) and give schools more robust guidance regarding positive behaviour policies that are evidence-based wherever possible. These policies should take a step-wise approach to behaviour management meaning that isolating or fixed-term excluding a child for minor infractions would not take place, “The challenge for schools is to enact polices that do not aim simply to control students but rather aim to treat students with respect and enable them to develop as individuals with a sense of agency within a community of learners” (Johnson & Sullivan, 2016, p. 163). As evidenced in Chapter 1, there has been movement to close specialist behaviour units such as Pupil Referral Units[27] diverting funding to schools instead. It is argued that many schools lack the professional resources and expertise to support children with severely challenging behaviour and so the restoration of specialist behaviour facilities is indicated. Although my research shows that many could be supported in mainstream settings, there will always be children for whom a specialist placement is imperative to have any chance of acquiring a decent education.

Far from being disinterested in biological and psychological aspects of their students’ development, there is strong evidence to suggest that teachers are keen to understand these mechanisms particularly relating to behaviour and learning. Blakemore (2018, p.16), reflecting on her experiences of engaging in conferences and masterclasses with teachers, wrote that they are an “avid audience” for her research and that “teachers tend to be really interested in the findings from adolescent brain science because it gives them a window […] about what’s going on in the brains of the young people they teach.” The findings of this study are, therefore, potentially valuable to teachers and could make a difference to their practice, particularly by signposting potential interventions to support learning and inclusivity.

As well as importance to policy and practice, this study is of theoretical importance, particularly in making a contribution to the rare and emerging field of ‘qualitising’ which is essentially the opposite of the widespread practice of ‘quantitising’, where qualitative data is converted into numerical codes that can be analysed statistically (Miles & Huberman, 1994). *Qualitising* involves the transformation of quantitative data into a qualitative form which could involve devising narratives to explore the meaning of numerical data that can be analysed qualitatively. In this study, a quantitative analysis of data variables (Chapter 4) lead to the identification for the need to conduct a case study analysis of participants with extreme

[27] Pupil Referral Units (PRUs) are specialist institutions, run by local authorities, that provide a reduced education for children who have been permanently excluded from secondary school.

outlier values involving modal profiling (Chapter 5). According to Onwuegbuzie and Leach (in press), modal profiles "are detailed narrative descriptions of a group of individuals that are based on the most frequently occurring attributes in the group that they represent." Normative profiling, where a narrative relating to an individual is compared with a standard such as a normative group also featured in Chapter 5, which is innovative in this context.

As stated in Chapters 1 & 2, quantitative research into biopsychological association with school behaviour in adolescents is equally rare. Because such evidence is not commonly conducted and disseminated, many assumptions have been made about adolescent behaviour. For example, a common misconception evident in statements made by adults is 'hormones' are directly responsible for challenging behaviour in adolescent, which is not supported by the data analyses in this study except for boys in the extreme outlier category and even so, it would be inappropriate to infer causality. The findings of this study are key to dismissing this and many other misconceptions such as pubertal stage being related to adverse behaviours and that psychosocial difficulties are associated with inclusionary practices in schools.

In conclusion, the most important aspect for me is the moral imperative, that is, the welfare of children and staff in schools. In the narrative above, I proposed that punishing children for having a disability is immoral. In Chapter 2, the impact of poor behaviour on teachers and other children was stated. It is hoped that the evidence provided by this research is used to support a model of behaviour provision that is inclusive in the mainstream school setting for boys with challenging behaviour, based on an understanding of their responses to psychological and biological factors. If it is in the child's best interest, evidence from this study may hasten and make more reliable their transfer to specialist provision where it is indicated. If significantly challenging behaviour of some and general misbehaviour in schools is reduced, staff benefit from a better teaching and working environment and as a consequence, the learning experience of all children will improve. The dissemination of these findings is important in instigating debate and the need for change.

## 6.5 Dissemination

> *"I hope that someday we will learn the terrible cost we all pay when we ignore or mismanage those people in society who most need our help."*
>
> The Hon. Judge Sandra Hamilton, Alberta.

This statement, made in the context of teacher classroom management, highlights not only the importance of behavioural research but also the need for the dissemination of the findings of such. The communication of research findings is particularly important in the context of a professional doctorate, the purpose of which is to challenge and inform practice in a vocational setting.

The principal aim of dissemination of the project findings to teachers, school leaders and educational policy-makers is the potential for a significant, positive impact on the behaviour, inclusion and achievement of boys with challenging behaviour. Greater understanding will help the design and implementation of specific strategies and interventions with a reduction in psychological distress for the children, their families and school staff, which makes the project worthwhile.

It is believed that, if the evidence from this study is presented in a persuasive manner and is widely communicated, school leaders may decide to allocate more resources to educational rehabilitation programmes that consider the natural changes that take place in adolescent psychology. Lerner & Steinburg (2009) state that, in general, school policies are not orientated towards social development and the timing of puberty, which often leads to lost opportunities for promoting positive youth development. This can be attributed in part to a lack of information and evidence provided to school leaders.

This dissertation will, by convention and according to regulations, be placed in the University Library. It is a realistic prospect that without further action, the important findings and recommendations contained therein could be lost forever. Since the 1st October 2017, the University of Cambridge Board of Graduate Studies made it a requirement for all doctoral students to provide a digital and hard copy of their thesis. Individuals can choose to have their thesis made open source to allow wider dissemination, which I will permit in the case of this dissertation.

Although open source publication may improve the circulation of this dissertation, there are methods of communication that are likely to be more successful in widening its readership and impact. It is hoped that several journal publications and conference appearances will follow the completion of the project. It is feasible that the findings and recommendations are communicated through invitations to contribute to courses such as initial teacher training, educational policy and the few remaining modules that feature classroom management. It must be remembered that the latter is a cause of concern for many student and newly qualified teachers in particular. In England, it is a requirement for state schools to undertake five days of professional development training each year. It may be possible to provide resources so that senior leaders can present key findings of this study with activities such as discussion groups. There may be a medium, probably through charities and support groups, where parents of children with challenging behaviour could be informed and advised to either improve inclusivity or gain admission to an appropriate placement. Knowledge gained through this study has already helped one child with a hyperkinetic disorder, who was persistently put in isolation in his mainstream academy, to gain entry to a supportive special school following advice given to his parents (Section 6.6).

The findings in Sections 6.2 and the recommendations in Section 6.6 are particularly important and will be disseminated more widely. It is feasible to publish these in publications with a wide teacher readership, such as quality newspapers with science and education sections (e.g. The Guardian and The Times) and the publication of a teacher guide as recently produced by the Times Educational Supplement entitled, “Two hormones and a neurotransmitter” (Parr, 2019). In this short booklet, technical and scientific information were expressed in an accessible way.

With a growth in the number of people who have access the Internet, websites and Twitter feeds are a timely and efficient way of disseminating research information. Likewise, video repositories such as YouTube are an increasingly popular way of gaining information about contemporary research. I found this technique useful during the dissemination of the research findings of a previous study conducted with dyslexic children as participants (Butler, 2011). In particular, teachers and teaching assistants found the information presented in a video format to be interesting and easier to contextualise and assimilate. Through Internet searches, researchers and those with a more general interest, can engage with the research process and access findings. Greene (2009) authored a website to disseminate the findings of his PhD, which indirectly led to his model of proactive and collaborative solutions to challenging behaviour being adopted in a whole school district in one US state and incorporated into the strategies of young offender institutions. This adds weight to a plan for dissemination through online resources, which I am currently considering.

## 6.6 Recommendations

This Section is a discussion of possible behaviour strategies or interventions that these findings may inform. Understanding how biopsychological development with age affects social emotions and behaviour, for example, could transform strategies and enable the design of programmes that optimise learning for children and young people with alternative needs. In this Section, I will recourse to instruments and programmes that are beyond the scope of this research. In doing so, I justify their inclusion as a contribution for the better management of problematic behaviour in schools, with a focus on supporting teachers. To illustrate, it is known that social cognition helps shape learning and academic performance and may assist in the development of an understanding of the origins or educational success and failure (Burnett et al., 2011), so the next pages will make reference to such strategies in relation to the study findings.

This study has shown that a number of measures are predictive of challenging behaviour as well as psychosocial difficulties during pre- and early-adolescence. Despite being reliable, it would be impractical to assess all of these factors in a school setting, for example, collecting biological samples, pubertal and anthropometric data from children would be costly and raise a number of important ethical issues and objections. In any case, should abnormal plasma testosterone, cortisol or an atypical pubertal stage be identified, it would be difficult to design specific interventions around these biological measures. Teacher understanding of the issues faced by early or late developing children may be helpful and they may note that although a child may look like an adult in size, this does not reflect their psychological development and their ability to cope with the demands placed on them (Chapter 2). A key message for teachers is that awareness and empathy is needed as a first step. This may be due to a lack of teacher knowledge that dissemination of the project findings will work towards addressing.

This study provided evidence of the disadvantage faced by boys with psychosocial difficulties. Screening for additional needs can be easy and cost-effective and I am compelled to call attention to the relevance of the instruments analysed in this research. A number of schools subscribe to an online version of the Strengths and Difficulty Questionnaire (SDQ). This is often scheduled during computing lessons during year 7 (first year of secondary schooling in the UK) where every child has access to a computer. The results can be downloaded from the provider's website by secure connection and analysed by specialist teachers. High total scores are indicative of later mental health problems and individual scores can indicate the focus for individualised support. A free, paper-based version can be downloaded by schools if the online questionnaire provision is too costly (https://youthinmind.com/products-and-services/sdq/).

Equally resourceful to assess students’ psychosocial state is the Social Communication Disorders Checklist (SCDC), which is a simple 12 question survey for parents, teachers and children themselves. The checklist is available to schools, specialist clinics and researchers from academic sources. This could be completed and scored during registration time (the first part of the school day) during the first term of secondary schooling by children and parents or by primary teachers and parents. Its simple layout can indicate the need for professional assessment of conditions such as autism. Results can inform the need for specialist support throughout the child’s schooling or the need for a specialist placement. The findings of this study are that boys with scores indicative of an autistic spectrum disorder are often repeatedly punished or excluded by schools, so if such difficulties can be identified early, strategies can be supportive rather than punitive.

The findings of chapters 4 and 5 show that children with hyperkinetic disorders such as Attention Deficit Hyperactivity Disorder (ADHD) often face multiple detentions and exclusionary practices in school. However, the SDQ only has one subset of questions relating to hyperactivity that could not be used for screening purposes rather than an indication that screening for ADHD is advisable. A reliable and widely used screening tool for ADHD and a number of other behavioural and academic issues is the Conner’s Comprehensive Behaviour Rating Scale (Sparrow, 2010). It is applicable to children aged between 6 and 18 years-old. Because the materials are copyrighted, and it would be expensive to screen groups but an awareness through dissemination to middle-leaders in schools could lead to it being used more frequently for children with challenging, particularly disruptive behaviour. These are just the measures included in this study, so this list is not restrictive; there are many other tests and screening tools used to identify potential causes of problematic behaviour in school-age children.

Identification of specific psychosocial problems or contexts for challenging behaviour can lead to interventions that positively support behaviour changes and inclusivity. These include, pharmaceutical interventions, nurture groups, training to develop Theory of the Mind (ToM) or mindfulness, positive behaviour strategies such as ‘Plan B’ (Greene, 2009), cognitive-based therapy (CBT), solution-focussed programmes, withdrawal sessions and in-class support including peer mentoring (Boxhall, 2000; Butler, 2010, 2011; Sutherland & Sutherland, 2008; Wearmouth et al., 2004). Outcomes have often been highly favourable and compelling evidence has been provided to support the often behaviourist theories behind these successes. The most promising interventions will now be outlined as a full discussion is not possible within the confines of this dissertation and the reader can discover more for themselves if interested. It is not appropriate to discuss pharmaceutical interventions for ADHD or those relating to CBT since these cannot be introduced by teachers. However, group interventions based on social cognitive theory can be delivered by teachers to improve situational perception and behavioural capabilities (Rogers & King, 2013). Likewise, social skills training-based cognitive-behavioural intervention can also be introduced into schools without the need to be led by trained therapists (Spence et al., 2000). These programmes, designed for adolescents with high-functioning autism, may also be of benefit to boys with poor social cognitive functioning (White et al., 2010).

Nurture groups are focused, short-term interventions consisting of small groups of children led by a nurture group teacher and classroom assistant. Children attend the nurture group according to their individual needs and focus on social and emotional needs. The groups help children to attend to the needs of others, to listen to others and be listened to (Boxhall, 2000). The nurture group approach has been used in primary schools for a number of years and is beginning to become more widespread in secondary education as a method of support for children with social, emotional and behavioural difficulties (Syrnyk, 2012). As well as helping children to develop academically and socially, the nurture groups also promote self-confidence, self-respect, responsiveness to others and a pride in behaving well and achieving.

Early adolescence could be a fruitful time for interventions or educational programmes to focus on empathy. In the context of this project, the suggestion is for the use of Theory of Mind (ToM), mindfulness and peer support. ToM is given to the theory of understanding the behaviour of conspecifics and being able to interpret and predict behaviours in others (Korkmaz, 2011). Individuals with social communication disorders such as autism (as discussed in the previous Section) usually have poor ToM ability which leads to adverse behaviour and may account for their high levels of exclusion. Mindfulness in the context of education is the ability or state to be aware and purposefully pay attention in a non-judgemental way and has been shown in several studies to support socioemotional functioning and the cognitive abilities of adolescents in the school setting. Such cognitive abilities include reading comprehension and working memory. Improvements gained also include social cognition, which has been shown to reduce fixed-term exclusion and improve school attendance (Caballero et al., 2019). Caballero used the Mindful Attention Awareness Scale (MAAS) to assess mindfulness in their study and found it to be reliable in educational settings with good psychometric properties. They suggest that mindfulness is not a fixed trait and so interventions can be developed to improve mindfulness in individuals where a need is evident.

