Conduct Problems and Callous-Unemotional Traits in Adolescence: Social Cognitive and Personality Features

Author: Anne Helen Gaule

Prepared under the supervision of Professor Essi Viding & Professor Eamon McCrory

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Clinical, Educational, and Health Psychology Research Department

Division of Psychology and Language Sciences

University College London, UK

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Declaration

I, Anne Gaule, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature:

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Abstract

Despite over 20 years of research into conduct problems (CP) and callous-unemotional (CU) traits in adolescence, little is known about processes that might be relevant for shaping the social environments of these individuals. The current thesis addressed this gap in research by investigating four domains thought to relate to social functioning: prosocial behaviour [Chapter 2], social information use [Chapter 3], personality [Chapter 4], and theory of mind (ToM) [Chapter 5]. Research presented in Chapter 2 showed that adolescents with CP and high levels of CU traits (CP/HCU) demonstrated especially low prosocial behaviour relative to adolescents with CP and lower levels of these traits (CP/LCU) and typically developing (TD) adolescents. Although both groups with CP displayed reduced prosocial intentions compared to TD adolescents, adolescents with CP/HCU engaged in especially reduced prosocial actions relative to other groups. Findings outlined in Chapter 3 indicated that adolescents with CP/HCU and CP/LCU showed no difference in degree of social information use relative to TD adolescents. However, adolescents with CP/LCU appeared less cooperative than other groups when using social information. In Chapter 4, personality correlates of CP/CU were examined in a community sample through the development of a new six-factor adolescent personality instrument that measures Honesty-Humility as well as traditional dimensions of personality. Including Honesty-Humility improved prediction of both CP and CU in regression models, indicating the potential importance of this factor for understanding social functioning of individuals high in CP and CU. In Chapter 5, the relationship between ToM and CU traits was investigated in a community sample of adolescents. Higher CU traits were associated with better mind representation, which we assessed using a new experimental adolescent measure.

Together, these findings contribute to a more comprehensive understanding of CP and CU in adolescence, and further underline the importance of acknowledging heterogeneity in adolescent CP.

Impact statement

The current thesis adds to a knowledge base that attempts to understand thinking and personality patterns of young people with conduct problems (CP) and how these might vary as a function of callous-unemotional (CU) traits. Although this research does not have direct implications for treatment of psychopathology, scientific research is crucial to being able to develop clinical practices based on accurate and detailed knowledge. Accordingly, our findings can be considered in a clinical and practical context – although it should be acknowledged that these will need replication and extension before strong conclusions can be drawn.

The findings from Chapter 2 imply that adolescents with CP and high CU traits (CP/HCU) and those with CP and lower CU traits (CP/LCU) differ in their engagement in prosocial behaviours. While adolescents both groups demonstrated similarly reduced prosocial choice in our paradigm relative to TD adolescents, only adolescents with CP/HCU demonstrated especially reduced prosocial action. Clinicians, educators, and others who work with children might want to consider that adolescents with CP/HCU may be especially unmotivated to engage in prosocial behaviours – which may in turn impact their social relationships. There is a need to develop treatment adjuncts that understand nuanced differences in reduced prosocial behaviours in CP/HCU and CP/LCU.

The findings from Chapter 3 imply that adolescents with CP/LCU may have difficulty factoring others' feedback into their existing beliefs. Adolescents in this group were less likely, relative to adolescents with CP/HCU and TD adolescents, to use cooperative strategies when presented with social information - apparently driven by a tendency to stick with their initial beliefs. This may in turn impact their social relationships. Clinicians, educators, and parents might therefore consider helping these adolescents to find a ‘middle-grounds’ between their own beliefs and those of others.

Chapter 4 provides data on a new six-factor personality measures Honesty-Humility, as well as the traditional dimensions of personality. Inclusion of Honesty-Humility improved prediction of both CP and CU traits, indicating the potential importance of this factor for understanding social functioning of individuals with high levels of CP and CU traits. Personality inventories have proven useful in clinical practice for formulating diagnoses, developing insight into clinical conditions, and in selecting the optimal form of treatment. A more nuanced measure of personality may thus have future benefit for clinical formulation.

Chapter 5 was designed to shed light on mixed findings regarding theory of mind (ToM; or the understanding of others’ beliefs and desires) in relation to CU traits. We assessed the relationship between these traits and ability to represent others’ minds via a novel adolescent measure. High CU traits were associated with better mind representation. This implies that previous mixed results in ToM research might relate to the propensity, rather than ability, of adolescents with high CU traits to engage in mental state inference. While these findings do not have direct implications for clinical practice, they suggest directions for future research that may inform clinical practice down the line.

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Key Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ASPD	Antisocial Process Screening Device
AUDIT	Alcohol Use Disorder Identification Test
BES	Basic Empathy Scale
CASI-4R	Child and Adolescent Symptom Inventory, Revised
CD	Conduct disorder
CP	Conduct Problems
CP/HCU	Conduct problems with high levels of CU traits
CP/LCU	Conduct problems with low levels of CU traits
CU	Callous Unemotional
DUDIT	Drug Use Disorder Identification Test
HCU	High levels of CU traits
ICU	Inventory of Callous and Unemotional Traits
IQ	Intelligence Quotient
LCU	Low levels of CU traits
MVC	Maximum Voluntary Contraction
PCL-R YVI	Psychopathy checklist revised youth version
PPT	Personality Pairs Task
SDQ	Strengths and Difficulties Questionnaire
SES	Socio-economic status
TD	Typically Developing
WASI	Wechsler Abbreviated Scale of Intelligence

Chapter One – Introduction

1.1 Conduct Disorders in Childhood

Conduct Problems (CP) in childhood and adolescence refer to repeated and persistent patterns of antisocial and disruptive behaviour that violates the rights of others or age appropriate social norms (Castillo et al., 2007). Young people with CP present a significant cost, both to themselves and to society. CP constitutes one of the most common reasons for referral to child and adolescent mental health services (CAMHS) (National Collaborating Centre for Mental Health et al., 2013), and the long term societal cost of severe behavioural problems have been estimated to be around £260, 000 per child (Parsonage et al., 2014). Severe CP in childhood and adolescence predicts poor outcomes in adulthood, such as being at increased risk of incarceration, poor mental health (e.g. substance abuse), and early mortality (Fergusson et al., 2005; Kratzer & Hodgins, 1997). Given the substantial maladaptive outcomes for young people with CP, there is a strong imperative to understand why some children and adolescents are at risk of behaving antisocially.

CP and severe antisocial behaviour in adolescence has been the focus of extensive research which attempts to understand causes, and identify cognitive and developmental underlying factors (Dodge & Pettit, 2003; Miller et al., 2010; Viding et al., 2008; Viding, Fontaine, et al., 2012). Most notably, this research has highlighted the importance of looking at CP as a heterogeneous, rather than a unitary, construct. It has become increasingly clear that young people who develop CP may have different causal pathways leading to their behaviour and may thus have different requirements for intervention. Numerous attempts have been made to identify clear subgroups of young people with antisocial behaviour based on their severity, persistence, and associated risk factors. One particular approach has gained a lot of traction as having significant potential for explaining different patterns of aggressive and antisocial behaviour (Frick & Marsee, 2018). This is looking at levels of what are referred to as callous-unemotional (CU) traits (Frick & White, 2008). These are traits such as a lack of remorse and guilt, a lack of empathy with others, and shallow affect (Frick et al., 2003). Before going into more detail regarding the research on CP with CU traits, it is important to first to present the research underlying their definition, and the evidence supporting the utility of these traits as a differentiating factor for young people with CP.

1.2 CU traits as a differentiating factor in childhood CP

In the early 1990s, Robert Hare and colleagues formalised ways of assessing severe patterns of antisocial behaviour in adulthood that are combined with lack of empathy and remorse – what is termed as psychopathic personality disorder. Hare's model - the 'two factor model of psychopathy' - specifies two factors of behaviour/traits. The first factor includes traits which have been referred to as the 'hallmark of the psychopathic personality': interpersonal traits (e.g superficial charm, superficial relationships, a lack of empathy) and emotional traits (e.g. absence of guilt, shallow affect, a lack of anxiety) (Christian et al., 1997; Cleckley, 1976; Hare, 1999). The second factor includes traits and behaviours, which have been considered to define antisocial personality disorder (APD) such as antisocial behaviour and unstable lifestyle (e.g. multiple arrests, aggression, multiple marriages, and lack of long-term employment). Numerous studies have demonstrated that these factors are separable using factor analysis and have differential correlates, indicating different developmental and causal pathways (Hare et al., 1990; Hare & Neumann, 2008; Harpur et al., 1989). These studies also demonstrate that, when these factors co-occur in the same individual, this individual is likely to show an especially severe and chronic pattern of anti-social behaviour.

Paul Frick and colleagues later extended this two-factor model of psychopathy in adulthood to understanding the behaviour of children and young people who display severe CP (Frick, 1994). Although psychopathy is clearly an adult personality disorder, Frick et al. observed similar separable dimensions in clinic-referred children with CP: one dimension being characterised by callous-unemotional (CU) interpersonal style (e.g. lack of guilt, lack of empathy, shallow affect), the second being characterised by poor impulse control and antisocial behaviour (e.g. reactive aggression, rash decisions; engaging in illegal activity). While the second dimension charted behaviours characteristic of broad CP, the first, CU, dimension had characteristics that diverged from CP symptoms and suggested a different aetiology (Frick, 1994). Later research extended these findings by identifying a small, unique cluster of adolescents who exhibited CP (including CD or Oppositional Defiant Disorder, ODD) and who also showed high scores on the CU dimension of the two-factor model (Christian et al., 1997; Lynam, 1997). This subgroup, henceforth referred to as CP/HCU, comprised children and adolescents who demonstrated more severe antisocial behaviour than the group of children and adolescents with CP and lower levels of these traits (CP/LCU). They showed more extreme and more varied problem behaviour - including instrumental aggression - had higher rates of police contact, and were more likely to have parents with a history of Antisocial Personality Disorder (Christian et al., 1997). These findings implied the existence of a unique subgroup of adolescents with CP/HCU, whose traits fit more closely with the traits of those with psychopathic personality disorder in adulthood and who may be at risk of developing psychopathy later in life. Importantly, subsequent research on CU traits demonstrated their distinct utility (over other symptom dimensions of psychopathy such as narcissism/interpersonal and impulsivity/lifestyle traits) for differentiating a group of children and adolescents with CP/HCU that differ from those with CP/LCU on important biological, cognitive, emotional, and social characteristics (De Brito et al., 2021; Frick & Marsee, 2018). For example, whereas adolescents with CP/HCU display reduced empathy and guilt relative to healthy adolescents and are more likely to engage in premeditated aggression, those with CP/LCU tend to show typical levels of guilt and empathy, and are more likely to engage in reactive aggression (Fanti et al., 2008; Frick et al., 2003). In recognition of their importance for the development of prevention and intervention programs, the DSM-5 now includes a 'Limited Prosocial Emotions' specifier to identify young people with conduct disorder who also display CU traits (Colins et al., 2021; Kimonis et al., 2014).

1.3 Aetiology and stability of CU traits

Elevated levels of CU traits in childhood and adolescence (both in the presence and absence of CP) appear to be moderately to strongly heritable - i.e. a moderate to large degree of variation in these traits is attributable to genetic variation (Larsson et al., 2008; Viding & McCrory, 2018). Heritability estimates of CU traits range between .42-.60, and are most commonly derived from studies employing the standard twin design, in which researchers compare the similarity of monozygotic (identical) and dizygotic (fraternal) twins (Frick et al., 2014; Henry et al., 2018; Moore et al., 2019; Viding & McCrory, 2012).

There is evidence for considerable shared variance in the genes influencing CU and CP (Viding et al., 2007). However, research also indicates that CP and CU have at least partially distinct aetiological underpinnings (Bezdjian et al., 2011; Forsman et al., 2008; Frick et al., 2014; Viding et al., 2007). It appears that CP combined with high levels of CU (CP/HCU) is strongly heritable (i.e. group differences between CP/HCU children and the rest of the population are largely due to genetic factors), whereas CP combined with lower levels of CU traits (CP/LCU) is more influenced by environmental factors (Viding et al., 2005, 2008). Research on the developmental trajectories of CP and CU also indicates an asymmetric relationship, whereby high levels of CU in childhood almost invariably denote high levels of CP over development, but high levels of CP are only moderately associated with high CU (Fontaine et al., 2011). It should be noted, however, that the three cited studies indicating differential heritability and developmental trajectories of CP/HCU vs CP/LCU were carried out in the same large sample of twins (the Twins Early Development Study) (Fontaine et al., 2011; Viding et al., 2005, 2008). This is because the sample size of this study was sufficiently large that it was powered to focus on extremes of the distribution of CP and CU (Viding et al., 2005, 2008). These findings need to be replicated in other large twin samples. It is also important to note that a genetic predisposition for CP/HCU does not directly result in the development of adult psychopathy. The way in which a person develops is always shaped by a complex interplay between genetic propensities, and their environmental context (Viding & McCrory, 2018).

1.4 Measurement of CU traits

Multiple instruments have been designed to measure CU traits in childhood and adolescence. These include the Antisocial Process Screening Device (APSD; Frick & Hare, 2001), the Youth Psychopathic Traits Inventory (YPI; Andershed et al., 2002), the Psychopathic Checklist-Revised Youth Version (PCL-R YVl; Forth et al., 2003), the Child Problematic Traits Inventory (CPTI; Colins et al., 2014) and the Inventory of Callous-Unemotional Traits (ICU; Kimonis et al., 2008). All of these measures target the underlying affective deficits that are common across conceptualisations of psychopathy (De Brito et al., 2021; Viding & Kimonis, 2018). However, they vary in terms of their means of assessing CU traits, including self-report (ICU, YPI, ASPD), parent and teacher ratings (ICU, ASPD, and CPTI), and semi-structured interviews by a professional rater combined with file information (PCL-R YV). A high score on one of these measures is generally indicative of a high score on another (Viding & Kimonis, 2018), however it should be noted that the measurement instrument used to assess CU traits still likely to influence findings in studies of CU traits in development. Assessment of CU traits is further complicated by the fact that symptoms do not always manifest in the same manner across time in young people (i.e. heterotypic continuity) (Cicchetti & Rogosch, 1996; Viding & Kimonis, 2018). Accordingly, and like most forms of childhood psychopathology, CU traits appear to be only moderately stable over development (Mash & Dozois, 2003), and vary based on both developmental stage and the measurement instrument being used (Viding & Kimonis, 2018).

Of the instruments described so far, the ICU is the only measure which has been specifically designed to measure CU traits; the others (such as the ASPD) contain only a few items to measure the construct and also include other items assessing e.g. impulsive and antisocial behaviours (Docherty et al., 2017). The ICU has been used in over 250 peer reviewed studies (Kemp et al., 2021), and there is strong evidence that the full ICU measure has strong internal consistency and construct validity (Cardinale & Marsh, 2020). The ICU has distinct advantages for use with adolescents: it is relatively brief (which makes it easy to implement in studies with young people) and, as a multi-informant measure, it gives a comprehensive assessment of CU traits (e.g. White et al., 2009).

There is a strong rationale for comparing groups of children and adolescents with CP/HCU and CP/LCU, and their typically developing (TD) peers, when trying to investigate cognitive and affective processing patterns in adolescents with clinically concerning levels of CP (continuous analyses may be more appropriate for community samples without clinically concerning levels of CP). First, effects of CU traits do not always emerge as interactions, and can instead lead to suppressor effects in correlational analyses (Frick, 2012). Second, there is evidence that CP and CU are not independent (as evidenced by previously mentioned research indicating that high CU traits are nearly always accompanied by high CP but that high CP may or may not be associated with high CU) (Fontaine et al., 2011). This absence of bivariate normality is a strong argument in favour of using a group analysis approach (Frick, 2012). Third, studies that employ a group comparison approach have successfully identified groups of adolescents with CP that show different patterns of cognitive-affective processing (e.g. Lawing et al., 2010; O'Nions et al., 2014; Roberts et al., 2020; Sakai et al., 2016; Schwenck et al., 2012; Viding, Sebastian, et al., 2012). Finally, a person centred approach makes it easier to interpret the translational relevance of findings, which can be challenging in the presence of potential suppressor effects. It should be noted, however, that no official 'cut-off' point currently exists for assigning young people to CP/HCU and CP/LCU groups (for studies attempting to establish this, see Docherty et al., 2017; Kemp et al., 2021). Therefore, one common approach to determine group assignment is the median split approach. This involves collecting a sample of adolescents with CP and assigning those who score above the group median as CP/HCU and anyone who scores below or equal to the group median as CP/LCU. This method has been used in a host of research studies to date, and has successfully delineated differential cognitive affective processing in CP/HCU and CP/LCU (see e.g. Lawing et al., 2010; Martin-Key et al., 2017; O'Nions et al., 2014, 2017; Roberts et al., 2020; Schwenck et al., 2012; Viding, Sebastian, et al., 2012).

1.5 Neuro-cognitive and behavioural correlates of CP/HCU and CP/LCU

As discussed above, CU traits have presented distinct utility for identifying adolescents with CP who present with particularly severe antisocial behaviour. Adolescents with CP/HCU are more likely to engage in premeditated, instrumental aggression, and demonstrate less empathy and guilt than adolescents with CP/LCU. Given these differing behavioural profiles, it has been suggested that different neurocognitive difficulties contribute to CP/HCU and CP/LCU (Blair, 2013; Blair et al., 2014).

A number of studies support this proposition. For example, adolescents with CP/HCU appear to show distinct atypicalities in emotion processing relative to adolescents with CP/LCU and typically developing (TD) peers. Studies have demonstrated that adolescents with CP/HCU demonstrate a reduced capacity to feel fear and anxiety (Frick et al., 1999; Lynam et al., 2005). In fact, childhood fearlessness has been shown to predict CU traits in early adolescence (Barker et al., 2011). As well as feeling less fear and anxiety themselves, adolescents with CP/HCU also appear to have a reduced ability to recognise, attend to, and react to fear and distress cues in others. This includes facial expressions (Blair et al., 2001, 2004; Dadds et al., 2006; Hodsoll et al., 2014; Marsh & Blair, 2008), vocal tones (Blair et al., 2005; Muñoz, 2009), and body postures (Muñoz, 2009). This is also reflected at a neural level: adolescents with CP/HCU demonstrate reduced activity in the amygdala (a brain region associated with emotional processing) when viewing fearful faces relative to TD adolescents (Jones et al., 2009; Marsh et al., 2008; Viding et al., 2012). Although the largest impairments are seen for fear and distress cues, there is some evidence that atypical processing of emotions in CP/HCU extend to positive emotions, such as happiness (Dawel et al., 2012; Hodsoll et al., 2014; O'Nions et al., 2017).

Adolescents with CP/HCU also consistently demonstrate impairments on experimental measures of empathy. Broadly defined, empathy is the process by which individuals are able to recognise, understand, share in, and react to the emotional states of others (de Waal & Preston, 2017). It is generally agreed that empathy is separable into two distinct components: cognitive and affective. Affective empathy is defined as affective responses to the emotional states of others, including emotional contagion (or spontaneously sharing the emotions of another) and emotional reactivity (negative arousal or distress in response to another's emotions) (Frick & Kemp, 2021; Lockwood et al., 2013). Cognitive empathy is commonly referred to as the ability to represent the beliefs and intentions of others (or 'theory of mind'/ToM) (Blair, 2013). I will henceforth refer to cognitive empathy as ToM.

As might be expected from the atypical emotion processing that this group demonstrates, CP/HCU in adolescence has been strongly linked to impairments in affective empathy (Kemp et al., 2021; Waller et al., 2020). For example, survey data in a normative sample of over 2000 children aged 3-13 found that high CU traits in boys were consistently associated with low parental ratings of affective empathy (Dadds et al., 2009). Children and adolescents with CP/HCU also report resonating less with others' emotions than CP/LCU and TD peers in response to a range of stimuli including film clips, sound clips, and vignettes of others experiencing and expressing emotions (de Wied et al., 2012; Jones et al., 2010; Pardini et al., 2003; Schwenck et al., 2012). This group also seems to have trouble understanding the reasoning behind the emotions of characters in stories (Anastassiou-Hadjicharalambous & Warden, 2008). One study has indicated that this atypical affective empathy might be related to reduced amygdala activity when engaging in affective empathy processing (Sebastian et al., 2012), although this has not been replicated (Gao et al., 2019).

Findings regarding ToM in relation to CP/HCU are more mixed. Many studies have observed ToM to be intact in adolescents with CP/HCU, as long as processing of emotions is not involved (e.g. Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014; Sebastian et al., 2012). There is, however, also some experimental evidence - as well as evidence from studies employing questionnaire measures - that CP/HCU (or, in some studies, high CU traits in community samples) is associated with poor ToM (Brouns et al., 2013; Kahn et al., 2013; Pardini et al., 2003; Roberts et al., 2020; Sharp & Vanwoerden, 2014). Mixed findings in this domain may be related to the fact that many measures of ToM, including questionnaire measures, conflate cognitive and affective content, limiting the interpretability of findings (also proposed to be a problem in the adult ToM literature - for a discussion, see Lockwood et al. (2013)). It is also possible that adolescents with CP/HCU are *able* to engage in (non-affective) ToM processing but, that they have a lower *propensity* – or a reduced motivation - to do so relative to adolescents with CP/LCU and TD peers (Roberts et al., 2020). This, however, has yet to be empirically investigated.

Overall, the literature to date gives strong evidence that that empathic processing is disrupted in CP/HCU - at least when emotion processing is involved - with consistent evidence for deficiencies in affective empathy and mixed evidence regarding ToM/cognitive empathy.

Research has also demonstrated a strong link between CP/HCU in adolescence and impaired learning and decision-making – especially in relation to emotion. Adolescents with CP/HCU (as well as those with CP/LCU) have demonstrated poor behavioural performance on passive avoidance learning tasks, as well as reduced representation of expected value at a neural level (White et al., 2016). Adolescents with CP/HCU also show difficulty recognising contingency changes in tasks requiring response reversal, and this impairment appears to increase as the salience of the change is reduced (Budhani & Blair, 2005). Furthermore, adolescents with CP (both HCU and LCU) demonstrate marked atypicalities in their processing of reward and punishment cues. This is particularly notable in relation to punishment (although atypical reward processing is also observed e.g. Finger et al., 2008; Hawes et al., 2021; White et al., 2016). Adolescents with CP show reduced physiological responses to aversive stimuli (an indicator of arousal) (Fairchild et al., 2008; van Goozen et al., 2004), and to cues signalling impending punishment (Fairchild et al., 2008; Loeber et al., 2007; Syngelaki et al., 2013). At a neural level, adolescents with CP show deficits in negative prediction error signalling (that is, the neural response when an event is less rewarding than expected) in the ventro-medial prefrontal cortex, a key region involved in reinforcement learning (Blair et al., 2014; Finger et al., 2008; White et al., 2016). It has been argued that atypical representation of reward and punishment cues impairs the ability of adolescents with CP to learn the negative value of antisocial actions, and could thus be a mechanism leading to their severe antisocial behaviour (Blair et al., 2014). Interestingly, a recent study has indicated that differential responsiveness to reward and punishment cues in CP adolescents is negatively associated with severity of CU traits, implying that adolescents with CP/HCU may have particular difficulty differentiating between rewards and punishments (at least in the context of the experimental paradigm in question) (Zhang et al., 2021). Being able to differentiate a reward from a punishment is key to being able to learn from these stimuli. In line with the findings of Zhang et al., adolescents with CP/HCU have been shown to be less concerned than those with CP/LCU that aggressive behaviour would result in punishment, as well as a lack of concern about being punished for their transgressions (Pardini, 2011).

To summarise, extant research appears to support the proposition that children and adolescents with CP/HCU and CP/LCU may differ in important aspects of emotional and empathic processing and in their decision-making (Blair, 2013). However, it is also worth noting that, while there are some areas where findings are relatively consistent (e.g. impaired processing of fear/distress emotions in CP/HCU), there are also areas where findings are not clear-cut, such as the ToM literature. This may relate to sample characteristics, or use of group-based vs continuous analysis. Mixed findings might also relate to task characteristics. Indeed, it has recently been argued that an important limitation to current research in the field of cognitive psychology is that many tasks lack the sensitivity and specificity of measurement to test the theoretical questions that they are designed to investigate (Press, Yon, & Heyes, 2022; Stantik et al. 2022).

Also notable is that, while some of the research described so far is relevant to understanding how individuals with CP/HCU and CP/LCU interact with their social environment, our understanding of social cognition (or processes that enable us to engage with our social world; Frith, 2008) in these populations remains limited. This is especially concerning when we consider that a reduced motivation and capacity to form authentic relationships with others is a key feature of CP/HCU adolescence, and that many of the current programmes that are designed for reducing CP target social relationships (Hare & Neumann, 2008; Viding & McCrory, 2019, Pilling et al., 2013). Indeed, around one third of children and adolescents with CP do not respond to current treatment programmes - further highlighting the need for both research into social cognition in this population, and also for person centred research that recognises the heterogeneity of adolescents with CP (Beauchaine, Webster-Stratton, & Reid, 2005).

1.6 A closer look at social cognition in CP/HCU and CP/LCU

1.6.1 Evidence for atypical social affiliation in CP/HCU

Research to date has demonstrated that children and adolescents with CP/HCU exhibit atypical social functioning. They have been shown to display disorganised and incoherent attachment patterns with caregivers, and high CU traits have been associated with poor parent-child relationships (Fite et al., 2008; Pardini et al., 2007; Pasalich et al., 2012; Schneider et al., 2003). Similarly, peer relationships of adolescents with CP/HCU typically involve instability and conflict (Muñoz et al., 2008). It has been proposed that high CU traits in adolescence are characterised by reduced affiliative reward – in other words, a deficit in the seeking out or enjoyment of affiliative relationships (Viding & McCrory, 2019; Waller & Wagner, 2019). In line with this proposition, adolescents with CP/HCU are more likely to endorse social goals that are associated with revenge, dominance, and (forced) respect in hypothetical conflict scenarios relative to adolescents with CP/LCU, and also do not appear to be interested in resolving social conflicts in order to bond with others (Pardini, 2011; Pardini & Byrd, 2012). A study of over 700 11-13 year olds also found that the relationship between CP and both indirect and direct bullying increased as CU traits increased (Viding et al., 2009).

At a more mechanistic level, research has identified atypicalities in some key cognitive and behavioural processes that promote affiliation in adolescents with CP/HCU. For example, adolescents with CP/HCU demonstrate both a reduced desire to join in with, and a reduced neural response to, laughter relative to TD peers – providing some indication that CP/HCU may be associated with atypical processing of positive affect signals that promote social affiliation (O'Nions et al., 2017). High CU traits in childhood and adolescence are also associated with reduced eye contact with caregivers (Dadds et al., 2012), and reduced orienting to mothers' faces in early infancy (Bedford et al., 2015). This reduced facial orienting has also been shown to predict subsequent development of CU traits (Bedford et al., 2015).

Thus, research to date indicates that CP/HCU is associated with atypical social affiliation and has also identified some potential mechanisms that may underlie this. However, our knowledge of atypical social affiliation in CP/HCU remains limited; it is based on a small number of studies actively comparing adolescents with CP/HCU and CP/LCU in relatively few domains of social cognition. Shedding more light on the social-cognitive mechanisms that underlie atypical engagement in behaviours that promote social affiliation in CP, and systematically investigating how this differs in adolescents with CP/HCU and CP/LCU, would improve our understanding of social difficulties in CP and the development of psychopathy (Viding & McCrory, 2019). Better understanding in this domain would not only broaden the current knowledge base, but could also prove useful for the design of mechanistically informed treatments and interventions that meet the individual needs of adolescents with CP.

The current thesis thus aims to improve our understanding of social cognitive processing in CP and CU traits in two important ways. First, through empirical investigation of two key areas of social cognitive processing adolescents with CP/HCU and CP/LCU in which there is little or no prior research – prosocial behaviour and social information use. And second, through the development and use of novel tasks to provide more precise and specific measurement in two domains where more detailed research is needed in relation to CP and CU traits – personality characteristics and ToM.

1.6.2 Prosocial choice and effort

Antisocial and prosocial behaviours are not two ends of a single behavioural continuum. Research has documented a generally negative association between CP and prosocial behaviour (for review see Memmott-Elison et al., 2020), but has also highlighted that adolescents with CP show individual differences in the degree to which they engage in prosocial behaviour (Hawley, 2003; Kokko et al., 2006). For example, Hawley et al. (2003) identified a group of 'Machiavellian' adolescents, who used both prosocial strategies and aggressive strategies in order to achieve their aims. Adolescents with CP/HCU are characterised by prioritisation of their own needs over the needs of others and, accordingly, research has demonstrated a negative association between CU traits, but not CP, and teacher, and parent reports of prosocial behaviour (Foulkes et al., 2017; Milledge et al., 2019). However, to date only two experimental studies have explored the relationship between prosocial behaviour and CP/HCU further using task-based measures. Both of these studies employed a task where researchers promised a donation to charity on behalf of the participants at the beginning of the experiment, and then offered participants the choice to keep small amounts of money from this donation for themselves on every round (Sakai et al., 2012, 2016). Choosing to keep the money on each round would increase participants' own task winnings, but at the cost of lowering the overall charitable donation. In the first study, the authors compared adolescent boys with CP/HCU to TD boys in their degree of 'prosocial costly helping', and found that boys with CP/HCU behaved significantly less prosocially than TD boys (Sakai et al., 2012). They also found that prosocial costly helping correlated negatively with CU traits but showed no association with CP. The authors subsequently extended this study to actively compare adolescents with CP/HCU, adolescents with CP/LCU, and TD adolescents on the same task (Sakai et al., 2016). Here they found that only the CP/HCU group differed from TD adolescents on prosocial costly helping, and that the CP/LCU group did not significantly differ from the CP/HCU group or the TD group. Thus, extant data indicate that adolescent boys with CP/HCU demonstrate especially low prosocial behaviour on an experimental task – thus mirroring self-report and informant report data. Findings regarding adolescents with CP/LCU are less clear. As mentioned previously, one study (which included dimensional measures of CP and CU traits) found that high levels of CU traits, but not CP, were important in predicting low prosocial behaviour (Milledge et al., 2019). When combined with the finding of Sakai et al. (2016) that adolescents with CP/LCU did not differ from TD adolescents in experimentally assessed prosocial behaviour, this gives some initial indication that CP/LCU is not especially associated with low prosocial behaviour. However, it is difficult to draw strong conclusions based on only two studies, especially given that only one of these employed group-based analysis. More research is clearly needed that directly compares CP/HCU, CP/LCU and TD adolescents on measures of prosocial behaviour.

Another limitation of current experimental evidence relating prosocial behaviour to CP and CU traits is that this relationship has only been examined via a single experimental paradigm that indexes one aspect of prosocial behaviour: prosocial choice (Sakai et al., 2012, 2016). Furthermore, in the task used by Sakai and colleagues, choices to help the other and choices to help the self were directly pitted against one another. In real life, the choice to help others does not always come at a direct cost to the self (or vice versa). It has recently been argued that a more ecologically valid way to assess prosocial behaviour is in a context where participants are offered equal opportunities to benefit the self and the other (Lockwood et al., 2017). Tasks that do not pit the self against the other may therefore yield a clearer measure of prosocial cognition in CP.

It is clear that more research exploring prosocial behaviour in adolescents with CP/HCU and CP/LCU is needed – in particular, more research is needed that directly compares these groups with one another and with TD adolescents, and that does so using more ecologically valid paradigms.

1.6.3 Social information use

As discussed previously, CP in adolescence is associated with dysfunctional peer relationships. There is also substantial evidence for reduced social competencies and social information processing biases in CP (Crick & Dodge, 1994; Webster-Stratton & Lindsay, 1999). However, less is known about the precise information processing mechanisms that underlie these difficulties and how these relate to CU traits. Research to date has indicated that partially divergent patterns in social cognitive processing might underlie social difficulties in CP/HCU and CP/LCU. For example, adolescent boys with CP/HCU appear to place a great degree of importance on respect and dominance in social interactions relative to adolescent boys with CP/LCU (Pardini, 2011; Pardini & Byrd, 2012), but do seem to have a good understanding of the social consequences of their aggression (Pardini, 2011). On the other hand, there is evidence that *lower* levels of CU traits in children (aged 7-12 in a clinical sample) are associated with atypical social understanding, as indexed by less flexible, less relevant, and more overtly aggressive social problem solving solutions (Waschbusch et al., 2007). As with prosocial behaviour, few studies directly compare how adolescents with CP/HCU, adolescents with CP/LCU, and TD adolescents process social information. What is more, it appears that social information *use* (here defined as the degree to which feedback from others is incorporated into beliefs and the strategies used to do so) is yet to be explored in these populations. Using social information is of crucial importance as it guides our social decision-making, and facilitates learning and cooperation (Boyd & Richerson, 1985; Sigmund et al., 2010). Atypicalities in this domain may hamper one's ability to form and maintain social relationships. Investigating this in adolescents with CP/HCU and CP/LCU would shed light onto the cognitive mechanisms that underlie their difficulties with peers, and may give insight into atypical social affiliation in CP/HCU.

1.6.4 Personality correlates of CP and CU

Personality, or 'consistent patterns of thinking, feeling, and behaving manifested by individuals' (Jones et al., 2011) is considered important to the development and manifestation of CP and will likely explain why some young people's social relationships derail more easily than those of their peers. Studies investigating the relationship between CP and its personality correlates in adolescence to date have largely been conducted using the 'five factor model' of personality (FFM). This research has consistently found a negative relationship between CP and Agreeableness (friendliness/compassion vs critical/rational) and Conscientiousness (efficient/organised vs extravagant/careless) (e.g. Heaven, 1996; John et al., 1994; Lewis et al., 2014; Roccas et al., 2002). Low Agreeableness and Conscientiousness have also been found relate to important manifestations of CP (including bullying) and to predict teenage offending (Bollmer et al., 2006; Mõttus et al., 2012). Although less research has looked at the relationship between FFM personality traits and CU traits, the studies carried out to date indicate that low Agreeableness and Conscientiousness also predict high levels of CU traits. Recently a novel six-factor personality model has been proposed that is thought to more fully capture both risk for CP and risk for high levels of CU traits. This model, designed for research with adults, is called the HEXACO, an acronym for its six-dimensions (Lee & Ashton, 2008). These are: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness-to-experience (O). Most of these factors have similar counterparts in the FFM. The key difference between this measure and the FFM is its inclusion of the Honesty-Humility factor, which indexes individual differences in sincerity, fairness, and greed. Research using the HEXACO with adults has demonstrated that low Honesty Humility predicts important indices of adult antisocial behaviour (ASB) including delinquency, and criminal offending, and that it does so beyond other HEXACO and FFM factors (Dunlop et al., 2012; Hodson et al., 2018; Lee & Ashton, 2008). This indicates the incremental utility of a measure that includes Honesty-Humility for understanding the personality correlates of ASB in adulthood. Honesty-Humility also appears to be an important correlate of premeditated, instrumental aggression, an important feature of psychopathy in adulthood and also of CU traits in adolescence (Book et al., 2012; Lee & Ashton, 2012).

However, to date, no adolescent version of the HEXACO has been developed and validated for use with English-speaking populations. Given its apparent incremental validity over existing measures for measuring ASB in adults, a six-factor measure that includes a measure of Honesty-Humility would be an important addition to adolescent research as it has distinct potential to add to our understanding of personality correlates of CP and CU. This might be particularly interesting in relation to CU traits, given that high levels of these traits in adolescence are associated with manipulative behaviour, and premeditated aggression (Frick & White, 2008).

1.6.5 Theory of Mind

One process that, counterintuitively, may contribute to atypical affiliation in adolescents with CP/HCU is the apparently intact ability to understand others' beliefs and desires (referred to as cognitive empathy or, and henceforth, theory of mind (ToM)) in CP/HCU that is seen in many studies (e.g. Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014; Sebastian et al., 2012). Alone this is no problem, but, when coupled with reduced affective empathy and recognition of distress in others, this may contribute to the propensity for premeditated violence and manipulation of others seen in CP/HCU (Fontaine et al., 2018; Viding & McCrory, 2019). However, and as discussed previously, research relating CU traits to ToM has generated mixed findings: some studies indicate intact ToM in adolescents with high levels of CU traits (so long as emotion processing is not involved) (Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014; Sebastian et al., 2012), and others indicate impairment in this domain (Brouns et al., 2013; Roberts et al., 2020; Sharp & Vanwoerden, 2014). It has been suggested that these mixed findings might relate to ToM measures conflating cognitive and affective content (Lockwood et al., 2013). Mixed findings might also relate to ToM measures indexing *ability*, as opposed to *propensity*, to engage in ToM processing in adolescents with high CU traits (Roberts et al., 2020). Although has not been directly investigated, support for this proposal comes from the fact that task-based studies finding intact ToM in adolescents with high CU traits have employed relatively simple cartoon or story based paradigms (e.g. Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014), whereas task-based studies finding ToM impairment in adolescents with CP/HCU have used a more complex video based paradigm designed to present a larger cognitive challenge (Roberts et al., 2020; Sharp & Vanwoerden, 2014).

Another issue that the aforementioned studies investigating ToM in relation to CU traits have in common is that they employ ToM paradigms that are 'pass or fail' measures of mental state inference. In these tasks (whether cartoon based, story based, or video based), participants are asked to interpret what characters are thinking in different scenarios. They 'pass' the test if they give the correct response (correctness here determined by the task authors based on logic or consensus). Although these measures give insight into participants ability to *infer* mental states of others, they give us little insight into what might drive individual differences in the ability to make these inferences (Conway et al., 2019, 2020). It is plausible that high CU traits in adolescence are associated with more subtle deficits in ToM that are not picked up on by current tests. Conway et al (2019) argues that understanding individual differences in mind representation – or in understanding how others' minds might *vary* – may help us to understand what drives individual difference in mental state inference. One way to understand mixed findings in the literature relating CU traits to ToM might therefore be to explore the ability of these adolescents' to represent other minds through more sensitive ToM measures. Overall, it is clear that more research is needed to better understand how adolescents with CP/HCU engage in ToM and how this relates to reduced social affiliation in these individuals.

1.7 Relevance of the current thesis

The research in the current thesis is unarguably varied, as is the research question driving the thesis. However, there are overarching themes that it addresses that should be noted. One broad theme that this thesis allows us to explore is motivation in relation to CU traits. A 'motivational framework' has been proposed for adult psychopathy, which argues that adult psychopaths are capable of typical behavioural responding if sufficiently motivated - even in areas where they have previously shown consistently atypical responding, such as recognition of distress emotions (Groat & Shane, 2020). As mentioned in section 1.6.4, a similar suggestion has been made in the relation to CP/HCU in adolescence. Roberts et al. (2020) suggested that there is a divergence between, on the one hand, propensity, and on the other ability in individuals with CP/HCU to engage in some cognitive processes, such as ToM. This is due to their apparent ability to perform standard ToM tasks, but an apparent lack of willingness to do so on more complex tasks (e.g. Roberts et al. 2020). This remains to be explicitly tested. However, the research carried out in Chapters 2, 3, and 5 might give us more insight into this purported propensity/ability divergence which, in turn, could give further impetus to its formal study in relation to CP/HCU in future research studies.

Chapter 2, which explores prosocial choice and effort, employs a task in which participants must first choose whether they wish to engage in effort - either for themselves (self-benefitting effort) or for someone else (prosocial effort). If participants make the choice to engage in effort, they are then given the opportunity to follow through and make this effort through exerting force on a gripper. Importantly, they are presented with this decision on an equal number of self-benefitting and prosocial trials. Any difference in performance on self-benefitting vs prosocial trials in the CP/HCU group that differentiates them significantly from other groups would give further evidence in support of an ability/propensity divergence; it would demonstrate that they are able to engage in choice and force behaviours (as they are doing them for themselves), but are less willing to do so for someone else. Chapter 3 gets at this question from perhaps an even more fundamental perspective. In Chapter 3, we investigate social information use – the degree to which adolescents with CP/HCU, those with CP/LCU, and TD adolescents use social feedback from others to inform their judgments, and the strategies they use to do so. As mentioned previously, adolescents with CP/HCU have difficulties in building and maintaining social relationships. What is more, they have unstable relationships with others and tend to endorse social goals that promote conflict (such as dominance and respect), rather than cohesion (Webster-Stratton & Lindsay 1999; Pardini et al., 2011). If adolescents with CP/HCU differ from TD and/or CP/LCU groups in social information use in our study e.g. through reduced social information use (as we predict), this would imply that social difficulties in CP/HCU might be generated, at least in part, by an inability to effectively use social information. However, if they show typical social information use, one could argue that they have intact ability to use social information – but might choose not to use information in some social scenarios which could generate conflict. Although it is difficult to interpret a null finding, this raises an interesting point for further study. For example, an interesting follow-up could be to run the same task as we ran in Chapter 3 (where participants are asked to estimate the number of animals on a screen, are presented with social information in the form of another person's estimate, and given the opportunity to update their initial estimate) but introduce a source of conflict or hierarchy into the task. This could be done by changing the source of the social information from an 'unknown other' to a potentially competitive source such as 'a boy who is very good at tasks such as these' or even a known classmate. If this were to lead to less, or atypical, social information use in the CP/HCU group relative to other groups, this would imply that adolescents with CP/HCU are choosing not to use social information when this does not meet their social goals.

Finally, in Chapter 5 we explore whether the individual differences in performance previously seen on ToM tasks in adolescents with high CU traits are related to a reduced ability to represent other people's minds. In other words, we look at whether mixed performance on ToM tasks in those with high CU traits might be due to a poorer understanding of how others' minds vary. If adolescents with higher CU traits show typical performance on this task, this would again rule out a lack of understanding as an explanation for mixed performance on previous ToM tasks. It would also give some support in favour of a typical ability to understand others' minds in those with high CU traits, but a reduced propensity to do so in certain situations unless sufficiently motivated. This could then be tested in future studies, for example by seeing whether adding a performance based incentive improves performance on the MASC task, a mental state inference task in which adolescents with CP/HCU have previously performed poorly relative to TD adolescents (e.g. Roberts et al. 2020).

Another broad theme of the research in this thesis is the development of precise, sensitive, and ecologically valid measures for use with adolescents, that allow us to test specific theoretical questions. Chapter 2 was motivated, in part, by the fact that previous tasks used to probe prosocial behaviour in adolescence are not ecologically valid. First, they normally directly pit prosocial and less prosocial choices against one another within a single decision. So, by choosing to help someone else, participants are forgoing a potential benefit to themselves – usually financial. While these kind of direct trade-offs can occur in real life, it is not universally the case that helping someone else comes at a direct and immediate cost to oneself. In reality, there are many situations where helping someone else comes at little to no cost to oneself – or where cost comes in terms of time and effort as opposed to financial loss. Second, most tasks to date that have been used with adolescents to asses prosocial behaviour have looked only at prosocial choice. In real life, prosocial behaviours involve not only a choice to behave prosocially, but involve us to make some form of effort – e.g. holding a door open for somebody, or helping a teacher to tidy a classroom. In order to address this, we adapted an adult task (the 'prosocial effort task'; Lockwood et al., 2017) for use with adolescents, and explored its relationship with CP/HCU and CP/LCU. The prosocial effort task involves making both prosocial *choices* and prosocial *effort*. Importantly, it also offers participants equal opportunities to benefit themselves and to benefit another person. We believe that this task makes a valuable contribution to adolescent research as it is both more sensitive than previous tasks – assessing two aspects of prosocial behaviour as opposed to one – and also more reflective of real-life behaviours.