Despite early adolescence being identified as the most fruitful time for interventions, there is evidence to suggest that interventions can be useful at any stage during adolescence. In a study cited by Blakemore (2017), 660 young people between the ages of 11 and 30 were ‘trained’ in order to develop a number of different cognitive skills. Individuals made more progress in late rather than early adolescence, “which is interesting as that result goes against the traditional assumption that earlier is always better for learning” (Blakemore, 2017, p.17). However, early identification of the need for intervention would allow for sustained support to be provided rather than leaving it when it is too late. The key point is that an intervention can be successful at any age and should be considered whenever problematic behaviour arises.

A good example of a positive behaviour strategy is the Collaborative Problem Solving® (CPS) approach. This model has been extremely effective with children and adolescents exhibiting a wide range of SEBD in a variety of settings including schools. There are two major tenets: (1) challenges are due to ‘lagging thinking skills’ rather than labelling behaviours as attention-seeking, manipulative, limit-testing, or a sign of poor motivation; and (2) ‘that these challenges are best addressed by teaching children the skills they lack (rather than through reward and punishment programs and intensive imposition of adult will)’ (Greene, 2009). This is similar to the ‘metaphorical suitcase’ approach described by Sproson (2004) in the literature review where children with SEBD are given items (skills) for their suitcase to help them cope with triggers for challenging behaviour. There are various testaments to the effectiveness of these strategies.

The main principle of solution-focussed programmes is to support individuals to refocus upon solutions to their problems rather than the problems themselves. There are a number of core components such as solutions can be found without understanding the problem, everyone is capable of helping themselves, focus on the future as the past cannot be changed and that if you have an idea where you want to be, it makes it easier to get there. Resources and guides can be purchased for teachers to use during group sessions. Research in schools shows that only a small number of sessions are required and several studies have found positive outcomes in terms of behaviour improvement and improved social skills (Butler, 2010; Focusing on Solutions: A Positive Approach to Improving Behaviour, 2005).

Withdrawal is simply a method of deescalating situations where challenging behaviour is causing serious disruption. The child is taken out of the situation by a trusted adult or can self-withdraw to them as a method of support when things go wrong. It gives them the opportunity to calm down and be talked through the triggers for the behaviour and more appropriate strategies and responses (Butler, 2010).

However, not all behaviour management strategies used in schools are successful, which could be attributable to a lack of specificity: “a ‘one size fits all’ strategy is unlikely to be successful for our most vulnerable students” (Neville-Tisdall & Milne, 2008, p.69). Conversely, this may account for the success of the CPS strategy in which the child or young person is assessed as a unique individual with interventions designed around identified needs. Anecdotally, I have had successes with boys exhibiting severely challenging behaviour using the “Plan B approach” introduced as part of my study of CPS techniques.

The list of interventions is not exhaustive. There are many other strategies and interventions to improve behaviour in schools. For example, I have also trialled teaching early adolescents about the neurological changes that occur during puberty. As predicted by Burnett et al. (2011), pupils found learning about the changes going on in their brains very interesting but as of yet, no evaluation of these metacognitive approaches to behaviour support has taken place to ascertain if any benefits exist (Kuhn, 2006). Whole-school approaches to support behaviour and inclusion are integral to any plan to improve the challenging behaviour of children with SEBD. Sproson’s (2004, p. 135) notion that good classroom and school management strategies based on positivity and respect, with the provision of coping strategies developed for use by those with challenging behaviour, leads to a high degree of success, “if success is defined as having a classroom, indeed a whole school, in which students can learn and feel safe.” By supporting those with behavioural difficulties, it is hoped that they can be included in mainstream education with the promotion of achievement and wellbeing for all.

When considering behaviour in schools, generally as well as for those with SEND, it is important to note that there is no ‘golden bullet’ or specific intervention that will work in all situations and for all students (Greene, 2009). A seminar held to consider student behaviour had the truthful title, “If there was an answer, somebody would have found it by now” (Sproson, 2004, p. 137). However, some approaches do seem to reduce incidents of misbehaviour, particularly those that have a sociocultural approach and those that tailor interventions or strategies constructed around the needs of individual children with challenging behaviour. Despite the almost exclusively adolescent population in secondary schools, policy is not orientated towards the implications of pubertal timing and the associated social development needs. Lerner & Steinburg (2009) report that this represents a lost opportunity for promoting positive, socially valued youth development rather than fostering deviant peer activities. Sociocultural approaches attempt to create a learning environment where all children feel included and able to work with, rather than against, the aims and aspirations of the school (Younger et al., 2005).

## 6.7 Future Horizons

In terms of future research, there are a number of interesting potential future horizons that could stem from this project. Firstly, there is little research on the effects of biological factors on behaviour in school, particularly for those physically developing early or late with challenging behaviour. The number of children this represents is only 0.1% of the ALSPAC sample but potentially corresponds to 10,000 per million boys in the general school population, thus a substantial problem. This finding justifies more research involving boys with atypical pubertal development or testosterone and cortisol values.

It would be interesting to conduct a similar study to this in local schools using the Development and Well-Being Assessment (DAWBA) (*Dawba*, n.d.), the Social Communication Disorder Checklist (SCDC) and the Strengths and Difficulties Questionnaire (SDQ) to see if associations exist between the former and latter two in children with and without challenging behaviour. The DAWBA is a standardised assessment for common child mental health problems, including ADHD. This would also be useful in exploring if general screening for behaviour and learning difficulties and potential mental health problems in children would be useful and justified.

Research conducted by Blakemore & Choudhury (2006), which is highly relevant to education, shows that it is arguably worth investing more in educational rehabilitation that considers the natural developmental changes in adolescent psychology than paying for the consequences of inaction such as disruption, underachievement and crime. In the emerging field of educational neuroscience, cross-cultural collaboration between the fields of biology, education and the cognitive and developmental behavioural sciences are encouraged (*Welcome to the International Mind, Brain and Education Society (IMBES) Website*, 2013). Particularly pertinent is the IMBES aim to improve teachers' understanding of adolescent behaviour in order that they may devise learning strategies that support students in an holistic way.

The potential psychobiological basis for such varying behaviour is an interesting line of research as it could affect how such behaviour is managed and supported by senior professionals in schools and youth organisations. As with other potential findings of this research, if the cause of the behaviour is predominantly neuropsychological, it is wholly inappropriate on a number of levels to attempt to manage it by the application of punishments. In particular, an understanding of how children with alternative socio-emotional needs can be included in mainstream schools and how to reduce exclusion is an ethical imperative (Burnett et al., 2011), indeed, a deeper understanding of the causes of adverse behaviour is likely to reinforce the need for schools to treat students in a holistic way, supporting their rights and providing a learning environment that is conducive to their needs. Many of the children in question will have an emotional, social or behavioural disability/difficulty, so their inclusion with reasonable adjustments could arguably be a legal requirement under current legislation (Disability Discrimination Act, 2005; Special Educational Needs and Disability Act (SENDA), 2001). Compelling data is tangible to professionals and will likely be more influential when negotiating resources and support for individuals.

This dissertation is submitted for the degree of Doctor of Education not Doctor of Philosophy, the principal difference being that a key aim of the former is that the research must be directly applicable to, and contribute to, improvements in *practice*. As I stated in the introduction of this dissertation, my motivation for commencing this research were my experiences as a Head of Year in a large secondary school in the UK, where many of the boys in my care faced an educational journey full of punishments and exclusion. The key point is that these sanctions made no difference to their behaviour other than making them miserable, suffer low self-esteem and exacerbate the difficulties they faced. This caused me to consider the morality of how they were managed and to look for solutions to help them. During my research I looked at possible related factors such as psychosocial problems and biopsychological difficulties, which led to this project.

I sincerely hope that the findings stated in this dissertation and my recommendations are considered by as many of those who can influence practice in schools to consider changes that positively support the wellbeing and inclusion of children.

# Chapter 6: Conclusions and Recommendations

"If you always do what you've always done, you'll always get what you've always got!"

(Attributed to Henry Ford, quoted from Sproson, 2004).

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# Appendices

## 1: Extract from ALSPAC questionnaire on pubertal self-assessment

# GROWING AND CHANGING (5)

There are important changes to a boy's body that can happen as early as 6 or as late as 20. At this time in life we have some questions we need to ask and which we would appreciate hearing about.

**This questionnaire can be filled in by either parent or son.**

As always, if you don't want to answer a question, put a line through it. Your answers will of course be kept in confidence and not attached to your name.

*If you can only answer some of the questions, please send those back.*

THANK YOU VERY MUCH FOR YOUR HELP.

A1. What is your son's height (without shoes)?

The best way to measure **height** is to ask your son to stand barefoot as straight as possible against a wall, to make a mark on the wall at the highest point on the child's head, and to measure the distance from the mark to the floor.

A2. What is your son's weight (without shoes)?

A3. In the past month, what was the average number of times that your son participated in **vigorous** physical activity (such as running, football, swimming, athletics)?

**PHYSICAL DEVELOPMENT**

We would like to assess the stage of your son's physical development using the drawings on the next pages. These indicate various stages of puberty commonly used by doctors to assess the growth and development of boys.

**We need to know which drawings most closely match your son's stage of development at the moment.**

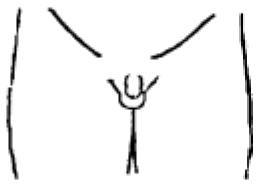
Not all children follow the same pattern of development.

**Just pick the stage that is closest, based on both the picture and the description.**

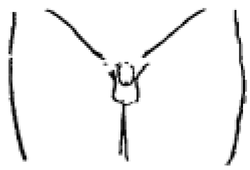
If there are any additional comments about your son's physical growth and development that you would like to make, then please do so here.

**SECTION B**

Boys go through the various stages of physical development at different ages. Some start as early as 6, others not until they are 16. We need your help in letting us know what stage your son is at. Please look at each of the drawings. It is also important to read the descriptions. Put a tick in the box that is **closest** to your son's current stage.

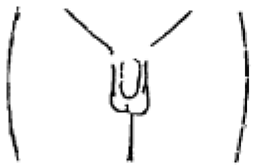


☐ 1 The size and shape of the testes, scrotum (the sac holding the testes) and penis are about the same as when he was younger.

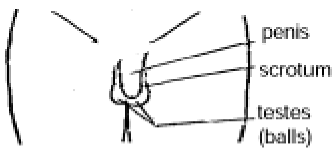


☐ 2 The penis is a little bit bigger. The scrotum has dropped and the skin of the scrotum has changed. The testes are bigger.

☐ 3 The penis has grown longer, the testes have grown and dropped lower.



☐ 4 The penis is longer and wider. The head of the penis is bigger, the scrotum is a darker colour and bigger. The testes are bigger.

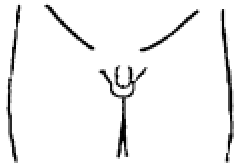



☐ 5 The penis, scrotum and testes are the size and shape of a man's.

☐ 6 Not sure

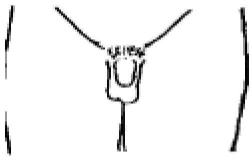
**SECTION C**

As part of development, at some stage hair will start to grow just above the penis. Please look at each of the drawings. It is also important to read the descriptions. Put a tick in the box that is **closest** to the amount of pubic hair that your son has.

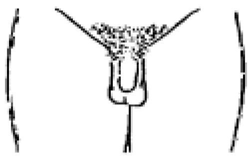


☐ 1 There is no hair at all.

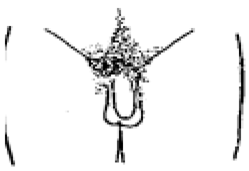
☐ 2 There is a little soft, long, lightly coloured hair at the base of the penis. It may be straight or a little curly.



☐ 3 The hair is darker and more curled. It has spread out and thinly covers a bigger area.



☐ 4 The hair is as dark and curly as that of a man, but it hasn't spread out to the legs.



☐ 5 The hair is like that of a man. It has spread out to the legs.

☐ 6 Not sure.

## 2: Research Ethics Review Checklist for Faculty of Education

### Section A: Details of the Project

| | |
|---|---|
| Student Name | Simon John Butler |
| Email | |
| Supervisor | Dr Ros McLellan |
| Supervisor email | |
| Registration Report Title | 'Understanding the Relationship between Social Cognition, Adolescent Boys' Development and their Behaviour in the School Context' |

### Section B: Checklist

| Code of Practice relating to Educational Research | | |
|---|---|---|
| 1a | Have you read the *Revised Ethical Guidelines for Educational Research* (2011) of the British Educational Research Association (BERA)? (if you have not read it, the latest version is available at http://www.bera.ac.uk/researchers-resources/publications/bera-ethical-guidelines-for-educational-research-2011 | Yes |
| 1b | Is this Code relevant to the conduct of your research? If you have answered 'no', please briefly explain why. | Yes |
| 1c | Do you agree to subscribe to the Code in carrying out your own research? | Yes |
| 2 | Are there any aspects of your proposed research which, in the context of BERA's Code of Practice, might give rise to concern amongst other educational | No |
| 3a | Will you be analysing an existing data set that has already been collected by someone else? | Yes |
| 3b | Have you have been given permission by the owner of the data set to undertake your own analysis and results | Yes |
| 4 | Will you be collecting your own research data for the study (through such techniques as interviewing people, observing situations, issuing questionnaires | No |
| **Obtaining 'Informed Consent'** | | |
| 5 | Are you familiar with the concept of 'informed consent'? (if you are not familiar with this concept you should first consult the following source: page 5 of the BERA guidelines above). | Yes |
| 6 | Does your research involve securing participation from children, young people or adults where the concept of 'informed consent' might apply? | No |
| 7a | Do you believe that you are adopting suitable safeguards with respect to obtaining 'informed consent' from participants in your research in line with the | Yes |
| 7b | Will all the information about individuals and institutions be treated on an 'in confidence' basis at all stages of your research including writing up and | Yes |
| 7c(i) | Will all the information collected about the institution(s) where research is based be presented in ways that guarantee the institution(s) cannot be identified from information provided in the report? | Yes |
| 7c(ii) | If not, has the appropriate responsible person given approval for the research on the understanding that the identity of the institution cannot be protected in the report of the research? | NA |

| | | |
|---|---|---|
| 7c(iii) | Will all the information collected about individuals be presented in ways that guarantee their anonymity? | Yes |
| 7c(iv) | If not, have these issues been explained to the relevant participants (and appropriate gatekeepers in the case of children or other vulnerable participants)? | NA |
| **The Involvement of Adults in the Research** | | |
| 8a | Will your research involve adults? | No |
| **The Involvement of Children, Young People and other potentially Vulnerable Persons in the Research** | | |
| 9a | Will your research involve children, young people or other potentially vulnerable persons (such as those with learning disabilities or your own students)? | No |
| **Other Ethical Aspects of the Research** | | |
| 10 | Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g. covert observation of people in public places) | No |
| 11 | Will the research involve the discussion of topics which some people may deem to be ‘sensitive’? (e.g. sexual activity, drug use, certain matters relating to political attitudes or religious beliefs) | No |
| 12 | Does the research involve any questions or activities which might be considered inappropriate in an educational setting? | No |
| 13 | Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind? | No |
| 14 | Will blood, tissue or other samples be taken from the bodies of participants? | No |
| 15 | Is pain or more than mild discomfort likely to result from the study? | No |
| 16 | Could the research involve psychological stress or anxiety or cause harm or negative consequences beyond the risks encountered in normal life? | No |
| 17 | Are there any other aspects of the research which could be interpreted as infringing the norms and expectations of behaviour prevailing in educational | No |
| 18 | Are there any other aspects of the research which could be to the participants’ detriment? | No |
| 19 | Will the study involve prolonged or repetitive testing? | No |
| 20 | Will financial inducements (other than reasonable expenses or compensation for time) be offered to participants? | No |

| | |
|---|---|
| On completion of the discussion, the 'knowledgeable person of standing' is asked to choose one of the following three responses, to delete the other two and to affirm their views by adding their signature. | |
| a | I have discussed the ethical dimensions of this research and, as outlined to me, I do not foresee any ethical issues arising which require further clearance. |
| b | There may be some ethical issues arising from this research. I think it would be prudent for the researcher to seek further advice and, possibly, Stage 3 clearance. |
| c | Ethical issues arise in this research which require further discussion; my advice is that Stage 3 ethical clearance should be sought. |

| | |
|---|---|
| Supervisor Name/ Signature | Dr Ros McLellan |
| Date | 1st October 2013 |
| | |

# 3: The data variables acquired from ALSPAC

| Code | Variable description |
|---|---|
| pub303 | A1: Child's height (cm) |
| pub304 | A2: Child's weight (kg) |
| pub350 | B: Development stage of testes, scrotum and penis |
| pub355 | C: Development stage of pubic hair (male) |
| pub360 | D1: Child's voice has changed |
| pub370 | A11/D2: Hair has started to grow in child's armpits |
| pub403 | A1: Child's height (cm) |
| pub404 | A2: Child's weight (kg) |
| pub450 | B: Development stage of testes, scrotum and penis |
| pub455 | C: Development stage of pubic hair (male) |
| pub460 | D1: Child's voice has changed |
| pub470 | A11/D2: Hair has started to grow in child's armpits |
| pub503 | A1: Child's height (cm) |
| pub504 | A2: Child's weight (kg) |
| pub550 | B: Development stage of testes, scrotum and penis |
| pub555 | C: Development stage of pubic hair (male) |
| pub560 | D1: Child's voice has changed |
| pub570 | A11/D2: Hair has started to grow in child's armpits |
| pub603 | A1: Respondent's height (cm) |
| pub604 | A2: Respondent's weight (kg) |
| pub650 | B (male): Development stage of testes, scrotum and penis |
| pub655 | C (male): Development stage of pubic hair |
| pub660 | A4 (male): Respondent's voice has changed |
| pub670 | A5 (male): Hair has started to grow in respondent's armpits |
| pub750 | B (male): Development stage of testes, scrotum and penis |
| pub755 | C (male): Development stage of pubic hair |
| pub760 | A2 (male): Respondent's voice has changed |
| pub770 | A3 (male): Hair has started to grow in respondent's armpits |
| pub803 | A1: Respondent's height (cm) |
| pub804 | A2: Respondent's weight (kg) |
| pub850 | B (male): Development stage of testes, scrotum and penis |
| pub855 | C (male): Development stage of pubic hair |
| pub860 | A4 (male): Respondent's voice has changed |
| pub870 | A5 (male): Hair has started to grow in respondent's armpits |
| pub903 | A1: Respondent's height (cm) |
| pub904 | A2: Respondent's weight (kg) |

| | |
|---|---|
| pub950 | B (male): Development stage of testes, scrotum and penis |
| pub955 | C (male): Development stage of pubic hair |
| pub960 | A4 (male): Respondent's voice has changed |
| pub970 | A5 (male): Hair has started to grow in respondent's armpits |
| kupemotion | SDQ emotional symptoms score (prorated) |
| kuhyper | SDQ hyperactivity score (prorated) |
| kupconduct | SDQ conduct problems score (prorated) |
| kuppeer | SDQ peer problems score (prorated) |
| kupprosoc | SDQ prosocial score (prorated) |
| kupebdtot | SDQ total difficulties score (prorated) |
| kwpemotion | SDQ emotional symptoms score (prorated) |
| kwhyper | SDQ hyperactivity score (prorated) |
| kwpconduct | SDQ conduct problems score (prorated) |
| kwppeer | SDQ peer problems score (prorated) |
| kwpprosoc | SDQ prosocial score (prorated) |
| kwpebdtot | SDQ total difficulties score (prorated) |
| tapemotion | SDQ emotional symptoms score (prorated) |
| tahyper | SDQ hyperactivity score (prorated) |
| tapconduct | SDQ conduct problems score (prorated) |
| tappeer | SDQ peer problems score (prorated) |
| tapprosoc | SDQ prosocial score (prorated) |
| tapebdtot | SDQ total difficulties score (prorated) |
| tcpemotion | SDQ emotional symptoms score (prorated) |
| tchyper | SDQ hyperactivity score (prorated) |
| tcpconduct | SDQ conduct problems score (prorated) |
| tcppeer | SDQ peer problems score (prorated) |
| tcpprosoc | SDQ prosocial score (prorated) |
| tcpebdtot | SDQ total difficulties score (prorated) |
| se100 | C1a: Degree to which child had temper tantrums in past school year |
| se101 | C1b: Degree to which child argued a lot with adults in past school year |
| se102 | C1c: Degree to which child was disobedient at school in past school year |
| se103 | C1d: Degree to which child deliberately annoyed people in past school year |
| se105 | C1f: Degree to which child was easily annoyed by others in past school year |
| se106 | C1g: Degree to which child was angry & resentful in past school year |
| se107 | C1h: Degree to which child was spiteful in past school year |
| se110 | C1k: Degree to which child started fights in past school year |
| se111 | C1l: Degree to which child bullied others in past school year |
| se114 | C1o: Degree to which child was physically cruel in past school year |
| se119 | C1t: Degree to which child showed unwanted sexual behaviour in past school year |
| kv8520 | N3a: In past 6 months child was not aware of others feelings |

| | |
|---|---|
| kv8521 | N3b: In past 6 months child did not realise when others were upset |
| kv8522 | N3c: In past 6 months child did not notice the effect of behaviour on family members |
| kv8523 | N3d: In past 6 months childs behaviour has disrupted family life |
| kv8524 | N3e: In past 6 months child as been very demanding of other time |
| kv8525 | N3f: In past 6 months child was difficult to reason with when upset |
| kv8526 | N3g: In past 6 months child did not seem to understand social skills |
| kv8527 | N3h: In past 6 months child did not pick up on body language |
| kv8528 | N3i: In past 6 months child did not understand how to behave in public |
| kv8529 | N3j: In past 6 months child did not understand when child was offending people |
| kv8530 | N3k: In past 6 months child did not respond when told to do something |
| kv8531 | N3l: In past 6 months child could not follow commands unless carefully worded |
| kv8532 | N3m: In past 6 months you have other comments or concerns about child |
| tb8520 | O3a: Frequency child not aware of other people's feelings over last 6 months |
| tb8521 | O3b: Frequency child doesn't realise when others upset/angry over last 6 months |
| tb8522 | O3c: Frequency child doesn't notice effect of their behaviour on other family members over last 6 months |
| tb8523 | O3d: Frequency child's behaviour often disrupts normal family life over last 6 months |
| tb8524 | O3e: Frequency child is very demanding of other people's time over last 6 months |
| tb8525 | O3f: Frequency child is difficult to reason with when upset over last 6 months |
| tb8526 | O3g: Frequency child doesn't seem to understand social skills e.g. interrupts conversations constantly over last 6 months |
| tb8527 | O3h: Frequency child doesn't pick up on body language over last 6 months |
| tb8528 | O3i: Frequency child doesn't understand how they should behave when out e.g. shops/other people's houses over last 6 months |
| tb8529 | O3j: Frequency child doesn't realise they offend other people with their behaviour over last 6 months |
| tb8530 | O3k: Frequency child doesn't respond when told to do something over last 6 months |
| tb8531 | O3l: Frequency child cannot follow a command unless carefully worded over last 6 months |
| tb8532 | O3m: Respondent has any other comments/concerns (tick & describe) |
| fh9540 | K1: Adult assessment of whether YP is awkward/troublesome, compared to others of same age: TF3 |
| fh9541 | K2a: Adult assessment of whether YP often had temper outbursts, past 6 months: TF3 |
| fh9542 | K2b: Adult assessment of whether YP often argued with grown-ups, past 6 months: TF3 |
| fh9543 | K2c: Adult assessment of whether YP often ignored rules or refused to do as they were told, past 6 months: TF3 |
| fh9544 | K2d: Adult assessment of whether YP often did things to annoy others on purpose, past 6 months: TF3 |
| fh9550 | K3: YPs teachers have complained about YPs awkward behaviour/disruptiveness, in past 6 months: TF3 |
| fh9570 | K8g1: Adult knowledge of whether YP has often played truant, past 12 months: TF3 |
| ccxa200 | A8a: Frequency this school year YP has arrived late to for lessons to avoid part of lesson |
| ccxa203 | A8d: Frequency this school year YP has gotten into physical fights in or out of school |
| ccxa204 | A8e: Frequency this school year the YP has been suspended or excluded from school |
| tc4050 | D39a: Over the last 6 months, study teenager was not aware of other people's feelings |
| tc4051 | D39b: Over the last 6 months, study teenager did not realise when others are upset or angry |
| tc4052 | D39c: Over the last 6 months, study teenager did not notice the effect their behaviour has on other members of the family |
| tc4053 | D39d: Over the last 6 months, study teenager's behaviour often disrupts normal family life |

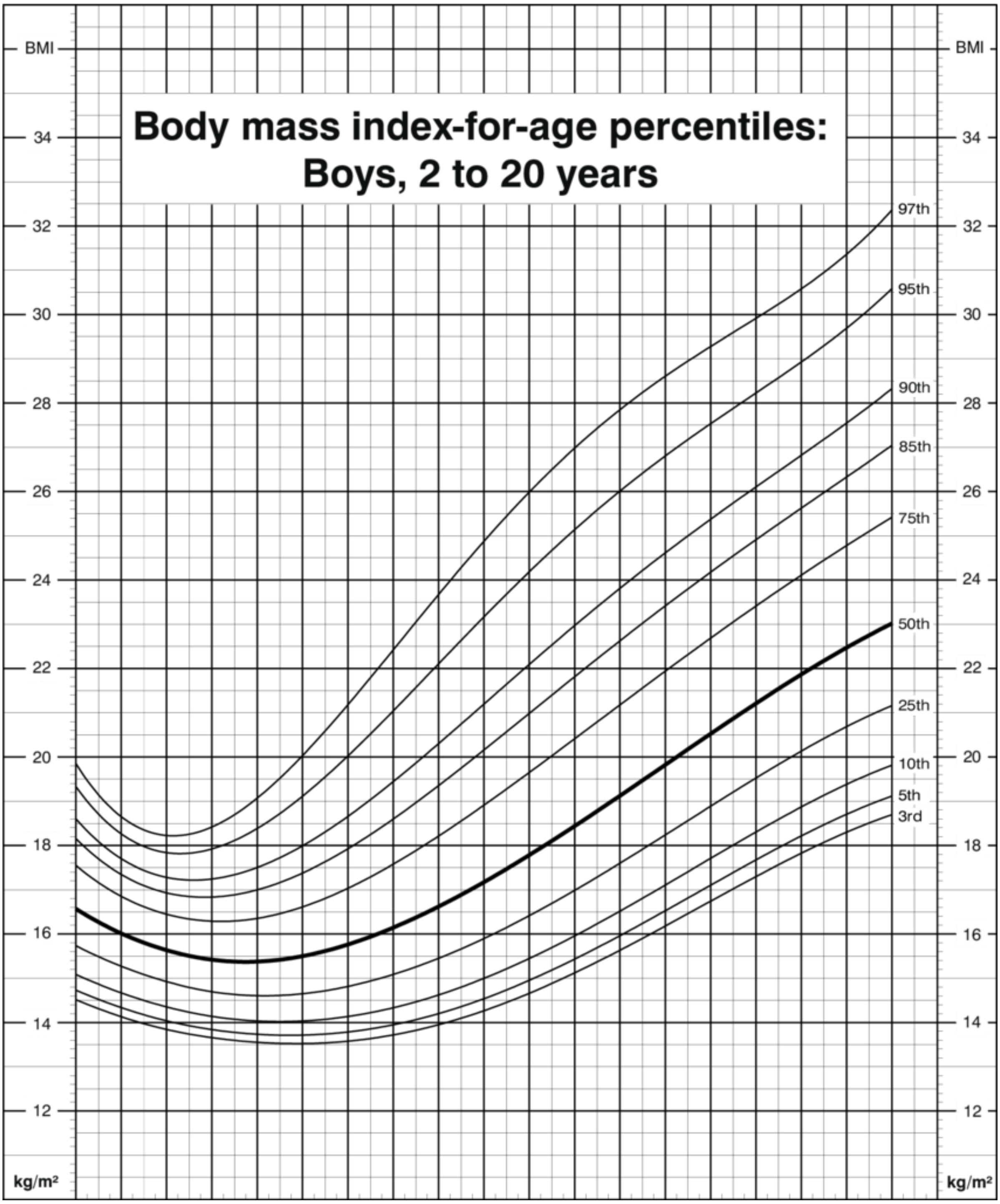
| | |
|---|---|
| tc4054 | D39e: Over the last 6 months, study teenager has been very demanding of other people’s time |
| tc4055 | D39f: Over the last 6 months, study teenager has been difficult to reason with when upset |
| tc4056 | D39g: Over the last 6 months, study teenager did not seem to understand social skills, e.g. interrupts conversations constantly |
| tc4057 | D39h: Over the last 6 months, study teenager did not pick up on body language |
| tc4058 | D39i: Over the last 6 months, study teenager did not understand how they should behave when they are out, e.g. in shops or other people's houses |
| tc4059 | D39j: Over the last 6 months, study teenager did not realise that they offend people with their behaviour |
| tc4060 | D39k: Over the last 6 months, study teenager did not respond when told to do something |
| tc4061 | D39l: Over the last 6 months, study teenager could not follow a command unless it was carefully worded |
| tc4062 | D39m: Respondent has further comment or concerns about study teenager's behaviour in the past 6 months |
| txa170 | A8a: During school year study child has had one detention |
| txa171 | A8b: During school year study child has had detention a number of times |
| txa172 | A8c: During school year study child has had a fixed-term exclusion or 'been suspended' from school even for a day |
| txa173 | A8d: During school year study child has been permanently excluded or 'expelled' from school |
| txa151 | A6b: During school year school has contacted parent/carer due to concerns about study child's behaviour at school |
| txa153 | A6d: During school year school has contacted parent/carer due to concerns about study child's attitude towards school or schoolwork |