In Chapter 4, we develop and validate an adolescent version of another adult measure, this time a personality measure: the HEXACO. We believe, again, that this makes an important contribution to the field as a more sensitive and nuanced measure of personality than those currently available for use with adolescents. Current adolescent personality measures, as discussed above, are mostly based on a five factor model (FFM) of personality. However, it has been argued that a six-factor model that includes a measure of Honesty-Humility can more fully capture personality characteristics – especially those that might relate to antisocial behaviour (Ashton & Lee, 2007). Indeed, studies using this measure with adult populations have shown that including Honesty-Humility in personality questionnaires improves prediction of antisocial and criminal behaviours (e.g. Ashton & Lee, 2008; Međedović, 2017). Another potential benefit of the HEXACO measure over the FFM lies in its utility for capturing personality characteristics specifically related to CU traits. This is due to the way in which it conceptualises the Agreeableness and Emotionality factors which are similar to, but distinct from, their Agreeableness and Neuroticism counterparts in the FFM. In particular, Emotionality in the HEXACO excludes the anger and hostility related traits that are captured by FFM Neuroticism, and is instead primarily related to sentimentality, anxiety, and empathy traits. HEXACO Emotionality may therefore have specific power to capture characteristics demonstrated by individuals who are high on CU traits (relative to FFM Neuroticism which includes both sentimentality and anger related traits). Agreeableness in the HEXACO excludes the sentimentality related traits captured by Agreeableness in the FFM. It also differs from FFM Agreeableness in that it captures anger related traits. HEXACO Agreeableness may therefore more specifically capture traits related to CP relative to FFM Agreeableness. These differences in conceptualisation between the two measures lead us to believe that the development and validation of an adolescent version of the HEXACO will provide a nuanced measure to the field for future research. This could then be used in future research to aid understanding the of development and persistence of CP and CU traits in adolescence.

Finally, in Chapter 5 we develop and validate an adolescent version of the Personality Pairs Task (PPT) (Conway et al., 2020). As mentioned above, this task (which was originally developed for adults) was designed to address the lack of empirical paradigms that are sensitive to individual differences in ToM. By developing an adolescent version of this task, we hope to extend the range of measures available for the study of ToM with adolescents, and thereby improve our understanding of what might drive the mixed findings observed in relation to CP/CU traits.

Thus, despite the diversity of the research covered in the thesis, it makes a clear contribution to the knowledge base on CP/CU in adolescence, while also making available new and sensitive measures that can be used by others in the field. What is more, a more nuanced understanding of how adolescents with CP and CU traits interact with their social environment will provide a research base that can be used to provide interventions that meet the individual needs of adolescents with CP.

1.8 Research in the current thesis

The current thesis aims to further our understanding of possible risk factors that are associated with developments of CP/HCU and CP/LCU. The research studies carried out explore prosocial behaviour in adolescents with CP/HCU and CP/LCU relative to TD adolescents, as well as degree to which, and strategies with which, these groups use social information. We also examine the personality correlates of CP and CU are in a community sample via the development of a novel, English language, adolescent version of the HEXACO – a well-established six-factor personality inventory frequently used with adults. Finally, the relationship between CU traits, and 'Mind-space' (or mind representation), is explored via a novel adolescent adaptation of the Personality Pairs Task (Conway et al., 2019).

Participants for the study presented in Chapter 2 were recruited from Mainstream and Alternative Provision schools in London and the Home Counties. A parental opt-out procedure was used, and informed assent was provided by all participants. Schools were offered an honorarium of £150 for their participation. Adolescent participants received £4 or £5 for completing the task, depending on task performance.

Participants for the study presented in Chapter 3 were recruited via a study funded by the Netherlands Organisation for Scientific Research (NWO), the German Research Foundation (DFG) and the Economic and Social Research Council (ESRC), examining social learning in adolescents with CP/HCU and CP/LCU. Research was carried out in Mainstream and Alternative Provision schools in London and the Home Counties. A mix of informed parental consent and a parental opt-out procedure was used, and informed assent was provided by all participants. Schools were offered an honorarium of £150 for their participation to acknowledge the time commitment necessitated by the study. Participants completed this study as part of a larger battery of experimental measures, and were not rewarded for their participation.

Participants for the study presented in Chapter 4 were recruited from mainstream schools in London and the South East of England to adolescents aged 11-16 (in a mixed gender community sample). A parental opt-out procedure was used, and data was only used from adolescents who provided informed assent. The study was administered by teachers during regular class time, and was completed via paper and pencil. Schools received a £50 honorarium per participating class. Participants were not rewarded for their participation.

Participants for the study presented in Chapter 5 were recruited from a London based mainstream school. A parental opt-out procedure was used, and all participants were required to provide informed assent in order to proceed with the experiment. Participants were adolescents, aged 11-16 (in a mixed gender community sample). The experiment was completed as part of a larger battery of task, and was administered via a tablet.

Given the preponderance of CP in boys and desire to maximise statistical power, studies one and two only included boys (aged 11-16). Research protocols for all studies were approved by the University College London Research Ethics Committee (Project ID: 0622/001).

1.9 Thesis outline

The current thesis presents four empirical chapters, addressing gaps in the current understanding of social cognitive and personality correlates of conduct problems (CP) and callous-unemotional (CU) traits.

Chapter 2 empirically examines prosocial behaviour in adolescents with CP and high levels of CU traits (CP/HCU), adolescents with CP and low levels of CU traits (CP/LCU) and typically developing (TD) adolescents. Boys aged 11-16 (N = 87) completed a task measuring prosocial choice and prosocial force. It also explores the cognitive mechanisms driving prosocial behaviour by using computational modelling to look at reward by effort discounting for the self and for the other in participants.

Chapter 3 details a study examining social information use in adolescents with CP/HCU, adolescents with CP/LCU, and TD adolescents. Boys aged 11-16 (N = 108) completed a brief and simple perceptual judgement task: they estimated the number of animals on a screen, were provided social information in the form of another participants' estimate, and were then asked to provide a second estimate. This tasked assessed participants' degree of social information use, as well as their strategy when using social information.

Chapter 4 details the development of a novel six-factor adolescent personality measure (the 'Adolescent HEXACO') and the associations of the personality factors charted by this questionnaire with CP and CU. This was designed to provide an English language, adolescent-friendly version of an established six-factor personality questionnaire, originally developed for adults. This questionnaire is thought to be more suited for studying personality correlates of antisocial behaviour and psychopathic traits. We then used this measure to explore personality correlates of CP and CU in a mixed gender community sample of adolescents aged 11-16.

Chapter 5 details a study looking at mind representation in relation to CU traits. A mixed gender community sample of adolescents aged 11-16 completed the 'Adolescent Personality Pairs Task' in which they had to estimate the extent to which different personality traits commonly co-occur in the average person their age. We then looked at whether their accuracy on this task related to their self-reported level of CU traits.

Chapter 6 discusses the findings from the four empirical chapters, as well as their implications and clinical relevance, and considers avenues for future research.

1.10 Dissemination

The findings from Chapter 2 were presented as a poster at the Society for the Scientific Study of Psychopathy (SSSP) conference in Las Vegas in 2018, and the University College London Institute of Mental Health Conference (online) in 2021. The findings from Chapter 3 have been published in JCPP Advances, and were presented at the SSSP conference (online) in 2021. The findings for Chapter 4 have been submitted for review in the Journal of Psychopathology and Behavioural Assessment.

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Chapter Two – Examining Prosocial Choice and Effort in Adolescents with Conduct Problems and Varying Levels of Callous-Unemotional Traits

1. Introduction

Forming close affiliative bonds, placing importance on the needs of others and making effort to meet those needs, is considered essential for human functioning (Baillet et al., 2014; Baumeister & Leary, 1995; Eisenberg et al., 2007). However, a striking minority of individuals do not show typical levels of prosocial behaviour. Young people with conduct problems (CP) display antisocial behaviour that incurs large individual and societal costs (National Collaborating Centre for Mental Health et al., 2013; Richards et al., 2009). A substantial body of research has documented a negative association between antisocial and prosocial behaviours in adolescence (for review see Memmott-Elison et al., 2020). However, antisocial and prosocial behaviours do not exist on two ends of a single behavioural continuum, and it is important to note that there are individual differences in prosocial behaviour among adolescents with CP (Hawley, 2003; Kokko et al., 2006). Adolescents who display a combination of CP and high CU traits (CP/HCU) are considered a particularly vulnerable group. They are at increased risk, relative to peers with CP/LCU, for persistent antisocial behaviour and psychopathic personality disorder in adulthood (Frick & Marsee, 2018; Lynam et al., 2007). They also share many features with adult psychopaths including lack of empathy and guilt, behaviour that clearly prioritises their own needs over those of others, and severe and premeditated antisocial behaviour (Frick & White, 2008; Viding & McCrory, 2018). High CU traits in childhood and adolescence are a strong negative predictor of both prosocial behaviour and prosocial motivation, and are associated with atypical social affiliation (Foulkes et al., 2017; Milledge et al., 2019; Viding & McCrory, 2019; Waller & Wagner, 2019). Recent studies that included measures of both CP and CU traits have indicated that high levels of CU traits, but not of CP, predict low prosocial behaviour in both questionnaire (Milledge et al., 2019) and experimental (Sakai et al., 2012) measures. However, experimental research directly comparing CP/HCU, CP/LCU and TD groups in relation to prosocial behaviour in adolescence is limited. One study that investigated prosocial costly helping in both male adolescent patients clinically referred for CP/HCU and in TD adolescents found that adolescents with CP/HCU differ from TD peers in prosocial costly helping (Sakai et al., 2012). However, this study did not include a CP/LCU comparison group, and had a relatively small sample size. A more recent study by the same authors addressed this by directly comparing CP/HCU, CP/LCU and TD adolescents on the same task (Sakai et al., 2016). This study found that adolescents with CP/HCU were particularly likely to benefit the self at a cost to others relative to TD adolescents, whereas adolescents with CP/LCU did not significantly differ from either CP/HCU or TD groups (Sakai et al., 2016). Thus, initial research suggests that CP/HCU may be a particularly strong risk factor for reduced prosocial behaviour. There is also initial (albeit limited) evidence that adolescents with CP/LCU do not substantially differ from TD adolescents in their prosocial behaviour.

An important limitation of prior studies investigating prosocial behaviour, including studies of adolescents with CP, is that they typically directly pit prosocial and less prosocial options against one another during a single choice (Crockett et al., 2014; Koenigs et al., 2010; Sakai et al., 2016). In real life our decisions and actions to benefit ourselves or others may not necessarily be in direct conflict with one another. Recent work by Lockwood and colleagues investigated 'prosocial behaviour in action' by employing computational modelling of an effort-based task where participants had equal opportunities to benefit themselves as well as others. The authors observed that healthy adult participants devalued rewards as the effort required to obtain them increased, and that they did this more strongly for other people than they did for themselves. Importantly, this self-other difference in reward by effort discounting correlated positively with self-reported psychopathic traits. A key element of the authors' task design is that once participants made a prosocial choice, they then had to energise a prosocial action in order to achieve the prosocial outcome (points towards a reward for someone else). This follow through is integral to real-life helping behaviours, thus adding to the ecological validity of the task. Exploring force behaviour as well as choice behaviour allowed the authors to gauge not only prosocial intentions but also prosocial action. Lockwood et al. observed that healthy adult participants not only made fewer choices to work for others than they did for themselves, they also displayed 'superficial prosociality' – that is, once having chosen to put in effort for others, they exerted less force to gain rewards than they did on trials where they chose to work for themselves.

While prosocial behaviours foster social connectedness and cooperation, their absence may represent an important mechanism that contributes to risk for antisocial behaviour and psychopathy. The current study used an adapted version of Lockwood et al.'s effort task to investigate 'prosocial behaviour in action' in adolescent boys with CP. We hypothesised that boys with CP/HCU would exhibit less prosocial motivation than our TD group-based on their similar behavioural presentation to adults with psychopathy (Frick et al., 2014; Viding & McCrory, 2018) and initial experimental evidence of reduced prosocial behaviours in this group (Milledge et al., 2019; Sakai et al., 2019; Viding & McCrory, 2019; Waller & Wagner, 2019). We specifically predicted that, relative to age matched TD controls, boys with CP/HCU would: (1) make significantly fewer prosocial choices (choices to work for the other relative to the self); (2) show stronger reward by effort discounting for the other relative to the self, and (3) make significantly less prosocial effort/show stronger superficial prosociality (force exerted for the other relative to the self). Based on heterogeneity in the literature relating CP to prosocial behaviour (Hawley, 2003; Kokko et al., 2006; Memmott-Elison et al., 2020), as well as initial evidence that CP/HCU is a profile that carries particular risk for low prosocial behaviour as opposed to CP/LCU (Milledge et al., 2019; Sakai et al., 2012, 2016), we predicted that the CP/LCU would not differ significantly from CP/HCU and TD controls on any measure of prosocial behaviour.

	CP/HCU $N_{descriptives}$ = 28			CP/LCU $N_{descriptives}$ = 31			TD $N_{descriptives}$ = 33				
	Mean *(SD)*	Min-Max	$N_{complete}$	Mean	Min-Max	$N_{complete}$	Mean	Min-Max	$N_{complete}$	*p* value	Post Hoc*
IQ (Full Score)[a,c]	87.14 *(8.98)*	750-111	28	89.10 *(13.09)*	70-11	31	96.70 *(15.07)*	74-127	33	0.02**	3<1 2<1
Age (Years)[b]	13.57 *(1.36)*	11.37-15.92	28	13.60 *(1.24)*	11.31-16.19	31	14.00 *(1.06)*	12.05-15.49	33	0.30	-
Pubertal Stage[a,d,e]	1:4:9:9:2	3-12	28	0:8:15:6:0	4-11	30	1:3:10:15:0	3-11	32	0.08	-
CASI Conduct Disorder[b.c]	9.91 *(4.90)*	4-20	28	6.79 *(3.83)*	3-18	31	0.27 *(0.63)*	0-2	33	0.008**	1<2<3
ICU[b]	45.50 *(5.77)*	38-58	28	31.52 *(4.83)*	21-37	31	19.48 *(6.06)*	9-31	33	<.0001	1<2<3
Ethnicity[e]	9:4:0:2:2	-	17	15:2:1:2:0	-	20	13:1:5:7:2	-	28	0.04[g]	
Alcohol Use And Disorders[a,g,h]	24:4:0	0-14	28	31:0:0	0-4	31	32:1:0	0-8	33	0.04[g]	-
Drug Use And Disorders[a,d, i]	25:3	0-16	28	30:1	0-11	31	33:0	0-2	32	0.07	-
SDQ Total Difficulties[b,c]	21.66 *(7.15)*	7-37.67	28	20.36 *(8.07)*	7-37	31	4.59 *(3.81)*	0-12	33	<.001**	1<2 1<3
SDQ Hyper-Activity[b]	8.18 *(2.11)*	4-11	28	7.44 (*2.45)*	1-11	31	1.73 *(2.30)*	0-10	33	<.001	1<2 1<3
SDQ Peer Problems[b,c]	3.13 *(2.06)*	0-7	28	3.55 *(2.54)*	0-9	31	1.38 *(1.63)*	0-5	33	<.001**	1<2 1<3

SDQ Emotional Problems[b,c]	3.43 *(3.34)*	0-10	28	4.35 *(3.30)*	0-14	31	1.18 *(1.89)*	0-7	33	<.0001**	1<2 1<3

Table 1: Group matching and participant characteristics data. *TD* - typically developing, *CP/LCU* - conduct problems and low levels of callous-unemotional traits, *CP/HCU* - conduct problems and high levels of callous-unemotional traits, *SD* - standard deviation, N – number of participants with complete measure, *WASI* - Wechsler Abbreviated Scale of Intelligence, *CASI* - Child and Adolescent Symptom Inventory, *ICU* - Inventory of Callous And Unemotional traits, *SDQ* - Strengths and Difficulties Questionnaire. Where not stated, analyses were performed using one-way ANOVA and post hoc tests were Bonferroni corrected for multiple comparisons.

'*' 1 = TD, 2 = LCU, 3 = HCU.
** Results for comparisons smaller than or equal to this threshold

[a] Measure obtained at testing phase, child report.
[b] Measure obtained at screening phase, teacher report.
[c] Assessed via three pairwise Mann-Whitney U tests due to violation of ANOVA assumptions. Directionality inferred through visual inspection of means.
[d] Assessed via Chi Square test, p value computed for a Monte Carlo test (Hope, 1968)). Post hoc tests were Bonferroni corrected for multiple comparisons
[e] Counts for Pubertal stages (Pre-pubertal: Early-pubertal: Mid-pubertal: Advanced-pubertal: Post-pubertal)
[f] Counts for self-identified ethnicity (White; Mixed/multiple ethnic groups; Asian/Asian British; Black/African/Caribbean background; Other ethnic group)
[g] Significance at p=0.05 did not remain after post-hoc tests with Bonferroni correction
[h] Counts for AUDIT risk categories (Low Risk:Increasing Risk:Higher Risk:Possible Dependence).
[i] Counts for DUDIT risk categories (Low Risk:Possible Drug Problems).

2. Methods

2.1 Participants

One hundred and five boys, aged 11-16 years, were recruited within London and the Home Counties from both mainstream and specialist provision schools. Screening questionnaires were administered to teachers. These provided a research diagnosis of current conduct problems; dimensional assessment of CU traits; an overall screen for psychopathology; demographic data for group-matching purposes (date of birth); and information regarding specialist education provision. Information sheets were sent to parents of participants, giving them the opportunity to opt their child out of the study. An ‘opt-out procedure’ was ethically permissible in the case of the current study as the research was non-invasive and in the public interest. Participants all received age-appropriate information sheets, which were verbally explained, and informed assent was obtained prior to participation. The study was approved by the University College London Research Ethics Committee (Project ID number: 0622/001).

Exclusion criteria for all participants in the study included a diagnosis of autism spectrum disorder or presence of significant learning difficulties (a score of <70 on our IQ measure). To recruit a representative group of adolescents with CP, common comorbidities (Attention Deficit Hyperactivity Disorder [ADHD], emotional problems and substance/alcohol abuse) were not used as exclusion criteria. Data from four CP/HCU participants and eight CP/LCU participants were excluded prior to descriptive analyses based on the exclusion criteria. One TD participant was also removed for incomplete data on our IQ measure. Our sample for descriptive analyses therefore consisted of ninety-two adolescents (28 CP/HCU, 31 CP/LCU, 33 TD). A further five CP participants were removed from the main analysis: two participants from the CP/HCU group due to lack of task understanding/compliance, and three participants (1 CP/LCU, 2 CP/HCU) for insufficient task data (failing to make a choice between the work or rest option on more than 80% of trials within the ‘self’ or ‘other’ condition) that led to inaccurate parameter estimates from our computational model. Thus, our final sample for analyses consisted of eighty-seven participants (25 CP/HCU; 29 CP/LCU; 33 TD).

2.2 Measures

2.2.1 Screening

Current conduct disorder symptoms were assessed using the teacher-rated Child and Adolescent Symptom Inventory (CASI-4R; Gadow & Sprafkin, 2005) Conduct Disorder Scale (CASI-CD). Items were rated on a 4-point scale from ‘Never’ to ‘Very often’. The measure showed good internal consistency in our sample (α = 0.90). CU traits were assessed using the well validated Inventory of Callous-Unemotional Traits (ICU; Essau et al., 2006) based on teacher ratings. The ICU contains 24 items rated on a 4-point scale from ‘not at all true’ to ‘definitely true’. The ICU total score was used to identify CU groups. The measure showed very good internal consistency in our sample (α = 0.92). Cut-off scores on the CASI-CD for inclusion in the Conduct Problems (CP) group were: a score of 3+ (ages 10-12), 4 + (ages 13-14), and 6+ (ages 15-16). These scores were used as they are associated with a clinical diagnosis of Conduct Disorder from teacher report according to the CASI manual (Gadow & Sprafkin, 2005). The median score on the ICU in the participants with CP (after exclusions) was 37, and the HCU/LCU groups were disaggregated by median split. Thirty-one adolescents met CP/LCU criteria with ICU total scores that were less than or equal to 37 and twenty-eight adolescents met criteria for CP/HCU with ICU scores greater than 37. Based on prior published research, a score of 37 on the teacher-rated ICU represents a clinically meaningful cut-off for HCU (Docherty et al. 2017).

We used a median split approach to separate the children with CP/HCU and CP/LCU groups for the following reasons:

1) Effects of CU traits do not often emerge as interactions and can instead lead to suppressor effects in correlational analyses (Frick, 2012).

2) This approach has, in the past, successfully identified groups of children with CP who have different social-cognitive processing patterns. The result-pattern in these two groups has demonstrated that researchers might have missed deficits in either group had they been combined (Schwenck et al., 2012; Viding et al., 2012)

3) Suppressor effects can lead to difficulties for interpretation, meaning that effects of CU traits may not emerge in interactions – despite CP/HCU and CP/LCU groups looking very different. Group centric analyses thus make it easier to interpret the translational relevance of findings. This is more challenging when examining suppressor effects in continuous analyses, for example. It is also important to note that using continuous measure of CP and CU can generate problems if modelled together. This is due to the absence of bivariate normality - high CU traits almost invariably denote high levels of CP, but not the other way around (Fontaine et al., 2011). Concerns regarding loss of power from dichotomizing relate to the case of bivariate normality (Cohen, 1983).

All typically developing (TD) participants were required to score below the CP median (37) on the ICU, in the normal range for the CASI, and below the cut-off for total difficulties on the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). Thirty-three children met criteria for inclusion in the TD group.

2.2.2 Group Matching

Data about participant age was provide by teachers. Participants completed the two-subtest version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), a measure of IQ. We also took a measure of pubertal development (the Pubertal Development Scale (PDS); Carskadon & Acebo, 1993), as our participants were drawn from an age range that encompasses significant developmental change (11-16). The PDS is a 5 item scale, where answers are given on a scale from 'has not yet started' to 'seems completed', and includes the option 'I don't know'. A higher score indicates a more advanced pubertal stage. This measure showed good internal consistency in our sample (α = 0.87). Participants indicated their ethnicity by selecting from the agreed list of ethnic groups provided by the UK government and the Office of National Statistics for the most recent census at the time of data collection (2011) (UK Government, 2011).

CP/HCU, CP/LCU, and TD groups were matched in their age, pubertal status, and self-reported ethnicity. However, they differed in IQ: the two CP groups (CP/HCU and CP/LCU) had significantly lower IQ scores on average than the TD group (see Table 1). All main analyses were therefore run with and without IQ included as a covariate – we also included age in these models for completeness. This did not have any impact on results (see Appendix 1.1).

2.2.3 Additional measures of participant characteristics

Participants also completed measures of substance use - the Alcohol Use Disorder (AUDIT; Babor et al., 1992) and Drug Use Disorder (DUDIT; Berman et al., 2005) tests. This was to ensure that these factors did not account for any differences in findings, as substance abuse problems commonly co-occur with conduct problems (Wiesner et al., 2005). The AUDIT and DUDIT measures include 10 and 11 items respectively. The first items in each measure are measured on a 5-point Likert scale (from 'Never' to 'Daily or almost daily'), and the last two items are scored on a 3-point scale (from 'no' to 'yes, during the last year'). Risk for alcohol use disorders were assigned as follows: an AUDIT score of 0-7 indicates low risk; 8-15 indicates increasing risk; 16-19 indicates higher risk; and a score of 20 or greater indicates possible dependence. Risk for drug use disorders (in male populations where you would not expect drug users) are assigned as follows: a DUDIT score of 1-5 indicates low risk, a score of 6 or greater indicates possible drug-related problems (Berman et al., 2005). These measures showed good internal consistency in our sample (α = 0.85 and α = 0.87 respectively).

Finally, we took teacher measures of participants' social and emotional difficulties – or symptoms that commonly co-occur with CP. For these, we used the hyperactivity, emotional problems and peer problems subscales of the Strengths and Difficulties Questionnaire (Goodman, 1997), as well as a measure of total difficulties (as screening for the TD participants) which is computed across all 'difficulties' subscales within the SDQ measure. The SDQ contains 25 items that are rated on a 3-point scale from 'Not very true' to 'very true'. The measure showed good internal consistency for all sub-scales measured in our sample (emotional problems, α = 0.90; peer problems, α = 0.62; hyper-activity, α = 0.82, total difficulties = 0.83).

2.3 Experimental design and procedure

Stimuli were programmed and presented on a Dell laptop using MATLAB (version R2016B, Mathworks; http://www.mathworks.com/) and Psychtoolbox (version 3.0.11; http://psychtoolbox.org/). A hand-held TSD121B-MRI (BIOPAC Systems) was used to record grip force. Participants received real time feedback on the force they were exerting via the PC screen (see Figure 1C).

The task design was a shortened version of Lockwood et al.'s prosocial effort task (Lockwood et al., 2017), adapted to suit children while retaining critical variation at effort and reward levels. The task format was piloted in a sample of 15 boys in the study age range (11-16) to confirm that it was tolerated and understood by the target group of adolescents. During the task, participants completed one block of 91 trials (3 calibration trials, 10 "training" effort trials, 6 practice decision trials, and 72 experimental trials). Experimental trials were made up of 36 decisions for the 'self', and 36 decisions for the 'other'. A short break was included around the midpoint of the experiment. The total duration of the task was around 12 minutes. On each trial, participants were offered a choice between a baseline option (one credit, 0% of Maximum Voluntary Contraction, (MVC)) and an alternative variable 'offer' (more effortful option - 30, 43, 57, or 70% of MVC, but worth more reward) (see Figure 1). Importantly, on the effortful trials, levels of reward (2, 4 or 6 credits towards gift vouchers) and the level of effort required varied independently.

In this task, participants had the opportunity to win either £4 or £5 in gift vouchers for themselves, and the same amount for the 'other'. Participants were informed that the outcomes of their choices in this game were truly leading to outcomes for another person - a student at another school. It was ensured that they were aware that this other student would not be playing the game for them, so there was no opportunity for reciprocation or retaliation. Unbeknownst to the participants, the other student was fictional. This minor deception was approved by the UCL Research Ethics Committee (project 0622/001), based on a report from a focus group of six adolescents who reviewed the study protocol and found this element of the study acceptable. The amount of vouchers that participants received for themselves and for the other boy depended on task performance: if they earned fewer than 90 credits (respectively), £4 of vouchers were awarded to the particpiant and to the other; if they earned more than or equal to 90 credits (respectively), £5 of vouchers were awarded to the participant and to the other.

Following the protocol of Lockwood et al., once the task started the participants were asked to grip a handheld dynometer with as much force as they could in order to establish their MVC. This was to account for individual differences in strength, and was then used as a subject-specific threshold for the levels of effort required to receive rewards in the experimental task. Following this, proposed effort levels were all proportional to the participants' individual MVC. In the experimental task, each trial presented participants with a choice between a low effort option (1 credit, 0% of MVC) and a variable 'offer' (more effortful option) which required more effort (30, 43, 57, or 70% of MVC) but also made more credits available (2, 4, or 6). The baseline option was assigned 1 credit in order to provide some incentive to choose this option if participants did not consider the variable offer worth their effort. Effort was represented by the proportion that a pie chart on the screen was filled with colour, the whole pie representing maximum effort (see Figure 1A, 1B). Reward and effort varied independently, with each effort-reward combination being sampled 3 times for each recipient (self vs other). Trials were presented in a fixed order. Of the 72 experimental trials, half of involved decisions for the self ('self' trials), and half for the other (‘other’ trials) (see Figure 1). Across both self and other trials, reward was gained by applying force to exceed a required level for more than 1 second within a 3 second time-window (see Figure 1C). Participants received 0 credits if they failed to make a choice between the low effort option and the more effortful option within 4 seconds at the choice stage. All trials were the same duration regardless of choice behaviour in order to ensure that decisions were influenced by effort discounting and not temporal delay discounting (Green & Myerson, 2004). No credits were awarded if the participant made no choice on a trial. Failure rates were low (<10% for all groups), indicating that participants were almost always able to reach the required amount of force. This also rules out the potential effects of risk aversion that may interact with effort discounting, as participants had a very high probability of receiving rewards from the options they chose.

Prior to the main task, participants tried out each effort level two times across 10 practice trials in order to learn about how the representational pie chart related to effort required. They then had the opportunity to learn to associate each level of effort with reward over six trials, where they could practice making choices between the ‘easy’ pie (low effort option) and the ‘effortful’ pie (the more effortful option). These practice trials also ensured that participants knew how to make responses within the time limit for each trial. They were shown that if a pie contained no colour (a blank pie), then minimal force (0%) was required. They were informed that this was the baseline offer and it was an opportunity to ‘rest’ if they liked – however that they still had to grip the dynometer (see Figure 1). Each practice trial was worth one credit. However, credits earned in practice trials did not count towards participants’ final reward and it was ensured that they were aware that this was only for training purposes.

Figure 1. Experimental Paradigm. Participants were presented on each trial with the following: (A) an Offer: a rest option which required no effort (0% of their Maximum Voluntary Contraction (MVC), corresponding to zero segments of the pie chart) for the low reward of 1 credit, or a more effortful option which generated higher reward (2-6 credits) but also required more effort (30-70% of MVC, corresponding to 1-4 segments of the pie chart). Reward and effort levels of the effortful offer varied independently on each trial. (B) a Choice between high and low effort options. (C) an opportunity to exert Effort (apply force by gripping the dynometer) to the required degree (marked by the yellow line). They had to squeeze the gripper for at least 1 second out of a 3 second window in order to receive the reward for that trial. Participants then (D) received Feedback about the outcome of the trial, corresponding to the offer that they had chosen. They received 0 credits if they were unsuccessful or if they made no choice at stage B. Crucially, on Self trials (E), participants received the offer, made the choice, exerted the effort and received the feedback on behalf of themselves, as well as receiving the reward themselves. On Other trials (F), participants received an offer, made their choice, exerted effort, and received feedback on behalf of a fictional ‘other’ named John - they were also informed that John would receive the reward gained. Participants completed 72 trials, 36 with outcomes for themselves and 36 with outcomes for the other person. Self and Other trials were interleaved.

3. Statistical Analyses

3.1 Demographic data

Demographic data from participants (for matching and assessment of additional behavioural characteristics) were analysed using one-way analysis of variance, chi squared test, or non-parametric equivalents where appropriate in SPSS (IBM Corp, 2020), R (version 1.4.1717) using R studio (R Core Team, 2020, 2015).

3.2 Choice Data

Analyses of behavioural data were carried out using a combination of MATLAB (2016, The MathWorks Inc.), R, and R Studio (R Core Team, 2020, 2015). To examine choice behaviour, we ran a generalised linear mixed-effects model (GLMM) using the *glmer* function from the lme4 package (Bates et al., 2015). The model included the following fixed effects: recipient, effort level (squared to mirror the computational model results), reward, and group, as well as a subject-level random variable. Reward and squared effort variables were z-scored before being entered into the model. Two way interactions were included between all variables except for effort and reward as these varied independently in the task design. Missed trials (where participants made no choice) were excluded from analyses. We tested fixed effects using a Type II Wald chi-square test. For specification and diagnostics of our choice model, see Appendix 1.2.

The decision to include only two-way interactions between fixed effects in this model was made due to the increase in power this gave us to detect the core interaction of interest for our hypotheses (that is, a group by recipient interaction) relative to a model containing three-way interactions, which were not the main focus of this study. The results of a model with three-way interactions between: (1) group, recipient, and effort, and (2) group, recipient, and reward are reported for completeness, and can be found in Appendix 1.3.

3.3 Computational modelling of reward by effort discounting

To precisely quantify the subjective influence of effort on rewards for each recipient (self and other), a range of computational models were created. These were designed to characterise how rewards were being discounted by effort on a subject level; or, in other words, how the interaction between effort level and reward level influenced choice behaviour for each participant. This approach allowed us to quantify reward discounting by effort using a single parameter - ‘K’. Models were fitted using Maximum Liklihood Estimation in Matlab (fmincon function) (in line with Lockwood et al., 2021; Lockwood et al., 2017; Lockwood et al., 2021). Each of the models contained idiosyncratic parameters characterising K, the degree to which reward was discounted by effort, and β, a noise parameter representing stochasticity of choices. Two features were varied to create the model space. The first of these was the mathematical function that characterises the form of the reward discounting (i.e., whether rewards were discounted linearly, hyperbolically, or parabolically by effort). The second of these was whether the degree of reward discounting by effort was characterised by a single K parameter (representing discounting for the self and for the other) or by two K parameters (one representing discounting for the self and one representing discounting for the other). Two classes of models were therefore created: Models 1 – 6 had one K parameter to represent reward by effort discounting for the self and the other, whereas models 7 – 12 had separate self and other K parameters. Within these models, we tested a further two classes of models that characterised whether separate parameters for noise (β, softmax) – these were models 4-6 and 10-12 - or single parameters for noise - models 1-3 and 7-9 - best explained behaviour.

The winning model, i.e. the model with the lowest AIC and BIC values, for all groups was model 10: a parabolic model with separate K parameters for the self and for the other and separate β parameters for the self and for the other. This is in line with Lockwood (2017) where model 10 is consistently among the models with the lowest AIC and BIC scores. It is also very close to the winning model in previous studies (model 7), which had separate K parameters but a single β parameter (Lockwood, Abdurahman, et al., 2021; Lockwood et al., 2017; Lockwood, Wittmann, et al., 2021).

Thus, discounting of rewards in our sample can be characterised using the following equation:

$$SV = R - KE^2$$

$$K = \begin{cases} K_{self} & \text{if self trial} \\ K_{other} & \text{if other trial} \end{cases}$$

In this model, SV is the subjective net value of a variable offer (more effortful option), given effort (E), and reward (R). The degree to which participants subjectively discount rewards by effort is represented by parameter K. A high K indicates that participants are discounting reward by effort to a higher degree – in other words, participants are less motivated to choose that trial as effort increases, even if reward is also high.

3.3 Discounting (*K*) parameter data

We next wanted to compare whether individual reward discounting by effort (i.e. K parameters) differed between groups and whether this varied by the recipient (self/other). Distribution of the K parameters extracted from model 10 was not normal (see Appendix

1.2). We therfore fit a series of mixed effects beta regression models using the 'gamlss.mx'package in R (R Core Team, 2015, 2020; Rigby & Stasinopoulos, 2005), exploring random intercepts and random slopes (for "Recipient") in the model equations for the mean as well as for the variance. We used the BIC criterion, with the sample size taken to be the number of observations for model comparison; this penalised additional parameters more than is usual with the BIC (when the sample size is taken to be the number of subjects). In the event, this decision made no difference to the conclusions. We also explored both parametric and non-parametric terms for the random effects. Random slopes were impossible to fit using parametric models due to non-convergence. For those models that could be fitted parametrically, the equivalent non-parametric models had the better fit. In the following we thus consider non-parametric random effects models only.

The "best" regression model, according to the BIC criterion, was a mixed effects model with four latent groups (for the random effects) that defined random intercepts and slopes for both the mean and the variance inflation parameters. This model had 24 parameters, however, and was thus considered too large to be realistic for this small data set. The best and most parsimonious model (with no more than 11 parameters) was a mixed effect model with two latent groups that defined random intercepts and slopes for the mean, and had a minimal model for the variance inflation containing only recipient and a random intercept term. Diagnostics of residuals suggested that there were no outliers (see Appendix 1.2), but that the residuals were not normally distributed. Bootstrapping was therefore used to estimate standard errors of coefficients and non-parametric bias-corrected and accelerated 95 % confidence intervals.

Our final model was a mixed effects model with two latent groups that defined random intercepts and slopes for the mean, and that had a minimal model for the variance inflation containing only recipient and a random intercept term. In the presentation of results, we need to take account of the non-parametric random effects. These essentially assume that there are two latent classes among the participants. These latent classes cut across, rather than overlap, our three groups (TD, CP/LCU and CP/HCU). According to the model estimates, the two latent classes differ in the extent to which they discount effort by reward for the self (non-parametric random intercept) as well as in the extent of the self-other difference (non-parametric random slope for the 'other').

3.2 Force Data

To analyse force exerted, we normalised participants' force as a proportion of their MVC. This was done to account for between-participant variability in force exerted. We then calculated the area under the force curve for the 3-second window in which force was exerted on each trial. Due to an error in our equipment, some trials in our data contained negative values force. This is due to recalibration of our gripper taking longer than expected to reach to 0 between each trial, leading to the beginning of the force curve in the 3-second time-window (used to compute the area of the force curve) being below 0 on some trials for some participants. However, upon checking our data, it appears as though this only affected the force curve while participants were preparing their movement – i.e. the gripper had always recalibrated to 0 (baseline) by the time participants had started squeezing. We therefore excluded all negative force values for our our force analyses. For completeness, we have included an example of force traces from one participant demonstrating the issue in Appendix 1.4, where we have also included analysis of force data with negative force included. Conducting analysis with and without negative force data did not change any of our main findings.

To analyse force data, we ran a Linear Mixed Effects Model (LMM) that predicted normalised force with fixed effects of recipient, effort level, reward, and group (including two-way interactions between all variables), as well as a subject-level random variable. For model specification and assumption checks please refer to Appendix 1.2. For the results of a model containing three way interactions between: (1) group, recipient, and effort, and (2) group, recipient, and reward variables, please refer to Appendix 1.3.

4. Results

4.1 Analysis of demographic data

Results of demographic analyses are summarised in Table 1. CP/HCU, CP/LCU, and TD groups were matched in age at testing ($F(2, 89) = 2.228$, $p = 0.30$, $\eta^2 = 0.03$). Groups also did not significantly differ in their pubertal stage ($\chi^2 = 13.33$, $p = 0.07$, $\phi_c = 0.28$). Groups differed significantly on self-reported ethnicity ($\chi^2 = 19.06$, $p = 0.04$, $\phi_c = 0.28$), but this significance did not hold when corrected for multiple comparisons using Bonforroni correction (p values for all comparisons > 0.22). It should also be noted that many participants, predominantly those in our CP groups, opted not to report their ethnicity (all questionnaires were voluntary). This comprised 39.29% of CP/HCU participants, 35.48% of CP/LCU participants, and 15.15% of TD participants.

Groups differed significantly in IQ: The TD group had significantly higher IQ scores than both the CP/HCU group ($U = 628$, $p = 0.02$, $\hat{A} = 0.68$) and the CP/LCU group ($U = 643$, $p = 0.05$, $\hat{A} = 0.64$), but the CP/HCU and CP/LCU groups did not differ from one another ($U = 446.5$, $p =$

0.85, $\hat{A}$ = *0.51*). We thus reran all of our main models with IQ as a covariate (as well as age for completeness). This did not change our results (see Appendix 1.1).

Groups differed significantly on CP as measured by the CASI. Mann-Whitney U tests revealed that the CP/HCU group had significantly higher CASI scores than the CP/LCU group (U = *0.008*, p = 0.02, $\hat{A}$ = *0.30*), and the TD group (U = *0*, p = <.0001, $\hat{A}$ = *0*), and the CP/LCU group scored significantly higher than the TD group (U = 0, p = <.0001, $\hat{A}$ = *0*) – in line with group assignment. Groups also differed significantly on CU traits as measured by the ICU (F(2, 89)=163.8, p <.0001; η^2 = 0.79). Post-hoc comparisons using the Bonferroni correction indicated that the CP/HCU group scores were higher than CP/LCU (p<.0001), and TD (p<.0001) on the ICU. Scores for the CP/LCU group were higher than for the TD group (p<.0001).

A Chi Square test revealed that groups differed significantly on self-reported alcohol use (χ^2 = 6.42, p = 0.04, ϕ_c = 0.26). This significant effect did not hold when corrected for multiple comparisons using Bonforroni correction (p for all comparisons > 0.079). Groups did not differ in drug use (χ^2 = 4.32, p = 0.08, ϕ_c = 0.21).

Groups differed on SDQ rated hyperactivity (F(2, 89) = 74.69, p = <.0001, η^2 = 0.03). The CP/HCU had significantly higher hyperactivity scores than the TD group (p >.0001), as did the CP/LCU group (p >.0001). The CP/HCU and CP/LCU groups did not differ from one another (p = 0.65). Groups also differed on SDQ rated emotional problems. The CP/HCU scored higher than the TD group (U = 261, p = 0.003, $\hat{A}$ = *0.28*), as did the CP/LCU group (U = 172.5.5, p<.0001, $\hat{A}$ = *0.17*). Again, the CP/HCU and CP/LCU groups did not significantly differ (*U=519,* p<.0001, $\hat{A}$ = *0.20).* Similarly, both CP groups scored higher than the TD group on SDQ rated peer problems (CP/HCU, U =235.5, p=.0008, $\hat{A}$ = 0.68; CP/LCU, U=239.5, p = 0.0002, $\hat{A}$ = 0.23), but did not differ from each other (U = 461, p = 0.68, $\hat{A}$ =0.53).

Our groups differed significantly on SDQ rated total difficulties (our screening measure for the TD group): The TD group scored lower than the CP/HCU group (U = 15.5, p = <.0001, $\hat{A}$ =0.02), and lower than the CP/LCU group (U = 16, p = <.0001, $\hat{A}$ =0.02). The CP/HCU and CP/LCU group did not differ from one another (U = 376, p = 0.38, $\hat{A}$ =0.43).

4.2 Analysis of experimental data

4.2.1 Choice behaviour

Results of our choice model are illustrated in Figure 2 (panels 2A & 2B), Table 2 and a full model summary is included in Appendix 1.5. We observed a significant group by recipient interaction whereby both the CP/HCU and the CP/LCU groups accepted a higher proportion of effortful trials for themselves than they did for the other relative to the TD group (χ^2 (2, N = 87) = 10.17, p = 0.006). In other words, both CP/HCU and CP/LCU groups were more likely to choose the effortful option on trials for themselves than they were to do so on trials for the other (relative to the TD group). A significant interaction between group and effort was also observed (χ^2 (2, N = 87) = 30.47, p < .001). The TD group showed a steeper drop in choice of the more effortful option as the effort required increased relative to both the CP/HCU and the CP/LCU groups (CP/HCU vs TD - p < .009; CP/LCU vs TD - p = 0.01). No significant difference in choice as effort increased was observed between CP/HCU and CP/LCU groups (p = 0.623). We saw a statistically significant interaction between group and reward (χ^2 (2, N = 87) =14.04, p = 0.001). The TD group and the CP/HCU were more likely to choose the effortful option as the reward level increased than were the CP/LCU group (TD vs CP/LCU - p = 0.0006; CP/HCU vs CP/LCU - p < 0.01) (see Figure 2b). No significant difference was seen between CP/HCU and TD groups (p = 0.53). Significant interactions were also seen between recipient and effort (χ^2 (2, N = 87) = 30.68, p < 0.001) and recipient and reward (χ^2 (2, N = 87) = 10.94, p = 0.006), whereby all groups were more likely to choose the more effortful option for the self than for the other as effort increased (p <.0001) and as reward increased (p <.001). Finally, we saw main effects of effort (χ^2 (1, N = 87) = 360.56, p < 0.001), reward χ^2 (1, N = 87) =38.30, p < 0.001), and recipient (χ^2 (2, N = 87) = 779.02, p < 0.001), as predicted based on prior studies using this paradigm (Lockwood, et al., 2021; Lockwood et al., 2017; Lockwood, et al., 2021). There were no overall group differences in choice of the harder work option (p = 0.98). These results show that participants' choices to help others were affected by the reward and effort levels on offer. Furthermore, participant choices were particularly affected by the recipient receiving the points on that trial (i.e. the 'recipient' variable): across all groups, participants were less willing to choose the more effortful option for another person than they were for themselves. This was particularly the case in CP/HCU and CP/LCU groups relative to the TD group.