CHILD_SAMPLES Testosterone_TF3 Testosterone nmol/l, TF3

Ch_SamCort_BBSCortisol nmol/l, BBS

## 4: Growth Chart illustrating BMI centiles for boys ages 2 to 20 years

Typical growth chart illustrating BMI centiles for boys ages between 2 and 20 years (Mayhew, 2018) derived from the United States Center for Disease Control.



# 5: Preliminary analyses between individual variables in each category

## 1. Introduction

Many variables exist in this study, acquired from ALSPAC, that appear several times in a child's history (Appendix 3). It would be time consuming and tedious for the reader if every construct was shown for every sampling year. Also, not every variable supplied by ALSPAC is relevant to the aims of this study. The aim of the univariate analyses that follow are twofold: (1) to select the variables that most accurately represent each theme, for example, pubic hair distribution as the most reliable measure of pubertal development; (2) although ALSPAC provide good evidence for the validity of their instruments, part of the doctoral journey was to corroborate this and check that all of the variables have internal validity and appear satisfactory in terms of alignment with each other; for example, an inverse relationship would be expected between the plasma protein SHBG and testosterone if the data were accurate and valid. The analyses that follow, therefore, provide a justification of which variables or combination thereof should be selected for use during the quantitative analysis (Chapter 4) and case study of extreme outliers (Chapter 5).

Psychosocial data variables and those relating to behaviour are defined in this dissertation as dependent or outcome variables. As with the biological variables, treated as independent variables, repeated sampling of psychosocial variables took place from the same participants at various ages. Potential associations between the ALSPAC psychosocial variables created from the Strengths & Difficulties Questionnaire (SDQ) and the Social & Communication Disorders Checklist (SCDC) were explored using Spearman correlation analysis. Behavioural variables created from one teacher questionnaire completed at age 10 to 11 and two teacher questionnaires and a parental questionnaire completed at ages 15 to 16 were then analysed. Finally, an analysis of these psychosocial with the behavioural variables took place to explore possible relationships.

In the sections that follow, bearing in mind the sampling constraints shown in Table 3.1, a combination of different statistical methods will be used as outlined in Chapter 3. Where appropriate, descriptive statistics will be provided. When dichotomous or nominal variables are analysed, contingency tables will be provided with Pearson chi square analysis and Cramér's *V* as a measure of association. Correlational analyses will be undertaken using either

Pearson correlation (where variables are interval or ratio) or Spearman rho correlation (for ordinal/dichotomous variables).

## 2. Behavioural variables

The ALSPAC dataset includes variables collected from a primary teacher questionnaire (PTQ) when children were 10 to 11 years of age (attending year 6, the final year of primary school). Only the eleven relevant variables to the study research questions were acquired, however, as these allowed consistent comparisons to be made between groups of participants, this was not problematic. Data was also taken from a single parent questionnaire (PQ) regarding elements of behaviour in and out of school during year 11 (children aged 15 to 16 years, attending the final year of secondary education). Behaviour variables were created from two teacher questionnaires completed during year 11. Table 1 shows all the data variables included in this study.

### 2.1 Analysis of primary teacher questionnaire (PTQ) variables

Results of the Spearman correlation indicated that there was a significant positive association between all PTQ behaviour variables, the smallest of which was 'degree to which child showed unwanted sexual behaviour towards others' ($r_S(3817) = .17$, $\rho < .001$) and the largest 'degree to which child was easily annoyed by others in the past school year' ($r_S(3312) = .84$, $\rho < .001$) and 'degree to which child deliberately annoyed people in the past school year' ($r_S(3431) = .78$, $\rho < .001$). This provides evidence of the accuracy of the teacher evaluation of participant behaviour and that it is valid to use the derived variable *total PTQ behaviour score* for analysis of behaviour at age 11 with other study variables. Challenging behaviour identified from the PTQ was only highly associated with challenging behaviour during year 11 in cases of extreme outliers (Chapter 5). A moderate association was seen between year 11 teacher complaints of awkward/disruptive behaviour with PTQ reports of: temper tantrums ($r_S(2243) = .33$, $\rho < .001$); argues with adults ($r_S(2243) = .38$, $\rho < .001$); and disobedience ($r_S(2243) = .38$, $\rho < .001$). Of most import is the finding that PTQ reports of argumentativeness with adults, disobedience and disruptive behaviour such as deliberately annoying others show a small to moderate, significant association with exclusion during year 11, not just for outlier participants: argumentativeness with exclusion, ($r_S(791) = .24$, $\rho < .001$); deliberately annoys others with exclusion, ($r_S(791) = .27$, $\rho < .001$); deliberately annoys others with exclusion ($r_s(791) = .24$, ρ < .001). This finding adds credence to the argument that early intervention is indicated for children with persistent challenging behaviour during their primary schooling (Chapters 5 & 6).

***Table 1: Spearman rho correlational analysis between PQ variables at age 16. Source: ALSPAC.***

| | PQ 1 | PQ 2 | PQ 3 | PQ 4 | PQ 5 | PQ 6 | PQ 7 | Key |
|---|---|---|---|---|---|---|---|---|
| **PQ 1** | 1.00 | | | | | | | PQ 1YP is awkward/troublesome compared to others of same age |
| **PQ 2** | 0.52 | 1.00 | | | | | | PQ 2 YP often had temper outbursts, past 6 months |
| **PQ 3** | 0.52 | 0.77 | 1.00 | | | | | PQ 3 YP often argued with grownups, past 6 months |
| **PQ 4** | 0.49 | 0.64 | 0.77 | 1.00 | | | | PQ 4 YP often ignored rules or refused to do as they were told, past 6 months |
| **PQ 5** | 0.49 | 0.58 | 0.60 | 0.63 | 1.00 | | | PQ 5 YP did things to annoy others on purpose, past 6 months |
| **PQ 6** | 0.44 | 0.42 | 0.49 | 0.55 | 0.43 | 1.00 | | PQ 6 YPs teachers have complained about YPs awkward behaviour/disruptiveness |
| **PQ 7** | 0.25 | 0.28 | 0.29 | 0.35 | 0.23 | 0.38 | 1.00 | PQ 7 Adult knowledge of whether YP has often played truant, past 12 months |

## 2.2 Analysis of parental questionnaire (PQ) variables

A Spearman rho correlational analysis shown in Table 1 indicated a significant positive association between all elements of the PQ (ρ < .001). There were 5616 observations in each correlational analysis. The variable statement relates to the variable in each row, e.g. the PQ question 1 (PQ 1) was worded, 'YP is awkward/troublesome compared to others of same age'.

Results of the Spearman rho correlation indicated that there was a significant positive association between all PQ behaviour variables. The smallest association was between the variable relating to truancy and all other variables ($r_s(701)$ = between .23 & .38, ρ < .001). This suggests that truancy is less highly related to other challenging behaviour variables except for rule breaking and challenging behaviour in school. A high association between truancy and challenging behaviour in school is evident for extreme outlier participants (Chapter 5). The highest associations were between being awkward/troublesome with temper outbursts; and between temper outbursts and arguing with grownups ($r_s(701) = .77$, ρ < .001). This is unsurprising as all three variables relate to argumentative and troublesome behaviour; temper outbursts would be viewed as troublesome by parents. The associations in the PQ provide evidence of the reliability of the data in the parent questionnaire.

## 2.3 Analysis of teacher questionnaire (TQ1) variables

A Spearman rho correlational analysis (Table 2) indicated a significant positive association between all elements of TQ1 (ρ < .001). The variable statement relates to the variable in each row, e.g. the TQ1 question was worded, ‘Frequency this school year YP has arrived late for lessons to avoid part of lesson’.

***Table 2: Spearman rho correlational analysis between TQ1 variables during year 11. Source: ALSPAC.***

| | TQ 1 | TQ 2 | TQ 3 | Key |
|---|---|---|---|---|
| **TQ 1** | 1.00 | | | TQ1 Frequency this school year YP has arrived late for lessons to avoid part of lesson |
| **TQ 2** | 0.29 | 1.00 | | TQ 2 Frequency this school year YP has gotten into physical fights in or out of school |
| **TQ 3** | 0.24 | 0.28 | 1.00 | TQ3 Frequency this school year the YP has been suspended or excluded from school |

Results of the Spearman correlation indicated that there was a significant, small to moderate positive association between all three TQ1 behaviour variables: (1) ‘arrived late to lessons to avoid part of lesson’ with ‘gotten into physical fights in and out of school’ ($r_s(1231) = .29$, $\rho < .001$); (2) ‘arrived late to lessons to avoid part of lesson’ with ‘been suspended of excluded from school’ ($r_s(1231) = .24$, $\rho < .001$); (3) ‘gotten into physical fights in and out of school’ with ‘been suspended of excluded from school’ ($r_s(1231) = .28$, $\rho < .001$). It could be expected that physically fighting would lead to fixed term exclusion according to the behaviour policies of many schools. Of interest, none of the students who were often excluded from school (*n*=184) were reported as being late or fighting indicating that other forms of challenging behaviour result in frequent exclusion. None of the participants who were not excluded, engaged in fighting or exhibited poor punctuality, which leaves 1032 sometimes excluded who fought and were deliberately late for lessons.

## 2.4 Analysis of teacher questionnaire (TQ 2) variables

The five TQ2 dichotomous (‘yes’/’no’) variables were analysed using Pearson’s Chi-squared ($\chi^2$) with Cramér’s *V*, Table 3 being a contingency table of this analysis. As having several detentions and having one detention are mutually exclusive, this variable combination was excluded from the analysis.

The contingency table analysis revealed that there is no statistically significant relationship between having: one detention and being permanently excluded, $\chi^2$ (1, $N$ = 2528) = 0.0057, ρ=.94 V=.0015; and schools contacting parents about behaviour concerns with pupils being permanently excluded, $\chi^2$ (1, $N$ = 2739) = 0.459, ρ=.83 V=.0041. It would not be expected that pupils whose only sanction is one detention to be later excluded, so the first finding is intuitive. However, it may be reasonably expected that permanent exclusion would be associated with schools contacting parents with behaviour concerns if the exclusion was due to persistent challenging behaviour. This adds strength to reports that most permanent exclusions occur due to pupils committing a single serious one-off offence such as assault on another pupil or member of staff or bringing a knife or drugs into school (*Annual Exclusion Data for Fenland District Schools, Cambridgeshire*, 2014; *Exclusion from Maintained Schools, Academies and Pupil Referral Units in England*, 2017).