It should be noted that data collection efforts were curtailed because of the pandemic. For the sake of transparency, we examined power for our models examining choice and force behaviour post-hoc (see Appendix 1.6). We acknowledge, however, that this is not standard practice, and as such the power analyses cannot be given much weight.

4.2.2 Computational modelling of reward by effort discounting

The best performing model (i.e. the model with the lowest AIC and BIC values) within each group was a parabolic model with separate discount parameters (Kself and Kother) and separate noise parameters (βself and βother). This 2K2β model (Model 10) performed better than all linear and hyperbolic models, and models with single K and β parameters.

However, the winning model in the majority (57%) of participants was Model 7. As this is only a marginal majority over model 10, we ran a linear mixed model predicting β parameters from model 10 with recipient and group as fixed factor, and a subject level random variables. This model found a main effect of recipient in predicting β parameters across participants, indicating that a model with two noise parameters does indeed best fit our data. The parameters from model 10 were therefore used in all subsequent analyses. In order to validate our model further we calculated the median R^2 to find out the variance in choices that the $2K2\beta$ model was able to explain for each group. For our CP/HCU this the model explained 85% of variance (SD = 0.20); for our CP/LCU group it explained 64% of variance (SD = 0.20); for our TD group it explained 64% of variance (SD = 0.22)). We also performed parameter recovery to test whether the parameters from our $2K2\beta$ model were recoverable in simulated data. This demonstrated good recovery of our four parameters (K_{self} = 89%, K_{other} = 87%, β_{self} = 74%, β_{other} = 75%; see figure 2E). These parameters were thus used for all further analyses.

4.2.3 Subject-level reward discounting by effort

Results are summarised in Table 3. These suggest that all of our participant groups discounted reward by effort more (i.e. were more motivated) for the self than for the other. Within the first latent class of our model, there is good evidence for this self-other difference in discounting in the TD group (β = 4.16, 95% confidence interval [0.36-7.61]). Point estimates for the CP/HCU group (β = 4.79) and for the CP/LCU group (β = 5.07) suggest that the self-other difference is even larger for these groups than for the TD group. In the second latent class, where motivation for the self is lower on average, the self-other difference is smaller in all three groups.

Despite the observed group differences in discounting for the self vs the other, we found limited statistical evidence for an interaction between group and recipient. Thus, while in our data the self-other difference in motivation is larger for the CP/HCU and CP/LCU groups, compared to the TD group, we cannot be confident that this result generalizes to the population.

4.2.3 Force behaviour

Results are illustrated in Figure 2 (g & h) and Table 2, and a full model summary is reported in Appendix 1.5. We observed a significant interaction between group and recipient (χ^2 (2, *N* = 87) = 20.67, p < 0.001): the CP/HCU group exerted significantly less effort on behalf of the other relative to the self when compared to the TD (p<.0001) and when compared to the CP/LCU (p = 0.0002) groups. We also observed a significant interaction between group and effort (χ^2 (2, *N* = 87) = 31.81, p < 0.001). The TD group showed a steeper increase in force as effort required increased relative to both CP/HCU (p = 0.0001) and CP/LCU (p = 0.003) groups. No interactions were seen between group and reward (p = 0.82), or recipient and reward (p = 0.27). We also saw main effects of recipient (χ^2 (1, *N* = 87) = 105.98, p <.001), effort (χ^2 (2, *N* = 87) = 2099.53, p <.001), and reward (χ^2 (1, *N* = 87) = 40.95, p <.001). No overall difference in force was observed between groups (p = 0.12).

4.2.4 Exploratory and covariate analyses

To explore our findings further, we used an LMM to examine whether participants' success on each trial varied as a function of group affiliation and recipient. We observed no difference in success across groups (p = 0.09), and success did not depend on the recipient of the points on that trial (p = 0.18). We also observed no group by recipient interaction (p=

0.72). This is consistent with previous studies using this task with adult populations (Lockwood et al., 2021; Lockwood et al., 2017; Lockwood, et al., 2021).

As our groups differed significantly on our IQ measure, covariate analyses were run for our choice and effort models with IQ included, with age also included for completeness. These variables did not significantly contribute to either of our models, and did not change our main findings. We ran further covariate analyses with these models, including the three measures of behavioural or emotional problems that differed between groups (hyper-activity, emotional problems, peer problems). Again, these variables did not contribute significantly to either of our models, or change any of our key findings. Full models and results for all covariate analyses are reported in Appendix 1.1.

It was unfortunately impossible to run covariate analyses for our beta regression model predicting reward discounting by effort by group and recipient, as there were not sufficient data for these to tell us anything statistically meaningful. This would, however, be worth doing in the future given that we saw significant differences between groups on several important variables.

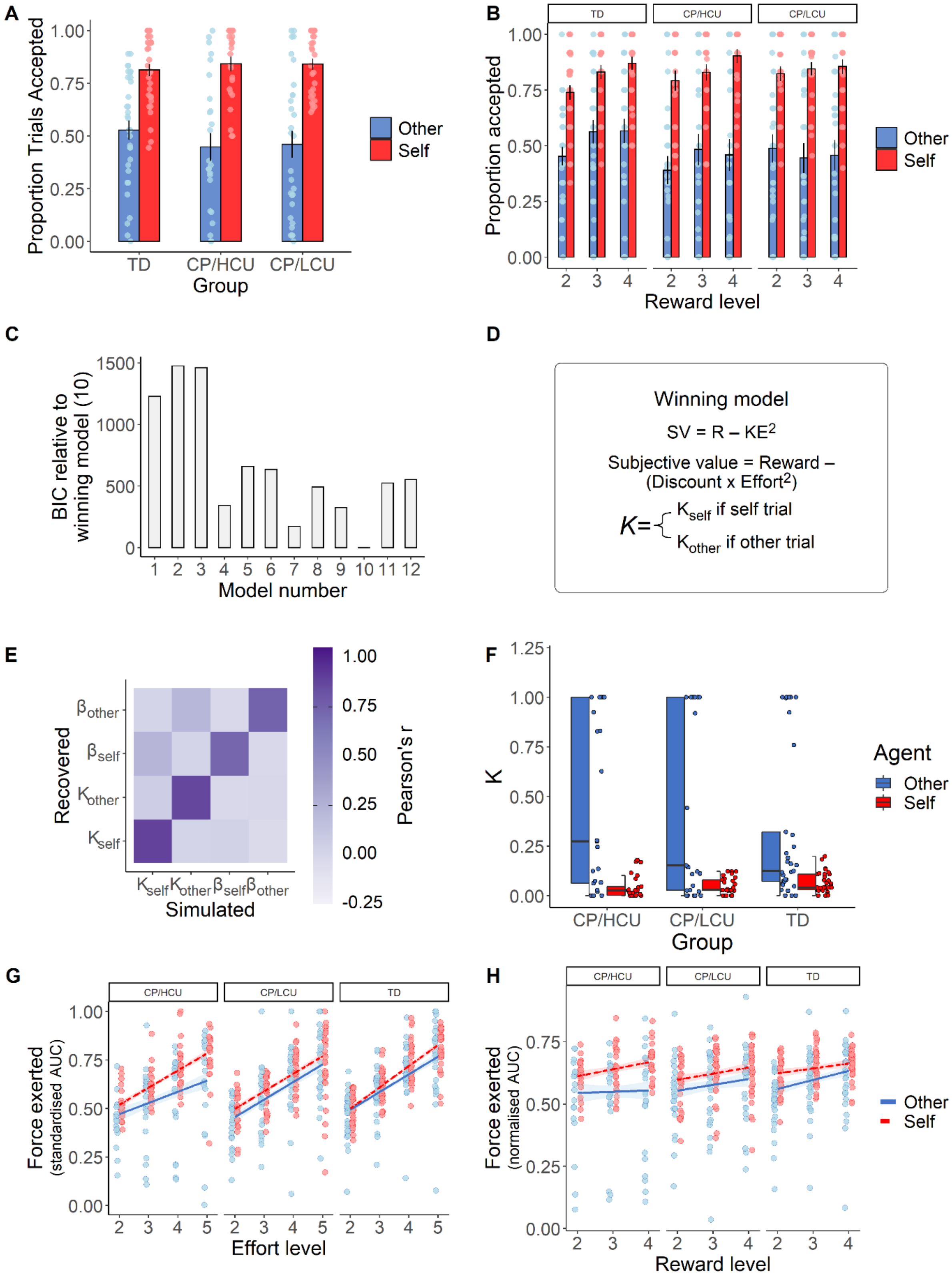

Figure 2. Prosocial choice, prosocial force, and computational modelling of prosocial and self-benefitting decisions. CP/HCU conduct problems and high levels of callous-unemotional

traits, CP/LCU – conduct problems and low levels of callous-unemotional traits. TD typically developing.

(A) Participants in all groups were less willing to accept the more effortful offer over the rest offer as the effort level increased. (B) The proportion of work offers accepted over the baseline option increased as reward increased. Across effort and reward levels, participants in all groups were less willing to accept effortful offers for the benefit of the other than for themselves. This tendency to work more for self than others was most pronounced at the higher reward levels and particularly when a high level of effort was required. Furthermore, CP/HCU and CP/LCU participants accepted significantly fewer effortful offers for the other than for themselves relative to the TD group. Data are represented as mean ± SE. (C) A range of computational models of effort discounting were compared. These varied in terms of whether models had a single or separate discount (K) parameter(s) for Self and Other trials (models 1-6 vs. models 7-12) and in the shape of the discount function: parabolic (models 1, 4, 7,10), linear (models 2, 5, 8, 11) or hyperbolic (models 3, 6, 9, 12). Models 7 and 10 had the lowest Bayesian Information Criterion (BIC) scores. Both of these models were parabolic and contained separate K parameters for self and other. However, model 10, that had separate choice stochasticity parameters (β) for self and other best fit our data according to the BIC criterion. This model was therefore selected as the winning model. Bars show model BIC. (D) Equation for the winning parabolic model with separate discount (K) parameters and separate choice stochasticity (β) parameters for self and other. (E) Parameter recovery using simulated data from the winning model and choice schedule showed excellent recovery of the model parameters. (F) Statistical comparison of the K parameters from the best fitting model showed participants showed steeper discounting for the other relative to the self across all groups, but that groups did not significantly differ from one another in reward discounting by effort for the self vs the other. Data are represented as median and interquartile range. (G) Force exerted (normalised areas under the curve during the effort period) for each effort level. Participants exerted less force for others overall across all effort levels ($p<.001$). (H) Force exerted for each reward level shows participants exerted more force for higher rewards, and that this was the case whether they were working for themselves or for someone else ($p<.001$). Across effort and reward levels, all participants put in less effort for the other than they did for themselves ($p<.001$), but the CP/HCU group showed this self-other difference in force to a larger extent than the other two groups ($p<.001$). TD participants also showed a steeper increase in force exerted as effort levels increased than CP/HCU and CP/LCU group.

	Model 1 (Choice data)			*Model 2 (Force Data)*		
	χ2	*Df*	*Pr(>Chisq)*	*χ2*	*Df*	*Pr(>Chisq)*
Group	0.03	2	0.9834087	4.43	2	0.12
Effort	360.56	1	< 2.2e-16 ***	2099.53	1	< 2.2e-16 ***
Reward	38.30	1	6.065e-10 ***	40.96	1	1.554e-10 ***
Agent	779.02	1	< 2.2e-16 ***	105.98	1	< 2.2e-16 ***
*Group * Effort*	30.47	2	2.423e-07 ***	31.81	2	1.237e-07 ***
*Group * Reward*	14.04	2	0.0008927 ***	0.39	2	0.8238445
*Group * Agent*	10.17	2	0.0061759 **	20.67	2	3.242e-05 ***
*Effort * Recipient*	30.68	1	3.042e-08 ***	11.63	1	0.0006497 ***
*Reward * Recipient*	10.94	1	0.0009421 ***	1.21	1	0.2706795

Table 2. Analysis of Deviance (Type II Wald test) of choice and force model data. Model 1: Generalised Linear Mixed Effects Model fitted to participants' choices to accept (coded as 1) or reject (coded as 0) the more effortful option on a particular trial by: group, effort level, reward, and recipient with subject included as a random factor. The model includes two-way interactions between all variables except effort and reward, which varied independently in the study design. Model 2: Linear Mixed Effects Model fitted to participants' force exerted by: group, effort level, reward, and recipient with subject include as a random factor. The model includes two-way interactions between all variables except effort and reward, which varied independently in the study design. Df = degrees of freedom.

	Predictors	Estimate	SE	95 % CI Lower	Upper
Mean	Intercept	-4.427	1.496	-8.039	-2.348
	Group (CP/HCU vs TD)	-0.219	0.460	-1.716	0.131
	Group (CP/LCU vs TD)	-0.167	0.491	-1.867	0.018
	Recipient: Other vs Self	4.126	1.958	0.361	7.611
	Interaction: Group (CP/HCU) * Recipient (Other)	0.659	0.734	-0.479	2.253
	Interaction: Group (CP/LCU) * Recipient (Other)	0.944	0.736	-0.092	2.971
	NP random intercept	1.925	1.443	0.048	5.578
	NP random slope (Recipient (Other))	-1.659	3.098	-7.337	4.687
Variance inflation	Intercept	-0.841	0.631	-3.363	-0.510
	Recipient: Other vs Self	3.459	1.201	0.235	3.619
	NP random intercept	-0.684	0.802	-1.169	2.145

Table 3. Coefficient estimates, bootstrapped standard errors and non-parametric 95 % C.I.s from a beta regression with nonparametric random effects of parameter K (indexing reward by effort discounting) on group and recipient. In this table, the slope coefficients (estimates) estimate the effect of an independent variable on log(K/(1-K)). A higher value of K (reward by effort discounting) indicates lower motivation – in other words, that the participants were less likely to choose the more effortful option on that trial if effort increased, even if reward was also high. A low K value indicates higher motivation. StdErr: Standard error estimated by bootstrapping (R = 2000). CI: Confidence interval bias-corrected and accelerated non-parametric bootstrap (R = 2000). NP: Non-parametric. CP/HCU conduct problems and high levels of callous-unemotional traits, CP/LCU conduct problems and low levels of callous-unemotional traits, TD typically developing.

5. Discussion

Here we observe that adolescent boys with conduct problems (both those with CP/HCU and CP/LCU) are less likely to choose to engage in prosocial behaviour compared with their TD peers. However, boys with CP/HCU - i.e. those at increased risk of developing psychopathy - demonstrate especially reduced prosociality. This differentiates boys with CP/HCU not only from TD peers, but also from boys with CP/LCU. As well as demonstrating reduced prosocial intentions, as indexed by reduced prosocial choice, boys with CP/HCU were less willing than both other groups to energise a prosocial action in order to actually achieve a prosocial outcome - in other words, they exerted less force to win points for others than they did for themselves relative to both CP/LCU and TD groups. These findings suggest that adolescent boys with CP/HCU may be a particularly vulnerable group, who show especially reduced engagement in behaviours that facilitate social connectedness. Our findings give new insight into potential behavioural mechanisms contributing to reduced prosocial behaviour in adolescent boys with CP, which may also underlie atypical social affiliation in this group.

As predicted, adolescent boys with CP/HCU made fewer prosocial choices in our experimental paradigm than did TD boys. This is in line with models that propose reduced prosociality and social affiliation to be one key feature of CP/HCU (Viding & McCrory, 2019; Waller & Wagner, 2019), as well as prior self-, parent-, teacher-, peer-report (Foulkes et al., 2017; Milledge et al., 2019) and experimental data (Sakai et al., 2012; 2016) suggesting that this group demonstrates particularly low prosocial behaviour. Prior studies that included CU traits when investigating prosocial behaviour in CP indicated that high levels of these traits might be the primary driver of low prosociality in adolescents with CP. We therefore predicted that adolescent boys with CP/LCU group would not significantly differ from TD boys in their prosocial choice. However, CP/LCU adolescents in our current study showed similar choice behaviour to the CP/HCU group – i.e. they made significantly fewer prosocial choices than the TD group. This differs from the findings of Sakai et al. (2016) which, to our knowledge, is the only prior experimental study that directly compares boys with CP/HCU, CP/LCU and TD boys. This being said, our study and the study of Sakai et al. do differ in some important ways. First, prosocial choice in Sakai et al.'s study directly pits benefit to the self against benefit to the other. On every trial, participants could accept or reject an offer to keep for themselves a portion of a predetermined charitable donation that was to be made on their behalf by the researchers. In contrast, our study allowed participants equal opportunity to benefit both themselves and the other. Real life choices to behave prosocially do not necessarily come at a direct cost to oneself. It could thus be argued that the current study examines prosocial choice in a particularly ecologically valid framework. A second difference between our study and that of Sakai et al. is in how the studies framed prosocial choice. Prosocial choice in the current study reflects incurring a potential gain for the other, whereas in Sakai et al.'s study prosocial choice reflects preventing a potential loss to the other. Research with healthy adults has indicated that people are generally more willing to incur a gain for others than to inflict a loss upon them (Baron, 1995; Leliveld et al., 2009). Adolescents with CP/HCU are characterised by reduced affective empathy, as well as reduced responsivity to others' distress (Blair et al., 2004; Jones et al., 2010; Viding et al., 2012; Viding & McCrory, 2018). These characteristics might make this group less susceptible to gain/loss framing in choices for others than CP/LCU adolescents, who do not share these affective-processing deficits. In other words, adolescents with CP/LCU group might be more averse to losses to others for others than adolescents with CP/HCU, but equally unwilling to choose to incur a gain for them. Future work could investigate this further by examining how prosocial choice differs between CP/HCU, CP/LCU and TD adolescents on a task that directly contrasts prosocial choices that incur a gain and prosocial choices that inflict a loss to another, and seeing whether choice behaviour relates to measures of affective empathy.

Our computational modelling of reward by effort discounting demonstrated that all participants were more motivated to accept effortful trials for themselves than for the other – similar to healthy adults (Lockwood et al., 2017). That is to say that, as effort levels increased, our participants devalued rewards more quickly when these rewards were for the other than when these rewards were for themselves. However, and in contrast with our predictions, we saw no significant evidence for a difference in reward by effort discounting between CP/HCU group and TD groups. Our prediction of a group difference was based on the prior observation that reward by effort discounting was associated with self-reported psychopathic traits in adults (Lockwood et al., 2017), as well as a handful of adolescent studies that indicated that CP/HCU might be a particular risk factor for reduced prosocial behaviour (Milledge et al., 2019; Sakai et al., 2012, 2016). While we did not find any significant evidence for group differences in subjective discounting of reward by effort, our data do indicate that the group reward by effort discounting followed a broadly similar pattern to the choice behaviour. That is, our two CP groups do appear to show less prosocial motivation (i.e. increased reward by effort discounting for others relative to the self) compared to the TD group. However, this difference does not reach significance in our study and precludes us from drawing conclusions regarding reward by effort discounting in CP.

Finally, and in line with our predictions, adolescent boys with CP/HCU differed from TD peers in the relative *effort* they were willing to make for themselves vs. someone else. What is more, this difference in relative effort for the self vs the other in CP/HCU also differentiated this group from the CP/LCU group (who showed similar prosocial effort to the TD). This observation provides the first evidence that a reduced propensity to put effort into prosocial action may be linked to the particularly low levels of prosocial behaviour observed in CP/HCU (Foulkes et al., 2017; Frick et al., 2014; Milledge et al., 2019; Viding & McCrory, 2019; Waller & Wagner, 2019). As observed in healthy adults, all of our participants demonstrated 'superficial prosociality' – i.e. they put more effort in to win points for themselves than they did for the other - despite having already chosen to help the other. This indicates that some degree of self-prioritisation is the 'norm'. However, adolescents with CP/HCU showed this superficial prosociality to an exaggerated extent - which may contribute to atypical social affiliation in this group. Fairness and reciprocity are considered important hallmarks of human social behaviour, and adults and children alike tend to be strongly averse to unfair behaviour - even punishing others that violate fairness norms (Fehr & Gächter, 2000, 2002; McAuliffe et al., 2017). Translated into real life situations, an especially reduced willingness to put in effort for others relative to yourself may be viewed as unfair behaviour by peers, and thereby may contribute to difficulties in maintaining social relationships in adolescents with CP/HCU.

Participants in the CP/HCU group were still winning points for the other (as indexed by a lack of difference in success rates on 'other' trials between our three groups). However, they appeared to be putting in the bare minimum effort to do so. Achieving the same outcome (i.e. winning points for others) as other groups by exerting less effort could be argued to be efficient or even optimal behaviour. However, the outcome may not the most important factor when it comes to prosocial behaviour and its role in social relationships. Research suggests that people consider personal sacrifice when engaging in prosocial behaviour to be more important than the outcome when they make social evaluations, -

presumably because sacrifice is taken as an important indicator of a person's moral character (Johnson, 2018). Given that CP/HCU is a profile associated with atypical social affiliation, and that only prosocial effort differentiated adolescents with CP/HCU from other groups, we speculate that putting effort into prosocial acts is one key aspect of facilitating good social connections with others. Future research could explore this further by investigating peer perceptions of acceptability or likeability of adolescents who exhibit different forms of prosocial transgressions. This would give insight into how different facets of prosocial behaviour might contribute to social difficulties for adolescents with CP/HCU and CP/LCU, and has potential to inform intervention strategies for CP.

It is also interesting to consider the role of motivation in prosocial effort. Previous research has indicated a divergence between ability and propensity in CP/HCU: for example adolescents with CP/HCU appear to be able to take the perspective of another, but seem less motivated to do so than TD adolescents (Roberts et al., 2020). The study gives initial indication that adolescents with CP/HCU may also be characterised by a reduced propensity to engage in prosocial effort. Another interesting avenue for future research might therefore be to explore whether adolescents with CP/HCU show more motivation for prosocial effort under different experimental conditions. For example, Hawley (2003) observed that adolescents high on Machiavellian (i.e. manipulative) traits used both prosocial and aggressive strategies to achieve their goals. Given that CU and Machiavellian traits appear to share some common variance (Kerig & Stellwagen, 2010; Vize et al., 2018), future studies could explore whether adolescents with CP/HCU engage in instrumental prosocial behaviour - in other words, whether they would be willing to make prosocial effort in situations where they stand to gain, as opposed to in a more general context such as the current experiment.

It is important to note some limitations to the current study. First, the study focused on males only, given the preponderance of CP in boys and the desire to maximise statistical power. Future work should also investigate these processes in girls with CP, especially given the findings that neurocognitive mechanisms underlying CP in females may not always be comparable to those seen in males (Freitag et al., 2018). Second, although this task documents potential mechanisms underlying reduced prosocial behaviour in boys with CP, we do not yet know how these mechanisms relate to real life prosocial behaviour. Future studies could help to shed light on this by looking at ecological momentary assessments or observer rated diary assessments of prosocial behaviour, and relate these to task performance metrics. Finally, three CP participants needed to be removed from all analyses due to failing to make enough responses at the choice stage of 'other' trials, which resulted in unreliable estimations of discounting parameters by our computational models. This behaviour is clearly relevant to our research question, as not making a choice for the other was the only way to guarantee zero points for the other person on that trial (as opposed to choosing the rest option where no effort is required but where the other still gains one point). Unfortunately, however, it was impossible to explore this further in the current dataset as so few participants demonstrated this choice pattern – perhaps because it was not an explicit option. Future studies might benefit from presenting participants with a third 'no point' option to see how this may influence choice behaviour.

Despite these limitations, the current study considerably extends our understanding of prosocial behaviour in adolescent boys with CP/HCU and CP/LCU. Adolescents with CP/HCU, a vulnerable group that are at risk of developing psychopathy in adulthood, demonstrated especially reduced prosocial behaviour relative to other groups, exhibiting not only in reduced prosocial choice but also reduced prosocial effort. This is in contrast to those with

CP/LCU, who only showed reduced prosocial choice. These findings offer an ecologically valid insight into prosocial processing in CP/HCU and CP/LCU, and gives important initial understanding of what may drive especially low prosocial behaviour and atypical social affiliation in CP/HCU. It also differentiated adolescents with CP/HCU and those with CP/LCU on an important index of social cognition. If replicated, these results could motivate further inquiry into behavioural training and intervention components that improve social functioning and reduce risk of antisocial behaviour in adolescents with CP/HCU and CP/LCU.

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Chapter Three – Social Information Use in Adolescents with Conduct Problems and Varying Levels of Callous-Unemotional Traits

This section is presented as an accepted journal article and is an exact copy of the version of the following publication.

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Supplementary material that is referenced to in this Chapter will appear in Appendix 2.

Social Information Use in Adolescents with Conduct Problems and Varying Levels of Callous-Unemotional Traits

RUNNING TITLE: Social Information Use in Adolescents with Conduct Problems

Gaule, A.[1] Bevilacqua, L.[1], Molleman, L.[2,3,4], Roberts, R.[1], van Duijvenvoorde, A. C.[5, 6], van den Bos, W.[2,3,4], McCrory, E.[1], Viding, E.[1,*]

[1] Division of Psychology and Language Sciences, University College London, UK

[2] Amsterdam Brain and Cognition, University of Amsterdam, Netherlands

[3] Center for Adaptive Rationality, Max Planck Institute for Human Development Berlin, Germany

[4] Faculty of Education and Psychology, Freie Universitat, Germany

[5] Institute of Psychology, Leiden University, Netherlands

[6] Leiden Institute for Brain and Cognition, Leiden University, Netherlands

[*] Corresponding author

Correspondence to: Professor Essi Viding, Division of Psychology and Language Sciences, UCL, *email: e.viding@ucl.ac.uk*

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Background: Adolescents with Conduct Problems (CP) are characterised by difficulties with social relationships and display atypical social cognition, such as when interpreting emotional expressions or engaging in social problem-solving. One important aspect of social cognition that warrants investigation is the degree to which these adolescents factor others' views into their already held beliefs, and strategies used to do so. Effective social information use enables attunement to social environment, cooperation, and social problem-solving. Difficulties in this regard could contribute to problems in social interactions in adolescents with CP, and may vary with adolescents' high (CP/HCU) versus low levels of callous-unemotional traits (CP/LCU).

Methods: We compared social information use in boys (11-16 years) with CP/HCU (n = 32), CP/LCU (n = 31) and typically developing (TD) peers (n = 45), matched for IQ. Participants provided estimates of numbers of animals on a screen, saw another adolescent's estimate, and could adjust their initial estimate. We compared two aspects of social information use: (1) degree of adjustment of initial estimate towards another's estimate; (2) strategy use when adjusting estimates.

Results: Degree of adjustment towards another's estimate did not vary across groups, but strategy use did. Adolescents with CP/LCU compromised less following social information than TD peers.

Conclusions: Findings suggest that while adolescents with CP are able to take social information into account, those with CP/LCU use this information in a way that differs from other groups and could be less efficient. This warrants further systematic investigation as it could represent a target for behaviour management strategies. Overall, this study highlights

the need for more research delineating the social-cognitive profile of adolescents with CP/LCU.

Key words: Conduct problems, callous-unemotional traits, social cognition

Abbreviations: CP – Conduct problems; CP/HCU – Conduct problems with high levels of callous-unemotional traits; CP/LCU – Conduct problems with low levels of callous-unemotional traits; TD – Typically developing.

1. Introduction

Conduct problems (CP) are one of the leading causes of referral to mental health services during childhood and adolescence (National Institute for Health and Care Excellence, 2013), and incur large individual and societal costs (Richards et al., 2009). The behaviour of young people with CP violates the rights of others and/or age appropriate norms (American Psychiatric Association, 2013). Adolescents with CP have difficulties with social relationships, are likely to experience social rejection, and to have lower social competence compared to peers (Dodge et al. 1986; Loeber & Farrington 2001; Webster-Stratton & Lindsay 1999). They demonstrate difficulties with social problem-solving, conflict-management and collaborative play - often relying on aggressive or coercive strategies (Dodge et al., 1986; Ladd, 1990).

Research into how adolescents with CP process social information can help to elucidate why they display antisocial behaviour and often demonstrate social difficulties. The influential Social Information Processing (SIP) model (Crick & Dodge, 1994) posits that aggressive responses to social stimuli occur as a result of cognitive processing biases or deficiencies over a sequence of steps that starts with cue encoding and finishes with response enactment (Crick & Dodge, 1994). The most prominent finding stemming from SIP research is the tendency of children and adolescents with CP to interpret ambiguous social cues as aggressive (‘hostile attribution bias’) (Verhoef, Rogier et al., 2019). Studies have also reported that aggressive behaviour is linked to both generation of atypical social responses and atypical evaluation of social responses when considering hypothetical scenarios in clinically referred (de Castro et al., 2005) and non-referred (e.g. Dodge et al., 1986) samples of children and adolescents.

A number of recent studies have focused on how different aspects of social-cognitive processing may differ between subgroups of adolescents with CP and potentially explain their varied pattern of social difficulties. High vs. low levels of callous-unemotional (CU) traits (including lack of remorse and empathy) are one way of subgrouping adolescents with CP (CP/HCU vs. CP/LCU) (Frick et al., 2014). Extant data suggests that partially divergent social-cognitive profiles may underlie antisocial behaviour and social difficulties in these groups. Adolescents with CP/HCU appear to place less importance on social affiliation than CP/LCU and typically developing (TD) peers (Blair et al., 2014; Viding & McCrory, 2019), whereas adolescents with CP/LCU may be less flexible and more aggressive when confronted with social problems than CP/HCU and TD peers (Blair et al., 2014; Frick et al., 2014; Waschbusch et al., 2006).

Specifically, adolescents with CP/HCU appear to be less responsive to others' distress, and demonstrate a lower propensity for social affiliation than TD peers and those with CP/LCU, perhaps driven by a lower responsiveness to positive affiliative cues (Blair et al., 2014; Hodsoll et al., 2014; O'Nions et al., 2017; Viding & McCrory, 2019; Waller & Wagner, 2019). They also demonstrate atypical evaluation of their own behavioural responses and appear to value non-typical social goals. For example, high CU traits have been associated with increased expectations that aggressive behaviour will produce positive consequences (Pardini et al., 2003) and a higher likelihood of endorsing social goals associated with respect, revenge, and dominance in mixed gender samples of adjudicated adolescents (Pardini, 2011). Additionally, adolescents with CP/HCU show reduced prosocial behaviour relative to CP/LCU and TD peers (in a clinical sample of adolescent males) (Sakai et al., 2016). However, adjudicated adolescents with CP/HCU do appear to have good understanding of the social consequences of their aggressive behaviour (Pardini, 2011) and children with CP/HCU (in a predominantly male clinical sample aged 7-9 years) demonstrate good understanding of others' intentions, at least when affect is not involved (Anastassiou-Hadjicharalambous & Warden, 2008). Thus, research indicates that adolescents with CP/HCU may possess typical social understanding, but prioritise their own goals in social situations - perhaps due to their reduced propensity to empathise and affiliate with others (Haas et al., 2018). This might contribute to their particularly serious antisocial behaviour and impoverished social relationships.

In contrast to those with CP/HCU, adolescents with CP/LCU appear capable of feeling guilt and empathy, and tend to aggress when there are environmental triggers such as a perceived threat (Frick & Viding 2009; Frick et al. 2018). Findings related to social cognition with this group are less clear, as the majority of social-cognitive research has focussed on CP/HCU or CP in undifferentiated samples. However, some evidence suggests that adolescents with CP/LCU may demonstrate atypical social understanding relative to CP/HCU peers. Waschbusch et al. (2006), in a (predominantly male and clinically referred) sample of children aged 7-12, found that CP accompanied with low levels of CU traits was associated with more overtly aggressive, less prosocial, and less flexible and relevant social problem-solving solutions than those of their peers with CP and higher levels of CU traits. However, the behavioural evidence-base is still relatively limited in terms of tasks utilised to date, as well as studies actively comparing CP/HCU and CP/LCU with TD adolescents.

To our knowledge, social information *use* – here defined as the degree to which feedback from others is incorporated into beliefs and the strategies used to do this – has yet to be examined in adolescents with CP. Social information is critical in shaping and guiding decision-making and behaviour, providing crucial inputs for a range of social-cognitive processes. We rely on social feedback to infer whether others approve of our decisions, choices, and behaviours (Cialdini & Goldstein 2004). Effective use of social information allows us to learn about successful behavioural strategies while avoiding costly individual trial-and-error (Boyd & Richerson, 1985; Kendal et al., 2018). It also enables individuals to attune to their social environment, facilitating cooperation and coordination with social partners (Boyd & Richerson, 1985; Sigmund et al., 2010; Surowiecki, 2005). Conversely, atypical social information use may hamper the formation and maintenance of social relationships. Investigating the degree to which adolescents with CP use social information (in the form of feedback from others) to adjust their judgments, as well as the strategies they use to do so, may shed more light on the cognitive mechanisms underlying social difficulties commonly observed in this group.

Studies examining this form of social information use typically employ belief updating paradigms: participants make a judgment or an estimate, receive information about another's judgment or estimate, and can then update their initial response if they choose. In these paradigms, updating one's initial estimate in response to information from others implies that a person perceives that using such information will improve their accuracy on the task – thereby improving their likelihood of winning points. Studies using this design indicate that TD adolescents use social information to a greater degree than adults (Costanzo & Shaw 1966; Knoll et al. 2015). This may be because adolescence is a sensitive developmental period, where young people are increasingly independent and tend to make decisions in pursuit of social acceptance (Gardner & Steinberg, 2005; Knoll et al., 2015). Research has also shown that adolescents frequently adopt relatively simple 'all-or-nothing' adjustment strategies to incorporate social information into their existing beliefs (copying social information or sticking with original estimates), rather than more complex integrative 'compromising' strategies (taking a weighted average of original estimates and social information) (Molleman, Kanngiesser, & van den Bos 2019). It is important, however, to consider that there may be individual differences among adolescents. Prior research has not addressed whether this form of social information use varies in adolescents with CP or in relation to CU traits. The present study, therefore, aims to shed light on how this form of social information use looks in these groups and whether this differs from TD adolescents.

CP/HCU, CP/LCU, & TD participants performed a task where they were asked to estimate the number of animals shown in an image and could then adjust their estimate after observing social information (another participant's estimate). This allowed us to examine:

(1) *The degree to which adolescents use social information* (as measured by the average degree of participants' adjustment of initial estimates towards the social information)

(2) *Strategies deployed by adolescents when using social information (*as measured by participants' relative use of simpler all-or-nothing vs compromising strategies to update initial estimates in response to social information)

In light of their reduced propensity for social affiliation (Blair et al., 2014; Viding & McCrory, 2019; Waller & Wagner, 2019) and their propensity to endorse social dominance (Pardini, 2011), we predicted that *adolescents with CP/HCU may demonstrate reduced social information use relative to CP/LCU and TD adolescents.* Given research showing that children and adolescents with CP are characterised by difficult peer relationships and demonstrate reduced social competence (Dodge et al., 1986; Ladd, 1990; Viding et al., 2009; Webster-Stratton & Lindsay, 1999), and that those with CP/LCU may be particularly rigid in their social problem-solving (Waschbusch et al., 2007), we predicted that *adolescents with CP, in particular those with CP/LCU, may be less likely to use compromising strategies than TD adolescents*.

2. Methods

2.1 Participants

121 boys aged 11-16 were recruited from UK mainstream schools and specialised alternative provision (AP) schools for adolescents with behavioural difficulties. Screening questionnaires were administered to teachers enabling: a classification of current CP; dimensional assessment of CU traits; an overall screen for commonly co-occurring symptoms with CP; and information regarding specialist education provision. Participants were presented with age-appropriate information sheets and assent forms, which were also verbally explained. All parental consent/child assent procedures were in line with General Data Protection Regulation recommendations; the study was approved by the University College London Research Ethics Committee (Project ID number: 0622/001). Exclusion criteria included a diagnosis of autism spectrum disorder or presence of significant learning difficulties (a score of <70 on the Wechsler Abbreviated Scale of Intelligence, a measure of IQ (WASI; Wechsler, 1999)). Two CP participants were removed from descriptive analyses for failing to meet our inclusion criteria. Eight additional participants (five CP, three TD) were subsequently removed from main analyses due to task responding that was qualitatively different from expected task behaviour (see section 2.2.3 for more detail). Thus final group Ns for descriptive analyses were: CP/HCU – 34,

CP/LCU – 34, TD – 48; final group Ns for main analyses were: CP/HCU – 32; CP/LCU – 31, TD – 45.

2.2 Measures

2.2.1 Participant characteristics

Participants in the CP group (N = 70) were required to meet age-appropriate cut-offs on the teacher-version of the *Child and Adolescent Symptom Inventory* (CASI-4R) Conduct Disorder Scale (Gadow & Sprafkin 2005). The cut-off scores associated with a clinical diagnosis of Conduct Disorder from teacher-report according to the CASI manual are: a score of 3+ (ages 10-12), 4 + (ages 12-14), and 6+ (ages 15-16) on the CASI-CD (Gadow & Sprafkin 2005). Two CP participants were removed based on our exclusion criteria, leaving a CP group N of 68 for descriptive analyses (59 recruited from AP schools, 9 from mainstream schools).

CU traits were assessed using the *Inventory of Callous-Unemotional Traits,* teacher-version (ICU) (Essau, Sasagawa, & Frick 2006). Boys meeting CP criteria were further assigned to groups based on whether their ICU score was higher (CP/HCU; N = 34) or lower than/equal to the group median of 37 (CP/LCU; N = 34). We employed a median split approach to separate the children with CP to groups with high and lower levels of CU traits (HCU vs. LCU), for the following reasons:

1) Effects of CU traits do not often emerge as interactions and can instead lead to suppressor effects in correlational analyses (Frick, 2012).
2) The median split approach has, in the past, successfully delineated groups of children with CP who have different social-cognitive processing patterns. The pattern of results

in these two groups has often been such that, if they had been combined, researchers might have missed deficits in either group (Schwenck et al., 2012; Viding et al., 2012).

3) Suppressor effects can generate difficulties for interpretation, which mean that effects of CU traits may not emerge in interactions, although the CP/HCU and CP/LCU children look very different. The group centric analyses thus make it easier to interpret the translational relevance of findings, which is more challenging when examining suppressor effects in continuous analyses, for example. It is important to note that concerns regarding loss of power from dichotomizing relate to the case of bivariate normality (Cohen, 1983), but using continuous measure of CP and CU can generate problems if modelled together, given the absence of bivariate normality - high CU traits almost invariably denote high levels of CP, but not the other way around (Fontaine et al., 2011)

Based on prior published research, 37 represents a clinically meaningful cut-off for HCU for both teacher and parent ratings (Docherty et al., 2017).

Typically developing (TD; N = 50 participants were recruited from mainstream schools and were required to score: (1) below the median score of the CP group on the ICU (which was 37); (2) within normal range (≤ 2) for the CASI; (3) within normal range (≥ 4) of the prosocial subscale of the Strengths and Difficulties Questionnaire (SDQ); and (4) below the cut-off of 16 for teacher-rated total difficulties (as per SDQ scoring norms; Youth in Mind 2016). Parent data for five TD participants on the following measures: CASI-4R, ICU, & SDQ, were included in lieu of missing teacher data (due to their being tested at home; see section 2.2.2.). Two TD participants were removed due to incomplete data on the WASI (key for group matching), leaving a TD group N of 48 for descriptive analyses.

Data on age, IQ, and emotional and behavioural difficulties were collected from all participants individually during testing to ensure that these factors do not account for any significant differences between groups in our findings. We also included child-rated measures of substance (alcohol and drug) use to ensure that these do not account for any findings, as substance use problems commonly co-occur with conduct problems (Wiesner et al., 2005). For more details about these measures and their scoring, and internal consistency in our sample, see Appendix S1.

Participants in the CP/LCU group were significantly younger than participants in the CP/HCU group (mean age 13.6 vs 14.6). Main analyses were therefore carried out with and without age as a covariate. Participants were matched for IQ at a group level (see Table 1). For completeness, main analyses were also carried out with and without IQ as an additional covariate. See Appendix S2, Table S1 and section 4.4 for more detail on covariate analyses. Table 1 summarises data on group matching and main participant characteristics. For full details of analyses see Appendix S3 and Table S2.

Characteristics and Questionnaires	TD controls			CP/LCU			CP/HCU			P value	Post hoc[f]
	Mean (SD)	Min-Max	N	Mean (SD)	Range	N	Mean (SD)	Min-Max	N		
IQ (full score)[a]	90.4 (11.40)	70-114	48	87.53 (10.30)	75-119	34	84.85 (8.85)	72-107	34	0.06	
Age (years)[b]	14.13 (1.26)	11.8-16.9	48	13.56 (1.38)	11.6-16.3	34	14.56 (1.22)	11.7-16.5	34	< .05**	2<3
CASI conduct disorder[b]	0.25 (0.64)	0-2	48	6.55 (3.22)	3-18	34	9.28 (4.76)	3-25	34	< .0001**	1 < 2 < 3
ICU[b]	19.31 (7.18)	2-31	48	30.03 (5.73)	14-37	34	46.68 (7.28)	38-63	34	< .0001**	1 < 2 < 3
Alcohol use and disorders[a,c]	47:1:0:0		48	33:0:1:0		34	29:4:1:0		34	0.08	
Drug use and disorders[a,d]	47:1		48	30:4		34	28:6		34	0.05*[e]	

Table 1: Group matching and participant characteristics data. Abbreviations: CASI, Child and Adolescent Symptom Inventory; CP/HCU, conduct problems and high levels of callous-unemotional traits; CP/LCU, conduct problems and low levels of callous-unemotional traits; ICU, Inventory of Callous And Unemotional traits; *N*, number of participants with complete measure; SD, standard deviation; SDQ, Strengths and Difficulties Questionnaire; TD, typically developing; WASI, Wechsler Abbreviated Scale of Intelligence. Where not

stated, analyses were performed using one-way ANOVA and post hoc tests were Bonferroni corrected for multiple comparisons. For summary of SDQ measures, see Table S2.

[a] Measure obtained at testing phase, child report.

[b] Measure obtained at screening phase, teacher report.

[c] Counts for AUDIT risk categories (Low Risk:Increasing Risk:Higher Risk:Possible Dependence).

[d] Counts for DUDIT risk categories (Low Risk:Possible Drug Problems).

[e] Significance at p=0.05 did not remain after posthoc tests with bonferroni correction (see Appendix S1)

[f] 1 = TD, 2 = LCU, 3 = HCU.

** Results for comparisons smaller than or equal to this threshold

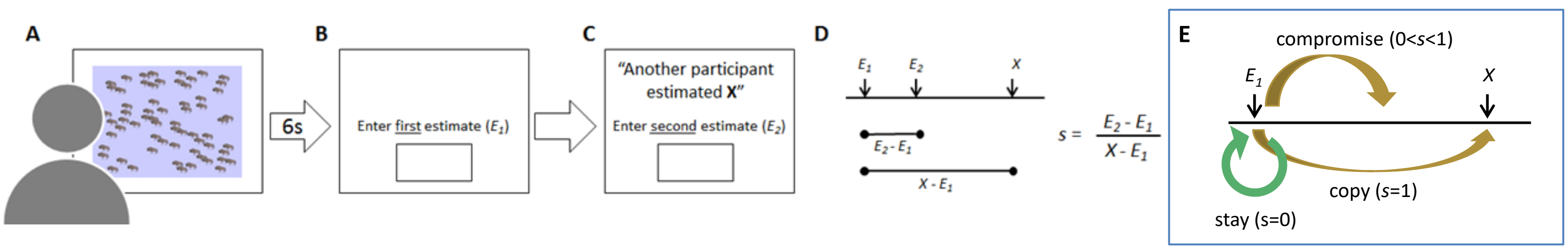

Fig. 1. *Task measuring social information use.* Participants: (A) observe a group of animals for six seconds; (B) enter first estimate (E_1) of total number of animals using computer keyboard; (C) observe social information (X): estimate of a (fictitious) participant from another school, alongside E_1, and enter second estimate (E_2). (D) Social information use per round (s) is calculated as degree of adjustment from E_1 to E_2, divided by distance between E_1 and X. (E) Illustration of task strategies: stay (s = 0) and copy (s = 1) represent all-or-nothing strategies.

2.2.2 Procedure

Participants were tested in a quiet room on their school premises or at home (5 TD participants). The experiment was programmed in *LIONESS Lab* (Giamattei et al., 2020), and presented on a Dell Latitude 7480 laptop. Experimental code is available on request. Data were collected as part of a larger battery of tasks.

2.2.3 The Berlin Estimation AdjuStment Task

The BEAST is a brief and simple perceptual judgement task, previously validated for use with adults (Molleman, Kurvers et al 2019) and adolescents (Molleman, Kanngiesser, et al., 2019). Fig. 1 illustrates the task design (see Appendix S4 and FigS1 for task instructions and example of one full trial). The task comprises five rounds in a fixed order. In each round, participants were presented with an image containing 43, 58, 34, 44, or 39 animals of different species for six seconds (importantly, the number of animals shown on each trial was chosen to ensure all five rounds were of a similar difficulty) (Fig. 1a). After the image had disappeared, participants were asked to make an initial estimate (E_1) of the number of animals seen (Fig. 1b). Importantly, the brief presentation time of images allowed an overall impression of the total number of animals, but prevented counting. No time limit was placed on entering E_1. Following E_1, participants were presented with social information (X), and asked to provide a second estimate (E_2, Fig. 1c). Social information use was characterised as degree of adjustment towards X, i.e. participants' adjustment of E_1 when making E_2 (Fig. 1d). For each round, the relative distance (s) a participant moved towards X was calculated as $s = (E_2 - E_1)/(X - E_1)$. Reordered as $E_2 = (1-s) \cdot E_1 + s \cdot X$, this shows that E_2 in each round is an average of E_1 and X, weighted by s. Adjustments were classified as compromising if participants' E_2 fell between their E_1 and X, and all-or-nothing if they stuck with E_1 when making E_2, or directly copied X (Fig 1e).

Participants were informed that the social information seen on each round was the estimate of an adolescent participant at another school. In reality, *X* was calibrated to participants' E_1 in a way that allowed for a relatively constant scope for adjustment in each round while experimentally controlling for possible 'distance weighting' effects, the observation that people tend to discount information deviating too strongly from initial estimates (Moussaïd et al., 2013; Appendix S5). This minor deception was approved by the UCL ethics committee (project code: 0622/001).

Participants were informed that they would earn points based on their accuracy. To ensure that participants could not learn their own skill or the accuracy of the social information provided across the five task rounds, no feedback was given to participants about their performance. This enabled as unbiased an estimate of social information use as possible (Molleman, Kurvers, et al., 2019). Participants were not rewarded for their participation.

Following Molleman, Kurvers et al. (2019), prior to calculating *s*, we excluded data from all rounds where a participant made adjustments considered qualitatively different from expected task behaviour: giving negative weight to *X* ($s < 0$; 23 cases (3.8% of all data)), or not determining E_2 as a weighted average of E_1 and *X* ($s > 1$; 50 cases (8.4% of data). Data from eight adolescents (two CP/HCU, three CP/LCU, three TD) were excluded from the main analyses for giving three or more responses out of the five task rounds that met these criteria. Following these data cleaning procedures, final group Ns for the main analyses were: CP/HCU – 32; CP/LCU – 31, TD – 45.

3. Statistical Analyses

For full details of statistical analyses of demographic and experimental data, please refer to Appendix S6, Table S2, and Tables 1 and 2.

4. Results

4.1 Basic behavioural results

Participants' initial estimate tended to be lower than the true value (averages as percentage of true value: CP/HCU (74%), CP/LCU (68%), TD (69%)) (see FigS2, panel A), a common observation in similar tasks (Molleman et al., 2020; Molleman, Kurvers, et al., 2019). Groups did not differ in the accuracy of initial estimates (see FigS2; $F(2, 105) = 0.88$, $p = 0.42$; $\eta^2 = 0.02$).

4.2 Social information use

In contrast with predictions, groups did not significantly differ on how much they adjusted their estimates following social information ($p = 0.75$; further details in Table 2 (Model 1), and Fig. 2; model specification and assumption checks in Appendix S7, FigS3. For covariate analysis with age and IQ, see Appendix S2 and Table S1. Mean adjustments across trials were less than 0.5 across groups (CP/HCU - 0.36 (SD = 0.28), CP/LCU – 0.32 (0.30), TD – 0.36 (0.23)) implying that participants assigned more weight to their own views than the social information (Fig. 2). This is also reflected on a trial level (proportion of trials $s<0.5$: CP/HCU – 68.75%, CP/LCU – 74.19%, TD – 80.00%). The majority (92.41%) of participants' data fell within $0 \leq s \leq 1$ (FigS4), and within-participant variation in adjustments was smaller than between-participant variation (TableS3).

	Model 1			Model 2		
Predictors	*Estimates*	*CI*	*p*	*Odds Ratios*	*CI*	*p*
(Intercept)	0.36	0.28 – 0.43	<0.001	0.42	0.23 – 0.91	0.013
Group (CP/LCU)	-0.04	-0.16 – 0.08	0.500	5.78	1.77 – 15.98	0.002
Group (CP/HCU)	0.00	-0.12 – 0.12	0.963	2.20	0.69 – 6.06	0.152
Random Effects						
σ^2	0.06			3.29		
τ_{00}	0.06 $_{ID}$			3.96 $_{ID}$		
ICC	0.48			0.55		
N	108 $_{ID}$			108 $_{ID}$		
Observations	499			499		
Marginal R^2 / Conditional R^2	0.003 / 0.481			0.068 / 0.577		

Table 2. Model 1 - Linear Mixed Effects model fitted to participants' mean adjustment (*S*) across five rounds by group with subject as a random factor. Model 2 - Generalized Linear Mixed Model fitted to decisions to use an all-or-nothing strategy (copy/stay) (coded as 1) or a compromising strategy (weighted combination of initial estimate and social information) (coded as 0) by group with subject (ID) as a random factor. σ^2 = residual variance, τ_{00} = random slope (between-group) variance. ICC = Intraclass-correlation. N = number of participants. CP/LCU conduct problems and low levels of callous-unemotional traits, CP/HCU conduct problems and high levels of callous-unemotional traits.

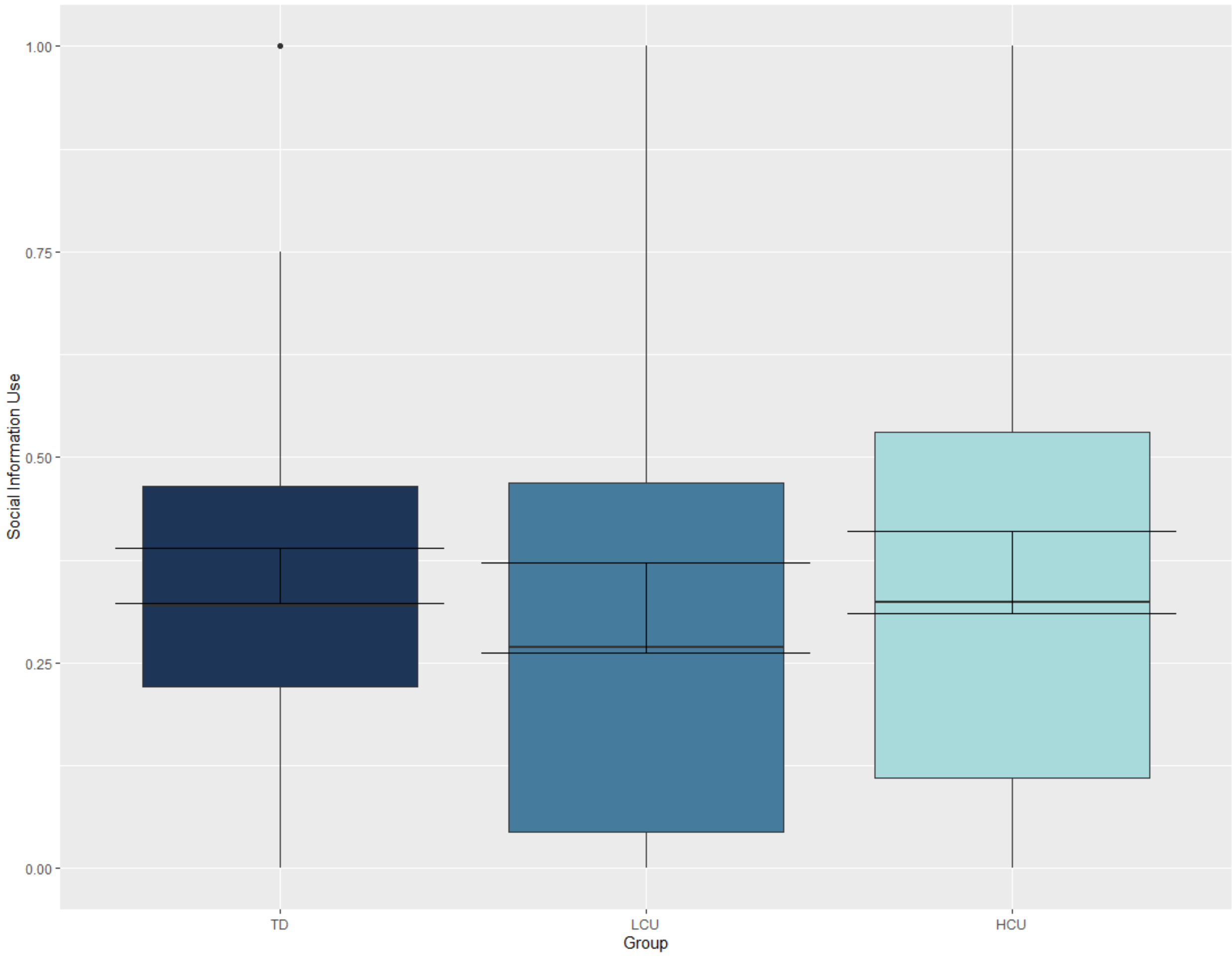

Fig. 2. Social Information Use by Group. TD - typically developing, CP/LCU conduct problems and low levels of callous-unemotional traits, CP/HCU conduct problems and high levels of callous-unemotional traits. Error bars represent standard-error. Box boundaries represent the first and third quartiles of data. Whiskers represent 1.5 x the interquartile range.

4.3. Strategy use

In line with predictions, a significant group difference in relative use of all-or-nothing vs compromising strategies was observed (χ^2 = 9.93, *p* = .007) (further details in Table 2 (Model 2) and Fig. 3; model specification and assumption checks in Appendix S7 and FigS3). Post-hoc Tukey comparisons revealed that this was driven by the CP/LCU group using a significantly lower proportion of compromising strategies than the TD group (*p* = 0.005). The CP/LCU group chose compromising strategies 35.86% of the time compared to 64.11% in the TD group (see Fig. 3), being more likely either to stick with their original estimate or copy the social information. There was no statistically significant difference in strategy use between CP/LCU and CP/HCU (*p* = 0.24), or CP/HCU and TD (*p* = 0.43) groups. To ensure that the observed group difference cannot be accounted for by the age difference between CP/LCU and CP/HCU groups, nor by group IQ, the model was re-run with age and IQ included as covariates. The main effect of group remained significant (χ^2 = 8.72, *p* = 0.013), and was still driven by a difference between CP/LCU and TD groups (*p* = 0.01) (model & full results in Appendix S2 and Table S1). Inspection of the frequency of different strategy usage by group (Fig. 3) led us to run exploratory analyses to investigate whether groups differed in their number of ‘stay’ responses. A significant group difference in stay (vs copy and compromising) responses was observed (χ^2 = 7.53, p = .023), driven by the CP/LCU group choosing ‘stay’ responses more frequently than the TD group (p = 0.02). No group difference in ‘copy’ (vs stay and compromising) responses was observed (χ^2 = 0.21, p = .90).

We ran three further models to examine whether variations in cognitive empathy, affective empathy, and cognitive perspective taking might account for findings. This led to no change in results (see Appendix S8, Table S4, and Table S5 for summary of measures and full models). Additionally, we used Spearman's Rho correlation analysis to examine how group membership, substance use, and SDQ rated emotional problems, peer problems, hyperactivity, and total difficulties related to strategy use. No statistically significant association was observed between strategy use and these measures. (TableS6), so no further covariate analyses were run.

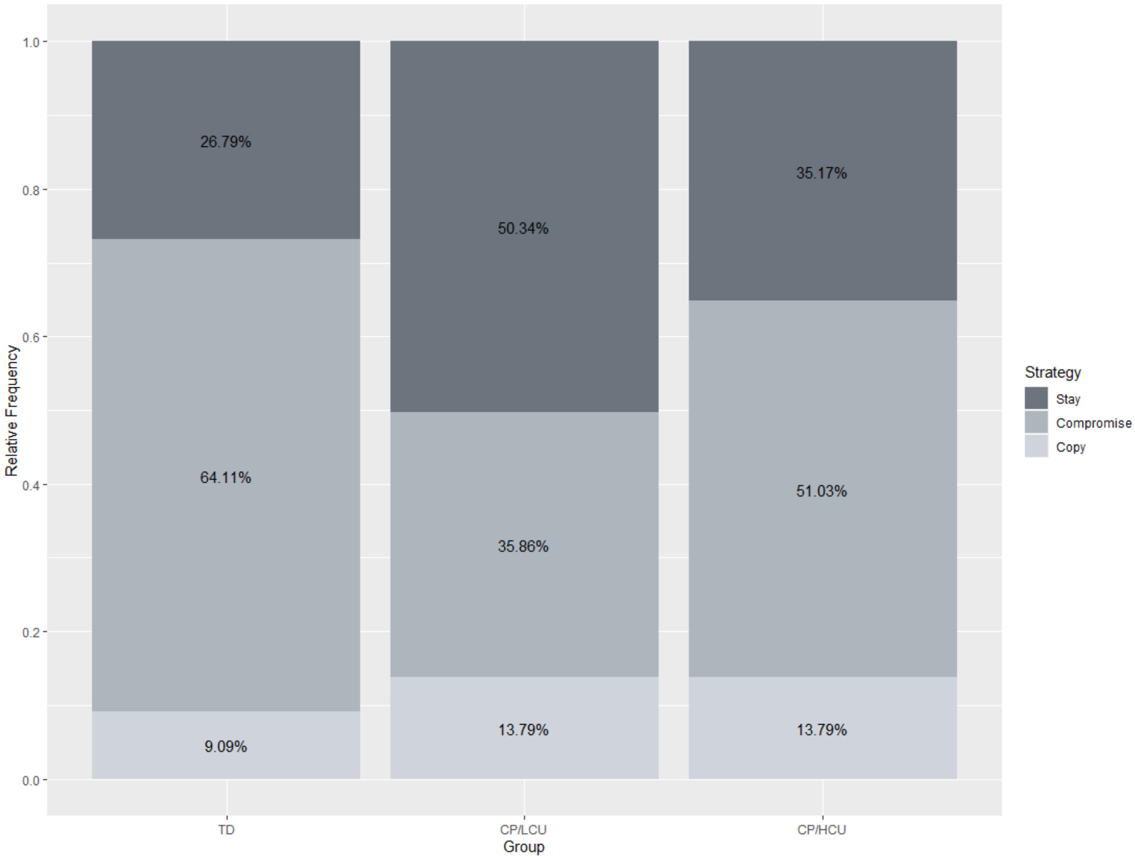

Fig. 3. Relative frequency of strategy use by group. TD - typically developing, CP/LCU conduct problems and low levels of callous-unemotional traits, CP/HCU conduct problems and high levels of callous-unemotional traits.

5. Discussion

Using a brief and simple estimation updating task, we assessed two important aspects of social information use in adolescents with CP/HCU, CP/LCU and TD peers: *degree* of social information use, and *strategy* when using social information. We hypothesised that: (1) adolescents with CP/HCU would use social information to a lesser degree than other groups and (2) adolescents with CP, in particular those with CP/LCU, would be less likely to adopt compromising strategies when using social information. We found no support for the first hypothesis: there were no group differences in degree of social information use. However, in line with our second hypothesis, a group difference was observed in strategy adopted when using social information. CP/LCU participants were less likely to use compromising strategies relative to TD participants.

Our prediction that CP/HCU would use social information to a lesser degree than other groups was based on research demonstrating a lower propensity for social affiliation (O'Nions et al., 2017; Sakai et al., 2016) and a higher likelihood of endorsing dominant social goals in CP/HCU adolescents relative to CP/LCU (Pardini, 2011). We therefore reasoned that they may be less likely to incorporate social information into their behaviour. However, two key aspects of our study may explain why we did not find the predicted pattern of performance in the CP/HCU group. First, studies that have demonstrated atypical processing of affiliative signals in CP/HCU group have used affective stimuli (Hodsoll et al., 2014; O'Nions et al., 2017), whereas the BEAST task did not require processing of affect. Second, the study that demonstrated endorsement of dominant social goals looked at hypothetical conflict situations using vignettes (Pardini et al., 2011), whereas our measure of social information use was more abstract – feedback from an anonymous other. Our findings thus suggest that in the absence of affect or potential conflict, and when provided time to deliberate, CP/HCU adolescents do not differ from their peers in social information use. Future studies could explore whether this is also the case when CP/HCU adolescents are making affective judgments (e.g. judging the emotion of a face and seeing another person's judgment), or whether manipulating the source of the social information might impact task behaviour in this group (e.g. providing information from 'a person who is very good at similar tasks' to introduce a competitive element to the task).

Although *degree* of adjustment in response to social information was similar across groups, our analyses revealed that *strategies* used to adjust estimates differed. Specifically, adolescents with CP/LCU compromised significantly less when incorporating social information into their initial judgments. Interestingly, this appears to be driven by this group sticking with their initial responses as opposed to copying the social information. This complements the finding of Waschbush et al. (2006) that CP/LCU is associated with poorer and more rigid social problem-solving. We propose that less compromising responses to others' feedback might generate difficulties in social interactions for these adolescents. For example, an unwillingness to accept or find middle-ground with another person's point of view could be perceived as hostile, a trait strongly associated with aggression (Buss & Perry, 1992). Future work could build on this by examining social information use in more ecologically-valid contexts (e.g. using information from a known other or affectively charged information). Further research might also help elucidate whether the reduced compromising observed in the CP/LCU group in this study, as well as the propensity for rigid responding demonstrated by children with CP and lower levels of CU traits in the study of

Waschbusch et al. (2006), relates to social information specifically, or might reflect a general lack of flexibility. One way to explore this would be to look at the relationship between performance on this task and executive functioning, as relationships have been demonstrated between both CP (Ogilvie et al., 2011) and CU traits (Platje et al., 2018) and deficits in this domain in adolescence. CP/LCU has been suggested to be linked with experience of hostile and inconsistent parenting and to be associated with increased stress reactivity, threat and frustration-triggered aggression, and difficulties in emotion regulation (Blair et al., 2014; Frick et al., 2014; Lovallo, 2013). It is plausible that early life experiences of adolescents with CP/LCU could also contribute to difficulties in optimally integrating information from others, perhaps partly due to difficulties in trusting others. The current study, along with the study of Waschbusch et al. (2006) clearly highlights the need for more research directly investigating social-cognitive processing in CP/LCU relative to CP/HCU and TD peers.

It is important to note some limitations of the current study. First, this study focused only on males. We chose to do this because CP is more prevalent in males, and there are studies suggesting that aetiology of both CP and CU may differ for males and females (e.g. Fontaine et al., 2010). Future work should also examine social information use in females with CP. Second, it may be helpful to include both parent and teacher ratings of CP and CU in future studies, as opposed a single rater. Third, our sample size was constrained by the difficulty of working with a hard to reach population that are challenging to recruit/engage in research (young people with CP). Although this sample size is typical of studies in the field (e.g. Hodsoll et al., 2014; Schwenck et al., 2012), it is important to bear this in mind when considering our results, and we would like to highlight the need for replication of this study before strong conclusions are drawn based on these findings. Fourth, we would like to acknowledge the lack of agreed upon cut-off criteria for use of the ICU measure (assessing CU traits). This may limit comparison across studies that use a person-centred approach. Additionally, future work could expand the range of domains and measures assessed, as well as exploring how different sources and types of social information impact performance on the BEAST task. In relation to measures, future studies might benefit from assessing executive functioning (as discussed above). It may also be of interest to include diary assessments of aggression and prosocial behaviour/friendship measures to probe how the task relates to social functioning, as well as measures of suggestibility to give more insight into factors that may be driving task responding. In relation to the source and type of social information received by participants, as noted above, future studies could contrast use of different kinds of social information e.g. affectively charged vs non-affectively charged information. Including information from a human confederate source might also better mimic real-world contextual cues that may influence adolescent decision-making. Finally, it is worth noting that the way that the social information was framed in the current study (as coming from 'another child at another school') may have created school-based allegiances whereby participants viewed the 'other' as belonging to an out-group; this is known to be important in adolescent decision-making e.g. Horn (2006), and to affect performance on social information processing tasks with adults e.g. Izuma & Adolphs, (2013). It may therefore be worthwhile to investigate whether social information from in-group (e.g. same school) and out-group (e.g. other school) sources impacts task performance in these groups.

6. Conclusion

To our knowledge, this is the first study to investigate social information use in adolescents with CP. Although overall degree of social information use was similar across groups under the conditions of our study, adolescents with CP/LCU used fewer compromising strategies than TD adolescents when integrating this information with their initial beliefs. This main finding indicates that practice considering ‘middle grounds’ between their thoughts and those of others might be a potential target for behaviour management for adolescents with CP/LCU. However, more research is needed in order to establish this, including replication of this study, research with adolescent girls with CP, and research using different forms of social information. Overall, our observations add to what we already know about social information processing in CP and also motivate future research so that we can develop a more nuanced understanding of the social-cognitive differences between adolescents with CP and their peers. This study further highlights the importance of acknowledging and investigating heterogeneity among adolescents with CP. A more comprehensive understanding of both commonalities and differences among different adolescents with CP, as well as their profile of social-cognitive strengths and weaknesses, has the potential to inform tailored clinical interventions and behaviour management practices.

Key points and Relevance

- Adolescents with Conduct Problems (CP) are characterised by antisocial behaviour and difficulty with social relationships. Their presentation can vary depending on whether they have high (CP/HCU) vs low levels of callous-unemotional traits (CP/LCU).
- This is the first study to examine social information use (degree of adjustment of beliefs in response to social information and strategy used to do so) in adolescents with CP/HCU, CP/LCU, and typically developing (TD) peers.
- While all groups adjusted beliefs in response to social information to the same degree as TD adolescents, CP/LCU adolescents used fewer compromising strategies.
- This finding provides a potential explanation for social difficulties in children with CP/LCU and suggests avenues for future research that have the potential to inform behaviour management for this group. This finding also adds to the evidence base indicating heterogeneity among children with CP.

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Chapter Four – The Development and Validation of the Adolescent HEXACO and an Exploration of its Relationship with Conduct Problems and Callous-Unemotional Traits.

This section is presented as an exact copy of a version that has been submitted as a manuscript to the 'Journal of Behaviour and Psychological Assessment'.

Supplementary material that is referenced to in this Chapter will appear in Appendix 3.

The Development and Validation of the Adolescent HEXACO and an Exploration of its Relationship with Conduct Problems and Callous-Unemotional Traits.

Gaule, A. [1†*] (0000-0003-1287-2204) , Kwao, G. [1†], McCrory, E. [1] (0000-0001-5336-5079), Viding, E. [1] (0000-0001-8468-8874)

[†] These authors contributed equally to this work

* Corresponding author

[1] Division of Psychology and Language Sciences, University College London, UK

Correspondence to: Anne Gaule, Division of Psychology and Language Sciences, UCL. Email: anne.gaule.11@ucl.ac.uk

Statements & Declarations

Conflicts of interest: The authors have no conflicts of interest to declare that are relevant to the content of this article

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Author Contributions:

Conceptualisation: Anne Gaule, Essi Viding ; *Methodology* : Anne Gaule, Essi Viding, Grace Kwao; *Data collection* : Anne Gaule, Grace Kwao; *Data analysis:* Anne Gaule, Grace Kwao; *Writing –original draft preparation*: Anne Gaule, Grace Kwao, Essi Viding; *Writing – review and editing*: Eamon McCrory, Essi Viding, Grace Kwao, Anne Gaule; *Funding Acquisition*: Anne Gaule; *Supervision*: Essi Viding, Eamon McCrory.

Abstract

Personality research can help shed important light on the development of conduct problems (CP) and advance our understanding of associated risk factors. A recently developed model of personality, the HEXACO Personality Inventory (HEXACO-PI), is highly relevant to the study of CP. However, while numerous studies have looked at the relationship between HEXACO measured personality traits and antisocial behaviour in adulthood, few have addressed its relationship with CP in developmental samples. What is more, an English-language version the HEXACO has yet to be developed and validated for use with adolescents. The current study sought to address this. We developed an adolescent friendly, pictorial version of the HEXACO with adolescents aged 11-16 in UK (N=1095) – the Adolescent HEXACO. Exploratory Factor Analysis was used to select the items for each trait dimension and Confirmatory Factor Analysis confirmed the six-factor structure of our measure. Convergent validity was established with the expected traits in the Five Factor Model (FFM) of personality in line with the development of the original HEXACO-PI. Finally, analyses demonstrated strong relationships between Adolescent HEXACO factors and both CP and callous unemotional (CU) traits, an important risk factor for development of CP. What's more, the inclusion of Honesty-Humility (the sixth factor measured by the Adolescent HEXACO) in regression models improved prediction of both CP and of CU traits relative to the five Adolescent HEXACO factors considered peripheral to factors measured by the FFM. These results and their implications are discussed.

Keywords: Conduct problems; Callous-unemotional traits; Personality; HEXACO

1. Introduction

Conduct problems (CP) refer to antisocial behaviour during childhood and adolescence, encompassing behaviours that violate the rights of others and/or age appropriate norms (National Institute for Health and Care Excellence, 2013). CP in childhood and adolescence is one of the primary reasons for referral to mental health services for young people in the UK (Romeo et al., 2006), and incur significant individual and societal costs. It has been argued that personality, or 'consistent patterns of thinking, feeling, and behaving manifested by individuals' (Jones et al., 2011), plays an important role in development and persistence of CP (Miller & Lynam, 2001). To date, a large amount of research has been devoted to exploring this relationship.

Research to date has typically focused on how CP relates to the well-established Five-Factor Model of personality functioning (FFM; Costa & McCrae, 1992). This model has five broad domains: Agreeableness (empathetic vs antagonistic), Extraversion (outgoing vs. reserved), Conscientiousness (organised vs impulsive/careless), Neuroticism (emotional instability/hostility vs confident), and Openness (creative/curious vs cautious). Research with adults has consistently shown that individuals with antisocial behaviour (ASB – or CP in adulthood) tend to exhibit low Agreeableness and Conscientiousness (Miller & Lynam, 2001; Vize et al., 2018, 2019; Saulsman & Page, 2004). Meta-analyses also demonstrate a small positive relationship between ASB and Neuroticism (Jones et al., 2011; Miller & Lynam, 2001), although recent research suggests that this relationship may be dependent on the form of ASB being examined (Vize et al., 2019b). Research with adolescent populations has shown similar patterns to these adult findings. Studies relating juvenile delinquency and externalising behaviours (including aggression, impulsivity, lying, and hyperactivity) to the FFM have found relationships between these behaviours and low Agreeableness and

Conscientiousness (Heaven, 1996; John et al., 1994; Lewis et al., 2014, Tackett, 2006). Findings have been less consistent when it comes to the relationship between CP and other personality features including Neuroticism, and Extraversion (Malouff et al., 2005). Low levels of Agreeableness and Conscientiousness have also been related to bullying behaviours in young adolescents (10-13 years), and have been shown to predict offending later offending in children - further underlining their importance in relation to CP (Bollmer et al., 2006; Mõttus et al., 2012).

In addition to CP, the relationship between the FFM and callous-unemotional (CU) traits in adolescents has received recent attention. CU traits, including lack of empathy and remorse, can co-occur with CP, and are typically associated with a particularly severe and persistent CP (Frick, et al., 2003; Frick, 2012). Adolescents with high levels of CU traits demonstrate psychosocial impairments including reduced prosocial behaviour and poor peer relationships (Blair et al., 2014; Sakai et al., 2019; Viding & McCrory, 2012). Community studies of adolescents using a range of methods have reported that high CU traits are associated with low Agreeableness and Conscientiousness (Borroni et al., 2014; Essau et al., 2006; Romero & Alonso, 2017; Salekin et al., 2010) – a pattern that is very similar to that seen in relation to CP. Findings relating CU traits and other FFM factors are more mixed (Romero & Alonso, 2017).

In summary, research using the FFM of personality demonstrated a clear and consistent relationship between CP/ASB and low levels of Agreeableness and Conscientiousness in both adults and in adolescents. Although less research has addressed the relationship between personality and CU traits in adolescents, there is an emerging evidence base indicating that that low levels of Agreeableness and Conscientiousness also relate to high levels of CU traits, which can often accompany severe CP.

While the FFM model of personality is the most widely studied in the literature, a more recently developed six-factor model of personality may more fully capture personality risk factors associated with CP and CU traits (Ashton & Lee, 2007). This model, derived through cross-cultural lexical analysis of personality structure, is called the HEXACO. This model is made up of six dimensions: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness-to-experience (O). The Extraversion, Conscientiousness, and Openness-to-experience factors in the HEXACO are comparable to their counterparts in the FFM. Agreeableness in the HEXACO shares some aspects of FFM Agreeableness (such as sympathy and a tendency towards gentleness), however it does not include aspects related to sentimentality. Emotionality in the HEXACO shares similar features with FFM Neuroticism (e.g. they both capture traits related to anxiety and stability). However, HEXACO Emotionality excludes aspects of FFM Emotionality that relate to anger and hostility. Instead, HEXACO Emotionality contains the sensitivity and sentimentality-related traits that are associated with Agreeableness in the FFM (Ashton et al., 2014). The novel sixth HEXACO factor, Honesty-Humility, measures how individuals differ in sincerity, fairness, greed, and modesty, as well as the extent to which one is willing to exploit and manipulate others. This factor shares some traits with Agreeableness in the FFM. Importantly, this factor also measures additional traits such as sincerity and lack of greed (Ashton & Lee, 2007). The inclusion of an Honesty-Humility factor in personality inventories has significant potential to allow a more nuanced understanding of the relationship between individual differences in personality and CP and CU traits relative to other personality models (such as the FFM).

In line with this, research with adults has demonstrated that prediction of antisocial personalities and criminal behaviour is improved by including the Honesty-Humility in personality inventories (Ashton & Lee, 2008; Dunlop et al., 2012; Hodson et al., 2018; Međedović, 2017). Individuals who are low in Honesty-Humility are more prone to a combination of characteristics that are associated with antisocial behaviour. These include: egotism (de Vries et al., 2009), unethical decision-making (Gelder & De Vries, 2012), performing premeditated and vengeful acts (Lee & Ashton, 2012b), and engaging in violence to achieve goals (Medjedovic, 2012). Additionally, several studies have demonstrated that Honesty-Humility can be useful in differentiating subtypes of aggression. Whereas low HEXACO Agreeableness is associated with aggressive behaviour more generally, demonstrating low levels of Honesty-Humility appears to correlate more strongly with proactive, premeditated aggression (Book et al., 2012; Dinić & Smederevac, 2019; Lee & Ashton, 2012), something that also characterises individuals with high levels of CU traits (Frick et al., 2003). It should be noted, however, that there is debate in the literature regarding inclusion of Honesty-Humility in measures of personality assessments and whether it meaningfully differs from Agreeableness (for discussion see Ashton & Lee, 2020; Lynam, Crowe, & Vize, 2020). In addition to Honesty-Humility, other HEXACO factors that appear to be important correlates of ASB in adults are low Agreeableness, Conscientiousness, and Emotionality (Ashton & Lee, 2008; Book et al., 2016; Dunlop et al., 2012; Međedović, 2017).

In adolescents, associations between HEXACO traits and CP have largely been studied in relation to aggression and bullying. Similar to the adult literature, low Honesty-Humility in adolescence is related to higher self-reported likelihood of engagement, and actual engagement, in aggressive behaviour in community samples of adolescents (Allgaier et al., 2015; MacDonell & Willoughby, 2020). Studies also suggest low Honesty-Humility to be the strongest correlate of bullying behaviours (Book et al., 2012; Volk et al., 2018) across several forms of bullying (Book et al., 2012; Farrell et al., 2014) and also of antisocial behaviour more generally (Mularczyk et al., 2020). As well as low Honesty-Humility, low levels of Agreeableness and Conscientiousness also appear to be important predictors of bullying behaviours (Book et al., 2012; Farrell et al., 2014; Spadafora et al., 2020). Additionally, some studies have found relationships between bullying and low Emotionality and Openness (Farrell et al., 2014; Pronk et al., 2021; Volk et al., 2018), although this may be dependent on the form of bullying in question (Farrell et al., 2014). To our knowledge, only one study exists examining the relationship between CU traits and HEXACO dimensions in adolescence (Mularczyk et al., 2020). The authors found that higher ratings across subscales of the Inventory of Callous and Unemotional traits (Essau et al., 2006), a commonly used measure of CU traits, were related to lower ratings of Honesty-Humility, Agreeableness, Emotionality, and Conscientiousness in a community sample.

Thus, there is an emerging evidence base indicating that the HEXACO model of personality may add a useful dimension for understanding ASB in adults. The Honesty-Humility factor appears to provide predictive validity for ASB over and above the traditional FFM factors, as well as the other HEXACO factors that overlap with the traditional FFM factors (e.g. Ashton & Lee, 2008). The HEXACO measure also has additional potential utility over the FFM for capturing personality characteristics specifically related to CU traits – thus adding to its relevance for use with adolescent populations. As mentioned above, the HEXACO conceptualises Agreeableness and Emotionality personality factors in a way that is similar to, but distinct from, Agreeableness and Neuroticism in the FFM. In particular, Emotionality in the FFM excludes the anger and hostility related traits that are captured by FFM

Neuroticism and is related primarily to sentimentality, anxiety, and empathy traits – important characteristics of individuals who are high on CU but not necessarily shared by those who are high on CP. Agreeableness in the HEXACO excludes the sentimentality related traits captured by FFM Agreeableness. It also differs from FFM Agreeableness in that it captures anger related traits. HEXACO Agreeableness may therefore more specifically capture traits related to CP relative to FFM Agreeableness. The HEXACO may thus provide a more nuanced measure for understanding CP and CU than the FFM.

However, less research exists exploring the relationship between the HEXACO dimensions and CP in adolescent populations, and only one study has explored how HEXACO measured personality traits relate to CU traits in adolescence. Furthermore, previous studies examining HEXACO measured personality in relation to CP or to CU traits in English speaking adolescent populations have used the original adult versions of the HEXACO-PI or HEXACO-60 questionnaires (Ashton & Lee, 2007, 2009; Book et al., 2012; Dane et al., 2018; Farrell et al., 2014; Farrell & Volk, 2017; Mularczyk et al., 2020; Volk et al., 2018), or scales whose English translations are yet to be validated (Spadafora et al., 2020). However, these HEXACO measures have not been validated for use with adolescents, and the adult measure contains statements that are not targeted at this population (including statements, for example, regarding workplace behaviour). Thus, although the findings from these studies are largely in line with what we might expect from looking at the adult literature, the use of measures not specifically designed for adolescents could potentially lead to personality profiles that are not be entirely reliable. Future studies exploring the relationship between CP, CU, and HEXACO personality factors with English speaking adolescents might benefit from a measure designed for and validated with this population.

Two adolescent adaptations of the HEXACO have been validated to date: The HEXACO Middle School Inventory (HEXACO MSI; Sergi et al., 2019) and the HEXACO Simplified Personality Inventory (SPI; de Vries & Born, 2013). While both measures are well adapted to adolescent populations, one has been validated in Italian, the other in Dutch. To our knowledge, their English translations have been yet to be validated for use with English speaking adolescents, thereby presenting a similar potential problem as use of the adult HEXACO when used with this population. Furthermore, neither measure included illustrations, which were added to the measure validated here to add interest and clarity.

The first aim of the current study was to validate an English-language, illustrated version of HEXACO-60 for adolescents. We hypothesised that an Adolescent HEXACO measure would show a clear six-factor structure in EFA and CFA, and these will reflect the six HEXACO factors. We further expected that the Adolescent HEXACO would show good construct validity. Specifically, we expected moderate to strong positive correlations between Adolescent HEXACO Extraversion, Conscientiousness, Agreeableness, and Openness-to-Experience factors and their respective counterparts in the FFM, and a moderate negative correlation between Adolescent HEXACO Emotionality and FFM Emotional stability (where low scores indicate Neuroticism). Finally, in line with Ashton & Lee (2009), we expected that there would be a moderate positive correlation between Adolescent HEXACO Honesty-Humility and FFM Agreeableness, but that this would be smaller than the correlation between FFM Agreeableness and Adolescent HEXACO Agreeableness

Our second aim was to investigate the relationship between the Adolescent HEXACO and CP and CU traits in adolescents. We hypothesised that CP would correlate negatively with Honesty-Humility, Agreeableness and Conscientiousness. In line with Mularczyk et al.,

(2020) we also predicted that the CU traits would correlate negatively with Honesty Humility, Emotionality, Agreeableness, Conscientiousness.

Finally, in light of the ongoing uncertainty regarding the value of the Honesty-Humility factor, our third aim was to investigate its predictive utility over and above the other HEXACO factors (considered peripheral to FFM factors), including Agreeableness (Lynam, Crowe, & Vize, 2020; McCrae & Costa, 2008) in relation to CP and CU traits. We hypothesised that that including Honesty-Humility in separate regression models predicting (1) CP and (2) CU traits would improve the prediction of these models over and above other HEXACO factors.

2. Materials and Methods

2.1. Questionnaire Development

The items which make up the adolescent HEXACO were derived through adaptation, where appropriate, of the items which make up the original, adult HEXACO-60 (Ashton & Lee, 2009) in order to make these more suitable for an adolescent population. For example, statements about the workplace were changed refer to a school setting; e.g. 'I wouldn't use flattery to get a raise or promotion at work, even if I thought I would succeed' became 'I wouldn't flatter a teacher to get a better grade, even if I thought it would work'. Additionally, items in the adolescent HEXACO were presented with colour illustrations to encourage engagement (see Fig 1. for example). As in the original HEXACO-60 personality measure, responses were made on a five-point Likert response scale (1 = Strongly disagree to 5 = Strongly agree). Instructions were as follows: "*On the pages in this booklet, you will find a series of statements about you. Please read through each statement and decide how much you agree or disagree with this statement. You can indicate how well each statement* *describes you by ticking one of the following boxes: (Example responses). Please answer every statement, even if you aren't completely sure of your response.".*

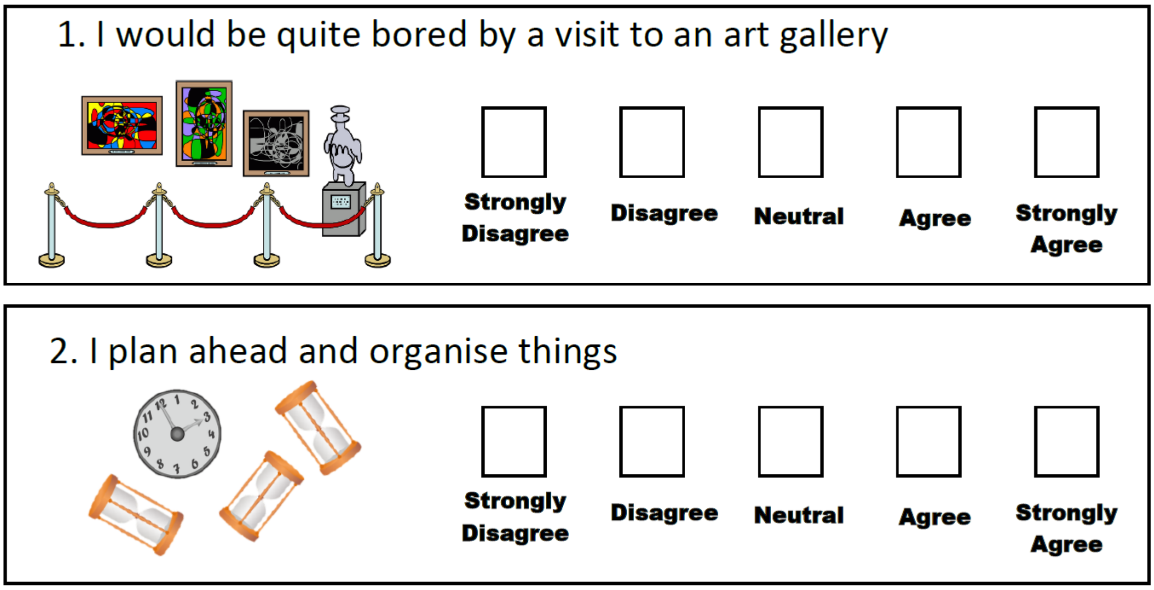

Fig. 1. Example Items from the Adolescent HEXACO.