***Table 3: Chi-squared analysis of TQ2 dichotomous variables with Cramér's V coefficient. Source: ALSPAC.***

| | | | Yes | No | Total |
|---|---|---|---|---|---|
| One detention | Number of detentions | Mutually exclusive | | | |
| One detention | Fixed-term excluded | Yes | 37 | 641 | 678 |
| | | No | 67 | 1790 | 1857 |
| | | Total | 104 | 2431 | 2535 |
| | | Chi2 | 4.3171 | | Pr=0.05 |
| | | Cramer's V | 0.0413 | | |
| One detention | School concerns attitude | Yes | 217 | 484 | 701 |
| | | No | 232 | 1613 | 2546 |
| | | Total | 449 | 2097 | 1845 |
| | | Chi2 | 118.1621 | | Pr=0.001 |
| | | Cramer's V | 0.2154 | | |
| One detention | School concerns behaviour | Yes | 298 | 398 | 696 |
| | | No | 402 | 1446 | 1848 |
| | | Total | 700 | 1844 | 2554 |
| | | Chi2 | 112.4614 | | Pr=0.001 |
| | | Cramer's V | 0.2103 | | |
| Number of detentions | Fixed-term excluded | Yes | 92 | 347 | 439 |
| | | No | 38 | 2194 | 2232 |
| | | Total | 130 | 2541 | 2671 |
| | | Chi2 | 293.7217 | | Pr=0.001 |
| | | Cramer's V | 0.3316 | | |
| Number of detentions | Permanently excluded | Yes | 2 | 434 | 436 |
| | | No | 3 | 2227 | 2230 |
| | | Total | 5 | 2661 | 2666 |
| | | Chi2 | 2.0475 | | Pr=0.01 |
| | | Cramer's V | 0.0277 | | |
| Number of detentions | School concerns attitude | Yes | 295 | 159 | 454 |
| | | No | 222 | 1999 | 2221 |
| | | Total | 517 | 2158 | 2675 |
| | | Chi2 | 730.8610 | | Pr=0.001 |
| | | Cramer's V | 0.5227 | | |
| Number of detentions | School concerns behaviour | Yes | 366 | 92 | 458 |
| | | No | 424 | 1796 | 2220 |
| | | Total | 790 | 1888 | 2678 |
| | | Chi2 | 675.1509 | | Pr=0.001 |
| | | Cramer's V | 0.5021 | | |
| Permanently excluded | One detention | Yes | 1 | 3 | 4 |
| | | No | 673 | 1851 | 2524 |
| | | Total | 674 | 1854 | 2528 |
| | | Chi2 | 0.0057 | | Pr=0.940 |
| | | Cramer's V | 0.0015 | | |
| Permanently excluded | Fixed-term excluded | Yes | 4 | 1 | 5 |
| | | No | 125 | 2629 | 2754 |
| | | Total | 129 | 2630 | 2759 |
| | | Chi2 | 63.7657 | | Pr=0.001 |
| | | Cramer's V | 0.1520 | | |
| Permanently excluded | School concerns attitude | Yes | 3 | 3 | 6 |
| | | No | 516 | 2213 | 2729 |
| | | Total | 519 | 2216 | 2735 |
| | | Chi2 | 3.7642 | | Pr=0.05 |
| | | Cramer's V | 0.0371 | | |
| Permanently excluded | School concerns behaviour | Yes | 2 | 4 | 6 |
| | | No | 802 | 1931 | 2733 |
| | | Total | 804 | 1935 | 2739 |
| | | Chi2 | 0.459 | | Pr=0.830 |
| | | Cramer's V | 0.0041 | | |
| School concerns attitude | School concerns behaviour | Yes | 426 | 106 | 532 |
| | | No | 386 | 1863 | 2249 |
| | | Total | 812 | 1969 | 2249 |
| | | Chi2 | 823.6968 | | Pr=0.001 |
| | | Cramer's V | 0.5442 | | |

Analyses revealed a significant but small relationship between having several detentions and being permanently excluded, $\chi^2$ (1, $N$ = 2666) = 2.0475, ρ=.001 V=.0277; and being permanently excluded and fixed-term excluded, $\chi^2$ (1, $N$ = 2759) = 63.7657, ρ=.001 V=.152. These further confirm that more pupils are excluded for a single offence rather than persistent poor behaviour, which would result in a higher relationship between these two variables and permanent exclusion. There is a significant but small association between school concerns regarding attitude to school and permanent exclusion, $\chi^2$ (1, $N$ = 2735) = 3.7642, ρ=.05

V=.0371 and pupils having one detention and fixed-term exclusion, $\chi^2$ (1, *N* = 2535) = 4.3171, ρ=.05 V=.0413. Whereas the latter may be expected in that attitude to school would not predict a serious disciplinary offence, it would be reasonable to anticipate that a serious sanction such as fixed-term exclusion would follow the sort of challenging behaviour that would result in several rather than just one detention. In fact, a significant, moderate association is shown between a pupil having several detentions and fixed-term exclusion, $\chi^2$ (1, *N* = 2671) = 293.7217, ρ=.001 V=.3316. It is feasible that fixed-term exclusion is given as punishment for a one-off serious offence as described above, when the headteacher decides that permanent exclusion is not indicated. In fact, one of the participants introduced in Chapter 1 was fixed-term rather than permanently excluded for assault on another pupil.

A contingency table analysis of all remaining variables revealed a significant, moderate relationship between them. It would be expected that children whose behaviour leads to one detention being given may lead the school to contact parents about their attitude to school, $\chi^2$ (1, *N* = 1845) = 118.1621, ρ=.001 V=.2154 and concerns about their behaviour, $\chi^2$ (1, *N* = 2554) = 112.4614, ρ=.001 V=.2103. Policy in many schools require parents to be notified before an after-school detention is given, although this is not a legal requirement (*School Discipline and Exclusions*, n.d.). The highest associations were seen between a number of detentions being given and concerns about attitude, $\chi^2$ (1, *N* = 2675) = 730.8610, ρ=.001 V=.5227; a number of detentions and schools having concerns about behaviour, $\chi^2$ (1, *N* = 2678) = 675.1509, ρ=.001 V=.5021 and concerns about behaviour with concerns about attitude $\chi^2$ (1, *N* = 2249) = 823.6968, ρ=.001 V=.5442, all of which would be expected. The association between concerns about attitude and that of behaviour confirms the findings of studies that link despondency and disillusionment regarding education to poor behaviour (Greene, 2009; Sutherland & Sutherland, 2008).

## 2.5 Pairwise Spearman rho analysis of PQ & TQ1 behaviour variables

A pairwise Spearman rho correlation was applied to the ordinal behaviour variables of the parental questionnaire (PQ) and teacher questionnaire 1 (TQ1). The results of this analysis are shown in Table 4.

***Table 4: Pairwise Spearman rho analysis of all behaviour variables excluding those from TQ2. N = 440, ρ = .001. Source: ALSPAC.***

| | Awkward troublesome | Temper outbursts | Argumentative | Disobedient | Annoying | Disruptive | Truant |
|---|---|---|---|---|---|---|---|
| Late for lessons | 0.1901 | 0.2369 | 0.2500 | 0.2525 | 0.1633 | 0.3414 | 0.2420 |
| Physical fights | 0.1797 | 0.1913 | 0.2475 | 0.1998 | 0.1677 | 0.2251 | 0.0896 |
| Fixed-term excluded | 0.2727 | 0.2550 | 0.2844 | 0.3365 | 0.1692 | 0.5039 | 0.1994 |

Results of the Spearman correlation indicated that there was a significant positive association between the two variables: parent reporting that the school has contacted them with concerns that the young person exhibits disruptive behaviour in school and the school data that the young person has been fixed-term excluded, ($r_S(439) = .50$, $\rho < .001$). The test for normality between the two sources of data using the Shapiro-Wilk W test, indicated that the data were statistically normal. The link between exclusion and schools informing parents of persistent disruptive behaviour is, therefore, logical. The idea of close collaborative working between parents, when informed of challenging behaviour and the support for this by schools, is discussed in Chapter 6.

A significant positive, moderate association between disruptive behaviour and being frequently late for lessons existed, ($r_S(339) = .34$, $\rho < .001$). A small but significant positive association was seen between all other variable pairings, the smallest association being between truancy and fighting, ($r_S(339) = .10$, $\rho < .001$) and the highest being between disruptive behaviour and fighting ($r_S(339) = .24$, $\rho < .001$). The latter indicates a general problem of challenging behaviour with some participants as it is unlikely to be an issue of causality between the two measures, that is, disruptive behaviour in school is unlikely to result in fighting and vice versa. It could be that fighting, and truancy are both weakly linked to general challenging behaviour.

The Spearman correlation indicated a moderate significant positive association between temper outbursts and fixed-term exclusion, ($r_S(339) = .26$, $\rho < .001$). A stronger association may have been expected in that frequent temper outbursts would be linked to fixed-term exclusion. However, it must be remembered that temper outbursts were reported as occurring at home and not school providing evidence to anecdote that a child's behaviour in school is often different to that at home (Butler, 2010) except for those with psychosocial problems where the converse is true.

## 2.6 Chi Squared ($\chi^2$) and Cramer's *V* analysis of TQ2 and all other behaviour variables

The parental questionnaire (PQ) ordinal variables were analysed with teacher questionnaire 2 (TQ2) dichotomous variables using Pearson's Chi-squared ($\chi^2$) with Cramér's *V*, Table 5 being a contingency table of this analysis. Possible responses to the PQ were, 'No more than others', 'Little more than others', 'Lot more than others' based on young people the same age. For reasons of space, these responses are abbreviated in the Table.

The analysis did not find a statistically significant association between permanent exclusion and any of the PQ or TQ1 variables. From earlier analyses, most exclusions appear to occur due to serious one-off events rather than persistent poor behaviour and in this case, the poor behaviour is reported by parents (Section 4.3.1.4). The last of association between truancy and permanent exclusion, $\chi^2$ (2, *N* = 1774) = ,0374 ρ=.981 V=.0046 provides evidence that schools are unlikely to permanently exclude students based on truancy. Standard Educational Welfare Service procedure is to support parents in the first instance before issuing a caution then prosecuting parents for poor attendance (Malcolm et al., 2003).

Fixed-term exclusion did not reveal anything other than small, positive associations with other variables, except for teacher reports to parents of disruptive behaviour, $\chi^2$ (2, *N* = 547) = ,133.9309 ρ=.001 V=.4564. It is observed that there is not an exact association between parent reports of fixed-term exclusion and data from schools, which is likely to be due to different methods of reporting. Schools were required to simply state whether a pupil had been fixed-term excluded whereas parents were required to choose between 'never', 'sometimes' or 'often'. Not all parents may have reported exclusions. Contingency table analysis of both measures of fixed-term exclusion showed a significant, moderate association, $\chi^2$ (2, *N* = 1906) = 135.8294, ρ=.001 V=.5991.

Only small, significant positive associations were seen between one detention being given and all PQ variables except for 'temper outbursts' and 'argumentative' which were not statistically significant at the $\rho < 0.05$ level. Behaviour that is disruptive enough for parents to be aware is likely to attract more than one detention, confirmed in the data 'disruptive behaviour in school' with 'multiple detentions,' $\chi^2$ (1, *N* = 422) = 160.9255, ρ=.001 V=.5553, a high association.

Multiple detentions were positively associated with all other PQ variables, the highest being disobedience, $\chi^2$ (1, *N* = 1732) = 156.4775, ρ=.001 V=.3281 and awkward/troublesome behaviour, $\chi^2$ (1, *N* = 1734) = 162.8331, ρ=.001 V=.3064. This provides evidence that disobedience and awkward/troublesome behaviour at home is repeated in school since there is a significant correlation between parental and teacher reports regarding these values.

During analysis of TQ2 variables it was shown that school contact with parents regarding concerns about the young person's attitude showed a significant association with school's contacting parents with concerns about their behaviour. Predictably, therefore, these two variables show a significant association with those of the parent questionnaire, the highest of which is between school concerns regarding attitude and their report to parents of disruptive behaviour, $\chi^2$ (2, $N$ = 552) = 217.5974, ρ=.001 V=.6279. The smallest association was between school concerns regarding behaviour and parent reports of deliberately annoying behaviour at home, $\chi^2$ (2, $N$ = 1803) = 77.6915, ρ=.001 V=.2076. Again, although some association was seen, this is further evidence of differing behaviour between that of home and school.

In considering these analyses, the subjective nature of parental responses must be considered including opinion as to what is normal adolescent behaviour and who the "others" are referred to in the questionnaire. It could be that some parents consider challenging behaviour as normal for adolescents or compare their children to their friends, the behaviour of whom may not be typical when visiting the homes of others. However, the comparatively small proportion of participants who were scored "a little more" or "a lot more" by their parents is what would be expected, which adds validity to the reliability of the data.

***Table 5: Chi-squared analysis of TQ1 & PQ with TQ2 variables with Cramér's V coefficient. Pink colouring indicates a small association, yellow a moderate association and green a high association. Red indicates p > 0.05. No high associations were evident (i.e. Cramér's V coefficient > 0.75). Source: ALSPAC.***

| Awkward or troublesome compared to others | One detention | | | | Number of detentions | | | | Fixed-term excluded | | | | Permanently excluded | | | | School concerns attitude | | | | School concerns behaviour | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total |
| | No more | 202 | 655 | 857 | No more | 69 | 810 | 879 | No more | 20 | 885 | 905 | No more | 1 | 901 | 902 | No more | 80 | 839 | 919 | No more | 164 | 753 | 917 |
| | Little more | 238 | 512 | 750 | Little more | 175 | 625 | 800 | Little more | 47 | 781 | 828 | Little more | 0 | 823 | 823 | Little more | 214 | 621 | 835 | Little more | 316 | 518 | 834 |
| | Lot more | 11 | 38 | 49 | Lot more | 36 | 19 | 55 | Lot more | 15 | 41 | 56 | Lot more | 0 | 55 | 55 | Lot more | 35 | 23 | 58 | Lot more | 39 | 18 | 57 |
| | Total | 451 | 12005 | 1656 | Total | 280 | 1454 | 1734 | Total | 82 | 1707 | 1789 | Total | 1 | 1779 | 1780 | Total | 329 | 1483 | 1812 | Total | 519 | 1289 | 1808 |
| | Chi2 | 14.0314 | | Pr=0.001 | Chi2 | 162.8331 | | Pr=0.001 | Chi2 | 77.0370 | | Pr=0.001 | Chi2 | 0.9739 | | Pr=0.614 | Chi2 | 156.0871 | | Pr=0.001 | Chi2 | 130.7719 | | Pr=0.001 |
| | Cramer's V | 0.0920 | | | Cramer's V | 0.3064 | | | Cramer's V | 0.2075 | | | Cramer's V | 0.0234 | | | Cramer's V | 0.2935 | | | Cramer's V | 0.2689 | | |