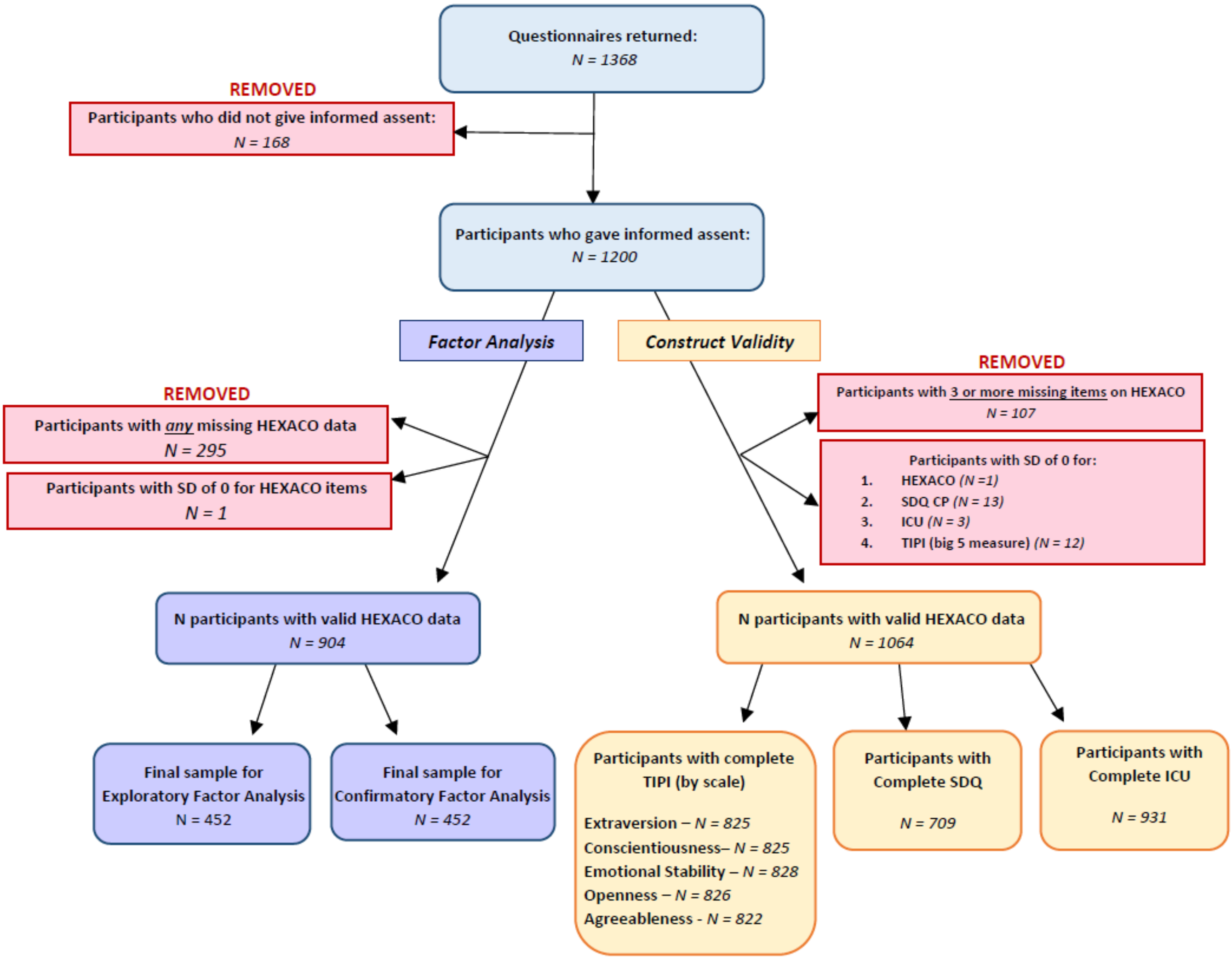

Fig. 2. Schematic of how final samples for factor analysis and construct validity analyses were derived. For detail on data cleaning, please see S1.

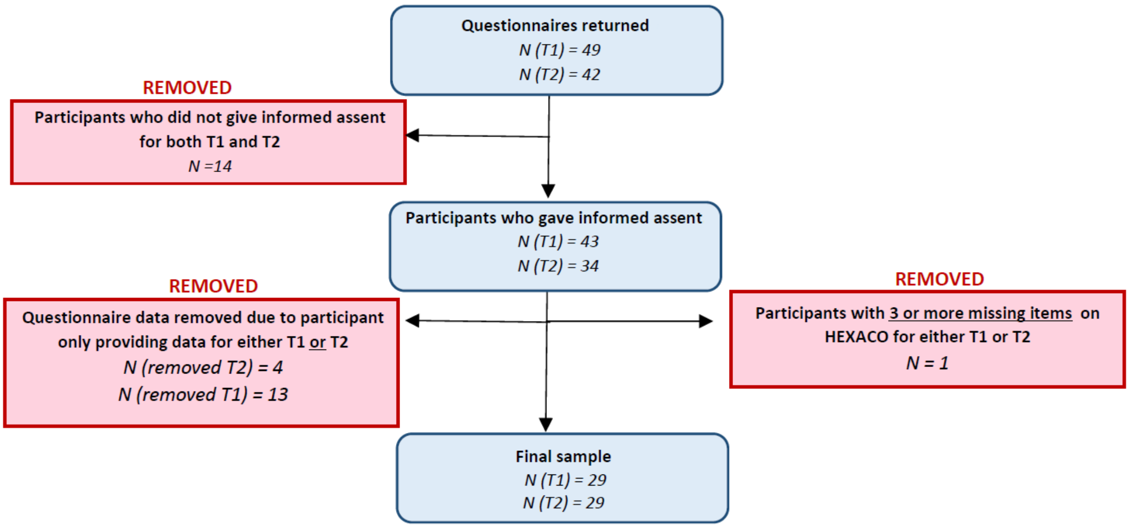

Fig. 3. Schematic of how final sample for test retest reliability was derived. For detail on data cleaning, please see S1.

2.2. Participants

A total of 1368 participants (aged 11-16 years), from three non-selective state secondary schools in London and the South-East of England took part in this study. Pupils participated in the study anonymously, and were not rewarded for their participation. Schools received a £50 honorarium per participating class in recognition of the time spent by teachers in supporting the project. Information sheets were sent to parents of participants, giving them the opportunity to opt their child out of the study. An 'opt-out procedure' was ethically permissible in the case of the current study as the research was non-invasive and in the public interest. The study was approved by the UCL Research Ethics Committee (0622/001). Information sheets for participants were developed using adolescent appropriate language and participants were required to provide informed assent – participants who did not provide informed assent (N = 168) were excluded from our final sample. This left a total sample of 1200 for further analyses (for a schematic of how we reached our final samples for factor analysis, please see Fig. 2.).

2.2.1 Exploratory and Confirmatory Factor Analyses

Due to limitations imposed by the COVID-19 pandemic all participants were recruited in a single recruitment effort and subsequently randomly assigned into groups for the factor analysis, rather than collecting separate samples for Exploratory and Confirmatory Factor Analyses (EFA and CFA respectively). As well as participants who did not provide informed assent, we also removed participants from our sample for factor analysis for the following reasons: (1) For completeness, participants with any missing data on the HEXACO measure (N = 295) were removed. (2) Any participants who gave the same response for every HEXACO item (indexed by a standard deviation of 0 across all items) were removed (N = 1) (see Fig. 2.) This left 904 participants in the final dataset for the validation of our Adolescent

HEXACO measure (mean age =13.29, *SD* = 1.5, male = 452, female = 417, prefer not to say = 35).

This dataset was then split into two samples of 452 for EFA (mean age =13.25, *SD* = 1.5, male = 220, female = 213, prefer not to say = 19) and CFA (mean age =13.31, SD = 1.5, Male= 229, Female=214, Prefer not to say = 18) using random sampling in SPSS (IBM Corp, 2020). For more information on data cleaning procedures for the factor analysis, see S1.

2.2.2 Construct validation

Data from any participant who gave informed assent and who completed the required measures (see section 2.3) were included in construct validation analyses. As the factor structure of Adolescent HEXACO was established using EFA and CFA prior to construct validation, we now included participants who had less than three missing data points on the Adolescent HEXACO (as we could impute missing data based on average scores of other items assessing the same factor). 106 participants were removed for having three or more missing Adolescent HEXACO items (see Fig 2.). For more information on data cleaning procedures for all of our measures for construct validation, see S1. For sample sizes for construct validation analyses please refer to fig 2. It should be noted that data for one measure (the SDQ) were missing for the first 284 participants due to administrative error.

2.2.3 Test-Retest Reliability

53 additional participants completed the HEXACO-60 to measure test re-test reliability of our measure. The time between completion of the two questionnaires was two weeks. Fourteen participants were removed for not providing informed assent at either time one (T1) or time two (T2). Complete data from seventeen participants were further removed for failure to complete the questionnaire at either T1 or T2. Finally, one participant was

removed for failing to answer 3 or more HEXACO items. This left a final sample of 29 for test-retest reliability analysis (mean age at T1 = 12.14, SD = 1.09, male = 18, female = 10, prefer not to say = 1).

2.3 Additional Measures

In addition to the Adolescent HEXACO, participants completed the following questionnaires in order to establish construct validity of the HEXACO measure that was developed. The number of participants with complete scores for each of these additional measures can be found in Fig. 2.

2.3.1 Ten Item Personality Measure (TIPI)

The TIPI (Gosling et al., 2003) is a ten-item questionnaire used to broadly measure the five-factor traits (Openness-to-experience, Conscientiousness, Extraversion, Agreeableness, Neuroticism). Each personality dimension is measured by two items. All items begin with "I see myself as…" and are followed by two descriptive items such as "Extraverted, enthusiastic". Responses are given on a seven-point Likert scale ranging from 1('disagree strongly') to 7 ('agree strongly'). This measure had fairly poor reliability in our sample: α (Extraversion) = 0.49, α (Agreeableness) =. 0.24, α (Conscientiousness) =.0.30, α (Emotional Stability) = 0.61, and α (Openness-to-experience) = 0.33. Alpha coefficients reported here are in accordance with the scale developer's expectations and are similar to the results found in studies validating the TIPI measure (Gosling et al., 2003). The reported low scale reliabilities are to be expected due to the scale's brief nature and the limited number of items per dimension. Therefore, we consider this scale suitable for measuring the Five-Factor traits in our sample.

We hypothesised that we would observe moderate to strong correlations between the HEXACO's Extraversion, Conscientiousness, and Openness dimensions with their respective counterparts in the FFM as measured by the TIPI.

2.3.2 Strengths and Difficulties Questionnaire - Conduct Problems Subscale (SDQ CP)

The SDQ CP (Goodman, 1997) is a five item subscale of the Strengths and Difficulties Questionnaire (SDQ). The SDQ is a brief emotional and behavioural screening questionnaire for young people. We used only the items that assess conduct problems. Example items include: 'I get very angry and often lose my temper' and 'I am often accused of lying or cheating'. Responses are given on a 2-point Likert scale from (0 = Not true, 2 = Certainly true). This measure had acceptable reliability in our sample (α =.60).

We hypothesised that CP, as measured by this scale, would correlate negatively with Adolescent HEXACO measured Honesty-Humility, Agreeableness, and Conscientiousness in our sample.

2.3.3 Inventory of Callous-Unemotional Traits (ICU)

The ICU (Frick et al., 2003) is a 24-item questionnaire containing three subscales: Callousness, Uncaring and Unemotional. It contains items such as "I do not care who I hurt to get what I want". Responses are given on a four-point Likert scale (0 = Not at all true, 3 = Definitely true). An example item includes 'I feel bad or guilty when I do something wrong'. This measure had an excellent reliability in our sample (α =.83).

We hypothesised that CU traits would correlate negatively with Adolescent HEXACO measured Honesty Humility, Agreeableness, Conscientiousness, and Emotionality.

2.4 Procedure

The questionnaire battery was administered by teachers on school premises and during regular class time. Participants in all samples received printed versions of the full questionnaire battery (containing all measures) in colour. Written instructions for questionnaire completion were included in the battery. Each participant was presented with the questionnaire battery in the same order: (1) information and assent, (2) the Adolescent HEXACO, (3) the Strengths and Difficulties Conduct Problem scale (SDQ-CP), (4) the Inventory of Callous-Unemotional Traits (ICU), (5) the Ten Item Personality Inventory (TIPI). A debrief page was included at the end of the questionnaire battery pack. For detail on how all questionnaire data were cleaned and prepared for analyses, please refer to S1. Those in the test-retest sample completed the same questionnaire battery twice, at a two-week interval. Data were manually entered by six independent researchers. Ten percent of this data was cross-checked for consistency and the proportion of data which was incorrectly entered was <1%. Data were also checked for out-of-range values and any identified were corrected. For detail on how questionnaire data were cleaned, please refer to S1.

3. Analysis and Results

3.1. Exploratory Factor Analysis (EFA) analysis procedure and results

To explore the latent structure of the Adolescent HEXACO, we conducted EFA restricted to six factors with Principal Component Analysis (PCA) and varimax rotation in SPSS (IBM Corp, 2020). Principal components analysis was chosen over other forms of EFA (e.g. Principal Factor Analysis) in line with the methods used in the original validation study of the HEXACO measure (Lee & Ashton 2018). Our choice to restrict our analysis to six factors was based on strong theoretical reasons to expect this factor structure (Ashton & Lee, 2009). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .80 (‘meritorious’) for our sample, indicating suitability for factor analysis (Kaiser & Rice, 1974). Bartlett's test of sphericity was also significant (χ^2 (1770) = 8547.87, p <.001), verifying that the variables in our dataset are sufficiently correlated such that factor analysis with this dataset is meaningful.

In order to determine the number of factors to retain in our dataset we employed a Scree plot (Cattell, 1966) (Fig. 4). This shows a clear break between the sixth and seventh dimensions, confirming our expectations of a six-factor solution. The six factors identified by EFA accounted for 38.2% of the item variance in the sample, in line with adult data from Ashton and lee (2009) where six factors accounted for 37.4% of item variance. All but one item (item 8) had their primary, positive, loading on the factor defined by the other items of its scale, and all primary loadings exceeded .30. In the cases where items loaded onto more than one factor, the item was assigned to the factor where the loading was strongest. No item loaded onto more than two factors. Three items were removed following EFA: Two items (item 33, intended measure Agreeableness, item 6, intended to measure Honesty-Humility) that failed to load onto any factor scale, and one item (item 8, intended measure Conscientiousness) for which the primary loading was on an unexpected scale (where items measuring Extraversion were clustered). Our full rotated factor matrix is reported in S2.

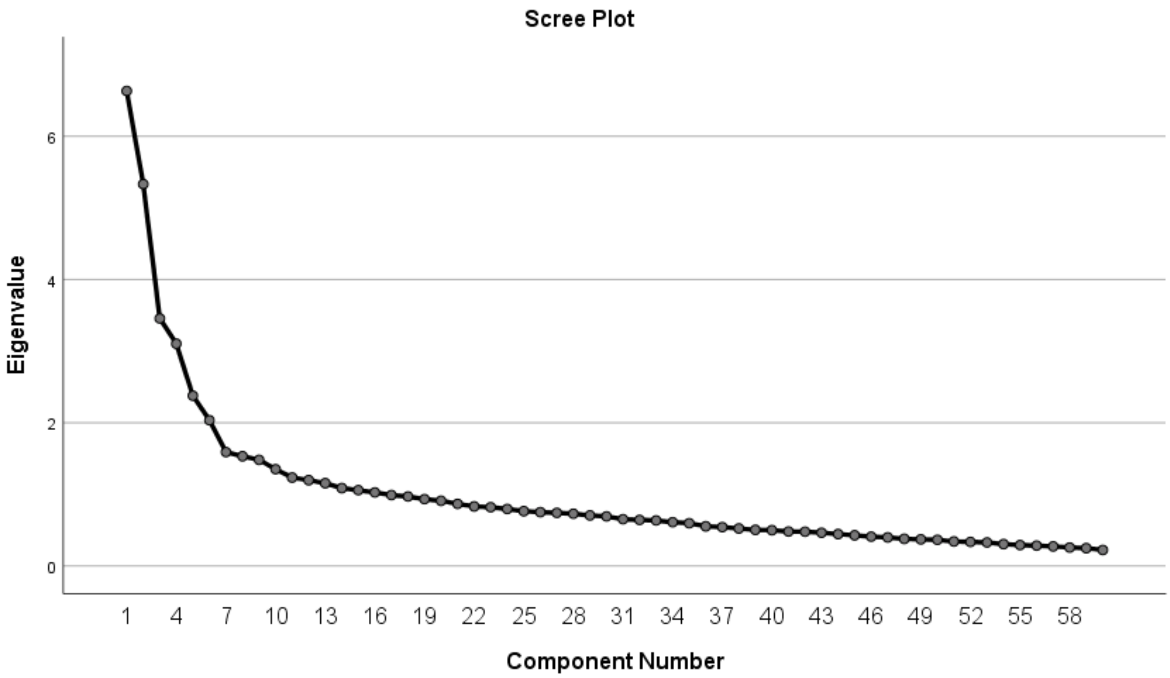

Fig. 4. *Eigenvalues from Principal Components Analysis demonstrating six-factor solution*

	1	2	3	4	5	6
1. Honesty-Humility	1					
2. Emotionality	.21**	1				
3. Extraversion	-.13**	-.21**	1			
4. Agreeableness	.28**	0.03	.19**	1		
5. Conscientiousness	.26**	.08**	.18**	.32**	1	
6. Openness-to-experience	.23**	.23**	0.05	.16**	.40**	1

Note: ****p<.001, **p<.01, *p<.05* (2-tailed*)*

Table 1. Intercorrelations between Adolescent HEXACO factor scores – corrected for multiple comparisons using Bonferroni correction. Computed on full sample (*N = 1095)*

3.2 Confirmatory Factor Analysis (CFA) analysis procedure and results

CFA was conducted in R with R Studio (R Core Team, 2020, 2015) to verify the six-factor structure of the Adolescent HEXACO. We assessed several model fit indices: (1) the incremental Comparative Fit Index (CFI; the relative improvement in fit of the specified model compared with the baseline model); (2) the Root Mean Square Error of Approximation (RMSEA; the discrepancy between the hypothesized model, with optimally chosen parameter estimates, and the population covariance matrix) (3) the Standardised Root Mean Square Residual (SRMR; the standardized difference between the observed correlation and the predicted correlation). Good fit indices for these measures are CFI > 0.90, RMSEA < 0.08, and SRMR < 0.08 (Browne & Cudeck 1993). The CFI value for our model was 0.64, indicating a poor model fit. However, the RMSEA and SRMR values for our model indicated good fit (RMSEA = 0.06, 95% confidence intervals [0.055-0.060]; SRMR = 0.08). It has been observed in previous research studies that the CFI often declines with a greater number of observed variables (in this case, questionnaire items). In contrast, RMSEA and SRMR values remain stable (Hu & Bentler, 1999; Kenny & McCoach, 2003) especially in small or medium sample sizes (N = 200-500) (Shi et al., 2019). As such, given the large number of observed variables in our model and our medium sample size for CFA, we consider RMSEA and SRMR fit indices to be more appropriate than CFI for the current study. Taken together, our model fit indices indicate some intercorrelation between our factors, which is indeed seen in our data (see Table 1). Although many correlations between Adolescent HEXACO scales were significant, these were generally low – in line with previous validation studies of this measure with adults (Ashton & Lee, 2009, p. 60; Lee & Ashton, 2018).

Overall, RMSEA and SRMR fit values from our model, the moderately high loadings observed in the EFA, the scree plot clearly showing six-factors, and the high internal consistency values reported in Table 2, suggest that our model reasonably fits our data.

Subscale	N Items	Cronbach's alpha (Raw) (α)
Honesty-Humility	9	.72
Emotionality	10	.82
Extraversion	10	.77
Agreeableness	9	.73
Conscientiousness	9	.74
Openness-to- experience	10	.76

Table 2. Internal consistency reliabilities for the HEXACO-60 subscales. Computed on full sample (*N* = 1095)

	N	*Mean*	*SD*	Minimum	Maximum
Honesty-Humility	1064	3.06	0.70	1.00	5.00
Emotionality	1064	3.17	0.77	1.00	5.00
Extraversion	1064	3.00	0.67	1.00	4.80
Agreeableness	1064	3.00	0.64	1.00	4.78
Conscientiousness	1064	3.02	0.62	1.00	4.89
Openness-to-experience	1064	3.05	0.67	1.30	4.90
TIPI Extraversion	825	4.05	1.51	1.00	7.00
TIPI Conscientiousness	825	4.79	1.33	1.00	7.00
TIPI Emotional Stability	828	4.14	1.62	1.00	7.00
TIPI Openness	826	5.01	1.32	1.00	7.00
TIPI Agreeableness	822	4.59	1.20	1.00	7.00
SDQ CP scale	709[a]	2.64	1.90	0.00	10.00
ICU	931	26.08	9.28	1.04	64.00

Table 3. Descriptive statistics for the HEXACO-60 subscales, TIPI, ICU, and CP scales. *Note*: Emotionality, Extraversion, and Openness-to-Experience subscales had 10 items, Honesty-Humility, Agreeableness, and Conscientiousness sub-scales had 9 items (for further details, see section 3.1). ICU: Inventory of Callous-Unemotional traits, SDQ CP: Strengths and Difficulties Conduct problems. TIPI: Ten Item Personality Inventory. N = number of participants included in analysis. SD = standard deviation.

3.3 Construct Validation

Construct validation analyses were carried out in SPSS (IBM Corp, 2020) using responses from all adolescents who provided data for the measures in question. Sample Ns for each analysis are reported in the relevant summary table. Post hoc comparisons of relative strength of correlations were conducted using online software (Soper, 2022). For sample Ns and descriptive statistics of all measures, see Table 3. For details on data cleaning and management, please refer to S1.

3.3.1 Correlations with TIPI FFM Measure

In order to assess the associations between the six personality (as measured by the Adolescent HEXACO) and (FFM traits as measured by the TIPI), Pearson correlation analysis was conducted. Bonferroni correction was used to control for the probability of making a Type I error on multiple comparison. Corrected p values are presented in Table 4. The highest correlations were between the following Adolescent HEXACO measured factors and their FFM counterparts: Conscientiousness ($r(825) = 0.58$, $p < .001$), Agreeableness ($r(822) = 0.53$, $p < .001$), and Extraversion ($r(825) = 0.57$, $p < .001$). Adolescent HEXACO Openness-to-experience showed a moderate correlation with FFM Openness ($r(828) = 0.45$, $p < .001$). Moreover, HEXACO Emotionality showed a moderately strong negative correlation with FFM Emotional Stability ($r(828) = -0.49$, $p < .001$).

In line with predictions, Adolescent HEXACO Honesty-Humility showed a moderate correlation with FFM Agreeableness ($r(822) = 0.22$, $p < .001$). Post hoc statistical comparison of the relative strength of the correlations between (1) Adolescent HEXACO Agreeableness and FFM Agreeableness and (2) Adolescent HEXACO Honesty-Humility and FFM Agreeableness indicates that correlation (1) was significantly stronger than correlation (2) ($z = -7.84$, $p < .001$).

3.3.2 Correlation with CP

Correlations between the Adolescent HEXACO subscales and CP, adjusted for multiple comparisons using the Bonferroni correction, can be found in Table 5. The strongest relationship was a negative correlation between HEXACO Agreeableness and CP (as measured by the SDQ) ($r(709) = -0.53$, $p < .001$). There were also a moderately strong negative correlations between both CP and HEXACO Honesty-Humility ($r(709) = -0.34$, $p < .001$) and SDQ CP and HEXACO Conscientiousness ($r(709) = -0.40$, $p < .001$). CP showed weaker, but still significant, correlations with Openness-to-Experience ($r(709) = -0.18$, $p < .001$), Emotionality ($r(709) = -0.12$, $p < .001$), Extraversion ($r(709) = -0.12$, $p < .001$).

3.3.3 Correlation with CU

Bonferroni corrected correlations can be found in Table 5. Significant negative correlations were observed between CU traits and all our HEXACO measured personality factors. The strongest relationship was a negative correlation between CU traits and Emotionality ($r(931) = -0.51$, $p < .001$). Moderate to strong negative correlations were also observed between CU traits and HEXACO Conscientiousness ($r(931) = -0.41$, $p < .001$), Honesty-Humility ($r(931) = -0.39$, $p < .001$), Agreeableness ($r(931) = -0.39$, $p < .001$), Openness to Experience ($r(931) = -0.35$, $p < .001$), and Extraversion ($r(931) = -0.20$, $p < .001$).

3.3.4 Predictive utility of Honesty-Humility

Two separate hierarchal multiple regression analyses were conducted to determine the predictive utility of the Honesty-Humility factor. Model 1 used the HEXACO factor scales to predict CP. Step 1 included scales that were theoretically similar to the FFM (that is, Emotionality, Extraversion, Conscientiousness, Agreeableness, and Openness-to-experience). Step 2 involved the addition of Honesty-Humility as a predictor. Results are reported in Table 6. All Adolescent HEXACO scales except Extraversion (step 1 – $p = .77$; step 2 – $p =$

0.55) and Openness-to-experience (step 1 - p = .35; step 2 – p = .21) were significant negative predictors of CP in both step 1 and step 2 of the regression model. Step 1 of the model was significant overall (F (5,703) = 80.89, p <.001) and accounted for 36.5% of the variance in CP scale scores. Prediction of CP scores was significantly improved with the inclusion of Honesty-Humility in step 2, which explained a further 1.7% of the variation in scores. The change in R^2 change was significant (F (1,702) = 18.98, p <.001), and step 2 (containing all six factors) explained 38.2% of the variance in CP scores in the full model. Honesty-Humility was also a significant negative predictor of CP (β = -.14, p <. 001), meaning that as Honesty-Humility decreased, CP scores increased. However, Agreeableness was the most important predictor of CP in both step 1 (β = -.46, p <.001) and step 2 (β = -.42, p <.001) of the regression model.

Model 2 is also reported in table 6. Similar to Model 1, in Model 2 the HEXACO factor scales that were theoretically similar to the FFM were used to predict CU trait scores in step 1. In step 2 Honesty-Humility was included as an additional predictor. Step 1 of Model 2 was significant (F (5,925) = 216.67, p <.001), and this model (containing the five HEXACO factors peripheral to the FFM factors) explained 53.7% of the variance in ICU scores. As reported in Table 6, all subscales were significant predictors of CU traits, with the most important predictor being Emotionality (β = -.51, p <. 001). As in Model 1, the inclusion of Honesty-Humility in the step 2 of the regression significantly improved the model's prediction of CU traits, explaining an additional 3.4% of the variance in scores. This R^2 change was significant, F(1,924) = 75.27, p <.001, with all scales together explaining 57.1% in the variability in scores. Honesty-Humility significantly predicted of CU traits, (β = -.20, p <. 001) when included in the second step of the model, but Emotionality remained the most important predictor (β = -.50, p <. 001).

3.4 Test Re-test Reliability

Pearson's correlations between each subscale of the Adolescent HEXACO at T1 and T2 were good (mean =0.85, SD = 0.40, all values > 0.7) – indicating that responses to the questionnaire remain stable over time. For correlation values, see Table 7.

HEXACO Scale	Measure	TIPI FFM Scale				
		Agreeableness	Emotional Stability	Extraversion	Conscientiousness	Openness
Honesty-Humility	Correlation[a]	.22**	-0.05	-.15**	.11**	.08*
	N	*822*	*828*	*825*	*825*	*826*
Emotionality	Correlation	.29**	-.49**	-0.04	.07*	0.04
	N	*822*	*828*	*825*	*825*	*826*
Extraversion	Correlation	.09**	.44**	.57**	.19**	.29**
	N	*822*	*828*	*825*	*825*	*826*
Agreeableness	Correlation	.53**	.26**	-.03	.22 **	.16**
	N	*822*	*828*	*825*	*825*	*826*
Conscientiousness	Correlation	.14**	.18**	.004	.58**	.24**
	N	*822*	*828*	*825*	*825*	*826*
Openness-to-Experience	Correlation	.12**	-0.03	.03	.20**	.45**
	N	*822*	*828*	*825*	*825*	*826*

Table 4. Pearson Correlations between traits as measured by the Adolescent HEXACO and Five Factor traits. TIPI = Ten Item Personality Inventory. N = number of participants with complete measure.

[a] All correlations corrected for multiple comparisons using Bonferroni correction.

**p<.05* (2-tailed)

***p<.01* (2-tailed)

HEXACO Scale	Measure	Conduct Problems	CU traits
		SDQ CP	ICU
Honesty-Humility	Correlation[a]	-.34**	-.39**
	N	*709*	*931*
Emotionality	Correlation	-.12**	-.51**
	N	*709*	*931*
Extraversion	Correlation	-.12**	-.20**
	N	*709*	*931*
Agreeableness	Correlation	-.53**	-.39**
	N	709	*931*
Conscientiousness	Correlation	-.40**	-.41**
	N	709	*931*
Openness-to-Experience	Correlation	-.18**	-.35**
	N	709	*931*

Table 5. Pearson's correlations between the measures of HEXACO, conduct problems and callous-unemotional (CU) traits. CP – Antisocial Behaviour, SDQ CP – Strengths and Difficulties Questionnaire, Conduct Problems scale; ICU – Inventory of Callous-Unemotional traits.

[a] All correlations corrected for multiple comparisons using Bonferroni correction.

***p<.01* (2-tailed)

	Model 1: SDQ CP			Model 2: ICU		
	Beta *(Standardised)*	*t*	*p*	Beta *(Standardised)*	*t*	*p*
STEP 1:						
(Constant)		20.66	<.001		46.95	<.001
Emotionality	-0.10	-3.09	0.002	-0.52	-22.54	<.001
Extraversion	0.01	0.29	0.77	-0.20	-8.45	<.001
Agreeableness	0.46	-14.56	<.001	-0.27	-11.53	<.001
Conscientiousness	-0.28	-8.36	<.001	-0.23	-9.53	<.001
Openness-to-experience	-0.03	0.92	0.36	-0.10	-3.95	<.001
STEP 2:						
(Constant)		21.27	<.001		48.28	<.001
Honesty-Humility	-0.14	-4.36	<.001	-0.20	-8.68	<.001
Emotionality	-0.08	-2.61	0.009	-0.50	-21.99	<.001
Extraversion	-0.02	-0.60	0.55	-0.23	-10.19	<.001
Agreeableness	-0.42	-13.01	<.001	-0.22	-9.27	<.001
Conscientiousness	-0.26	-7.60	<.001	-0.20	-8.34	<.001
Openness-to-experience	0.04	-4.32	0.21	-0.07	-3.00	.003

Table 6. Multiple hierarchical regression models. *Model 1* – Step 1 predicts CP using all Adolescent HEXACO factors except for Honesty Humility. Step 2 includes all factors. *Model 2* – Step 1 predicts CP using all Adolescent HEXACO factors except for Honesty Humility. Step 2 includes all factors. N(Model 1) = 709, N(Model 2) = 931. SDQ CP = Strengths and Difficulties Questionnaire, conduct problems scale. ICU = Inventory of Callous-Unemotional traits.

Subscale	Correlations between Adolescent HEXACO subscales at Time 1 and Time 2*
Honesty-Humility	0.83
Emotionality	0.88
Extraversion	0.89
Agreeableness	0.79
Conscientiousness	0.81
Openness-to- experience	0.87

Table 7. Test-retest reliability: Pearson's correlations between HEXACO subscale scores at Time 1 and Time 2 (time interval – 14 days). All correlations corrected for multiple comparisons using Bonferroni correction.

*all *p*'s <.001

4. Discussion

In the current study we developed and validated an English-language HEXACO-PI for use with adolescents and explored its relationship with conduct problems (CP) and callous-unemotional (CU) traits in a community sample aged 11-16. In line with our hypotheses, the Adolescent HEXACO captured the six established HEXACO factors, and there were significant associations between the Adolescent HEXACO dimensions, FFM scales, CP, and CU traits. Moreover, we also found that inclusion of an Honesty-Humility factor in our HEXACO model improved predictive power of both CP and CU traits in adolescents. We consider these findings and their implications in more detail below.

4.1 Validation of the Adolescent HEXACO

In line with our hypotheses, factor analysis indicated that our novel Adolescent HEXACO measure had a six-factor structure that captured the six HEXACO dimensions reasonably well. Whilst not all CFA fit indices indicated a good fit, RMSEA and SRMR - the two most appropriate indices for the nature of our data (see Kenny & McCoach, 2003; Shi et al., 2019) - indicated a well-fitting model. Moreover, internal consistency was greater than 0.70 for all Adolescent HEXACO factor subscales, suggesting that items within each scale reliably tested the same construct. Adolescent HEXACO subscales also showed good test-retest reliability over a two-week time-period.

Findings from our construct validity analyses, investigating the association between Adolescent HEXACO and TIPI FFM factors were again in line with our hypotheses. Strong, positive correlations were observed between Extraversion, Conscientiousness, and Agreeableness on the Adolescent HEXACO and the TIPI (our FFM measure), and a moderately strong correlation was observed between Openness-to-experience on the

HEXACO and Openness on the TIPI. These findings indicate good convergent validity of our measure (Ashton & Lee, 2007). Additionally, and in line with initial hypotheses, Emotionality was significantly negatively correlated with TIPI Emotional Stability (where low scores indicate Neuroticism). Finally, again in line with our expectations, a moderate correlation between Adolescent HEXACO Honesty-Humility and Adolescent HEXACO Agreeableness was observed. Although this correlation was significant, post hoc tests revealed that the strength of the correlation between Adolescent HEXACO Honesty-Humility and Adolescent HEXACO Agreeableness was significantly smaller than that observed between HEXACO Agreeableness and FFM Agreeableness. This finding is important as it suggests that the Honesty-Humility factor meaningfully differs from the Agreeableness, at least as measured by our Adolescent HEXACO (Lynam, Crowe, & Vize, 2020) (for further discussion see section 4.4). A moderate correlation between the two is to be expected, as the HEXACO Honesty-Humility scale contains traits that are peripheral to Agreeableness in the FFM (such as sympathy). However, Honesty-Humility also measures sincerity and lack of greed. Thus, the correlation with FFM Agreeableness should be weaker than that between HEXACO Agreeableness and FFM Agreeableness, as demonstrated in our data.

In sum, the factor structure and internal consistency of items within factors of the Adolescent HEXACO, as well as the convergence between the Adolescent HEXACO factors and FFM factors observed here suggests that the Adolescent HEXACO is valid, and is measuring the same traits as the adult HEXACO (Ashton & Lee, 2007, 2008, 2009).

4.2 Associations with CP

In line with predictions, we observed significant negative correlations between Adolescent HEXACO Honesty-Humility, Agreeableness, Conscientiousness, and our measures of CP (the

SDQ CP scale; Goodman, 1997). This suggest that these traits have potential utility in explaining risk for CP. This aligns with previous research using both the HEXACO model and the FFM to look at the associations between personality and CP in adolescence and ASB in adulthood (Book et al., 2012; Farrell et al., 2014; Heaven, 1996; John et al., 1994; Lewis et al., 2014; Spadafora et al., 2020).

Overall, our study suggests that traits related to low Agreeableness (which include being quick tempered, resentful, and aggressive) are related to CP in adolescence, perhaps unsurprisingly as such traits characterise adolescents with CP. Low agreeableness was the strongest correlate of CP and was also the strongest predictor in the regression model. This is in line with previous research in adults who engage in criminal behaviour (e.g. Međedović, 2017), as well as previous studies with adolescents with CP that have employed the FFM (Malouff et al., 2005). Although not all studies find low Agreeableness to be the strongest predictor of CP, previous research using both the FFM and the HEXACO has demonstrated a clear and consistent negative relationship between CP and low agreeableness in both adult and adolescent samples (Ashton & Lee, 2008; Book et al., 2016; Dunlop et al., 2012; Lee & Ashton, 2012; Međedović, 2017; Miller & Lynam, 2001; Saulsman & Page, 2004; Vize et al., 2018, 2019).

Honesty-Humility showed a moderate negative correlation with CP - however, this correlation was weaker than the correlations seen between CP and Agreeableness and Conscientiousness. This is in contrast to previous studies with adolescents that observed low Honesty-Humility to be the strongest predictor of general aggressive behaviour and bullying in adolescent samples (Book et al., 2012; Mularczyk et al., 2020). However, there are still relatively few studies looking at HEXACO personality traits in relation to CP in adolescence, and the measurement instruments used to assess CP vary. Here we used a screening measure of CP that has been developed to mirror diagnostic criteria for oppositional and conduct disorders in adolescence, whereas the prior studies used measures of aggression and bullying, with only partial overlap to CP symptoms. This is also the first study to investigate the relationship between CP and personality using a HEXACO measure developed for and validated with adolescents. It is interesting to note that some studies have indicated that Honesty-Humility is more strongly related to pre-meditated retaliation intentions, whereas Agreeableness is related to both premeditated and reactive aggression (in adolescents and young adults samples) (Book et al., 2012; Lee & Ashton, 2012). Our measure of CP (the SDQ CP scale) is short, containing only five items, and is not sensitive to reactive vs instrumental aggression. An interesting follow up to the present study would be to examine the relationship between Honesty-Humility and Agreeableness and different forms of aggression using the Adolescent HEXACO.

In line with some previous studies (Farrell et al., 2014; Pronk et al., 2021; Volk et al., 2018), we observed a relationship between CP and low Emotionality in our sample. We chose not to make any predictions regarding the relationship between Emotionality and CP, as this relationship is less consistently observed in prior research than the relationships observed between CP and Agreeableness, Conscientiousness, and low Honesty Humility. Accordingly, Emotionality was the weakest predictor of CP in our regression model. Overall, this indicates that HEXACO Emotionality may be relevant in predicting CP, but less important than factors such as Agreeableness, Conscientiousness, and Honesty-Humility.

4.3 Associations with CU traits

We observed significant, negative, correlations between all Adolescent HEXACO factors and CU traits. Low Emotionality was the strongest correlate of CU traits, and low Emotionality was also the strongest predictor of CU traits in our regression analysis. Emotionality in the HEXACO measures fear, sentimentality, anxiety, empathy, and dependence related traits – low Emotionality therefore denotes lower degree of these traits (Ashton & Lee, 2007). Individuals with high CU traits are characterised by low emotional reactivity to distressing stimuli, and empathy deficits (Blair et al., 2014; Essau et al., 2006; Frick, Cornell, Barry, et al., 2003; Frick & Marsee, 2018; Waller et al., 2020). It is interesting to note that the only other study investigating HEXACO traits in relation to CU and CP (Mularczyk et al., 2020) observed Emotionality (as measured by the ICU) to be the strongest correlate of CU traits in canonical correlation analyses. What is more, they find that introducing CU traits into a regression analysis removed an observed association between Emotionality and CP. Thus, the current findings, in line with prior research, suggest that low Emotionality may be an important feature specifically linked to high levels of CU traits – although this needs to be replicated. This finding also indicates that a strength of the HEXACO, over FFM measures that primarily find Agreeableness and Conscientiousness to be the strongest predictors of CU traits, is it more sensitively captures variance in personality that relate to CU traits specifically.

The negative relationships observed between CU traits and Honesty-Humility, Agreeableness, and Conscientiousness were in line with our predictions. We predicted that CU traits would be associated with low Honesty-Humility due to the characteristics and psychosocial impairments that high levels of these traits are associated with in adolescence (e.g. reduced prosocial behaviour, lack of remorse, poor peer relationships) as well as the findings of Mularczyck et al. (2020) who observed that low Honesty-Humility (as well as low

Agreeableness and low Conscientiousness) was a significant negative correlate of CU traits in both Pearson's and Canonical correlation analyses. Our predictions regarding the relationships between CU and low Agreeableness and Conscientiousness were also based on the findings of Mulaczyck et al. (2020), as well as research with the FFM that has consistently demonstrated similar findings in adolescent populations (e.g. Borroni et al., 2014; Essau et al., 2006; Romero & Alonso, 2017; Salekin et al., 2010). This study thus adds to the literature implying that Honesty-Humility, Agreeableness, and Conscientiousness are important personality correlates of adolescents with high CU traits.

The observation that Openness-to-experience shows a moderate, negative correlation with CU traits is in line with many, but not all, previous studies investigating personality correlates of CU traits using the FFM (e.g. Essau et al., 2006; Romero & Alonso, 2017; but see Borroni et al., 2014). However, it should be noted that these correlations tend to be smaller than those between the CU traits and Agreeableness and Conscientiousness. The one other study to date that has looked at CU traits in relation to the HEXACO model in adolescents did not observe any relationship between CU traits and Openness-to-Experience (Mularczyk et al., 2020), despite Openness-to-experience in HEXACO and Openness FFM models being theoretically similar. Although a relationship is seen in our results, it is important to note that this factor made the smallest contribution to the regression model predicting CU traits and had the second smallest correlation with CU traits following Extraversion. More research is thus needed to understand the relationship between Openness-to-Experience and CU traits.

Our results regarding Extraversion were similar: a small but significant negative correlation was observed between Extraversion and CU traits, and Extraversion was a significant predictor of CU traits in our regression model. This has been observed in some (e.g. Romero & Alonso, 2017) but not all (see e.g. Borroni et al., 2014; Essau et al., 2006) studies using the FFM to explore personality in relation to CU, and was not observed by Mularczyk et al., (2020) in relation to Extraversion in the HEXACO. This, again, indicates the need for further research using the HEXACO model in relation to CU traits.

4.4 Predictive Power of Honesty-Humility

In line with our hypotheses, inclusion of Honesty-Humility significantly improved prediction of both CP and CU traits in our two regression models. This finding supports previous research, observing that inclusion of a Honesty-Humility factor in personality measures provides predictive validity above and beyond the other five HEXACO factors (Ashton & Lee, 2008; Dunlop et al., 2012; Hodson et al., 2018). It is interesting to note that Honesty-Humility captured more additional variance in our model predicting CU traits than in our model predicting CP. Given the limited prior research exploring HEXACO personality factors in relation to CU, we did not make any predictions regarding this. However this is in line with the characteristics that define high CU traits in adolescence (such as lack of guilt and propensity to engage in premeditated aggression), as well as research demonstrating that Honesty Humility is a better predictor of instrumental aggression than of reactive aggression (Book et al., 2012; Lee & Ashton, 2012)

Overall, the finding that Honesty-Humility captures meaningful variance in both CP and CU in our models (when all other factors are also included) provides evidence that Honesty-Humility adds meaningful variance to personality inventories (for debate, see Ashton & Lee, 2020; Lynam, Crowe, & Vize, 2020).

4.5 Limitations and future avenues of research

It is important to acknowledge several limitations to the current study. Firstly, due to limitations imposed by the COVID-19 pandemic all participants were recruited in a single recruitment effort and subsequently randomly assigned into groups for the factor analysis. We acknowledge that standard procedure is to collect a sample for EFA, and collect the CFA sample post EFA analysis. Second, SDQ data is missing from the data of adolescents from one school due to administrative error – leading to our having less data for this measure than our other measures of construct validity. However, this affected fewer than 300 participants (of a full sample of 1398) and notwithstanding this error, the expected patterns of HEXACO traits in relation to CP were observed. We therefore believe it unlikely that this significantly compromises the validity of our findings. Third, we recruited opportunistically from mainstream schools. We endeavoured to recruit as representative sample as possible by only contacting large, non-selective schools, however it is important to note that our sample only included adolescents currently in mainstream education. This excludes an important subgroup of adolescents who might be receiving alternative education in provision schools – which often includes adolescents with elevated levels of CP. Third, it is important to note that there is considerable shared variance among the traits measured in the Adolescent HEXACO. This presents a problem as it limits our interpretation of how different HEXACO factors relate to unique outcomes. However, shared variance is also a reality of many psychological traits and is a problem common to most personality measures – including the adult HEXACO (see Ashton & Lee, 2009). Although this should not be overlooked, it does not negate the value of modelling different personality factors and exploring their relationship with different behaviours or measures of psychopathology. It is, however, important that this shared variance is acknowledged and kept in mind when considering findings. Finally, we only validated the adolescent HEXACO as a self-report measure. Given the susceptibility of self-report measures to desirability bias, especially when measuring socially undesirable traits such as greed and CP, it would be worthwhile to develop parent-, teacher-, and peer-rated versions of the adolescent HEXACO questionnaire in future to check interrater reliability.

In order to further validate and extend the current findings, future research should use the Adolescent HEXACO to explore personality correlates of CP and CU in clinical samples of adolescents. Future research using larger samples could also use person-centred analysis techniques to explore whether subgroups of adolescents exist with distinctive patterns of Adolescent HEXACO traits, and whether these subgroups differ in their level of CP and CU traits (as has been used in the adult literature for example to explore psychopathic traits in relation to social reward valuation; Smeijers et al., 2021).

5. Implications and Conclusions

The current study developed and validated a novel, English-language, illustrated personality measure for adolescents – the Adolescent HEXACO - in a community sample of 11-16 year olds. This study is also the first to provide insight into the relationship between CP, CU, and personality, using a six-factor model of personality designed specifically for use with adolescents. The Adolescent HEXACO was found to have good psychometric properties, as well as good construct and convergent validity. Using Exploratory and Confirmatory Factor Analysis, we identified six clear dimensions in our measure. These were: Honesty-Humility, Emotionality, Extraversion, Agreeableness, Conscientiousness, and Openness-to-experience. In line with expectations, we observed strong associations between these personality dimensions and measures of CP and of CU traits. Low scores on Adolescent HEXACO measured Agreeableness was the strongest correlate and predictor of CP, suggesting that traits of anger, and antagonism were most important in explaining antisocial behaviour in adolescents in our sample. CU traits showed the strongest association with low scores on Adolescent HEXACO measured Emotionality, implying that presence of these traits was best explained by reduced levels of empathy and emotional arousal/distress in our sample. Importantly, our findings also highlight the value of including Honesty-Humility when considering the personality correlates of CP and CU traits.

The findings from the current study provide a foundation for future research aiming to understand the personality risk factors associated with CP and CU traits in adolescents. They also provide a detailed and comprehensive description of the personality profiles of adolescents with high levels of CP and of CU traits. If replicated, these findings have potential to aid in the early detection of CP in non-clinical populations, and to inform interventions for behaviour management. For example, as low Agreeableness is consistently found as a predictor of CP, interventions could focus on modifying interpersonal strategies. The findings also support the value of using a six-factor measure, including measurement of traits related to Honesty and Humility, when considering CP and CU traits in adolescence.

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Chapter Five - Assessing the Relationship between Mind Representation and Callous Unemotional Traits

1. Introduction

Callous-unemotional (CU) traits refer to a lack of empathy, a lack of guilt and remorse, and shallow affect (Frick et al., 2014). High levels of CU traits in childhood and adolescence are a risk factor for particularly severe and chronic antisocial behaviour (Fontaine et al., 2018; Frick et al., 2014; Viding & Kimonis, 2018). They are also a marker of poor social functioning in community samples: high CU traits in adolescents are related to peer rejection and victimisation (Fontaine et al., 2010; Piatigorsky & Hinshaw, 2004), bullying behaviours (Viding et al., 2009), and a reduced pleasure in affiliating with others (Waller & Wagner, 2019). Furthermore, CU traits have been shown to be associated with atypical neurocognitive functioning, including reduced emotion recognition skills (Ciucci et al., 2015), poor recognition of distress cues (Blair & Coles, 2000; Muñoz, 2009), reduced experience of distress emotions (such as fear and anxiety; Roose et al., 2011), and low self-reported engagement in prosocial behaviours (Foulkes et al., 2017). These atypicalities may, at least in part, underlie the social difficulties and reduced pleasure in social affiliation observed in individuals with high levels of CU traits.

A further important aspect of social and emotional processing involves theory of mind (ToM), or the ability to understand others' beliefs, desires, and intentions (Fonagy & Allison, 2012; Frith & Frith, 2006; Premack & Woodruff, 1978). The ability to engage in ToM enriches our understanding of other people's behaviour and is considered a key factor in successful navigation of social environments. Accordingly, impairment in ToM ability is a feature of several psychiatric disorders - including autism spectrum disorders and schizophrenia - that are generally associated with poor social functioning (Happé & Frith, 1995; Murphy, 2006; Popolo et al., 2016). Given the cold and uncaring profile of adolescents with high CU traits, their tendency to form shallow affiliations, and their social difficulties, one might expect that CU traits also relate to atypical ToM. However, research exploring ToM in relation to high CU traits has produced mixed results. There is some experimental evidence, as well as evidence from studies employing self-and other-report measures, that CU traits are associated with poorer ToM (Brouns et al., 2013; Dadds et al., 2009; Kahn et al., 2017; Pardini et al., 2003; Sharp & Vanwoerden, 2014). However, many experimental studies (the majority of which have been conducted in clinical samples of adolescents with CP and high levels of CU traits) indicate intact ToM ability in this group - at least when tasks focus on understanding others' thoughts (cognitive ToM), rather than emotions (affective ToM) (Anastassiou-Hadjicharalambous & Warden, 2008; Cheng et al., 2012; Jones et al., 2010; O'Nions et al., 2014; Schwenck et al., 2012). Many measures of ToM (in particular questionnaire measures) do not separate cognitive and affective ToM, so it is possible that mixed findings relate to the degree to which ToM measures require mentalising about emotions (given evidence for compromised emotion processing in those with high CU traits). It is also possible that adolescents with high CU traits have an intact ability, but a reduced propensity, to engage in ToM processing (Roberts et al., 2020). In other words, these individuals appear to be able to understand others' perspectives/beliefs and desires, but might be more or less motivated to do so under different experimental (or real life) conditions. Mixed findings might, therefore, relate to the degree to which different tasks are likely to capture differences in propensity to engage in ToM. Overall, despite considerable research using a range of methods, the relationship between ToM and high CU traits remains poorly understood.

There is, however, a strong argument that the current measures available to the field are not particularly sensitive to what might be driving individual differences in ToM performance, thus limiting our understanding of ToM in relation to children and young people's mental health and behavioural difficulties - including high CU traits. A key limitation of current ToM tasks (such as the Sally-Anne task (Baron-Cohen et al., 1985) and the Movie Assessment of Social Cognition (MASC; Dziobek et al., 2006)) is that they assess participants' ability to correctly *infer* a character's mental state, rather than looking at individuals' *representation* of others' minds (from which mental state inferences are generated; Conway et al., 2019) – the latter, arguably, being a more sensitive way of quantifying how someone understands other minds. 'Correctness' of mental state inference in traditional ToM tasks is a binary notion (typically determined by consensus or experimenter logic), that gives little insight into nuances in mental state inference, and that does not leave room for measuring subtle individual differences in ToM ability (Conway et al., 2019). Conway and colleagues (2019) propose that investigating individual differences in the *representation* of others' minds is important, as understanding differences at a representational level will help us to understand what may drive differences in the ability to make mental state inferences (and how this may vary from one individual to next). They propose that we assess mind representation within a 'Mind-space' framework, analogous to the 'Face-space' framework that has been employed successfully in the face processing literature (Valentine et al., 2016). In the Mind-space framework, others' minds are represented as vectors in a multi-dimensional psychological space. This space is constructed through experience (which, it should be noted, is most likely constrained by genetically influenced traits of the perceiver), and represents any discriminable features of people's minds – such as personality features or intelligence. When we encounter individuals, we locate their minds within this multidimensional space - allowing us to make mental state inferences for these individuals based on what we understand about how minds vary (Conway et al., 2019, 2020). Conway et al. (2019, 2020) propose that individual differences in mental state inference are due to one or more of three factors: (1) accurate representation of others' minds (or an accurate Mind-space), (2) the accuracy with which one might locate a target mind within Mind-space, and (3) the propensity (or motivation) of an individual to represent minds within their Mind-space, and the degree of effort which they need to expend to do so with precision.

In order to test part (1) of this theory, Conway and colleagues developed the Personality Pairs Task (PPT), which assesses individuals' understanding of common covariance between personality traits in the population (Conway et al., 2020). In this task, participants are asked to estimate how likely they think two personality features are to go together in the same individual, and their estimates are compared to real life responses to a well-validated personality questionnaire: the HEXACO 60 (Ashton & Lee, 2009). The closer a participant's estimation of the covariance between personality features is to the actual correlation between these features in the population, the better their ability to represent other minds is thought to be – which should in turn predict ability to make mental state inferences. In support of this theory, accuracy on the PPT in a sample of healthy adults positively predicts performance on the MASC task, a well validated experimental measure of ToM (Conway et al., 2020).

The PPT has, thus, already shown promise as a sensitive measure of ToM in adults. A logical next step is to expand this measure for use with adolescents. The current Chapter focuses on a study that assessed the relationship between performance on an adolescent friendly version of the PPT (the Adolescent PPT) and CU traits, which are an important clinical indicator of risk for severe conduct problems in adolescence. Given mixed findings in prior research, it is difficult to make directional predictions regarding the relationship between ToM (as measured by this task) and CU traits. However, we considered that any sensitivity gained by employing a PPT task might yield some initial insight into whether differences in mind representation are related to CU traits. If the Adolescent PPT task shows promise in capturing individual differences in mind representation that relate to CU traits, then this research could be built on in the future. For example, future studies could explore Adolescent PPT task performance in relation to tasks that have captured mixed ability to engage in ToM processing in those with high CU traits, such as the MASC task (e.g. Roberts et al., 2020; Sharp & Vanwoerden, 2014) or paradigms assessing understanding of false beliefs (e.g. Anastassiou-Hadjicharalambous & Warden, 2008). Understanding how CU traits relate to mind representation would also highlight where more research is needed in relation to CU traits. If we observe that mind representation in these individuals is accurate, this would indicate that future work would need to address other proposed sources of individual differences in mental state inferences such as propensity or ability to locate others *within* Mind-space in adolescents with high CU traits.

2. Methods

2.1 Participants

128 participants between the ages of 11-16 were recruited from a UK-based mainstream school via opportunity sampling. Information sheets were sent to parents of participants, giving them the opportunity to opt their child out of the study. Use of an opt-out procedure was ethically permissible in the case of the current study as the research was non-invasive

and in the public interest. This procedure was approved by the UCL Research Ethics Committee [0622/001]. Adolescent participants were presented with age appropriate information sheets and were required to give informed assent in order to participate in the study. The school received a £50 honorarium for each participating class to recognise as a recognition of the time spent by school staff in supporting the project. Pupils who took part in the study were entered into a draw to win £50 of Amazon vouchers.

Exclusion criteria included a diagnosis of autism spectrum disorder or presence of severe learning difficulties. Five participants were removed on the basis of these criteria. Information regarding formal clinical diagnoses was provided post data collection by the teachers of participating pupils. A further 17 participants were removed for incomplete questionnaire data (N = 5) or for completing the questionnaires but not taking part in the experimental task (N = 12). Finally, two participants were removed due to outlying data on our measure of CU traits (see section 4). This left a final sample of 101 adolescents for final analysis (mean age = 13.91, SD = 0.6, male = 60, female = 41).

Sample size was informed by an *a priori* power analysis using G*Power statistical software (Faul et al., 2007). This analysis revealed that 120 participants would be required in order to have a power of 0.80 to detect a correlation of .25 (at an alpha of .05). The chosen correlation size was informed by a prior study that explored cognitive perspective taking and psychopathic traits in young adults (Lockwood, Bird, et al., 2013). After exclusions, the current sample of 101 participants for this study gave a power of .73 to detect the same correlation (0.25).

2.2 Measures

2.2.1 The Personality Pairs Task

Participants completed an adapted version of the Personality Pairs Task (PPT) (Conway et al., 2019), developed for the current study. The adult version of the PPT comprises 72 questions, each made up of items measuring traits on the HEXACO-60, a personality inventory developed for adults that captures six personality dimensions: Honesty-Humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), Openness-to-Experience (O) (Ashton & Lee, 2009). On every trial of the adults PPT, participants are asked to rate how likely it is that the average person would be well described by a set of two of these traits. For example, participants might be asked: "On average, how likely is it that someone who people think of as having a quick temper, would also make decisions based on the feeling of the moment rather than on careful thought?"

Our adolescent version of the PPT (the Adolescent PPT) employs the same experimental design and question structure as the adult task, but instead uses items from the newly developed Adolescent HEXACO (Chapter 3; Gaule, Kwao, McCrory & Viding; *manuscript submitted for publication*). The Adolescent HEXACO is a six-factor measure of personality that captures the same traits as the HEXACO-60, but with items adapted for adolescents aged 11-16: It uses simpler language, includes pictures to aid engagement, and includes questions about school behaviour rather than workplace behaviour. Participants were instructed to think about the average person their age and of their personality. They were then informed that they would be asked some questions to which they should respond on a sliding scale and for which there are no right or wrong answers. An example item from the Adolescent PPT can be found in Figure 1. Full instructions for the Adolescent PPT can be found in Appendix 4.1.

It should be noted that the Adolescent HEXACO questionnaire contains three fewer items than the adult HEXACO-60. This was due to their failing to load onto any HEXACO factor scale or for having a primary loading on an unexpected scale – see Chapter 3, section 3.1. Due to the uncertainty and small time-windows imposed on data collection for the current thesis by COVID-19 school closures, data for the current study were collected prior to validation of the Adolescent HEXACO. We therefore designed the Adolescent PPT using the equivalent Adolescent HEXACO items for each question as were used in the adult PPT. This resulted in 6 Adolescent PPT items containing Adolescent HEXACO items that turned out to be invalid (or to not capture the expected variance in the Adolescent HEXACO measure). We therefore ran our main analysis both with and without participant estimates for these items included in participants mean PPT difference score. This did not change results (see Appendix 4.2). Given that these items do not represent the personality factors that we intended to measure, section 4 of this Chapter reports results with averages that exclude these items.

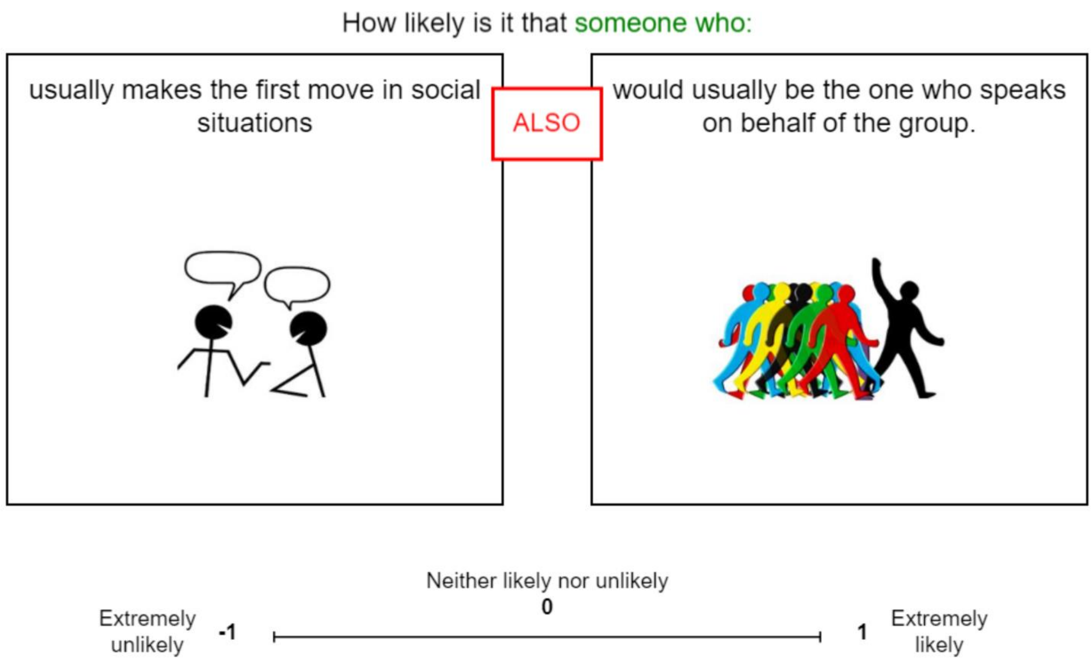

Figure 1. Example item from the Adolescent PPT.

2.2.2 The Inventory of Callous-Unemotional Traits, Youth form

The Inventory of Callous-Unemotional traits (youth version) (ICU; Essau et al., 2006) is a 24 item self-report measure. Responses are made on a four-point Likert scale ('Not at all True' to 'Definitely True') and relate to an individual's degree of callousness, uncaringness and lack of emotion (e.g. *"I do not care if I get into trouble"*). This scale showed good internal reliability in our sample (a= .86).

2.3 Procedure

The PPT was administered as part of a larger battery of tasks by teachers on school premises and during regular class time. Participants completed the task battery on their own personal tablet devices. All participants completed the testing battery in the same order and the study was run under exam like conditions to ensure focus.

3. Analysis

3.1 Data Cleaning Procedure

We first inspected Adolescent PPT data for trials where participants had responded in a time that was judged too short to have fully read and comprehended the item. We chose a cut-off of at least 500ms for item comprehension, based on the typical reading speeds of adolescents in the age range of our participants (Carver, 1992). Response times on 3.12% of data in our sample fell below this cut-off. We then calculated the average response time of participants for whom more than 10% of trials fell within this range (nine participants). All of these participants had an average response time of greater than 500ms (minimum average response time: 1500ms); therefore no participant was excluded on the basis of PPT response time.

Adolescent PPT difference scores and ICU total scores were then inspected for outliers (determined as participant scores higher than 1.5 times the interquartile range). Two participants were excluded from the final sample for outlying scores on the ICU. For boxplot and further descriptive statistics about our ICU measure, see Appendix 4.3.

3.2 Main analysis

Ground truth (or population) correlations between item responses in the validation sample of the Adolescent HEXACO (N = 1095, see Chapter 4 for sample characteristics) were calculated using Pearson's correlation in R and R Studio (R Core Team, 2020, 2015).

All remaining analyses were conducted in SPSS in SPSS (IBM Corp, 2020). Difference scores for each item of the Adolescent PPT were calculated as the absolute difference between (1) estimated correlation for each item (as indicated by the participant's response on each trial), and (2) the ground truth correlation for the Adolescent HEXACO questions contained in that item. Each participant's final PPT score reflected their average absolute difference score. A smaller average absolute difference score indicates better task performance (i.e. a more accurate Mind-space).

The relationship between Adolescent PPT scores and scores on the ICU were investigated using Pearson's correlation analysis (two tailed).

4. Results

Descriptive statistics of our main measures are reported in Table 1. Results are illustrated in Fig. 2. A significant negative association was observed between Adolescent PPT scores and ICU scores ($r(1) = -.20$ $p = .04$). This shows that higher ICU scores were associated with an improved mind representation ability in our sample. However, it should be noted that a correlation of ±0.2 represents a small effect size indicating that strength of relationship between PPT and ICU scores is relatively weak, despite being statistically significant (Cohen, 1992).

	Adolescent PPT Difference Scores	ICU
N	101	101
Mean	0.39	23.16
SD	0.12	8.06
Minimum	0.14	4
Maximum	0.73	43

Table 1. Descriptive statistics for Adolescent PPT, CPT, & CU traits. N = Number of participants; PPT = Personality Pairs Task, ICU = Inventory of Callous-Unemotional Traits, CPT = Cognitive Perspective Taking Scale.

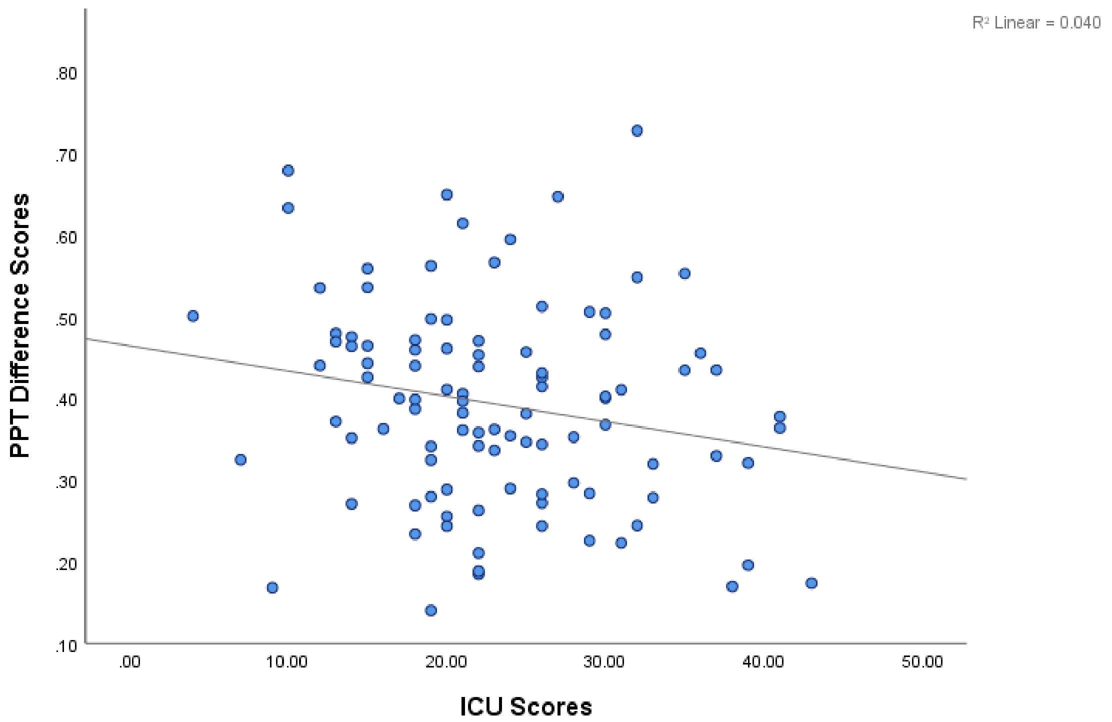

Figure 2. Graph displaying correlation between participants' mean absolute PPT difference score and ICU score. PPT – Personality Pairs Task; ICU – Inventory of Callous-Unemotional traits.

5. Discussion

In the current study we explored ToM in relation to CU traits in a community sample of adolescents via a novel measure that assesses mind representation (or Mind-space): the Adolescent Personality Pairs Task (PPT). We observed that higher levels of CU traits related to better performance on the Adolescent PPT in our sample, i.e. participants with higher CU traits in our sample were better at estimating which traits did and did not co-occur in the general population. If replicated, our observation would imply that adolescents with high CU traits have a good, if not superior, ability to represent others' minds relative to adolescents who score lower on these traits. Our findings also indicate that the Adolescent PPT has promise for capturing individual differences in mind representation that are related to CU traits.

Previous task-based experimental research investigating the relationship between ToM and CU traits has demonstrated mixed results. However, the measures used to assess ToM in these studies mostly examined ability to make 'correct' (or rational) mental state inferences. They lacked the sensitivity to assess the mind representation underlying the generation of these inferences, thus limiting our understanding of why differences in task performance were observed. Our finding, that high CU traits were associated with better mind representation, gives us a more nuanced picture of ToM in relation to high CU traits. It also gives some support to the proposition that adolescents with higher CU traits are less motivated, rather than less able, to make inferences about other minds (Conway et al., 2020; Roberts et al., 2020).

Conway et al. (2019; 2020) propose that individual differences in mental state inference are due to one or more of three factors. These are: (1) ability to accurately represent others' minds (or an accurate Mind-space), (2) the accuracy with which one can locate another person's mind within Mind-space, and (3) the propensity (or motivation) of an individual to locate minds within their Mind-space, and the degree of effort needed to do so with precision. As CU traits were associated with intact (if not superior) mind representation in our sample, this would imply that mixed findings might instead be driven by an inability to locate others' minds within this space – or a reduced propensity to do so. In order to test the relationship between accuracy of mind representation (Mind-space) and ability to accurately locate others within Mind-space, Conway et al. (2020) related the performance of healthy adult participants on the PPT (accurate Mind-space) to their ability to make trait and intelligence judgments about other people based on very short ('thin slice') video clips of their behaviour (ability to locate others within Mind-space). In their experiment, accuracy in trait and intelligence judgments was determined through comparison of participants' trait and intelligence judgements in response to the video clips to real trait and intelligence values provided by the individuals depicted in each video. The authors observed that better ability to represent others' minds predicted ability to make accurate judgments about important characteristics of those individuals - i.e. more accurate mind representation led to higher accuracy locating others within this Mind-space. That is, typically more accurate Mind-space is associated with better ability to locate others within Mind-space. However, it may be that adolescents with higher CU traits find the mental computation that is required to locate others in Mind-space more difficult than their peers, even though they seem to be able to represent minds accurately. Future work could test whether this is the case. It might also be of interest to explore the degree to which adolescents with high CU traits are less likely (or able) to incorporate situational factors into their mental state inferences – another factor that could affect performance on current standard ToM measures (Conway et al. 2020).

Adolescents with high CU traits might also find it more effortful or less rewarding to engage in the processing required for mental state inference. Indeed, it has already been suggested that high CU traits might be associated with a reduced propensity, rather than a reduced ability, to engage in ToM computations (Roberts et al., 2020). Studies that have observed no difference in (non-affective) ToM ability in adolescents with high CU traits have mostly used relatively simple stories or cartoon-based scenarios (Anastassiou-Hadjicharalambous & Warden, 2008; Jones et al., 2010; O'Nions et al., 2014; although see Schwenck et al., 2012). However, adolescents with high CU traits demonstrate poorer ToM ability than their peers in studies that employ a more complex, video based task (Dziobek et al., 2006), that was designed to be more challenging than story and cartoon based tasks (Roberts et al., 2020; Sharp & Vanwoerden, 2014). Roberts et al. (2020) suggested that poor performance on complex ToM tasks may reflect a lack of motivation to engage in more difficult ToM computations in these adolescents, particularly if doing so does not produce direct benefits for the adolescent themselves. Future studies might investigate this by examining whether performance of adolescents with high CU traits on complex ToM tasks improves when incentivised (e.g. through reward) and whether it does so more noticeably than for adolescents with lower CU traits.

Our finding that CU traits positively relate to accurate mind representation is potentially at odds with questionnaire studies which found that high CU traits are associated with reduced self-reported ToM ability (e.g. Brouns et al., 2013; Pardini et al., 2003). Even if adolescents with higher CU traits are less motivated to engage in ToM, it is logical to assume that an intact ability to do so would be reflected in self-report measures. However, many of the questionnaire studies employ the perspective taking scale of the Interpersonal Reactivity Index (IRI PT; Davis, 1980), and it could be argued that the majority of items in this scale assess individuals' propensity to take others' perspectives (an index of ToM) rather than ability. For example, items such as 'I try to look at everybody's side of a disagreement before I make a decision' or 'Before criticizing someone, I try to imagine how I would feel if I were in their place', do not ask participants if they *can* take others perspective – they ask if they actually *do* so in social situations. Development of a questionnaire measure that explicitly measures both propensity and ability to engage in ToM might, therefore, shed light on mixed findings. Another explanation for mixed findings might relate to questionnaire measures (including the IRI PT) using items that measure both affective and cognitive (or non-affective) ToM. We already know that adolescents with high CU traits demonstrate atypical emotion processing (Blair & Coles, 2000; Ciucci et al., 2015; Muñoz, 2009) and struggle with affective ToM (Anastassiou-Hadjicharalambous & Warden, 2008). Therefore, conflating affective and cognitive ToM in questionnaire measures assessing this ability might plausibly generate mixed results. Naturally, these two possible explanations are not mutually exclusive. Finally, it is possible that adolescents with high CU traits do not have good insight into their own ToM ability. Not many studies to date have explored metacognitive ability in relation to CU traits, but there is some evidence that children and adolescents with high CU traits have poorer ability to evaluate their own behaviour (Ezpeleta et al., 2013; Platje et al., 2018), which may explain their lower scores on questionnaire measures of ToM.

It is important to acknowledge some limitations to the current study. First and foremost, is our assumption that the Adolescent PPT has similar properties to the adult PPT. Ideally, we would have validated the Adolescent PPT by assessing participants' performance on this task in relation to the MASC task in our sample (mirroring the validation of the adult PPT), as well as exploring its relationship with CU traits. However, due to restrictions imposed by COVID-19 we unfortunately were not able to do so. We had to design the current study in such a way that it could easily run by schools with whole class groups and without experimenters present. Inclusion of an additional task in the battery completed by pupils - especially a long and complex task such as the MASC that involves video and audio stimuli - would have placed an undue burden on the teachers who administered the study and would have presented logistical difficulties in a multi-participant testing environment. However, our finding that the Adolescent PPT captures variance in mind representation that relates to CU traits indicates that it is worthwhile to follow up on this study by relating performance on this measure to performance on already established measures of ToM, such as the MASC task, in future studies. A second limitation of the current study is that it looks at CU traits in a community sample of adolescents, whereas much of the previous experimental research looking at the relationship between ToM and CU traits has been conducted in clinical samples of adolescents with CP. Future work should explore whether adolescents with CP and high CU traits also show good performance on the Adolescent PPT relative to their peers. Finally, it is worth noting that our final sample size after data cleaning (101 participants) was smaller than our desired sample size of 120 participants, which would have given us 80% power to reliably detect an effect in our study. This, again, was related to challenges in participant recruitment due to COVID-19, as well as the difficulty of administering a task remotely (which might explain our high rate of attrition). However, even with our smaller sample, we maintained above 70% percent power to detect our effect of interest - which is still moderately high.

Despite these limitations, the findings of the current study give us a more nuanced insight into ToM processing in relation to CU traits. In particular, they identify useful avenues for future research, including the need to further explore further the propensity of adolescents with high CU traits to engage in ToM. This study also suggests that PPT measure may be a helpful paradigm for examining individual differences in ToM ability in adolescents and in clinical populations.

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Chapter Six - General Discussion

This thesis was carried out with the broad aim of advancing the understanding of social cognition in adolescents with CP and high vs low levels of CU traits, as well as personality and cognitive correlates of CP and CU traits more broadly. This final Chapter provides a concise summary of findings, as well as implications and limitations from each empirical chapter – see Table 1 for an overview. This summary is followed by a discussion of how these findings align with and advance what is currently known about CP and CU traits in adolescents. We then conclude with a discussion of potential avenues for future research, as well as a consideration of the potential clinical and practical implications emerging from this work.

	Chapter 2	Chapter 3	Chapter 4	Chapter 5
Topic	Prosocial behaviour	Social information use	Personality correlates of CP/CU	Theory of Mind
Sample size	87	108	1095	101
Sample Characteristics	Group comparison (CP/HCU, CP/LCU, TD)	Group comparison (CP/HCU, CP/LCU, TD)	Normative	Normative
Analysis method	(1) GLMER (2) LMER (3) Beta Regression	(1) GLMER (2) LMER	Multiple Regression; Correlation	Correlation
Summary of findings	(1) CP/HCU and CP/LCU demonstrate less prosocial choice than TD. (2) CP/HCU engage in less prosocial effort than CP/LCU and TD. (3) No group differences in subjective discounting of reward by effort for self vs other.	(1) CP/LCU use less cooperative strategies to integrate feedback into existing beliefs than CP/HCU and TD. (2) No group differences in degree of social information use.	(1) Agreeableness is primary negative predictor of CP (2) Emotionality is primary negative predictor of CP (3) Inclusion of Honesty-Humility in models of personality improves prediction of both CP and CU	(1) High CU traits associated with better ability to represent others' minds (as indexed by ability to understand normal variation in personality traits)

Table 1. Summary of Chapters 2-5. CP/HCU conduct problems and high callous-unemotional traits; CP/LCU conduct problems and low callous-unemotional traits; TD typically developing; GLMER generalised linear mixed effect model; LMER linear mixed effects model.

6.1 Summary of findings

6.1.1 Chapter 2: Prosocial Choice and Effort in CP/HCU, CP/LCU, and TD adolescents

Chapter 2 was motivated by the dearth of existing experimental research investigating prosocial behaviour in CP, particularly those that directly compare prosocial behaviour in adolescents with CP/HCU and those with CP/LCU. Prosocial behaviour is considered fundamental to social and moral development, and a lack of prosocial behaviour might contribute to social difficulties that are seen in adolescents with CP/HCU and CP/LCU.

Adolescents with CP/HCU and with CP/LCU displayed similarly reduced prosocial choice relative to TD adolescents in our paradigm: both groups were less willing than were TD adolescents to accept effortful trials to win points when these trials were for another person as opposed to for themselves. Additionally, no difference was observed between our three groups in motivation to accept effortful trials (i.e. subjective discounting of rewards by effort) for the self vs the other. However, the CP/HCU group engaged in markedly less effort to win points on behalf of another person than they did for themselves, and they showed this difference in prosocial choice to a larger extent than both CP/LCU and TD groups.

Overall, our experimental findings indicate that while CP adolescents show reduced prosocial behaviour, this is particularly marked in those with CP/HCU. These findings are consistent with prior questionnaire and experimental studies indicating that low prosocial behaviour is associated with high CU traits in adolescence (Foulkes et al., 2017; Milledge et al., 2019; Sakai et al., 2012, 2016), and provide further insight into individual differences in prosocial behaviour among adolescents with CP (Hawley, 2003; Kokko et al., 2006).

The lack of difference between CP/HCU and CP/LCU groups in prosocial choice was not in line with our predictions: we predicted that only the CP/HCU group would differ in prosocial choice from TD adolescents. However, it is worth noting that our predictions were based on the very limited prior research that accounted for CU traits when investigating prosocial behaviour in CP. Studies employing correlational analysis techniques indicated that CU traits, but not CP, predict prosocial behaviour (Milledge et al., 2019; Sakai et al., 2012), and the one group-based study directly comparing CP/HCU, CP/LCU, and TD adolescents on a measure of prosocial choice found that only adolescents with CP/HCU differed from TD adolescents (Sakai et al., 2016). Our study is the first to investigate prosocial behaviour in these samples using a task that does not directly pit prosocial and less prosocial options against one another in a single choice. This difference may in part account for the pattern of findings in our study. It is also possible that the pattern of findings that we observed was due to the fact that we framed prosocial choice as a gain to another person, whereas the study of Sakai et al. framed prosocial choice as the option to avoid a loss to another. Our findings regarding some prosocial information processing deficits in the CP/LCU group requires replication. They also indicate that further research exploring what processes related to prosocial behaviour are in common vs. differ between CP/HCU and CP/LCU adolescents is warranted.

The lack of group difference in subjective discounting of reward by effort in our study was surprising and requires replication. We had predicted that the CP/HCU group would show steeper discounting of reward by effort for others (relative to the self) based on prior findings in healthy adults indicating that a greater difference in self-other discounting was associated with higher self-reported psychopathic traits. However, this prediction was based on only one prior study, carried out in participants of a different age group and who did not show clinical levels of antisocial behaviours; it also did not employ direct group comparison techniques.

The difference in prosocial effort that set CP/HCU apart from CP/LCU and TD groups, combined with models that have proposed reduced social affiliation to be a key feature of CP/HCU (Viding & McCrory, 2019; Waller et al., 2020), suggest that prosocial action may be an especially important facet of prosocial behaviour for building good social relationships. Research has demonstrated that people are highly averse to behaviour that they perceive as 'unfair' and that they appear to value the personal sacrifice that goes into prosocial acts even more than they do the outcome of these acts (Fehr & Gächter, 2002; Johnson, 2018; McAuliffe et al., 2017). Speculatively, it is possible that a marked difference in willingness to make effort for someone else, relative to that which one is willing to put in for oneself, might be perceived as unfair or selfish behaviour. This may, in turn, impact the ability of adolescents with CP/HCU to maintain good social relationships. Future research should explore how these experimental measures of prosocial behaviour relate to real life behaviours and social relationships. For example, it would be of interest to investigate how different facets of prosocial behaviour (such as choice to help someone and actual effort exerted in order to carry out that choice) contribute to social difficulties in adolescents with CP/HCU and CP/LCU. This could be done by indexing peer perceptions of acceptability or likeability of adolescents who engage in different forms of prosocial transgressions. It would also be of interest to explore what might motivate adolescents with CP/HCU to engage in prosocial effort – for example, whether they might be more willing to engage in this effort in situations where they stand to gain. Overall our findings highlight the need for increased research investigating prosocial behaviour in CP that directly compares those with high and those with low levels of CU traits. If replicated, our results may have implications for intervention and behaviour management programmes for adolescents with CP.

6.1.2 Chapter 3: Social Information Use in CP/HCU, CP/LCU, and TD Adolescents

This Chapter was motivated by a lack of research directly comparing social information use - here defined as the degree to which feedback from others is incorporated into beliefs and the strategies used to do this - in adolescents with CP/HCU and CP/LCU and their TD peers. Effective social information use is crucial in guiding decision-making and behaviour as it allows individuals to infer whether their behaviour is socially appropriate and to learn about successful behavioural strategies without engaging in trial and error learning (Boyd & Richerson, 1985; Cialdini & Goldstein, 2004). Atypicalities in this domain might hamper both relationship formation and relationship maintenance in adolescents with CP. To this end we employed a brief and simple behavioural estimation task (the BEAST task) to assess social information use in adolescents with CP/HCU, adolescents with CP/LCU, and TD adolescents. As in Chapter 2, we observed both similarities and differences among adolescents with CP/HCU and CP/LCU in this study. CP/HCU, CP/LCU, and TD groups were similar to each other in the *degree* to which they used social information. This was not in line with our prediction that adolescents with CP/HCU would use social information to a lesser extent than other groups. However, our predictions were, again, based on limited prior research. No study had used a similar belief updating paradigm in a CP sample, or in relation to CU traits. Rather, our predictions were based on studies indicating that adolescents with CP/HCU are less responsive to positive affiliative cues (Blair et al., 2014; Hodsoll et al., 2014; O'Nions et al., 2017) and also place higher value on atypical social goals such as dominance of others (Pardini, 2011) than adolescents with CP/LCU. However, the tasks assessing processing of positive affiliative cues in CP/HCU have all involved affective stimuli, whereas the BEAST task did not. Similarly, tasks evaluating social goals in CP/HCU involved assessment of hypothetical conflict scenarios, whereas the BEAST task was more abstract –

participants received information about another person's judgment regarding estimates of a number of animals on a screen and could choose whether or not to use this information. Future studies might explore whether similar behaviour patterns are seen with affective stimuli (e.g. judging the expression of a face and receiving another person's judgment), or when participants are given more information about the source of the social information (e.g. 'another boy who is very good at similar tasks') - introducing a competitive element to the task. If replicated, our findings provide further evidence that social understanding is intact in adolescents with CP/HCU (Haas et al., 2018).

While we did not observe a group difference in degree of social information use, we did observe a group difference in *strategy* use. That is, we observed a difference in the way in which participants incorporated social feedback into their already held judgements. In line with our predictions, adolescents with CP/LCU were less likely to use a cooperative strategy when updating initial estimates in response to social information, appearing to be more likely to stick with their initial judgement. Our prediction of a group difference in strategy use on this task was based primarily on a study demonstrating that lower CU traits are associated with poorer (less flexible and less relevant) social problem solving (Waschbusch et al., 2007), as well as on research indicating that adolescents with CP are characterised by lower social competence (e.g. Ladd, 1990; Webster-Stratton & Lindsay, 1999). If replicated, this finding has implications for behaviour management for adolescents with CP/LCU. Future studies should also extend these findings by investigating whether they hold in more ecologically valid contexts (e.g. when information comes from a known other, or has affective content).

Overall, the findings from Chapter 2 reinforce the importance of considering heterogeneity among adolescents with CP. They also highlight the need for further research that directly compares adolescents with CP/HCU, CP/LCU and TD peers, as the majority of research to date focusses on adolescents with CP/HCU or on adolescents with CP in undifferentiated samples.

6.1.3 Chapter 4: Exploring Personality Correlates of CP and CU via a New Adolescent Personality Measure

Personality, or ‘consistent patterns of thinking, feeling, and behaving manifested by individuals’ has been argued to play an important role in the development and the persistence of CP. Personality in relation to CP and CU in adolescence is typically assessed using the five factor model of personality (FFM), which encompasses Agreeableness, Conscientiousness, Extraversion, Neuroticism, and Openness (Costa & McCrae, 1992). However, a recent six-factor measure personality (the HEXACO), has been developed for adults (Lee & Ashton, 2018). This measure includes measures of five traits peripheral to those indexed by the FFM (Agreeableness, Conscientiousness, Emotionality, Extraversion, and Openness-to-Experience) as well as a novel, sixth, ‘Honesty-Humility’ factor. It has been suggested that this six-factor measure has incremental validity over the FFM for the understanding of the personality correlates of CP and CU traits in adolescence (or psychopathic traits in adulthood), due to its inclusion of ‘Honesty-Humility’, which measures the tendency to be fair and genuine when dealing with others. A six-factor measure of personality that includes a measure of Honesty-Humility may therefore add to understanding of the difficulties in social functioning of children with high levels of CP and

CU. Currently, however, no English language version of the HEXACO (an adult measure) exists that has been developed specifically for use with adolescents. Such a measure would enable a more comprehensive and nuanced exploration of how normal personality dimensions relate to CP and CU. To this end, Chapter 4 of this thesis aimed to validate an existing English language version of the HEXACO-60 (the 60-item version of the HEXACO; Ashton & Lee, 2009) for use with adolescents aged 11-16: the 'Adolescent HEXACO'. Exploratory and Confirmatory factor analyses (EFA and CFA respectively) confirmed the expected six-factor structure of our measure. Convergent validity analyses established that our measure converged with the expected traits measured in the Five Factor Model of personality (FFM; Costa & McCrae, 1992). We also found the relationships that we expected between Adolescent HEXACO measured traits and both CP and CU: CP was most strongly associated with, and best predicted by, low Agreeableness on the Adolescent HEXACO – indicating that high CP in adolescence relates to traits such as a critical nature, low cooperation with others, and being quick to anger. CU was both most strongly associated with, and best predicted by, low Emotionality – indicating that high levels of CU traits in adolescence relate to traits such as a reduced tendency towards anxiety/neuroticism, and emotional detachment from others. These findings were in line with prior research using the FFM & adult HEXACO measure with adolescents, and therefore further reinforced the validity of our measure (Bollmer et al., 2006; Heaven, 1996; Tackett, 2006). Moreover, inclusion of the novel sixth factor, Honesty-Humility, in regression models predicting CP (model 1) and CU traits (model 2) captured a significant degree of additional variance in these factors above the other five HEXACO factors.

Overall, this study adds an important measure to the battery available to researchers for examining CP and CU traits in adolescents. This measure can more fully capture personality profiles related to CP and CU through the assessment of six personality factors by including a measure of Honesty-Humility. The ability to obtain an accurate and comprehensive description of personality profiles of adolescents with high levels of CP and CU traits will arguably aid understanding of the development and persistence of CP, the nature of social functioning in these individuals, and aid in early detection of CP in non-clinical populations.

6.1.4 Chapter 5: Assessing the relationship between mind representation and callous-unemotional traits

Theory of mind (ToM) refers to the ability to understand others' beliefs, desires, and intentions (Premack & Woodruff, 1978). ToM is an important aspect of social and emotional processing in that it allows us to successfully navigate our social environments (Fonagy & Allison, 2012). High CU traits in adolescence are characterised by a lack of empathy, guilt, and remorse, and their presence is a risk factor for chronic CP (Frick & Marsee, 2018; Viding & Kimonis, 2018). High CU traits are also a marker of poor social functioning in community samples (Fontaine et al., 2010; Viding et al., 2009; Waller et al., 2020). Given this profile, one might expect high levels of CU traits to relate to impairments in ToM. However, research to date has produced mixed findings, with some studies observing intact ToM in adolescents with high CU traits (e.g. Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014; Schwenck et al., 2012), and others observing ToM impairments in this population (e.g. Anastassiou-Hadjicharalambous & Warden, 2008; Brouns et al., 2013; Pardini et al., 2003; Roberts et al., 2020; Sharp & Vanwoerden, 2014). Mixed findings may relate to the degree to which ToM measures require emotion processing (Anastassiou-Hadjicharalambous & Warden, 2008), or they may relate to an intact ability but reduced propensity (or motivation) in adolescents with high CU traits to engage in ToM under certain experimental conditions (Roberts et al., 2020). However, current measures of ToM lack the sensitivity to be able to explore individual differences in ToM ability. This limits our understanding of what might be driving diverse findings relating to ToM and high CU traits (Conway et al., 2019, 2020).