| Temper outbursts | One detention | | | | Number of detentions | | | | Fixed-term excluded | | | | Permanently excluded | | | | School concerns attitude | | | | School concerns behaviour | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total |
| | No more | 410 | 1114 | 1524 | No more | 214 | 1371 | 1585 | No more | 55 | 1576 | 1631 | No more | 1 | 1624 | 1625 | No more | 255 | 1398 | 1653 | No more | 429 | 1219 | 1640 |
| | Little more | 33 | 79 | 112 | Little more | 49 | 76 | 125 | Little more | 19 | 115 | 134 | Little more | 0 | 131 | 131 | Little more | 61 | 72 | 133 | Little more | 69 | 65 | 134 |
| | Lot more | 8 | 16 | 24 | Lot more | 18 | 10 | 28 | Lot more | 8 | 21 | 29 | Lot more | 0 | 29 | 29 | Lot more | 16 | 14 | 30 | Lot more | 24 | 6 | 30 |
| | Total | 451 | 1209 | 1660 | Total | 281 | 1457 | 1738 | Total | 82 | 1712 | 1794 | Total | 1 | 1784 | 1785 | Total | 332 | 1484 | 1816 | Total | 522 | 1290 | 1812 |
| | Chi2 | 0.8136 | | Pr=0.666 | Chi2 | 105.0667 | | Pr=0.001 | Chi2 | 68.9513 | | Pr=0.001 | Chi2 | 0.0985 | | Pr=0.952 | Chi2 | 101.4235 | | Pr=0.001 | Chi2 | 78.1499 | | Pr=0.001 |
| | Cramer's V | 0.0221 | | | Cramer's V | 0.2459 | | | Cramer's V | 0.1960 | | | Cramer's V | 0.0074 | | | Cramer's V | 0.2363 | | | Cramer's V | 0.2077 | | |

| Argumentative | One detention | | | | Number of detentions | | | | Fixed-term excluded | | | | Permanently excluded | | | | School concerns attitude | | | | School concerns behaviour | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total |
| | No more | 391 | 1087 | 1478 | No more | 208 | 1331 | 1539 | No more | 55 | 1534 | 1589 | No more | 1 | 1582 | 1583 | No more | 235 | 1368 | 1603 | No more | 406 | 1194 | 1600 |
| | Little more | 51 | 96 | 147 | Little more | 47 | 110 | 157 | Little more | 12 | 148 | 160 | Little more | 0 | 159 | 159 | Little more | 68 | 99 | 167 | Little more | 78 | 88 | 166 |
| | Lot more | 10 | 28 | 38 | Lot more | 28 | 18 | 46 | Lot more | 15 | 33 | 48 | Lot more | 0 | 46 | 46 | Lot more | 30 | 20 | 50 | Lot more | 38 | 11 | 49 |
| | Total | 452 | 1211 | 1663 | Total | 283 | 1459 | 1742 | Total | 82 | 1715 | 1797 | Total | 1 | 1787 | 1788 | Total | 333 | 1487 | 1820 | Total | 522 | 1293 | 1815 |
| | Chi2 | 4.6004 | | Pr=0.10 | Chi2 | 97.3801 | | Pr=0.001 | Chi2 | 86.0959 | | Pr=0.001 | Chi2 | 0.1296 | | Pr=0.937 | Chi2 | 128.5144 | | Pr=0.001 | Chi2 | 92.8000 | | Pr=0.001 |
| | Cramer's V | 0.0526 | | | Cramer's V | 0.2364 | | | Cramer's V | 0.2189 | | | Cramer's V | 0.0085 | | | Cramer's V | 0.2657 | | | Cramer's V | 0.2261 | | |

| Disobedient | One detention | | | | Number of detentions | | | | Fixed-term excluded | | | | Permanently excluded | | | | School concerns attitude | | | | School concerns behaviour | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total | | Yes | No | Total |
| | No more | 397 | 1121 | 1518 | No more | 196 | 1382 | 1578 | No more | 50 | 1571 | 1621 | No more | 1 | 1614 | 1616 | No more | 235 | 1408 | 1643 | No more | 403 | 1234 | 1637 |
| | Little more | 42 | 61 | 103 | Little more | 57 | 59 | 116 | Little more | 20 | 107 | 127 | Little more | 0 | 126 | 126 | Little more | 69 | 58 | 127 | Little more | 86 | 42 | 128 |
| | Lot more | 10 | 23 | 33 | Lot more | 26 | 12 | 38 | Lot more | 12 | 26 | 38 | Lot more | 0 | 37 | 37 | Lot more | 25 | 15 | 40 | Lot more | 28 | 11 | 39 |
| | Total | 449 | 1205 | 1654 | Total | 279 | 1453 | 1732 | Total | 82 | 1704 | 1786 | Total | 1 | 1777 | 1778 | Total | 329 | 1481 | 1810 | Total | 517 | 1287 | 1804 |
| | Chi2 | 10.5997 | | Pr=0.01 | Chi2 | 186.4775 | | Pr=0.001 | Chi2 | 107.6711 | | Pr=0.001 | Chi2 | 0.1010 | | Pr=0.951 | Chi2 | 181.0268 | | Pr=0.001 | Chi2 | 141.5013 | | Pr=0.001 |
| | Cramer's V | 0.0801 | | | Cramer's V | 0.3281 | | | Cramer's V | 0.2455 | | | Cramer's V | 0.0075 | | | Cramer's V | 0.3163 | | | Cramer's V | 0.2801 | | |

**Annoying**

| | One detention | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 381 | 1084 | 1465 |
| Little more | 58 | 104 | 162 |
| Lot more | 9 | 17 | 26 |
| Total | 448 | 1205 | 1653 |
| Chi2 | 7.8393 | | Pr=0.05 |
| Cramer's V | 0.0689 | | |

| | Number of detentions | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 197 | 1327 | 1524 |
| Little more | 63 | 116 | 179 |
| Lot more | 19 | 10 | 29 |
| Total | 279 | 1453 | 1732 |
| Chi2 | 112.0629 | | Pr=0.001 |
| Cramer's V | 0.2544 | | |

| | Fixed-term excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 53 | 1510 | 1563 |
| Little more | 21 | 170 | 191 |
| Lot more | 8 | 23 | 31 |
| Total | 82 | 1703 | 1785 |
| Chi2 | 54.8429 | | Pr=0.001 |
| Cramer's V | 0.1753 | | |

| | Permanently excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 1 | 1555 | 1556 |
| Little more | 0 | 189 | 189 |
| Lot more | 0 | 31 | 31 |
| Total | 1 | 1775 | 1776 |
| Chi2 | 0.1415 | | Pr=0.932 |
| Cramer's V | 0.0089 | | |

| | School concerns attitude | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 241 | 1344 | 1585 |
| Little more | 71 | 121 | 192 |
| Lot more | 17 | 15 | 32 |
| Total | 329 | 1480 | 1809 |
| Chi2 | 81.2939 | | Pr=0.001 |
| Cramer's V | 0.2120 | | |

| | School concerns behaviour | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 399 | 1181 | 1580 |
| Little more | 96 | 95 | 191 |
| Lot more | 22 | 10 | 32 |
| Total | 517 | 1286 | 1803 |
| Chi2 | 77.6915 | | Pr=0.001 |
| Cramer's V | 0.2076 | | |

**Disruptive**

| | One detention | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 105 | 303 | 408 |
| Little more | 29 | 30 | 59 |
| Lot more | 13 | 20 | 33 |
| Total | 147 | 353 | 500 |
| Chi2 | 15.3182 | | Pr=0.001 |
| Cramer's V | 0.1750 | | |

| | Number of detentions | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 47 | 377 | 424 |
| Little more | 34 | 24 | 58 |
| Lot more | 33 | 7 | 40 |
| Total | 114 | 408 | 522 |
| Chi2 | 160.9255 | | Pr=0.001 |
| Cramer's V | 0.5552 | | |

| | Fixed-term excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 9 | 431 | 440 |
| Average | 13 | 53 | 66 |
| Lot more | 18 | 23 | 41 |
| Total | 40 | 507 | 547 |
| Chi2 | 113.9309 | | Pr=0.001 |
| Cramer's V | 0.4564 | | |

| | Permanently excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 1 | 440 | 441 |
| Little more | 0 | 64 | 64 |
| Lot more | 0 | 39 | 39 |
| Total | 1 | 543 | 544 |
| Chi2 | 0.2340 | | Pr=0.890 |
| Cramer's V | 0.0207 | | |

| | School concerns attitude | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 48 | 394 | 442 |
| Little more | 46 | 20 | 66 |
| Lot more | 39 | 5 | 44 |
| Total | 133 | 419 | 552 |
| Chi2 | 217.5974 | | Pr=0.001 |
| Cramer's V | 0.6279 | | |

| | School concerns behaviour | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 102 | 343 | 445 |
| Little more | 52 | 14 | 66 |
| Lot more | 40 | 3 | 43 |
| Total | 194 | 360 | 554 |
| Chi2 | 147.7616 | | Pr=0.001 |
| Cramer's V | 0.5164 | | |

**Truant**

| | One detention | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 424 | 1176 | 1600 |
| Little more | 18 | 15 | 33 |
| Lot more | 5 | 14 | 19 |
| Total | 447 | 1205 | 1652 |
| Chi2 | 12.8908 | | Pr=0.001 |
| Cramer's V | 0.0883 | | |

| | Number of detentions | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 235 | 1435 | 1670 |
| Little more | 24 | 12 | 36 |
| Lot more | 18 | 5 | 23 |
| Total | 277 | 1452 | 1729 |
| Chi2 | 139.5713 | | Pr=0.001 |
| Cramer's V | 0.2841 | | |

| | Fixed-term excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 69 | 1649 | 1718 |
| Little more | 5 | 36 | 41 |
| Lot more | 9 | 15 | 24 |
| Total | 83 | 1700 | 1783 |
| Chi2 | 65.1654 | | Pr=0.001 |
| Cramer's V | 0.1912 | | |

| | Permanently excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 1 | 1709 | 1710 |
| Little more | 0 | 40 | 40 |
| Lot more | 0 | 24 | 24 |
| Total | 1 | 1773 | 1774 |
| Chi2 | 0.0374 | | Pr=0.981 |
| Cramer's V | 0.0046 | | |

| | School concerns attitude | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 281 | 1461 | 1742 |
| Little more | 29 | 12 | 41 |
| Lot more | 18 | 6 | 24 |
| Total | 328 | 1479 | 1807 |
| Chi2 | 133.2898 | | Pr=0.001 |
| Cramer's V | 0.2716 | | |

| | School concerns behaviour | | |
|---|---|---|---|
| | Yes | No | Total |
| No more | 458 | 1279 | 1737 |
| Little more | 36 | 5 | 41 |
| Lot more | 21 | 3 | 24 |
| Total | 515 | 1287 | 1802 |
| Chi2 | 115.4410 | | Pr=0.001 |
| Cramer's V | 0.2531 | | |

**Late for lessons**

| | One detention | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 257 | 991 | 1248 |
| Sometimes | 167 | 304 | 471 |
| Often | 26 | 29 | 55 |
| Total | 450 | 1324 | 1774 |
| Chi2 | 54.2909 | | Pr=0.001 |
| Cramer's V | 0.1749 | | |

| | Number of detentions | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 113 | 1172 | 1285 |
| Sometimes | 122 | 381 | 503 |
| Often | 32 | 27 | 59 |
| Total | 267 | 1580 | 1847 |
| Chi2 | 147.8728 | | Pr=0.001 |
| Cramer's V | 0.2830 | | |

| | Fixed-term excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 30 | 1279 | 1309 |
| Sometimes | 30 | 491 | 521 |
| Often | 7 | 52 | 59 |
| Total | 67 | 1822 | 1889 |
| Chi2 | 25.4049 | | Pr=0.001 |
| Cramer's V | 0.1160 | | |

| | Permanently excluded | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 1 | 1299 | 1300 |
| Sometimes | 0 | 521 | 521 |
| Often | 0 | 59 | 59 |
| Total | 1 | 1879 | 1880 |
| Chi2 | 0.4464 | | Pr=0.80 |
| Cramer's V | 0.0154 | | |

| | School concerns attitude | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 147 | 1173 | 1320 |
| Sometimes | 141 | 390 | 531 |
| Often | 38 | 21 | 59 |
| Total | 326 | 1584 | 1910 |
| Chi2 | 159.9719 | | Pr=0.001 |
| Cramer's V | 0.2894 | | |

| | School concerns behaviour | | |
|---|---|---|---|
| | Yes | No | Total |
| Never | 245 | 1075 | 1320 |
| Sometimes | 207 | 328 | 535 |
| Often | 42 | 18 | 60 |
| Total | 494 | 1421 | 1915 |
| Chi2 | 143.8271 | | Pr=0.001 |
| Cramer's V | 0.2741 | | |

| | | One detention | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 318 | 1087 | 1405 |
| | Sometimes | 125 | 226 | 351 |
| | Often | 9 | 14 | 23 |
| | Total | 452 | 1397 | 1779 |
| | Chi2 | 27.2779 | | Pr=0.001 |
| | Cramer's V | 0.1238 | | |

| | | Number of detentions | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 153 | 1299 | 1452 |
| | Sometimes | 101 | 275 | 376 |
| | Often | 14 | 12 | 26 |
| | Total | 2144 | 12688 | 26 |
| | Chi2 | 97.4523 | | Pr=0.001 |
| | Cramer's V | 0.2293 | | |

| | | Fixed-term excluded | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 34 | 1449 | 1483 |
| | Sometimes | 24 | 362 | 386 |
| | Often | 7 | 21 | 28 |
| | Total | 65 | 1832 | 1897 |
| | Chi2 | 54.2308 | | Pr=0.001 |
| | Cramer's V | 0.1691 | | |

| | | Permanently excluded | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 1 | 1478 | 1479 |
| | Sometimes | 0 | 382 | 382 |
| | Often | 0 | 27 | 27 |
| | Total | 1 | 1887 | 1888 |
| | Chi2 | 0.2767 | | Pr=0.871 |
| | Cramer's V | 0.0121 | | |

| | | School concerns attitude | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 186 | 1310 | 1496 |
| | Sometimes | 129 | 263 | 392 |
| | Often | 15 | 13 | 28 |
| | Total | 330 | 1586 | 1916 |
| | Chi2 | 117.6673 | | Pr=0.001 |
| | Cramer's V | 0.2478 | | |

| | | School concerns behaviour | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Physical fights | Never | 318 | 1178 | 1505 |
| | Sometimes | 166 | 226 | 392 |
| | Often | 17 | 9 | 26 |
| | Total | 501 | 1422 | 1923 |
| | Chi2 | 93.8343 | | Pr=0.001 |
| | Cramer's V | 0.2209 | | |

| | | One detention | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 415 | 1275 | 1690 |
| | Sometimes | 35 | 53 | 88 |
| | Often | 3 | 6 | 9 |
| | Total | 453 | 1334 | 1787 |
| | Chi2 | 10.5391 | | Pr=0.01 |
| | Cramer's V | 0.0768 | | |

| | | Number of detentions | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 215 | 1540 | 1755 |
| | Sometimes | 46 | 49 | 95 |
| | Often | 10 | 3 | 13 |
| | Total | 271 | 1592 | 1863 |
| | Chi2 | 135.8294 | | Pr=0.001 |
| | Cramer's V | 0.2700 | | |

| | | Fixed-term excluded | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 13 | 1775 | 1788 |
| | Sometimes | 44 | 59 | 103 |
| | Often | 10 | 5 | 15 |
| | Total | 67 | 1839 | 1906 |
| | Chi2 | 684.0955 | | Pr=0.001 |
| | Cramer's V | 0.5991 | | |

| | | Permanently excluded | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 1 | 1783 | 1784 |
| | Sometimes | 0 | 99 | 99 |
| | Often | 0 | 14 | 14 |
| | Total | 1 | 1896 | 1897 |
| | Chi2 | 0.0634 | | Pr=0.969 |
| | Cramer's V | 0.0058 | | |

| | | School concerns attitude | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 245 | 1563 | 1808 |
| | Sometimes | 69 | 34 | 103 |
| | Often | 13 | 1 | 14 |
| | Total | 327 | 1598 | 1925 |
| | Chi2 | 254.9165 | | Pr=0.001 |
| | Cramer's V | 0.3639 | | |

| | | School concerns behaviour | | |
|---|---|---|---|---|
| | | Yes | No | Total |
| Fixed-term excluded | Never | 419 | 1394 | 1813 |
| | Sometimes | 69 | 34 | 103 |
| | Often | 13 | 2 | 15 |
| | Total | 501 | 1430 | 1931 |
| | Chi2 | 126.6784 | | Pr=0.001 |
| | Cramer's V | 0.2561 | | |

Following the detailed analysis of behaviour variables above and considering the research questions, it is appropriate for the following behavioural variables to be analysed with biological and psychosocial variables in chapters 4 & 5: the year 6 behaviour total score since this was highly correlated with individual questions that contributed to it; individual elements of the parent questionnaire and two year 11 teacher questionnaires.

## 3. Psychosocial variables

As shown above and discussed in earlier chapters, psychosocial variables are taken from repeated measure parental questionnaires forming part of the SDQ and SCDC at various stages during adolescence. Each individual SDQ question is scored 0 (not true), 1 (somewhat true) or 2 (certainly true). These responses are added to give an overall score for each component scale out of 10 (Table 6). SDQ emotional symptoms are associated with stress and anxiety, including frequent psychosomatic illness, often being worried or unhappy, fearful and lacking in confidence. SDQ conduct problems include temper tantrums, disobedience, fighting and bullying others, lying, cheating and theft. SDQ hyperactivity includes components of the Connor Scale used to diagnose ADHD (Sparrow, 2010): restlessness, fidgeting, being easily distracted and impulsive. SDQ peer problems relate to how well the child interacts with others and they to them. A further useful measure, particularly in terms of social cognitive function, is the SDQ prosocial score, where participants are scored on their empathy, helpfulness and kindness to others. However, analysis does not show a high association between the prosocial and SCDC scores (below). The prosocial score does not contribute to the total difficulties score. Table 6 shows the normal, borderline and abnormal scores for each component of the SDQ, included for convenience here, which were explained in detail in Chapters 2 & 3. Note that the higher the score, the more profound the problem except for the prosocial score where the higher scores show positive prosocial traits.

***Table 6: Score ranges for the SDQ. Source: Youth in Mind (2018).***

| | Normal | Borderline | Abnormal |
|---|---|---|---|
| **Emotional symptoms** | 0-3 | 4 | 5-10 |
| **Conduct problems** | 0-2 | 3 | 4-10 |
| **Hyperactivity** | 0-5 | 6 | 7-10 |
| **Peer problems** | 0-2 | 3 | 4-10 |
| **Total difficulties score** | 0-13 | 14-16 | 17-40 |
| **Prosocial score** | 6-10 | 5 | 0-4 |

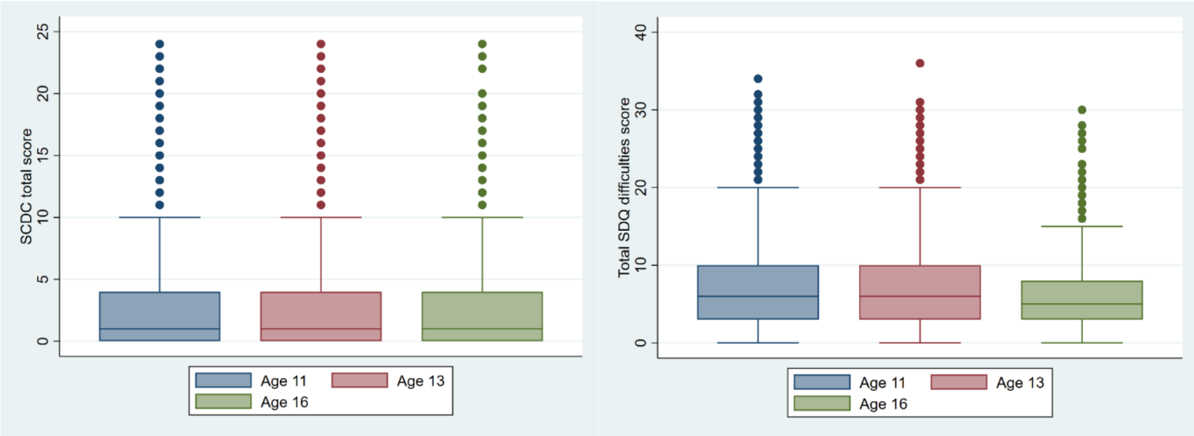
Convention for the SCDC is that a score of zero indicates no problems, an abnormal score is 8 or above and the maximum score is 24. An abnormal score provides a positive screen for poor social cognitive function and a potential autistic spectrum disorder. The coding used by ALSPAC did not allow scoring to this convention, so a coding revision was applied to Stata to provide the thresholds indicated in the literature. An additional variable was added to Stata that allowed the calculation of a total SCDC score from questionnaire responses to the 12 questions (Table 7) at ages 11, 13 & 16, when the questionnaires were completed by parents. The final question, "Parents had other concerns in past six months" was not included in the SCDC score as it requires a dichotomous response and is not part of the standard SCDC questionnaire.

***Table 7: Mean values for SDQ and SCDC observations.***
***Source: Cambridgeshire NHS Community Paediatrics***

| SDQ total score mean | | SCDC score mean | |
|---|---|---|---|
| Age 11 | 6.59 | Age 11 | 2.53 |
| Age 13 | 6.79 | Age 13 | 2.65 |
| Age 16 | 5.91 | Age 16 | 2.79 |

The psychosocial data is considered ordinal, rather than nominal, for the purposes of this study since both the SDQ and SCDC data results in a scale with defined boundaries. The data for all psychosocial variables is of right-skew normal distribution, which would be expected with most participants having low (normal) scores. The normal distribution is confirmed by quartile-quartile (Q-Q) comparison of all variables and Shapiro-Wilk value of $\rho < .001$. Figure 1 shows boxplots for both SDQ and SCDC total scores the mean values for which are shown in Table 7. For both measures, the mean and inter-quartile values and the range of data are very similar at ages 11 and 13, with a slight difference at age 16.

***Figure 1: Boxplots for both SDQ and SCDC total scores for each age.***




As stated above, as both the SCDC and SDQ prosocial scores are measures of social functioning (Chapter 2), it is expected that the two scores would show a high negative correlation since lower SDQ prosocial scores indicate poor functioning whereas higher SCDC scores are indicative of this. However, results of the Spearman correlation indicated that there was a statistically significant but moderate negative association between SCDC and SDQ prosocial scores at all ages: Age 11, ($r_s(2040) = -.33$, $\rho < .001$); Age 13, ($r_s(2268) = -.38$, $\rho < .001$); Age 16, ($r_s(1502) = -.48$, $\rho < .001$). The SCDC is an internationally accepted measure of social cognitive function, used in the diagnosis of social and communication disorders including autism, whereas the SDQ prosocial score is more indicative of the soundness of the participants social relationships. Being affected by an autistic spectrum disorder does not preclude an individual from being helpful, supportive and sympathetic towards others, which may account for the differences. However, as both scales are indicators of social cognitive functioning, the analyses of both will take place with the biological markers or variables. It should be noted that there is a strong relationship between these two variables across the sampling ages. This indicates little change in social cognitive function in the general study population, contrary to several papers which report a characteristic mid-adolescent decline in social cognition (Chapter 2) although this does occur in some individuals, notably extreme outlier cases (Chapter 5).

A pairwise correlational analysis (Table 8) indicated a significant positive association between all elements of the SDQ and between all ages (ρ < .001).

***Table 8: Pairwise correlational analysis between SDQ categories at ages 11, 13 & 16. Source: ALSPAC.***

| | Age 11 | | | | Age 13 | | | | Age 16 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | E | H | C | P | E | H | C | P | E | H | C | P |
| Emotion (E) | 1.00 | | | | 1.00 | | | | 1.00 | | | |
| Hyperactivity (H) | 0.3432 | 1.00 | | | 0.3399 | 1.00 | | | 0.3295 | 1.00 | | |
| Conduct (C) | 0.3067 | 0.4991 | 1.00 | | 0.3185 | 0.5238 | 1.00 | | 0.3130 | 0.4918 | 1.000 | |
| Peer problems (P) | 0.3913 | 0.2921 | 0.2958 | 1.00 | 0.4371 | 0.2649 | 0.2813 | 1.00 | 0.4125 | 0.1975 | 0.1926 | 1.00 |

The high positive association between conduct problems and hyperactivity should be noted, particularly during mid-adolescence (*r* (3513) = .52, ρ < .001). Although it would be expected, anecdotally and in the literature Chapter 2, for children with a hyperkinetic disorder to exhibit challenging behaviour, it would not necessarily lead to the extent of an abnormal SDQ conduct score (p.19). Of note is the high positive association between SDQ total score at age 16 and the hyperactivity score (*r* (2714) = .54, ρ < .001). This indicates that children with high hyperactivity scores face other significant difficulties (Section 4.3.3). A significant positive association also exists between emotional symptoms and peer problems at all three stages of adolescence but again, particularly during mid-adolescence (*r* (3512) = .35, ρ < .001). Emotional symptoms involve the internalising symptoms that would make an association with peer problems logical.

Analysis of the data showed associations of varying degrees between SDQ and SCDC variables at ages 11, 13 and 16. Only significant associations between the variables are discussed in the commentary that follows. Spearman correlation indicated that there was a significant positive association between the SDQ total difficulties score and the SCDC score at: age 11 ($r_s$(679) = .50, ρ < .001); age 13 ($r_s$(679) = .49, ρ < .001); and age 16 ($r_s$(679) = .54, ρ < .001). This is an interesting and unique finding. It is comparable to the only two published references on the matter: Bolte et al. (2011b), which principally compares the SCDC total score with the Social Responsiveness Scale, and Skuse et al. (2009) who compared ALSPAC participant SCDC scores with the SDQ total score. In both papers, a “robust correlation” was shown between the two scores. However, only Skuse et al. (2009) compared elements of the SDQ with individual SDQ sub-scores at age 8 whereas this analysis compares the same at three stages of adolescence. Findings of the Skuse study and that of this analysis are shown in Table 9. The differences shown are possibly because of the inclusion criteria used by Skuse, the sampling age and the fact that their data also includes female participants. However, it is reassuring to note that the findings of this study are within a similar range.

***Table 9: Comparison of SCDC and SDQ subscale variables between the findings of Skuse (2009) and this study. All findings are significant at the ρ < .001 level. Adapted from Skuse et al. (2009).***

| SDQ subscale | SCDC range age 8 | This study SCDC range | | |
|---|---|---|---|---|
| | | Age 11 | Age 13 | Age 15 |
| Prosocial behaviour | -.13 | -.35 | -.38 | -.48 |
| Hyperactivity | .20 | .45 | .46 | .51 |
| Emotional symptoms | .02 | .28 | .28 | .32 |
| Conduct problems | .09 | .49 | .49 | .56 |
| Peer problems | .39 | .29 | .29 | .24 |
| Total difficulties (0-40) | .41 | .54 | .54 | .59 |

In addition to significant associations between the SCDC and SDQ total difficulties scores, these data also shows a moderate to high association between the SCDC score and SDQ subscales in this study's three sample ages. The highest in the study dataset being with SDQ peer problems (r_s(683) = .22, ρ< .001) at age 11. In contrast, Skuse et al. (2009) only found small to moderate associations.