Conway et al. (2019) propose that individual differences in performance on current ToM tasks - typically pass or fail measures of one's ability to correctly infer others' mental states - are due to one or more of three factors. These are: (1) ability to accurately represent others' minds (or an accurate 'Mind-space'); (2) ability to accurately locate a target mind within one's Mind-space; and (3) propensity (or motivation) to locate minds within one's Mind-space, and the degree of effort needed to do so with precision. In support of (1), Conway et al. found that more accurate mind representation was associated with better performance on a measure of ToM that involves making mental state inferences in healthy adults via a novel measure of mental state representation – the Personality Pairs Task (PPT).

Mind representation ability in adolescence, and its relationship with CU traits, is yet to be explored and may give us more insight into conflicting findings in the literature. To this end, Chapter Five of the current thesis assessed the relationship between ToM and CU traits in a community sample of adolescents using an adolescent version of the Personality Pairs Task (the Adolescent PPT). We observed that higher levels of CU traits predicted better performance on the Adolescent PPT – in other words, adolescents with higher CU traits were *better* at representing others' minds in our sample. If adolescents with high CU traits are able to accurately represent others' minds (or have an intact 'Mind-space'), this suggests that their mixed performance on task-based experimental ToM measures (measures that assess ability to make mental state inference) might represent an inability or, perhaps more likely, a lack of motivation to accurately *locate* target minds within their representation of others’ minds. These findings help provide a more nuanced insight into ToM processing in adolescents with high CU traits and highlight important avenues for future research.

6.2 Limitations

It is important to consider a number of limitations when interpreting the findings presented in the current thesis. The first is the nature of our samples. In Chapters 2 and 3 (where we directly compared adolescents with CP/HCU, adolescents with CP/LCU and TD peers on measures of social cognition), we only included male adolescents. The first reason for this was that CP, as it is currently measured, is predominantly expressed in males and there is research suggesting that the aetiology of both CP and of CU traits differ for males and for females (Fontaine et al., 2010; Freitag et al., 2018). Moreover, investigating males and females would have significantly reduced our statistical power to detect group differences. For these reasons we decided to focus on males only. Naturally, it cannot be assumed that our findings in Chapters 2 and 3 would also apply to adolescent females with CP, or to those who identify as non-binary or transgender. Lack of research exploring similarities and differences among males and females with CP limits development of prevention and intervention programmes that meet the needs of adolescent females with CP (Freitag et al., 2018). It is thus very important that future research examines development, diagnosis, and social-cognitive functioning in this population.

We would also note that sample size for the study presented in Chapter 2 were constrained by the difficulty of working with a population that is challenging to recruit/engage in research, particularly during the COVID-19 pandemic when the recruitment efforts were severely disrupted. Although the sample size employed in this studies is comparable to or larger than many other studies in the field (e.g. Hodsoll et al., 2011; Roberts et al., 2020; Schwenck et al., 2012), replication is warranted. This is especially important when we consider the lack of other studies that directly compare CP/HCU, CP/LCU, and TD groups on measures of prosocial behaviour. Future work should also extend the current findings by including a broader battery of tasks. This would enable greater understanding of similarities and differences among adolescents with CP/HCU and CP/LCU in important social cognitive domains.

A third limitation of the current thesis is that three of our four studies were carried out fully (Chapters 4 & 5) or in part (Chapter 2) during the COVID-19 pandemic. This pandemic led to extended lockdowns when most schools were closed (or operating at reduced capacity) for long periods, resulting in a pause to in-person learning and to social connectivity for all of the participants in these studies. Research investigating the impact of lockdowns on adolescent mental health has found that periods of lockdown generally appear to have increased CP in this age group – especially in those who had existing neurodevelopmental disorders such as ADHD, which is commonly co-morbid with CP (Bentenuto et al., 2021; Nonweiler et al., 2020; Panchal et al., 2021). What is more, research with adults has shown that increased social isolation during the pandemic was associated with poorer performance on social cognition tasks, including reduced emotion recognition and reduced cooperative behaviour in economic trust games (Bland et al., 2022). It is thus important to consider the current findings in light of the exceptional circumstances under which the data were collected. This reinforces the need for the replication of our findings. However, where data collection was carried out in the pandemic, we endeavoured to collect representative samples of individuals for the studies reported. We also note that all participants would most likely have experienced similar impacts to their learning and social environments during the pandemic – an important consideration for our group comparison study. Additionally, we would like to point out that the data were collected once schools were open and running at full capacity (i.e. when lockdowns were lifted) so it can be assumed that the adolescents in our studies had returned to a fairly regular degree social contact at the time of testing.

On a practical level, as noted earlier, the COVID-19 pandemic also affected our recruitment opportunities for the current thesis. This led, for example, to our having to recruit participants for both EFA and CFA analysis for our large scale questionnaire validation study (Chapter 4) in a single recruitment effort. This also restricted our ability to validate the Adolescent Personality Pairs Task (Adolescent PPT; Chapter 5) by running it alongside the MASC task, a commonly used measure of ToM that was used to validate the adult PPT task. Inclusion of both the Adolescent PPT and the MASC task - which is both long and video-based - would have been too complex and time consuming for class-based administration by teachers.

The COVID-19 restrictions also meant that couldn't run the Adolescent PPT in a group comparison study with clinical samples of CP/HCU, CP/LCU, and TD adolescents – which was our original plan. This was due to the challenging behaviour of adolescents with CP, as well as the fact that CP is commonly co-morbid with ADHD symptoms (e.g. Thapar et al., 2001). It is unlikely that adolescents with CP – who can be difficult to engage in research, even in an in-person testing context - would have supported such a long study in an online format.

Despite these limitations, the novel findings in the current thesis have extended existing research in the field, and provide a basis for further research exploring social cognition in CP and CU.

6.3 Synthesis and future directions

CP in adolescence incurs large individual and societal costs. Despite the fact that CP in adolescence has been widely studied over the past decades, there is a relative dearth of investigation of the atypical social cognitive mechanisms that may contribute to CP and how these may differ between adolescents with CP/HCU, who are at increased risk of psychopathic personality disorder in adulthood, and those with CP/LCU, who present with less severe antisocial behaviour and do not display affective and interpersonal features that characterise psychopathy. Understanding similarities and differences between adolescents with CP is key to the design of effective intervention and behaviour management programmes that meet individual needs. Furthermore, broadening understanding of social cognition will help inform intervention programmes for children and adolescents with CP. This is particularly relevant, as many current programmes target these adolescents' social relationships despite the limited research in this domain (Pilling et al., 2013).

The current findings add to the literature in two key ways. First, by conducting two studies directly comparing adolescents with CP/HCU, CP/LCU, and TD peers on two important indices of social cognitive functioning: prosocial behaviour, and social information use (Chapters 2 and 3). Second, by using new and sensitive measures to look prosocial behaviour (Chapter 2), the personality correlates of CP and CU (Chapter 4) and the relationship between CU traits and mind representation (Chapter 5) in community samples of adolescents.

Collectively Chapters 2 and 3 provide new insight into similarities and differences among adolescents with CP/HCU and CP/LCU on two indices of social cognition that have received little to no prior research attention in these groups. Prosocial behaviour and antisocial behaviour are not considered two ends of a continuous behavioural spectrum. While in general CP in adolescence is associated with low prosocial behaviour, there are individual differences in the extent to which these adolescents are willing to engage in prosocial behaviours (Hawley, 2003; Kokko et al., 2006; Memmott-Elison et al., 2020). Chapter 2 adds to (limited) previous research indicating that the presence of high vs low CU traits is one useful way of indexing such individual differences. While adolescent boys with CP/HCU and CP/LCU in our study all chose prosocial options less frequently than TD boys, only those with CP/HCU put in markedly less prosocial effort than other groups. These findings are in line with previous research demonstrating that CP/HCU is associated with especially low prosocial behaviour across peer-, parent-, and teacher-report measures (Milledge et al., 2019). They are also in line with the low prosocial behaviour relative to peers that adolescent boys with CP/HCU have demonstrated on experimental measures of prosocial behaviour (Sakai et al., 2012, 2016). Additionally, our findings provide preliminary evidence that it is a reduced willingness to put in prosocial effort that distinguishes adolescents with CP/HCU from CP/LCU peers.

This raises some interesting questions about the behavioural profile of CP/HCU and the role of motivation in building good social connections. Adolescents with CP/HCU are characterised by particularly severe and instrumental aggressive behaviour, as well as by reduced or atypical social affiliation (Frick & Marsee, 2018; Viding & McCrory, 2019; Waller et al., 2020). Recent evidence suggests that atypical social engagement in CP/HCU might (at least in part) be related to a reduced propensity - as opposed to a reduced ability - to engage in behaviours that might promote social relationships, such as taking another’s perspective (Roberts et al., 2020). The current findings provide tentative further support for this proposition. Adolescents with CP/HCU are clearly able to put in effort for others, as evidenced by the fact that they are doing so for themselves in our study. However, they appear to be less motivated to put in effort on behalf of others than they are to put in effort for themselves. This indicates that, as well as possibly having a reduced propensity to take others' perspectives, adolescents with CP/HCU may also show a reduced propensity to engage in prosocial choice and effort – especially in conditions where there is no personal incentive to do so (such as in our experiment). If replicated, our results highlight a future avenue for research: examining a reduced propensity in adolescents with CP/HCU to engage in behaviours that promote social affiliation, and exploring whether this reduced propensity affects the quality of social relationships in this group. Speculatively, a reduced propensity to engage in behaviours that promote social affiliation becomes especially interesting if considered in association with our finding of apparently intact social information use in adolescents with CP/HCU (Chapter 3). Intact social understanding might, when combined with a reduced propensity to engage in behaviours that promote social affiliation and an impaired ability to understand others distress, be one reason why adolescents with CP/HCU are able to engage in severe aggression. This combination of characteristics may also contribute to these adolescents' shallow affiliations, as well as their capacity to engage in manipulative behaviour (Kerig & Stellwagen, 2010; Viding & McCrory, 2019; Waller et al., 2020).

Chapter 4 was designed to broaden our understanding of the traits and characteristics associated with CP and CU via the development of novel and more nuanced measure personality measure for adolescents. There is strong evidence that a six-factor model of personality, including measurement of an individuals' Honesty-Humility (or tendency towards fairness and authenticity) has incremental validity for capturing variance in CP and CU traits over existing five factor models (e.g. de Vries et al., 2020; Lee & Ashton, 2012;

Međedović, 2017, Costa & McCrae, 1992; although see also Lynam et al., 2020). This scale, the HEXACO, has been widely used in normal and forensic samples of adults (e.g. de Vries et al., 2020; Lee & Ashton, 2012; Međedović, 2017).

However, our understanding of the utility of the HEXACO measure for understanding CP/CU in adolescence has been limited by the fact that research to date (at least research carried out in English speaking populations) has either used the adult version of the measure (Ashton & Lee, 2007; Ashton & Lee, 2009; Book et al., 2012; Dane et al., 2018; Farrell et al., 2014; Farrell & Volk, 2017; Mularczyk et al., 2020; Volk et al., 2018), or a translated version of an adolescent measure that (to our knowledge) has yet to be validated in English (Spadafora et al., 2020). Employing HEXACO measures that were designed for, and validated with, adult populations in adolescent studies, or measures that were validated in a language not spoken by study the participants, risks generating unreliable personality profiles and limits the interpretation of the findings of these studies. In Chapter 4, we addressed this gap in the battery of personality assessments available for use with adolescents through our development and validation of the Adolescent HEXACO, which gave us new insight into HEXACO traits in adolescence and their relation to CP and CU. Our results highlighted that a six-factor personality measure that captures Honesty-Humility has incremental validity over previous measures for the understanding of CP and CU. Our results also indicate that the way in which the HEXACO conceptualises Agreeableness and Emotionality personality factors may be more suitable for understanding CP and CU in adolescence than the conceptualisation of their similar, but distinct, counterparts in the FFM (which are Agreeableness and Neuroticism). Whereas previous studies using the FFM tended to find Agreeableness or Conscientiousness to relate most strongly to CU traits, we found that HEXACO Emotionality was the strongest predictor of CU traits in our sample. This is in line with the finding of Mularczyk et al. (2020) who observed Emotionality to be the strongest canonical correlate of CU traits. We also found that Agreeableness was the strongest predictor of CP in our sample, in line with prior research using the adult version of this measure with adolescents (e.g. Romero & Alonso, 2017). Therefore, another strength of the HEXACO may be that it more sensitively captures variance in personality that relate to CU and CP specifically. Future research that uses the Adolescent HEXACO to investigate personality correlates of CP and CU in adolescence could broaden our understanding of these factors and could extend our understanding of atypical social functioning in adolescents with CP and CU traits.

Chapter 5 was designed to broaden our understanding of the relationship between CU traits and ToM in adolescence. Specifically, we wished to gain further insight into individual differences among adolescents in ToM through the development of a novel measure: the Adolescent Personality Pairs Task (Adolescent PPT) and to examine its relationship with CU traits. Prior research has generated mixed findings regarding this relationship – with some task-based experimental studies observing intact ToM in adolescents with high CU traits and some observing ToM impairments in these adolescents (Anastassiou-Hadjicharalambous & Warden, 2008; O'Nions et al., 2014; Roberts et al., 2020; Sharp & Vanwoerden, 2014). However, these studies have all employed 'pass or fail' ToM tasks that require participants to make mental state inferences (i.e. correctly indicate what a given character would be thinking in a certain scenario). It has been suggested that one way to understand individual differences in performance on ToM measures that assess the ability to make mental state inferences is to examine individuals' ability to represent others' mental states (suggested to underlie the generation of these mental state inferences; Conway et al., 2019, 2020). The aim of Chapter 5 of the current thesis was thus to examine mind representation ability in relation to CU traits in a mixed gender community sample of adolescents aged 11-16 using the Adolescent PPT. High CU traits in adolescence were associated with better mind representation in our sample, indicating that mixed prior findings might be related to an inability or, perhaps more likely, a low motivation of adolescents with high CU traits to locate others' minds within their Mind-space.

Chapters 4 and 5 of this thesis both advance our understanding of CP and CU in adolescence through the development and use of more sensitive measures to examine both personality and ToM. These measures give us more nuanced insight into the characteristics of CP and CU traits in adolescence, as well as insight into the way in which adolescents with high CU traits process information about other minds. Having shown good performance in community samples of adolescents, these measures should now be used to explore personality and mind representation in clinical samples of adolescents with CP/HCU and CP/LCU relative to TD adolescents.

Overall, this thesis has important implications for future research with adolescents with CP. The first is the clear importance of recognising heterogeneity in this vulnerable group. Of course, there are many ways in which adolescents with CP might differ from one another. However, Chapters 2 and 3 add to the considerable evidence demonstrating the importance of considering levels of CU traits in adolescents with CP – both in research and in treatment. We demonstrated that adolescents with CP/HCU and those with CP/LCU differ on important indices of social cognition. Those with CP/HCU showed especially low prosocial effort on our prosocial effort task, whereas those with CP/LCU performed similarly to TD adolescents. Those with CP/LCU demonstrated atypical strategies when using social information relative to TD adolescents, while those with CP/HCU did not show this same difference. In conjunction with prior research showing that adolescents with CP/HCU and CP/LCU differ on important neurocognitive and behavioural correlates, the work reported in these chapters provide yet more impetus for person-centred research that accounts for CU traits in CP. Ignoring this heterogeneity will inevitably lead to interventions and treatment programmes that will not be suitable for a portion of the population that they are designed to help.

A second implication of this thesis is that further research should target motivation in relation to CP/HCU. We have demonstrated apparently intact ability in this group to process social cognitive information across several indices. However, the behaviour of these adolescents does not reflect this. Adolescents with CP/HCU are characterised by difficult social relationships, behaviour that harms others and violates social norms, and a reduced interest in affiliating with others (Viding & McCrory, 2018). In the current thesis, we showed that these adolescents were able to make effort when this effort was in their own benefit, and yet were less willing to put as much effort in for other people then were adolescents in CP/LCU and TD groups. We also demonstrated that adolescents with CP/HCU do not differ from CP/LCU and TD adolescents in the extent to which they use social information, despite prior research indicating that they commonly prioritise their own goals (e.g. dominance) over those that will benefit others in social scenarios (Pardini, 2011). Finally, we showed that higher CU traits are associated with better ability to understand how others' minds vary, again despite their being associated with a reduced interest in social affiliation and a willingness to violate social norms (Viding & McCrory, 2018). Collectively, this implies that adolescents with CP/HCU may have a reduced motivation to engage in social cognitive processing – perhaps especially when it does not meet their own social goals. Further research that explicitly tests motivation to engage in social cognitive processing in relation CP/HCU could, therefore, be extremely useful in understanding how social relationships might derail in this group as well as what adolescents with CP/HCU require from behavioural intervention.

A third implication of this thesis is the need for nuanced and sensitive measures to understand CP and CU traits in adolescence. With the exception of Chapter 4, the studies in this thesis were developed to provide tools for more nuanced investigation of social cognitive processing in areas where (i) current tasks could be argued to lack ecological validity (i.e. prosocial behaviour), (ii) where few tasks exist to examine the process of interest (i.e. social information use), or (iii) where findings are mixed (i.e. ToM). Chapter 4 is the exception as personality characteristics have been extensively examined in adolescence and a variety of measures to assess these already exist. While this is the case, I would argue that the HEXACO shows clear improvement over these existing measures. The HEXACO was developed using lexical analysis of personality structure, the same technique as the current most popular personality measure in the field (the FFM). However, in contrast with the developers of the FFM (Costa & McCrae, 1992), the developers of the HEXACO (Ashton & Lee, 2007) included words from a large variety of languages in their analysis and not just English. The developers of HEXACO also included a larger set of English words in their analysis than did the developers of the FFM. The fact that six factors have been reliably recovered from this procedure is strong evidence in favour of the suitability of the HEXACO for the study of personality. What is more, research in the adult literature has consistently demonstrated the utility of this measure for understanding antisocial behaviour. Therefore, I would argue that the development of this measure for adolescents is of overall benefit to the field – and in particular the study of CP/CU - despite the number of measures that already exist.

6.4 Clinical and practical considerations

Findings from Chapters 2 and 3 shed new light on social cognitive processes in adolescents with CP/HCU and CP/LCU. If these findings are replicated, they have implications for intervention and behaviour management programmes and in how approaches of help are tailored for those with high vs low CU traits (see below). Furthermore, Chapters 4 and 5 provide new and more sensitive measures that can be used for empirical research. If used with clinical populations, these new measures have the potential to provide an evidence base that can further inform intervention and behaviour management programmes. This is especially important when we consider that many current interventions for adolescents with CP target these individuals' social relationships, despite there still only being a relatively limited research base exploring how they process social information (Pilling et al., 2013; Viding & McCrory, 2019). Reduced social competencies and social information processing biases in CP are well documented (Crick & Dodge, 1994; Webster-Stratton & Lindsay, 1999), but the precise information processing mechanisms that underlie these difficulties, and how these might vary with high vs low levels of CU traits, are less well understood.

Our findings imply that relationships of adolescents with CP may be impacted by a reduced willingness to choose to engage in prosocial acts, perhaps especially when these adolescents stand nothing to gain personally from choosing to behave prosocially. They further imply that an especially low motivation to engage in prosocial actions in adolescents with CP/HCU, which again could have an impact on social relationships. Future investigations that can investigate how these facets of prosocial behaviour can be promoted in adolescents with CP - and the degree to which they impact social relationships - may inform and advance current treatment programmes that seek to encourage these behaviours. For example, adolescents with CP/LCU, who appear to have typical levels of empathy with others, might be encouraged to choose prosocially by highlighting the positive impact that this would have on their peers. Adolescents with CP/HCU might be encouraged to engage in increased prosocial choice and prosocial actions through reward and positive reinforcement of these behaviours (shown to improve behaviour in other domains in this population - see Hawes et al., (2014) for a review), or perhaps by highlighting the personal benefits that they might incur by doing so. Our findings from Chapter 3 suggest that behaviour management programmes could consider the role of encouraging a 'middle ground' approach in adolescents with CP/LCU when they interact with others, and that they would potentially benefit from an approach that promotes greater flexibility in social problem-solving, especially when receiving feedback that challenges their existing beliefs. The benefits that encouraging such behaviour might have is supported by evidence that interventions that target social problem solving (among other social emotional skills) in children with CP have the best outcomes (Hawes et al., 2014), as well as studies demonstrating that social problem solving training appears to have a selective benefit for behaviour in adolescents with CP/LCU (Haas et al., 2011).

Chapters 4 and 5 were carried out in community samples of adolescents and, as a result, strong implications for clinical treatment for CP/HCU and CP/LCU cannot be derived from these studies. However, our findings from Chapter 4 – which mirror previous findings in the field - imply that especially low Agreeableness may be a subclinical marker of risk for CP, and low Emotionality a marker for low CU traits. Being low in Agreeableness and in Emotionality (as well as being low in Honesty-Humility, which was also seen in relation to both CP and CU in our sample) might plausibly also have impacts on social functioning of adolescents and thus represent a possible target for interventions in CP. Future work with adolescents with CP/HCU and CP/LCU will help us to learn about how personality traits, as measured by our newly validated Adolescent HEXACO, relate to behaviour in clinical populations. Future work should also use our newly developed PPT to assess mental state representation in adolescents with CP/HCU and CP/LCU relative to TD peers.

One important consideration when we think about clinical implications of our research, which has yet to be discussed in the current thesis, is whether we should be aiming to treat adolescent CP by trying to get these individuals to adapt to their social environments, or whether we should instead be trying to adapt environments to reduce any impairment or distress that they are experiencing that may contribute to their behaviour (Sonuga-Barke, Edmund, & Thaper, 2021). The research in the current thesis does not favour either approach to treatment. Rather, this research aims to add to the evidence base that clinicians can use to inform the approach to treatments. Indeed, many treatment approaches to CP are multi-faceted - for example involving changes to parenting and teaching practices in order to help those with CP (i.e. environmental adaptation) (e.g. Pilling et al. 2013). Research studies such as those carried out in this thesis could help to inform these kinds of approaches.

6.5 Conclusions

The current thesis was conducted with the broad aim of advancing current understanding of social cognition in relation to CP and CU traits in adolescence. We conducted two experimental studies directly comparing adolescents with CP/HCU and CP/LCU on two key measures of social cognition: prosocial behaviour and social information use. We found that adolescents with CP/HCU and adolescents with CP/LCU show reduced prosocial choice relative to TD adolescents. We further showed that adolescents with CP/HCU demonstrate especially reduced prosocial effort relative to both CP/LCU and TD peers. These findings are in line with previous research indicating more pronounced reductions in prosocial behaviour in adolescents with CP/HCU, and reinforce the importance of acknowledging heterogeneity among adolescents with CP. In terms of social information use, we found that adolescents with CP/LCU differed from adolescents with CP/HCU and TD adolescents in the strategies they used to incorporate social information into their already held beliefs. Adolescents with CP/LCU were significantly less likely to compromise with others' feedback, and they appeared more likely to stick with their initial judgement. These findings reflect previous evidence that CP/LCU is associated with poorer and less flexible social problem solving. As well as conducting these two studies in the clinical domain, we also conducted two further studies that developed new measures to assess personality and mind representation in adolescents. These measures allowed exploration of the relationship between personality and both CP and CU traits, and relationship between mind representation and CU traits, in community samples of adolescents. Here we identified (1) that including measurement of a sixth personality factor, Honesty-Humility, in assessments of adolescent personality improves prediction of CP and of CU traits above over and above the variance captured by the standard FFM traits, (2) that low Agreeableness is the best predictor of CP in adolescents, (3) that low Emotionality is the best predictor of low CU in adolescents, and (4) that higher levels of CU traits are associated with better representation of other people's minds.

Future research should use our newly developed measures to capture personality profiles and mind state representation in clinical populations of adolescents with CP/HCU and CP/LCU. The current findings regarding prosocial behaviour and social information use in adolescents with CP/HCU and CP/LCU should also be extended in future studies through assessment in under more ecologically valid conditions – such as looking at prosocial behaviour in these groups in situations where participants stand to gain, or looking at social information use when this information comes from known others or has affective content. It would also be of relevance to explore the relationships between metrics of these tasks and real life indices of social behaviour such as friendship quality. Finally, future research should explore whether the group level findings in Chapters 2 and 3 extend to adolescent females with CP.

Overall, this thesis extends current understanding of social cognition and personality features of CP and CU traits in adolescence. Through four empirical studies, we build a clearer picture of prosocial behaviour and social information use in adolescents with CP/HCU and with CP/LCU, as well as developing two new measures that enable a more nuanced insight into personality and ToM in adolescent populations (including - in the future - adolescents with CP/HCU and CP/LCU). Our findings not only address the dearth of research that has been conducted in the domain of social information process in adolescent CP, but they also lay the groundwork for future studies that can help build a clearer picture of the behaviour and characteristics of adolescents CP/HCU and CP/LCU. If replicated, our findings can be used to inform interventions and behaviour management programmes that meet the individual needs of adolescents with CP.

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Appendix 1.1 – Covariate analyses

Models with IQ and Age as covariates

Choice model with IQ and Age as covariates – specification

Specification of Generalised Linear Mixed Model predicting choice with IQ and Age included as covariates (for more details on choice model specification, see Appendix 1.3):

Choice ~ Group*Effort + Group*Reward + Group * Recipient +

Recipient *Effort + Recipient * Reward + Age + IQ + (1|ID)

Optimiser = bobyqa; optCtrl=list(maxfun=2e5).

Choice model with IQ and Age as covariates – results

	Chisq	*Df*	*Pr(>Chisq)*
Group	0.03	2	0.98274
Effort	360.55	1	< 2e-16 ***
Reward	38.30	1	6.1e-10 ***
Agent	778.86	1	< 2e-16 ***
Age	0.00	1	0.94893
IQ	0.07	1	0.79181
*Group*Effort*	30.41	2	2.5e-07 ***
*Group*Reward*	14.04	2	0.00090 ***
*Group*Recipient*	10.23	2	0.00599 **
Effort Recipient*	30.69	1	3.0e-08 ***
Reward Recipient*	10.94	1	0.00094 ***

Analysis of Deviance (Type II Wald test) of generalised mixed linear model predicting choice data, including Age and IQ as covariates – these did not significantly contribute to the model.

K parameter model with IQ and Age as covariates – specification

Specification of Beta Regression Model predicting choice with IQ and Age included as covariates (for more details on choice model specification, see Appendix 1.3):

K ~ Group*Recipient(Other) + Age + IQ, K=2, random = ~ Recipient(Other)|ID, sigma.fo = ~ Group* ~ Recipient(Other) + IQ + Age + MASS *~ Recipient(Other)

Force model with IQ and Age as covariates – specification

Specification of Linear Mixed Model predicting force with IQ and Age included as covariates (for more details on choice model specification, see Appendix 1.3):

Force ~ Group*Effort + Group*Reward + Group * Recipient +

Recipient *Effort + Recipient * Reward + Age + IQ + (1|ID)

Force model with IQ and Age as covariates – results

	Chisq	*Df*	*Pr(>Chisq)*
Group	6.91	2	0.03 *
Effort	1608.03	1	< 2e-16 ***
Reward	27.78	1	1.4e-07 ***
Agent	113.12	1	< 2e-16 ***
Age	0.92	1	0.34
IQ	0.73	1	0.39
*Group*Effort*	19.19	2	6.8e-05 ***
*Group*Reward*	0.56	2	0.76
*Group*Agent*	28.02	2	8.2e-07 ***
*Effort*Agent*	7.68	1	0.0056 **
*Reward*Agent*	2.55	1	0.11

Analysis of Deviance (Type II Wald test) of linear mixed model predicting force data, including Age and IQ as covariates – these did not significantly contribute to the model.

Appendix 1.2 Models with measures of behavioural/emotional problems as covariates

Choice model with measures of behavioural/emotional problems as covariates – Specification

Specification of Generalised Linear Mixed Model predicting choice with Hyperactivity, Peer problems and Emotional Problems (behavioural and emotional symptoms which significantly differed between groups) included as covariates (for more details on choice model specification, see Appendix 1.3):

Choice ~ Group*Effort + Group*Reward + Group * Recipient +

Recipient *Effort + Recipient * Reward + Hyperactivity + Peer problems + Emotional Problems + (1|ID)

Choice model with measures of behavioural/emotional problems as covariates – Results

	Chisq	*Df*	*Pr(>Chisq)*
Group	0.09	2	0.96
Effort	360.53	1	< 2e-16 ***
Reward	38.31	1	6.0e-10 ***
Recipient	779.60	1	< 2e-16 ***
Hyperactivity	0.00	1	0.95
Peer Problems	0.75	1	0.39
Emotional Problems	3.63	1	0.06 .
*Group*Effort*	30.68	2	2.2e-07 ***
*Group*Reward*	14.10	2	0.00087 ***
Group Recipient*	10.01	2	0.00670 **
Effort Recipient*	30.63	1	3.1e-08 ***
Reward Recipient*	10.93	1	0.00095 ***

Analysis of Deviance (Type II Wald test) of generalised mixed linear model predicting choice data, including hyperactivity, peer problems, and emotional problems as covariates – these did not significantly contribute to the model.

Force model with measures of behavioural/emotional problems as covariates – Specification

Specification of Linear Mixed Model predicting force with Hyperactivity, Peer problems and Emotional Problems (behavioural and emotional symptoms which significantly differed between groups) included as covariates (for more details on choice model specification, see Appendix 1.3):

Force ~ Group*Effort + Group*Reward + Group * Recipient +

Recipient *Effort + Recipient * Reward Hyperactivity + Peer problems + Emotional Problems + (1|ID)

Force model with measures of behavioural/emotional problems as covariates – Results

	Chisq	*Df*	*Pr(>Chisq)*
Group	2.17	2	0.34
Effort	1608.70	1	< 2e-16 ***
Reward	27.79	1	1.4e-07 ***
Recipient	112.79	1	< 2e-16 ***
Hyperactivity	0.01	1	0.92
Peer Problems	0.22	1	0.64
Emotional Problems	0.12	1	0.73
*Group*Effort*	19.31	2	6.4e-05 ***
*Group*Reward*	0.56	2	0.75
Group Recipient*	28.06	2	8.1e-07 ***
Effort Recipient*	7.68	1	0.01 **
Reward Recipient*	2.55	1	0.11

Analysis of Deviance (Type II Wald test) of linear mixed model predicting force data, including hyperactivity, peer problems, and emotional problems as covariates – these did not significantly contribute to the model.

Appendix 1.2 – Model specification and model diagnostics

Choice Model

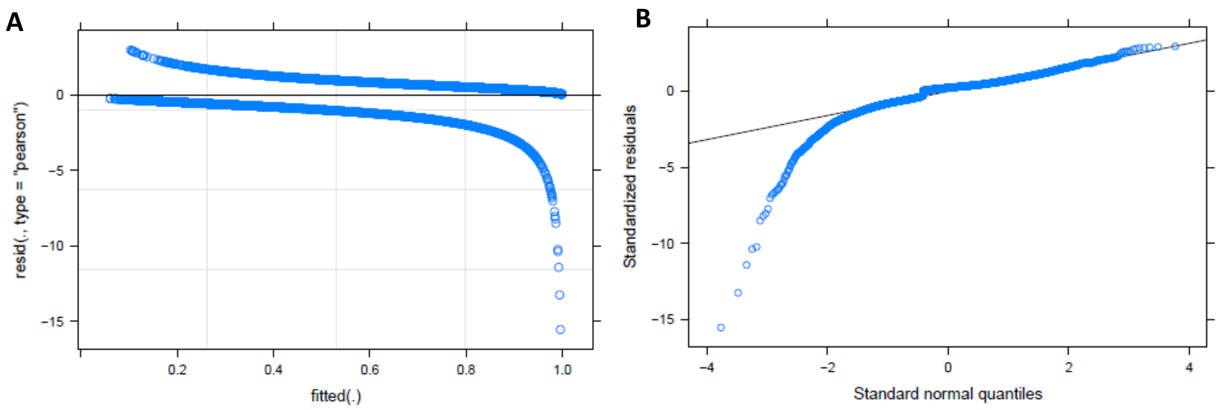
<u>*Model specification*</u>

A logistic regression model, testing whether participants' choice on each trial (coded as 1 for the effortful option or 0 for the rest option) was influenced by the following fixed factors: group (1: CP/HCU, 2: CP/LCU, 3: TD), Recipient (1: self, 2: other), Effort (included as a continuous variable, ranging from 2-5), and Reward (include as a continuous variable, ranging from 2:4). The model also included a subject level random intercept. Two-way interactions were included between all fixed factors except for that between Effort and Reward, as these varied independently in the experiment. The model was specified in R as follows:

Choice ~ Group*Effort + Group*Reward + Group * Recipient +
Recipient *Effort + Recipient * Reward + (1|ID),
Family = binomial

Optimiser = bobyqa; optCtrl=list(maxfun=2e5).

Model Diagnositics



Plots A. and B. are fitted vs residual and qq plots respectively, demonstrating that the residuals of our choice model deviate from the assumptions of linearity and normal distribution of residuals. Linear Mixed Effects models have been demonstrated to be robust against deviations in distributional assumptions (e.g. Schielzeth et al. 2020), we therefore consider this model appropriate for our data. A Levene test revealed no homoscadicity of residuals (F(2, 5994) = 1.73, p = 0.18).

K (Discounting parameter) Model

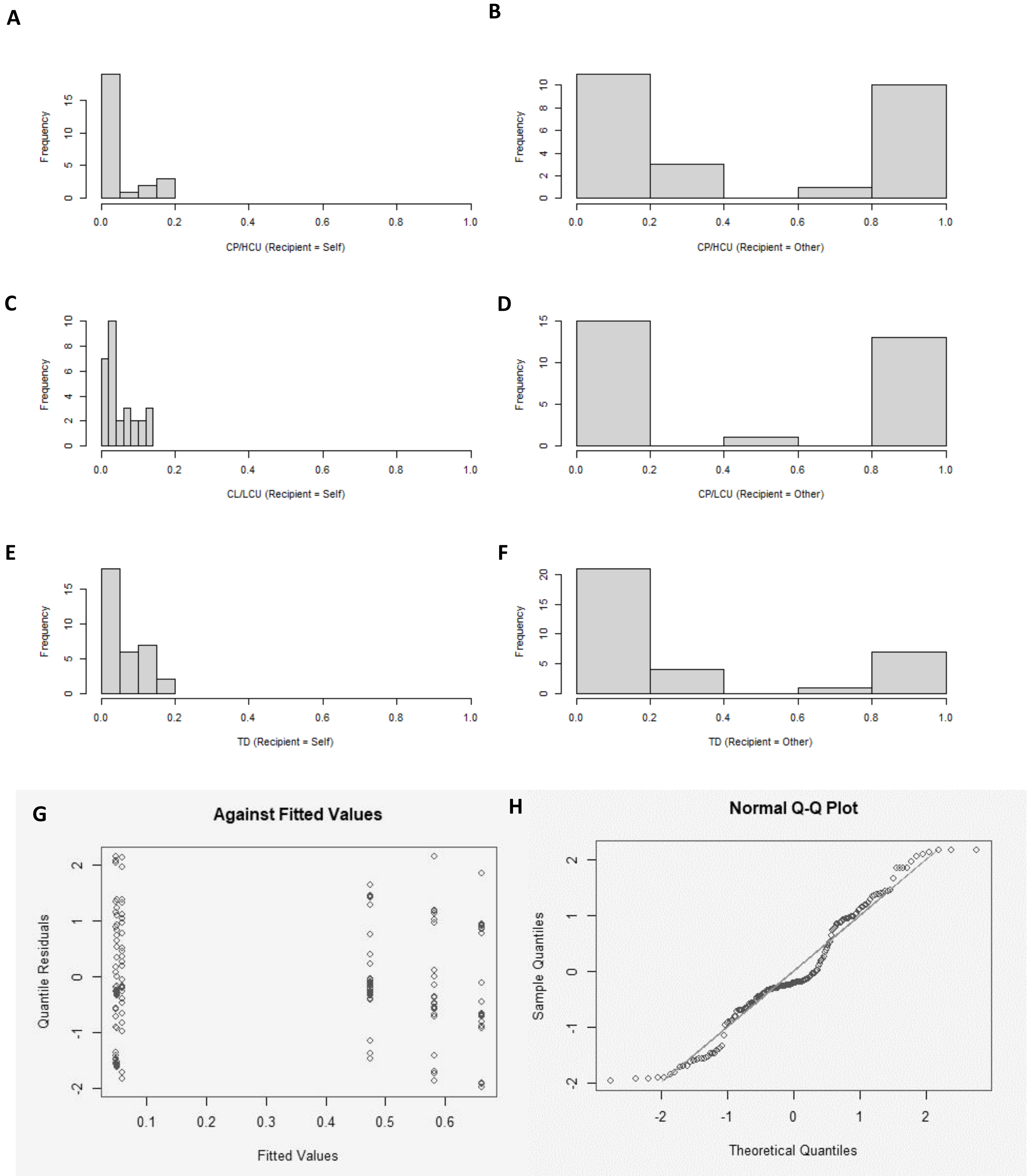
Model specification

A mixed effect beta regression model testing whether reward discounting by effort (K) differed by group and by Recipient. The model contained two latent groups that defined random intercepts and slopes for the mean, and had a minimal model for the variance inflation, containing only Agent and a random intercept term.

K ~ Group*Recipient(Other), K=2, random = ~ Recipient(Other)|ID, sigma.fo = ~ Group* ~ Recipient(Other) + MASS *~ Recipient(Other)

Mixture = np, family = BE.

Model Diagnositics



Plots A – F represent distribution of K parameters for self and other by group. This demonstrates that these distributions differ based on whether the recipient is the self or the other. Plots G and H are fitted vs residual and qq plots respectively. These demonstrate that residuals are linear and roughly normally distributed. CP/HCU – conduct problems and high callous-unemotional (CU) traits; CP/LCU = conduct problems and low CU traits, TD = typically developing.

Appendix 2.3 Force Model

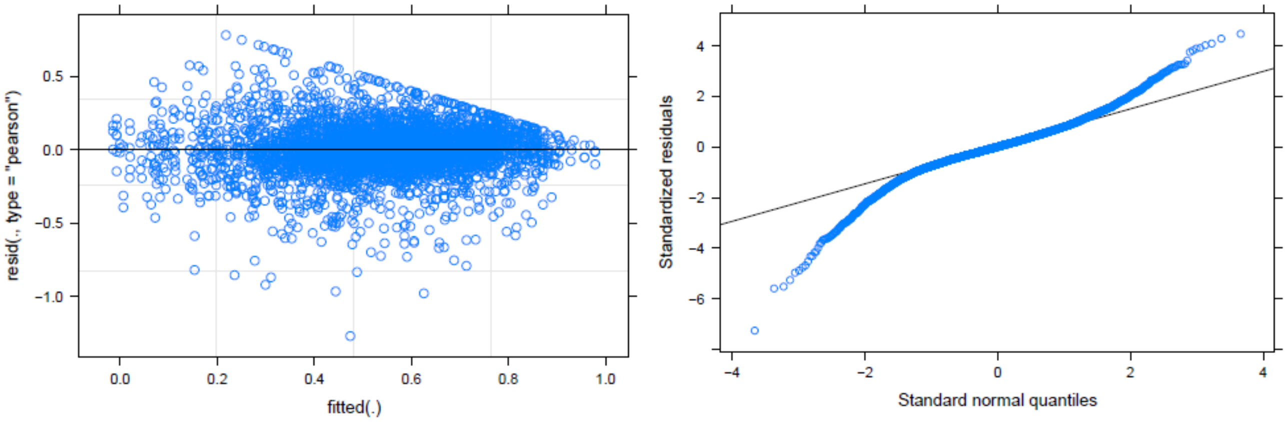
Model specification

A linear mixed effects model, testing whether participants' force exerted was influenced by the following fixed factors: group (1: CP/HCU, 2: CP/LCU, 3: TD), Recipient (1: self, 2: other), Effort (included as a continuous variable, ranging from 2-5), and Reward (include as a continuous variable, ranging from 2:4). The model also included a subject level random intercept. Two-way interactions were included between all fixed factors except for that between Effort and Reward, as these varied independently in the experiment. The model was specified in R as follows:

Force ~ Group*Effort + Group*Reward + Group * Recipient +

Recipient *Effort + Recipient * Reward + (1|ID)

Model Diagnositics



Plots A. and B. are fitted vs residual and qq plots respectively, demonstrating that the residuals of our force model are linear and roughly normally distributed. A Levene test revealed heteroscadicity of residuals (F(2, 3957) = 65.49, p = <.001), however Linear Mixed Effects models have been demonstrated to be robust against deviations in distributional assumptions (e.g. Schielzeth et al. 2020), we therefore consider this model appropriate for our data.

Appendix 1.3 – Choice and force models including three way interaction terms

	Chisq	*Df*	*Pr(>Chisq)*	*Chisq*	*Df*	*Pr(>Chisq)*
Group	0.03	2	0.98	4.45	2	0.12
Recipient	776.82	1	< 2.2e-16 ***	106.06	1	< 2.2e-16 ***
Effort	361.46	1	< 2.2e-16 ***	2097.50	1	< 2.2e-16 ***
Reward	38.12	1	6.640e-10 ***	41.22	1	1.362e-10 ***
Group Recipient*	10.26	2	0.0059236 **	20.69	2	3.216e-05 ***
*Group*Effort*	30.26	2	2.688e-07 ***	31.20	2	1.676e-07 ***
*Recipient*Effort*	30.71	1	2.997e-08 ***	11.89	1	0.0005638 ***
*Group*Reward*	13.83	2	0.0009951 ***	0.35	2	0.84
*Recipient*Reward*	10.65	1	0.0010982 **	1.14	1	0.29
*Group*Recipient*Effort*	1.25	2	0.54	2.95	2	0.23
Group Recipient*Reward*	0.75	2	0.69	4.30	2	0.12

Analysis of Deviance (Type II Wald test) of generalised mixed linear model predicting choice and linear mixed model predicting force data. Models include three-way interactions between: (1) Group, Recipient, and Effort, and (2) Group, Recipient, and Reward.