At age 11, Spearman correlation indicated a significant positive association between the SDQ emotion score and all elements of the SCDC questionnaire ($r_s$ (685) = .24, ρ< .001). A particularly high association was seen with the variable "child was difficult to reason with when upset" which could be expected for children who are nervous and worried. SDQ hyperactivity was significantly associated with high scores in all elements of the SCDC indicating that boys exhibiting hyperactivity are likely to exhibit poor social cognitive functioning ($r_s$ (685) = .37, ρ < .001) the highest association being a lack of understanding of social skills. A similar significant positive association was seen between the SDQ conduct and SDQ hyperactivity scores ($r_s$ (685) = .46, ρ < .001). It links the two behaviours in terms of difficulties experienced by participants, which is widely reported in the literature (Chapter 2). Again, these findings are logical, which adds further evidence for the reliability of this study's data. SDQ prosocial scores are negatively correlated with all SCDC elements ($r_s$ (685) = -.35, ρ < .001) with a lack of understanding of others' feelings showing the highest negative association (the relationship between these variables is discussed above).

Correlational analysis of the data collected at age 13 indicated a significant positive association between the SDQ emotion score and all elements of the SCDC but more highly than at age 11 ($r_s$ (685) = .27, ρ < .001). The most highly correlated was the SCDC variable "child cannot follow a command unless carefully worded", seen as an indicator of poor social cognition. There is evidence of a decline in the association between hyperactivity and social cognition compared with age 11 ($r_s$ (685) .40, ρ < .001). The SCDC variable "child's behaviour disrupts normal family life" is highly associated with the SDQ conduct score, understandably but more so than at age 11 ($r_s$(685) = .53, ρ < .001). The smallest association for the SDQ conduct score is with SCDC variable "child doesn't understand how they should behave when out, e.g. shops/other peoples' houses" ($r_s$(685) = .27, ρ < .001), expected since the latter is associated with a social or communication disorder rather than challenging behaviour, indicative of the former. SDQ peer problem scores showed a moderate association with SCDC elements ($r_s$(685) = .29, ρ < .001), whereas SDQ prosocial scores showed a moderate negative association with all SCDC elements ($r_s$(685) = -.38, ρ < .001), as at age 11.

During late adolescence (age 16) the value range of the SCDC score increased when compared with the SDQ emotion subscale increased at age 13 ($r_s$ (685) .33, ρ < .001). As at age 13, the smallest association was for the variable "study teenager did not understand how they should behave when out…" The highest association was the variable "study teenager's behaviour often disrupts normal family life". The association between social cognition and hyperactivity also shows a greater association than at age 13 ($r_s$ (685) .44, ρ < .001). The SDQ conduct subscale shows a similar high association with the SCDC score at age 13, again, the highest being "study teenager's behaviour often disrupts normal family life" ($r_s$(685) = .52, ρ < .001). The association between SCDC elements and the SDQ peer problems and prosocial scores showed similarity to those at age 13.

Although the data derived from both the SCDC and the SDQ is quantitative, it was collected via questionnaires leading to the potential issue of reliability and bias, which must be considered during analysis (Streiner & Sidani, 2009). During correlational analysis, reliability and bias may be identified with anomalous data taken into consideration and potentially excluded.

Following the analysis in this Section and considering the research questions, it is appropriate for the following psychosocial variables to be analysed with biological and behavioural variables. Chapters 4 and 5, therefore, analysed the following variables: SDQ hyperactivity, conduct and total scores collected at ages 11, 13 and 15; the SCDC total score collected at ages 11, 13 and 16.

## 4. Analysis of biological data

In the section, potential associations between the ALSPAC biological variables (age, pubertal (Tanner) stage, endocrinology and anthropometric measures), considered as independent variables, are explored using pairwise correlation analysis (Table 10). Free testosterone and Body Mass Index (BMI) values are not included since it is well known that they are highly correlated with bioavailable testosterone (BT) and height/weight as discussed in Chapter 2. However, very low and very high BMI values were discussed in Chapter 5, which focusses upon extreme outlier cases. The table lists variables available in the ALSPC dataset in each of the biological categories. As the study is longitudinal, sampling took place from the same participants at various junctures relating to either age or stage of schooling (Chapter 3, Figure 3.1).

***Table 10: Pairwise correlation between biological variables, $\rho < .001$. The number shown is the correlation coefficient. Source: ALSPAC***

| | Age (years) | Tanner stage | SHBG (nmol/l) | BT (nmol/l) | Height (cm) | Weight (kg) |
|---|---|---|---|---|---|---|
| **Age** | 1.0000 | | | | | |
| **Tanner** | 0.8271 | 1.0000 | | | | |
| **SHBG** | -0.6724 | -0.6421 | 1.0000 | | | |
| **BT** | 0.8238 | 0.8170 | -0.6157 | 1.0000 | | |
| **Height** | 0.8272 | 0.8225 | -0.6282 | 0.8045 | 1.0000 | |
| **Weight** | 0.7352 | 0.7281 | -0.1357 | 0.7389 | 0.8317 | 1.0000 |

Table 10 shows that all variables are highly correlated with each other at the ρ<.001 level. Results of the Spearman correlation indicated a significant positive association between age and Tanner stage, $r_s$(985) =.83, ρ (one-tailed) < .001. Pearson correlation also showed a significant positive association between age and bioavailable testosterone, $r_s$(985) =.81, ρ (one-tailed) < .001. Relationships between these three variables appear in Figure 2, which shows a regression discontinuity for both Tanner stage and BT at age 14 when the rate of increase of both variables slow. A linear relationship between these two variables is clear. A high inverse relationship is seen between age and free sex hormone binding globulin (SHBG) (Figure 3), which is expected because it is known that as serum testosterone increases, more becomes bound to SHBG (Aydın & Winters, 2016).

***Figure 2: Relationship between age, Tanner stage and bioavailable testosterone concentration***

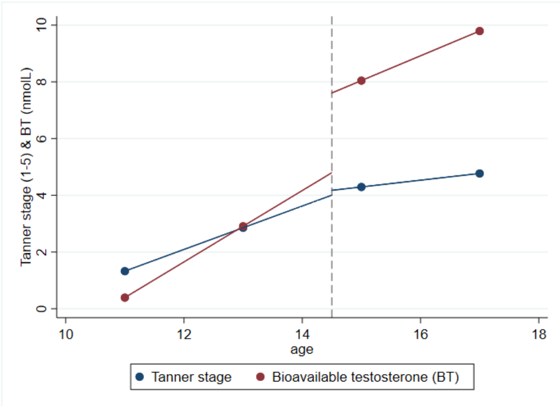
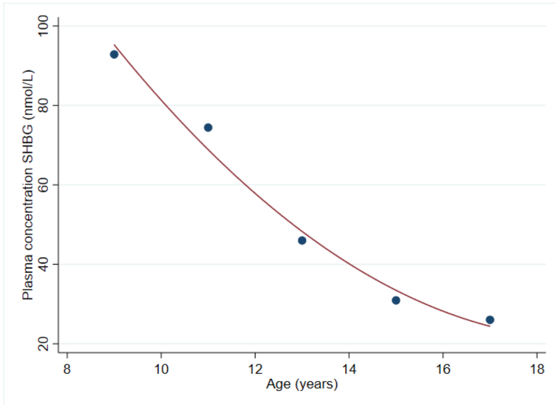



***Figure 3: Relationship between age and plasma SHBG***




Considering the various measures of testosterone, the highest association with other biological variables is BT, slightly above that of total serum (plasma) testosterone: Spearman correlation between age and free testosterone, $r_s$(985) = .85, ρ < .001 whereas for BT, $r_s$(985) = .87, ρ < .001. The same analysis between BT and Tanner stage indicated a significant positive correlation, $r_s$(619) = .84, ρ< .001. Pearson correlation between BT and height is also high, *r* (379) = .80, ρ < .001; and slightly less marked between BT and weight, *r* (379) = .74, ρ < .001. As illustrated in Figure 3, the inverse relationship between age and plasma SHBG is expected to represent high negative correlations between plasma SHBG and other independent variables, which was found in the data: (1) Spearman correlation for SHBG and Tanner stage, $r_s$ (619) = -.69, ρ < .001; (2) Pearson correlation for SHBG and BT, *r* (379) = -.78, ρ < .001; (3) SHBG and height, *r* (379) = -.73, ρ < .001; (4) SHBG and weight, *r* (379) = -.74, ρ < .001.

It is expected that children will gain height and weight with age and as puberty progresses. Both are highly correlated with Tanner stage and BT, although weight slightly less so (Figures 4 & 5) and discussed above. Figures 4 and 5 show two classical regression discontinuities at ages 12 and 14. This is because boys typically undergo peak height velocity (Chapters 2 & 3) between these ages with growth slowing at around age 15 with height and weight significantly correlated. Furthermore, Spearman correlation shows a significant positive association between the continuous variables, height and weight, with the ordinal variable Tanner stage: (1) height and Tanner stage, $r$ (3763) = .82, ρ < .001; (2) weight and Tanner stage, $r$ (3763) = .73, ρ < .001. As with height and weight with age, weight shows a slightly less marked correlation with Tanner stage.

***Figure 4: Relationship between age and height in adolescent boys***

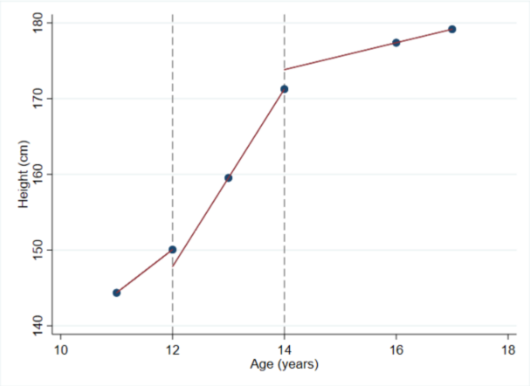
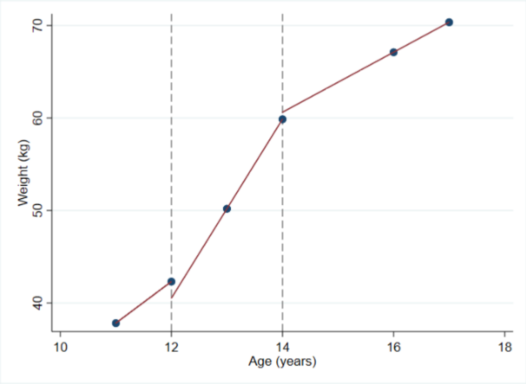



***Figure 5: Relationship between age and weight in adolescent boys***




Pairwise correlation of salivary cortisol concentration in the total population collected at age 8 did not show a significant association with Tanner stage, BT nor height. There was a small negative association shown between cortisol and weight, $r_s$(1330) = -.10, ρ < .05.

As the findings of all the analyses between biological variables in this Section are as expected and reflect evidence presented in the literature, the ALSPAC dataset is considered reliable. All biological and to an extent, anthropometric variables, are highly correlated. It is appropriate to select those variables associated with the study research questions (Section 1.4) to be used for analysis with psychosocial and behavioural variables. These are: Tanner stage determined by pubic hair distribution, salivary cortisol concentration and the plasma concentration of bioavailable testosterone.

# 6: Strengths & Difficulties Questionnaire components and scoring

Strengths and Difficulties Questionnaire

Each subscale of the SDQ has been colour coded below to make scoring quicker and easier. Simply add the figures corresponding to the boxes ticked by the parent for each subscale and write them in the provided space on your triplicate form. REMEMBER, the Total Difficulties score is the sum of the 4 problem scales and DOESN'T include the Prosocial score.

| | Not True | Somewhat True | Certainly True |
|---|---|---|---|
| 1 Considerate of other people's feelings | 0 | 1 | 2 |
| 2 Restless, overactive, cannot stay still for long | 0 | 1 | 2 |
| 3 Often complains of headaches, stomach-aches or sickness | 0 | 1 | 2 |
| 4 Shares readily with other children (treats, toys, pencils etc). | 0 | 1 | 2 |
| 5 Often has temper tantrums or hot tempers | 0 | 1 | 2 |
| 6 Rather solitary, tends to play alone | 0 | 1 | 2 |
| 7 Generally obedient, usually does what adults request | 2 | 1 | 0 |
| 8 Many worries, often seems worried | 0 | 1 | 2 |
| 9 Helpful if someone is hurt, upset or feeling ill | 0 | 1 | 2 |
| 10 Constantly fidgeting or squirming | 0 | 1 | 2 |
| 11 Has at least one good friend | 2 | 1 | 0 |
| 12 Often fights with other children or bullies them | 0 | 1 | 2 |
| 13 Often unhappy, down-hearted or tearful | 0 | 1 | 2 |
| 14 Generally liked by other children | 2 | 1 | 0 |
| 15 Easily distracted, concentration wanders | 0 | 1 | 2 |
| 16 Nervous or clingy in new situations, easily loses confidence | 0 | 1 | 2 |
| 17 Kind to younger children | 0 | 1 | 2 |
| 18 Often lies or cheats | 0 | 1 | 2 |
| 19 Picked on or bullied by other children | 0 | 1 | 2 |
| 20 Often volunteers to help others (parents, teachers, other children) | 0 | 1 | 2 |
| 21 Thinks things out before acting | 2 | 1 | 0 |
| 22 Steals from home, school or elsewhere | 0 | 1 | 2 |
| 23 Gets on better with adults than with other children | 0 | 1 | 2 |
| 24 Many fears, easily scared | 0 | 1 | 2 |
| 25 Sees tasks through to the end, good attention span | 2 | 0 | 1 |

Here are the score ranges for 'Normal' (N), 'Borderline' (B) and 'Abnormal' (AB) scores. When reviewing with parents remind them this is only an indication of possible problems and not a diagnostic test.

| | | | |
|---|---|---|---|
| Emotional Symptoms | N = 0-3 | B = 4 | AB = 5-10 |
| Conduct Problems | N = 0-2 | B = 3 | AB = 4-10 |
| Hyperactivity | N = 0-5 | B = 6 | AB = 7-10 |
| Peer Problems | N = 0-2 | B = 3 | AB = 4-10 |
| Total Difficulties Score | N = 0-13 | B = 14-16 | AB = 17-40 |
| Prosocial | N = 6-10 | B = 5 | AB = 0-4 |