Appendix 1.4 – Force model including negative curve

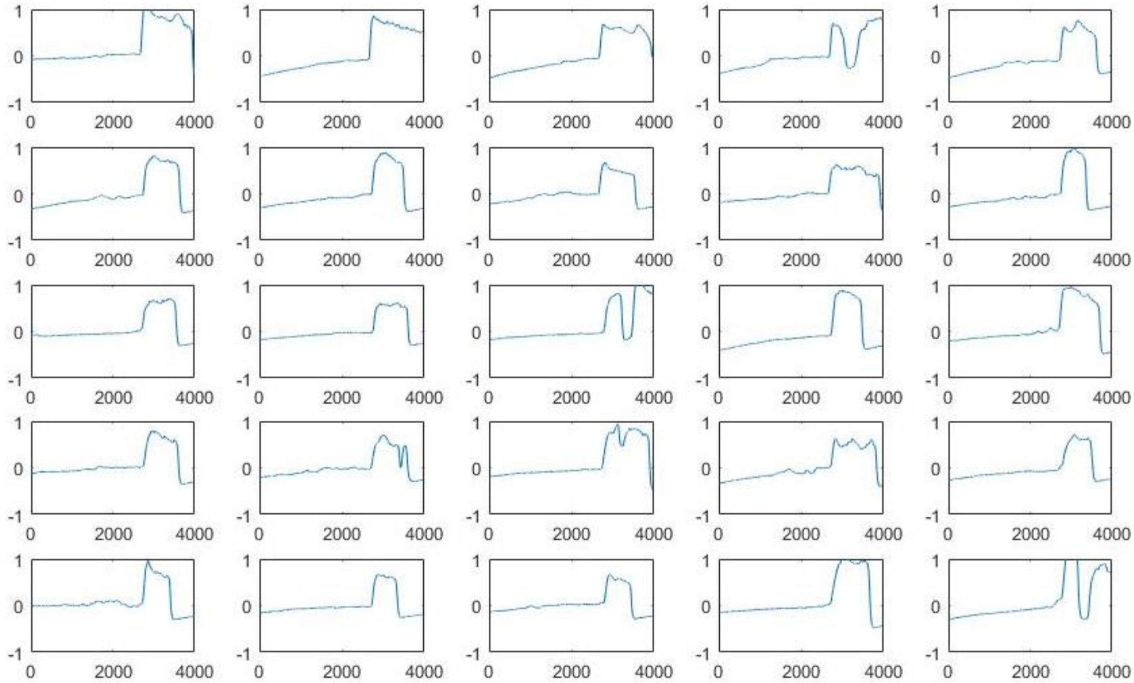


Figure demonstrating calibration issues for subset of raw force traces for one participant. It can be observed that the trace does not start from 0 at the beginning of each trial (as it should do). However, it can also be observed that the trace has always returned to 0 by the time the participant begins making effort (at around 3000 ms).

When the full force curves for each participant are included in analysis (including negative variance in force the resulted from equipment error) we still observe a significant interaction between group and recipient ($\chi2$ (2, N = 87) = 28.13, $p < 0.001$): the CP/HCU group exerted significantly less effort on behalf of the other relative to the self when compared to both the TD ($p<.0001$) and the CP/LCU ($p = 0.0002$) groups. We also observed a significant interaction between group and effort ($\chi2$ (2, N = 87) = 19.24, $p < 0.001$). The TD group showed a steeper increase in force as effort required increased relative to both CP/HCU ($p = 0.0001$) and CP/LCU ($p = 0.003$) groups. No interactions were seen between group and reward ($p = 0.76$), or recipient and reward ($p = 0.11$). We also saw main effects of recipient ($\chi2$ (1, N = 87) = 779.02, p <.001), effort ($\chi2$ (2, N = 87) = 360.56, p <.001), and reward ($\chi2$ (1, N = 87) = 38.30, p <.001).

The only difference in our findings is that a significant main effect of group was observed ($\chi2$ (2, N = 87) = 9.52, p = 0.14), whereby it appears that both CP/HCU and the CP/LCU groups put in significantly less force across all levels of recipient, effort, and reward than the TD group did (CP/HCU vs TD – p = 0.02; CP/LCU vs TD – p = 0.02) (see Figure S1). No overall difference in force was observed between CP/HCU and CP/LCU groups (p = 1.00). It is likely that this group difference in force exerted (only seen when data include negative force variance) is due equipment error occurring only during some testing sessions at some schools (CP and TD groups were largely sampled from different schools). This is something we are investigating further.

Appendix 1.5 – Full model summaries (choice and force data)

	Model 1: Choice			Model 2: Force		
Predictors	*Odds Ratios*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	1.17	0.75 – 1.84	0.492	0.17	0.10 – 0.23	<0.001
Group CP/HCU)	0.76	0.38 – 1.52	0.436	-0.03	-0.13 – 0.06	0.480
Group (CP/LCU)	0.81	0.41 – 1.57	0.524	-0.04	-0.13 – 0.05	0.339
Effort	0.46	0.41 – 0.52	<0.001	0.11	0.10 – 0.12	<0.001
Reward	1.28	1.14 – 1.44	<0.001	0.01	-0.00 – 0.02	0.138
Recipient (Self)	7.01	5.53 – 8.88	<0.001	-0.04	-0.10 – 0.01	0.115
Group (CP/HCU) * Effort	1.56	1.31 – 1.85	<0.001	-0.03	-0.04 – -0.01	<0.001
Group (CP/LCU) * Effort	1.43	1.21 – 1.69	<0.001	-0.02	-0.03 – -0.01	0.001
Group (CP/HCU) * Reward	0.91	0.77 – 1.08	0.284	-0.00	-0.02 – 0.01	0.705
Group (CP/LCU) * Reward	0.74	0.63 – 0.87	<0.001	0.00	-0.01 – 0.02	0.679
Group (CP/HCU) * Recipient (Self)	1.62	1.13 – 2.33	0.009	0.08	0.05 – 0.11	<0.001
Group (CP/LCU) * Recipient (Self)	1.64	1.15 – 2.32	0.006	0.02	-0.01 – 0.05	0.181
Effort * Recipient (Self)	0.67	0.58 – 0.77	<0.001	0.01	0.00 – 0.03	0.006
Reward * Recipient (Self)	1.26	1.10 – 1.45	0.001	0.01	-0.00 – 0.03	0.111
Random Effects						
σ^2	3.29			0.03		
τ_{00}	1.60 $_{ID}$			0.02 $_{ID}$		

ICC	0.33	0.34
N	87 $_{ID}$	87 $_{ID}$
Observations	5997	3960
Marginal R^2 / Conditional R^2	0.288 / 0.520	0.261 / 0.512

Table summarising estimates from mixed model analyses of choice and force data. Model 1: Generalised Linear Mixed Effects Model fitted to participants' choices to accept (coded as 1) or reject (coded as 0) the more effortful option on a particular trial by: group, effort level, reward, and recipient with subject include as a random factor. The model includes two-way interactions between all variables. Model 2: Linear Mixed Effects Model fitted to participants' force exerted by: group, effort level, reward, and recipient with subject include as a random factor. The model includes two-way interactions between all variables. . σ^2 = residual variance, τ00 = random slope (between-group) variance. ICC = Intraclass-correlation. N = number of participants. CP/LCU conduct problems and low levels of callous-unemotional traits, CP/HCU conduct problems and high levels of callous-unemotional traits, TD typically developing.

Appendix 1.6 - Power analysis for choice & force models

Post-hoc power analyses were run in R using SIMR (P. Green & MacLeod, 2015) with group sizes 25 (CP with high CU traits), 29 (CP with low CU traits), 31 (typically developing). Power analyses were designed to detect differences between the CP/HCU and TD groups.

To estimate an effect size of d=log(0.5) (-0.69) for our choice model, we have power of 94.90% [93.35, 96.18] (at alpha of 5%) to detect group differences in prosocial choice (2-tailed, 1000 simulations). An effect size of d= -0.69 indicates a difference of at least medium effect size, which would warrant further investigation.

To estimate the effect size to be detected in our force model, we first standardized our data with respect to (1) TD participants, (2) the lowest level of effort, (3) the lowest level of reward, (4) the pooled standard deviation across levels of recipient. This resulted in an effect size to be detected of 0.25. To estimate an effect size of d = 0.25 for our choice model, we have power of 100% [99.63, 100.00] (at alpha of 5%) to detect group differences in prosocial force (2-tailed, 1000 simulations). An effect size of d= 0.25 indicates a difference of a small effect size, which would warrant further investigation.

Supplemental References (Appendix 1)

Schielzeth, H., Dingemanse, N. J., Nakagawa, S., Westneat, D. F., Allegue, H., Teplitsky, C., Réale, D., Dochtermann, N. A., Garamszegi, L. Z., & Araya-Ajoy, Y. G. (2020). Robustness of linear mixed-effects models to violations of distributional assumptions. *Methods in Ecology and Evolution*, *11*(9), 1141–1152. https://doi.org/10.1111/2041-210X.13434

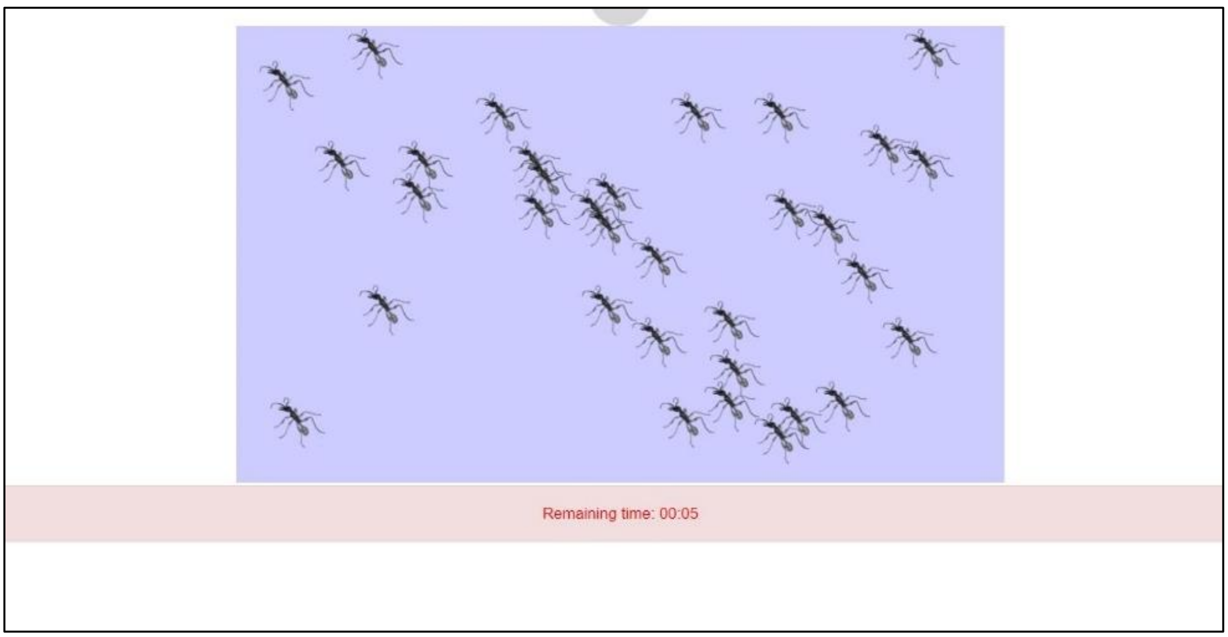
Appendix 2– Social Information Use in Adolescents with Conduct Problems and Varying Levels of Callous-Unemotional Traits

This section is an exact copy of the supplementary materials of the following publication.

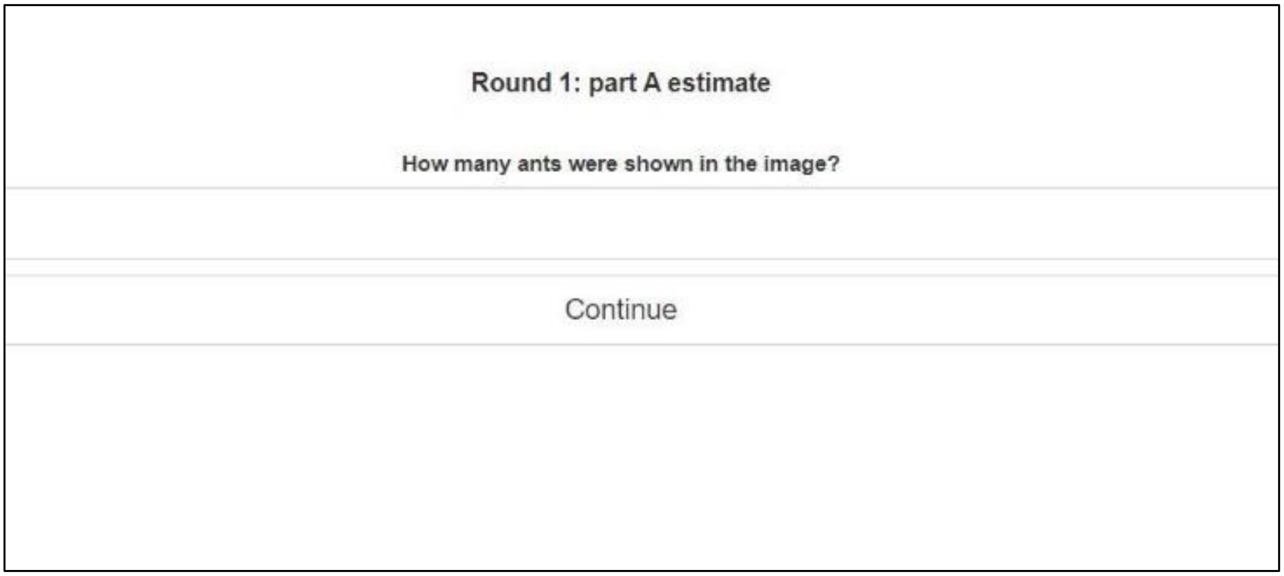
Gaule, A., Bevilacqua, L., Molleman, L., Roberts, R., van Duijvenvoorde, A. C., van den Bos, W. McCrory, E., Viding, E. (2022) Social Information Use in Adolescents with Conduct Problems and Varying Levels of Callous-Unemotional Traits. *JCPP Advances.*

FigS1 Example of one full experimental trial

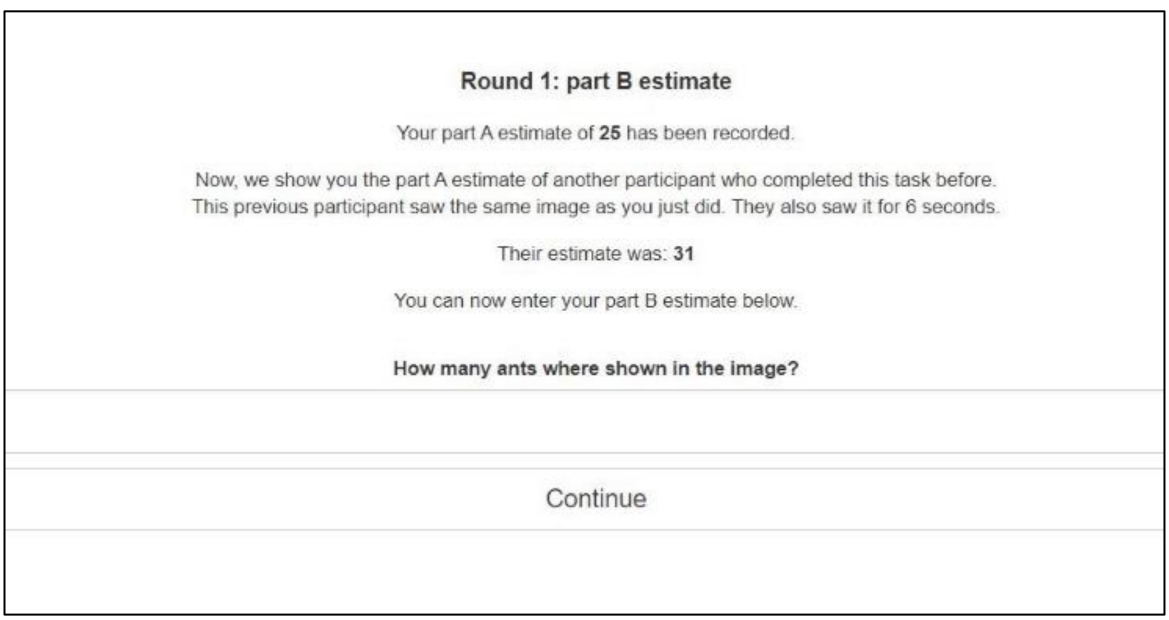
One experimental round:



BEAST task running. Round 1 screen 1 (zoomed in for clarity)

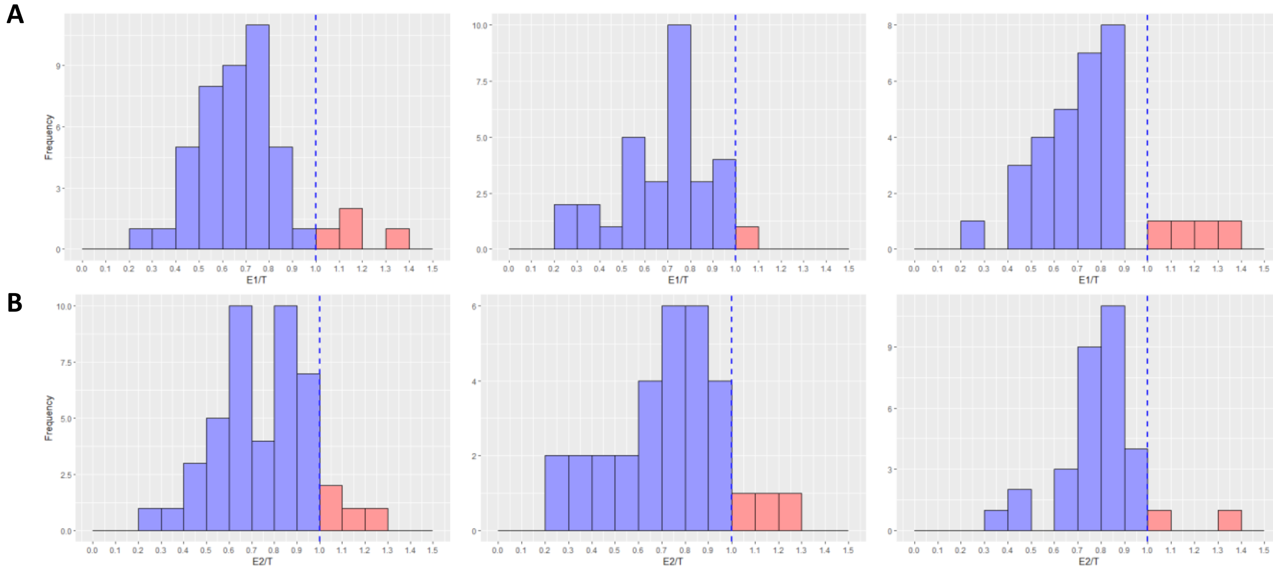


BEAST task running. Round 1 screen 2 (zoomed in for clarity)



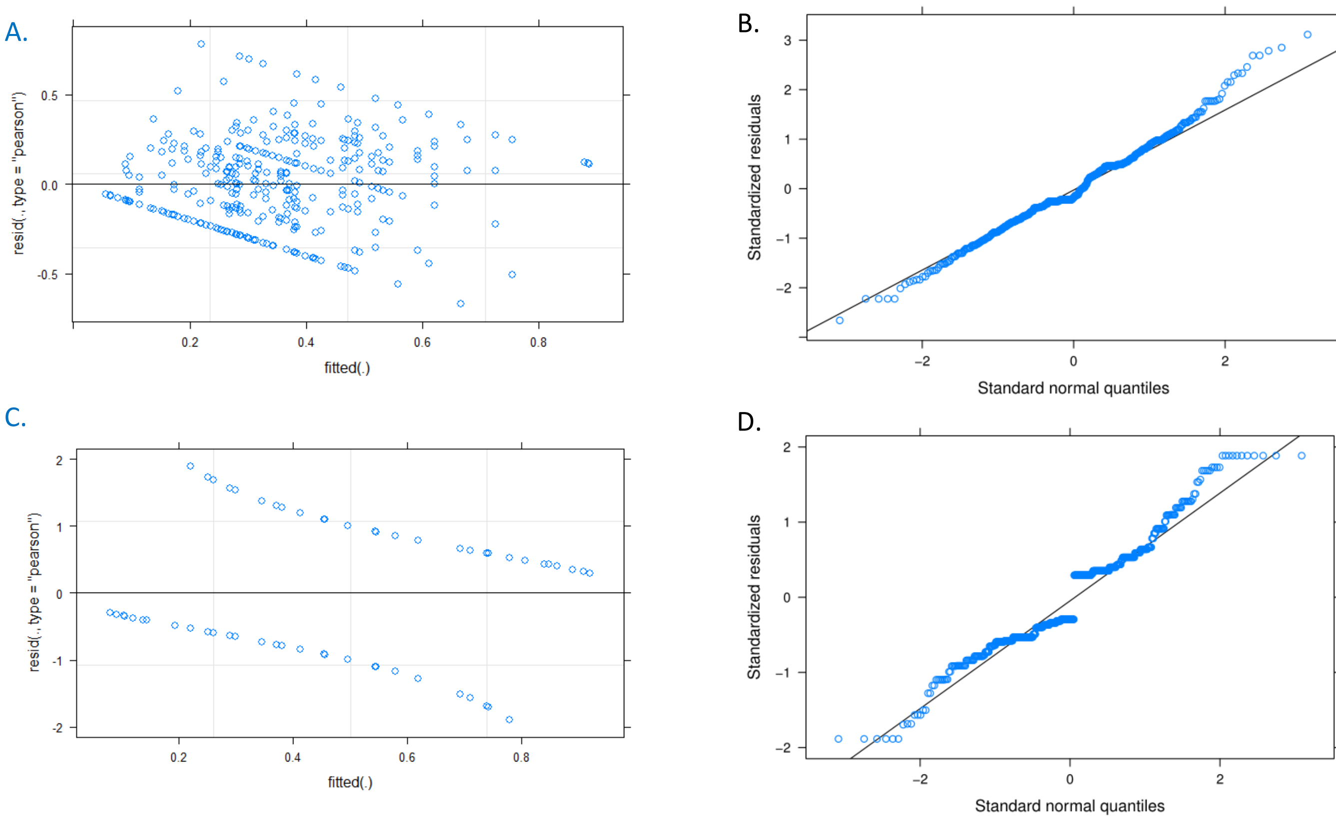
BEAST task running. Round 1 screen 3 (zoomed in for clarity)

FigS2 Accuracy in First and Second Estimates By Group



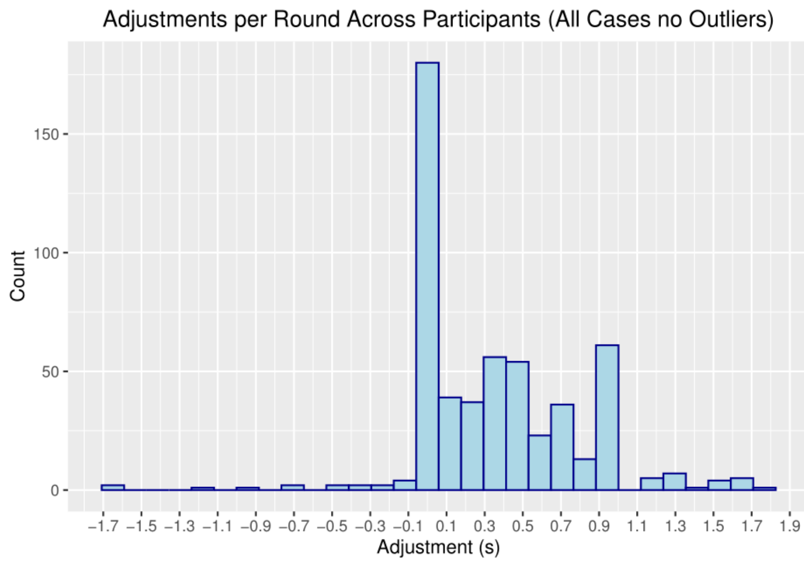
Accuracy in first and second estimates by group. Panels show frequency distributions of participants' estimates before (E1; panel A) and after (E2; panel B) receiving social information for each group (TD, CP/LCU, CP/HCU). Values were standardised by dividing E1 over the true value for each of the trials (which varied between 30 and 60 animals). The mean first estimates were all underestimates of the true values and were as follows: TD group - 69%, CP/LCU group – 68%, CP/HCU group – 74%. Accuracy of initial estimates between groups was compared using a one-way ANOVA – no group difference in accuracy was observed (F(2,105) = 0.88, p = 0.42, η^2 = 0.02).

FigS3 Model Assumption Checks



Residual plots for Models 1 & 2. Plots A. and B. are scatter and qq plots respectively, demonstrating that model 1 residuals are fairly, although not perfectly, normally distributed. Linear Mixed Effects models have been demonstrated to be robust against deviations in distributional assumptions (e.g. Schielzeth et al. 2020), we therefore consider this model appropriate for our data. A Levene test revealed no homoscadicity of residuals ($F(2, 496) = 0.07$, $p = 0.94$). Plots C. and D. are scatter and qq plots respectively, demonstrating that model 2 residuals are fairly, although not perfectly, normally distributed. Generalised Linear Mixed Models have been demonstrated to be robust against deviations in distributional assumptions (Schielzeth et al., 2020). A levene test revealed no homoscadicity of residuals ($F(2, 496) = 1.04$, $p = 0.35$).

FigS4 Social Information Use - Adjustments per Round (All Cases Included)



Histogram showing frequency of adjustments per round including qualitatively different responding i.e. outside range of $0 \leq s \leq 1$ (removed for main analyses). Two data-points were removed when preparing this graph for being more than three standard deviations from the mean (outliers).

Table S1 Age and IQ Covariate Analysis - Model Results:

	Chi Squared	*Df*	*p-value*
Model 1			
Group	*0.96*	*2*	*0.62*
IQ	*3.90*	*1*	*0.048**
Age	*0.24*	*1*	*0.63*
Model 2			
Group	*8.72*	*2*	*0.013**
IQ (Z score)	*0.995*	*1*	*0.32*
Age (Z score)	*0.00*	*2*	*0.998*

Table summarising analysis of Deviance (Type II Wald) tests of main models with age and IQ as covariates. Model 1 is a linear mixed model fitted to participants' mean adjustment (S) across the five rounds by group (Conduct problems (CP) with High callous-unemotional (CU) traits, CP with low CU traits, typically developing) with age and IQ included as covariates. Model 2 is a logistic generalized mixed model (GLMM) fitted to decisions to use an extreme heuristic (copy/stay) (coded as 1) or a compromising heuristic (coded as 0) with age and IQ included as covariates. Age and IQ scores were normalized to improve model fit.

Table S2 Additional Participant Characteristic Data – Strengths and Difficulties

Strengths and Difficulties [a]	TD controls			CP/LCU			CP/HCU			P value	Post hoc*
	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max	N	Mean (SD)	Min-Max	N		
Hyper-activity [b]	2.31 (2.01)	0-6	48	6.50 (2.73)	1-10	34	7.92 (2.31)	2-10	33	<.05**	1 < 2 < 3
Emotional difficulties [b]	1.00 (1.56)	0-5	48	3.53 (2.94)	0-10	34	3.88 (2.81)	0-10	34	<.0001**	1<2, 1<3
Peer problems[b]	1.11 (1.48)	0-5	48	2.91 (1.96)	0-8	34	3.54 (2.53)	0-9	34	<.0001**	1<2, 1<3
Prosocial behaviour	7.75 (2.08)	4-10	48	5.70 (2.44)	0-10	34	2.87 (1.53)	0-5	34	<.0001**	3 < 2 < 1
Total difficulties	4.85 (3.68)	0-15	48	17.26 (6.64)	3-32	34	21.44 (5.80)	7-35	33	<.01**	1 < 2 < 3

Table summarising strength and difficulties scores including subscales and total difficulties. TD typically developing, CP/LCU conduct problems & low levels of callous unemotional traits, CP/HCU conduct problems and high levels of callous unemotional traits, SD standard deviation, N number of participants with complete measure. Where not stated, analyses were performed using one-way ANOVA and post hoc tests were Bonferroni corrected for multiple comparisons.

’*’ 1 = TD, 2 = LCU, 3 = HCU.

** Results for comparisons smaller than or equal to this threshold

[a] All measures obtained at screening phase, teacher report.

[b] Assessed via three pairwise Mann-Whitney U tests due to violation of ANOVA assumptions. Directionality inferred through visual inspection of means.

Table S3 Within vs Between Participant Variation In Adjustments (*s*)

Group	Between Ppt Standard Deviation in *s*	Within Ppt Standard Deviation in *s*
TD	0.31	0.21
LCU	0.38	0.20
HCU	0.36	0.20

Standard deviation in adjustments (*s*) between participants in each group and within participants in each group. TD - typically developing, CP/LCU conduct problems and low levels of callous-unemotional traits, CP/HCU conduct problems and high levels of callous-unemotional traits.

Table S4 Additional Covariate Measures – Descriptive statistics

Supplemental Measures[a]	TD controls			CP/LCU			CP/HCU			P value	Post hoc*
	Mean (SD)	Min-Max	N	Mean (SD)	Range	N	Mean (SD)	Min-Max	N		
Cognitive Perspective Taking	17.08 (4.16)	9-26	45	15.88 (5.78)	7-28	32	13.69 (2.31)	2-21	33	0.01*	1 > 3
Cognitive Empathy	35.02 (4.85)	22-45	46	32 (4.36)	22-44	28	34.35 (3.55)	28-42	26	0.02*	1 > 2
Affective Empathy	33.99 (5.84)	22-45	46	32.51 (6.43)	22-44	28	32 (6.39)	20-49	26	0.37	

Table summarising scores on extra measures included as covariates.TD typically developing, CP/LCU conduct problems & low levels of callous unemotional traits, CP/HCU conduct problems and high levels of callous unemotional traits, SD standard deviation, N = number of participants that completed measure. Analyses were performed using one-way ANOVA and post hoc tests were Bonferroni corrected for multiple comparisons.

’*’ 1 = TD, 2 = LCU, 3 = HCU.

** Results for comparisons smaller than or equal to this threshold

[a] All measures obtained at testing phase, child report

Table S5 Additional Covariate Model Results

	Chi Squared	*Df*	*p-value*
Model 3 – Social information use			
Group	*0.07*	*2*	*0.97*
BES Cognitive Empathy	*0.65*	*1*	*0.42*
Model 4 – Strategy Use			
Group	*7.13*	*2*	*0.03**
BES Cognitive Empathy	*0.00*	*2*	*0.997*
Model 5 – Social information use			
Group	*0.26*	*2*	*0.88*
BES Affective Empathy	*0.01*	*1*	*0.94*
Model 6 – Strategy Use			
Group	*7.75*	*2*	*0.02**
Affective Empathy	*0.04*	*2*	*0.84*
Model 7 – Social information use			
Group	*0.36*	*2*	*0.83*
Cognitive Perspective Taking	*0.27*	*1*	*0.60*
Model 8 –Strategy Use			

Group	*9.45*	*2*	*0.01**
Cognitive Perspective Taking	*0.16*	*2*	*0.69*

Table of Analysis of Deviance (Type II Wald) tests of main models with additional variables included as covariates. *Model 1* is a linear mixed model fitted to participants' mean adjustment (S) across the five rounds by group (Conduct problems (CP) with High callous-unemotional (CU) traits, CP with low CU traits, typically developing) with cognitive empathy included as a covariate. *Model 2* is a logistic generalized mixed model (GLMM) fitted to decisions to use an extreme heuristic (copy/stay) (coded as 1) or a compromising heuristic (coded as 0) by group with cognitive empathy as a covariate. *Model 3* is a linear mixed model fitted to S across 5 rounds by group, with affective empathy included as a covariate. *Model 4* is a GLMM fitted to decisions to use an extreme heuristic by group with affective empathy taking included as a covariate. *Model 5* is a linear mixed model fitted to S across 5 rounds by group, with cognitive perspective taking included as a covariate. *Model 6* is a GLMM fitted to decisions to use an extreme heuristic by group with cognitive perspective taking included as a covariate.

Table S6 Additional covariate analyses

	Kendall's Tau	P Value	Adjusted P Value
Extreme Responding	1.00	0.00	0.00
Child Group	0.14	0.07	0.19
SDQ Emotional Problems	0.18	0.02*	0.08
SDQ Peer Problems	0.12	0.12	0.24
SDQ Hyperactivity	0.02	0.80	0.84
SDQ Total Difficulties	0.10	0.17	0.27
AUDIT (alcohol use)	-0.03	0.74	0.84
DUDIT (drug use)	-0.02	0.84	0.88

Kendall's Tau-B correlations between proportion of all-or-nothing responding relative to compromising responding and measures of commonly co-occurring symptoms with CP. *p* values were corrected for multiple comparisons using the Benjamin-Hochberg correction. The initial modest correlation between all-or-nothing responding and emotional problems (τ = 0.18, *p* = 0.02) revealed by Kendell's Tau-B analyses did not survive the correction for multiple comparisons.

Appendix S1 Supplemental Methods – Measure details and internal consistency

Conduct problems were assessed using the *Child and Adolescent Symptom Inventory* (CASI-4R; Gadow & Sprafkin 2005) Conduct Disorder Scale (CASI-CD). This scale contains nine items rated on a 4-point scale from 'Never' to 'Very often'. The measure showed good internal consistency in our sample (α = 0.89).

Callous and Unemotional Traits were assessed using all items from the *Inventory of Callous-Unemotional Traits* (ICU; Essau, Sasagawa, & Frick 2006). The ICU contains 24 items rated on a 4-point scale from 'not at all true' to 'definitely true'. The total *sum* score was used to identify CU groups. The measure showed very good internal consistency in our sample (α= 0.94).

IQ was assessed using the two-subtest version of the WASI (Wechsler, 1999). Substance use was assessed via the Alcohol Use Disorders Identification Test (AUDIT; Babor et al. 2001) and the Drug Use Disorders Identification Test (DUDIT; (Berman et al., 2005b). The AUDIT and DUDIT include 10 and 11 items respectively, and measure substance use, harmful use, and symptoms of dependence. The first items are measured on a 5-point scale ranging from 'Never' to 'daily or almost daily'. The last two items from each scale are rated on a 3-point scale and are coded as 0 ('no'), 2 ('yes, but not in the last year') or 4 (yes, during the last year'). Risk for alcohol use disorders based on AUDIT scores are assigned as follows: a score of 0-7 indicates low risk; 8-15 indicates increasing risk; 16-19 indicates higher risk; and a score of 20 or greater indicates possible dependence. Risk for drug use disorders (in male populations where you would not expect drug users) are assigned as follows: a score of 1-5 indicates low risk, a score of 6 or greater indicates possible drug related problems (Berman et al., 2005). Internal consistency for the AUDIT and DUDIT were α = 0.88, and α = 0.85 respectively.

Prosocial behavior and total difficulties (as screening in the TD participants), emotional problems, peer problems, and hyperactivity (as measures of symptoms commonly co-occuring with CP) subscales of the *Strengths and Difficulties Questionnaire* (SDQ; Goodman 1997). The SDQ contains 25 items, rated on a 3-

point scale from 'Not True' to 'Very True'. The SDQ has been extensively normed on a large-scale population of young people (e.g. Goodman 2001). The measures showed good internal consistency in our sample: Prosocial behaviour, α = 0.88; total difficulties, α = 0.93; emotional problems, α = 0.85; peer problems, α = 0.75; hyper-activity, α = 0.90.

Appendix S2 Age and IQ Covariate Analysis - Model Specification:

Model 1 – Social information use with age and IQ covariates: Mixed model regression analyses were designed using the *lmer* function of the *lme4* package in R, version 4.0.0 (R Core Team, 2020). Model 1. tested whether social information use (*s*) was influenced by age, IQ, and group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits, typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. The model was specified in R as follows:

s ~ age + IQ + group + (1|ID)

Model 2 – Strategy use with Age and IQ covariates: A logistic regression analysis model was designed using the *glmer* function of the *lme4* package in R, version 4.0.0. Model 2. tested whether participants' strategy use (coded as all-or-nothing; 1 or compromising: 0) was influenced by age, IQ and group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits (CP/LCU), typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. The model was specified in R as follows:

extreme ~ group + age + IQ + (1|ID)

Optimiser: Bobyqa

Appendix S3 Statistical Analyses of Participant Characteristics: Full Details

Groups (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits (CP/LCU), typically developing (TD)) were matched for IQ ($F(2, 113) = 2.89$, $p = 0.06$, $\eta^2 = 0.05$). Groups differed significantly in age ($F(2, 113) = 5.17$, $p = 0.007$; $\eta^2 = 0.08$), with the CP/LCU group being significantly younger than the CP/HCU group (post-hoc Bonferroni: $p = 0.005$).

Groups differed significantly on CP as measured by the CASI ($F(2,113) = 90.58$, $p < .0001$, $\eta^2 = 0.62$), with post-hoc comparisons using the Bonferroni HSD revealing that CP/HCU scored higher than CP/LCU ($p = 0.002$) and TD ($p < .0001$) groups, and CP/LCU higher than TD ($p < .0001$). Groups also differed significantly on CU traits as measured by the ICU ($F(2, 113) = 175.1$, $p < .0001$; $\eta^2 = 0.76$). Post-hoc comparisons using the Bonferroni correction indicated that the CP/HCU group scores were higher than CP/LCU ($p < .0001$), and TD ($p < .0001$) on the ICU. Scores for the CP/LCU group were higher than for the TD group ($p < .0001$).

Our measures of common co-occurring symptoms with CP revealed that groups did not differ on self-reported use of alcohol use ($\chi^2 = 8.19$, $p = 0.08$, $\phi_c = 0.19$). Chi square tests revealed a significant group difference in drug use ($\chi^2 = 6.34$, $p = 0.05$, $\phi_c = 0.23$). This significant effect did not hold when corrected for multiple comparisons using Bonforroni correction (all ps >0.5).

Groups differed on SDQ rated hyperactivity, with CP/HCU scoring higher than CP/LCU ($U = 391$, $p = 0.03$, $\hat{A} = 0.34$), and TD ($U = 81.5$, $p < .0001$, $\hat{A} = 0.05$), and CP/LCU higher than TD ($U = 208.50$, $p < .0001$, $\hat{A} = 0.13$).The CP/HCU and CP/LCU groups did not differ on emotional problems ($U = 520$, $p = 0.47$, $\hat{A} = 0.45$), but both groups differed from TD (CP/HCU, $U = 310$, $p < .0001$, $\hat{A} = 0.29$; CP/LCU, $U = 349$, $p < .0001$, $\hat{A} = 0.22$). Similarly, both CP groups differed from the TD group in peer problems (CP/HCU, $U = 331$, $p < .0001$, $\hat{A} = 0.45$; CP/LCU, $U = 360$, $p < .0001$, $\hat{A} = 0.22$), but did not differ from each other ($U = 5521.520$, $p = 0.49$, $\hat{A} = 0.45$).

ANOVA tests revealed that our groups differed significantly on screening measures for the TD group: SDQ rated prosocial behaviour ($F(2, 111) = 53.80$, $p < .0001$, $\eta^2 = 0.49$) and total difficulties ($F(2, 111) = 103.10$, $p < .001$, $\eta^2 = 0.65$). Post-hoc Bonferroni tests revealed that the TD group scored significantly higher than both the CP/HCU ($p < .0001$) and LCU ($p = 0.0001$) groups on prosocial behaviour, and that the CP/LCU group scored significantly higher than the HCU group ($p < .0001$). Post-hoc Bonferroni tests of the ANOVA of group scores on total difficulties revealed that the CP/HCU group scored significantly higher than both the TD ($p < .0001$) and LCU ($p = 0.005$) groups, and that the CP/LCU group scored significantly higher than the TD group ($p < .0001$). Two participants were removed from analysis of SDQ measures due to missing data.

Appendix S4 Experimental Materials

The experimental task was completed on a laptop. Below are the task instruction text and screenshots one of experimental round, as seen by the participants. Stimuli were presented in a fixed order.

Instructions:

Welcome. In this task you have to make a number of estimates. With your estimates you can win points. The number of points you can win in this task depends on how accurate your estimates are. Click below to proceed to the task instructions.
<Continue>

This task consists of 5 rounds. At the beginning of each round, you will observe an image showing a number of animals. For example: <image> The image will disappear after 6 seconds, upon which you have to estimate how many animals were displayed. The more accurate your estimate, the more points you can earn. We explain this later.

<Continue>

Once the image has disappeared, you have to enter your estimate of how many animals were displayed. This is your estimate for part A of a round. Once you have entered your estimate, part B of the round begins. You can observe the part A estimate of another participant. Over 100 people recently participated in this study and completed this task. In each round, you can observe the part A estimate of one of these previous participants. The previous participants saw the same image as you. They also saw it for 6 seconds. After the image disappeared, they also had to estimate how many animals were displayed. They could earn more points if their estimate was more accurate. You then have to enter a second estimate. You can enter the same estimate as in part A, or adjust it as you wish. This is your estimate for part B of a round. After that, the round is over and a new round begins. If you have any questions, please ask the researcher now!

<Continue>

The more accurate your estimates, the more points you can earn in this task. If you estimated the number of animals *exactly right*, you earn 100 points. For each animal that you are off, we subtract 5 points. Your points cannot become negative. For example, if the actual number of animals in an image was 60, and your estimate was 53, you were 7 off. This would mean that we subtract 7 x 5 = 35 points. If you have any questions, please ask the researcher now! Click 'Continue' if you understood your task. A brief quiz will follow to check your understanding.

<Continue>

To check your understanding of the task, please indicate for each of these statements whether they are correct or incorrect. In each round of this task you will view an image. You have to estimate how many animals were displayed in it. <Correct> <Incorrect>. Once you have entered your estimate, you can observe the estimate of another participant who completed this task before. You can then make a second estimate. <Correct> <Incorrect>. The more accurate your estimates, the more points you can earn. <Correct> <Incorrect>

<Continue>

When you click below, an image will appear showing a number of Ants. After 6 seconds, the image disappears. A box will appear in which you have to estimate how many Ants there were. Click below when you are ready.

<Continue>

AT END OF TASK: You have now finished this task. Once this study has completed, we will inform you of the results. Thank you for your participation

Appendix S5 Calibration of Social Information

Participants were informed that the social information seen on each round was the estimate of an adolescent participant at another school. In reality, if a participant's E_1 was *lower* than the true value, X was 1.2 times E_1 ($X = 1.2 \cdot E_1$); if their E_1 was *higher* than the true value (the real number of animals on the screen), X was 0.8 times E_1 ($X = 0.8 \cdot E_1$). This setup allowed for a relatively constant scope for adjustment in each round, while experimentally controlling for possible effects of 'distance weighting', the observation that people tend to discount information that deviates too strongly from their initial estimate (Moussaïd et al., 2013). If E_1 was exactly correct (equal to the true value), a coin flip determined whether X on that round would be higher or lower. This ensured that X was sometimes higher and sometimes lower than the initial estimate. This minor deception was approved by the UCL ethics committee (project code: 0622/001).

Appendix S6 Statistical Analyses

Demographic Data

Data for group matching and assessment of emotional and behavioural difficulties were analysed using one-way Analysis of Variance (or appropriate non-parametric equivalents) for continuous data and Chi-Squared tests for categorical data.

All analyses were carried out in R statistical software and R Studio (R version 4.0.0; Team, 2015). Tests and results are summarised in Table 1 and Table S1. Graphs of results (Fig 2) were produced using ggplot2 (Wikham, 2016), the table summarising mixed models (Table 2) was produced using sjPplot (Lüdecke et al., 2021). Mixed mdels were run using lmerTest (Kuznetsova et al., 2017).

Experimental Data

Basic behavioural results

Basic behavioural results were analysed using Analysis of Variance, comparing accuracy of initial estimate (E_1/true value) between groups.

Degree of social information use

Regression analyses were carried out using Linear and Generalised Linear Mixed Effects models with the R package ‘lme4’ (Bates et al., 2015). For a full description of the models and suitability see S11.

Degree of social information use by group (CP/HCU, CP/LCU, TD) was assessed using a Linear Mixed Effects model (Table 2, Model 1), including group as a fixed effect, subject as a random effect, and social information use in the task rounds (*s*) as the outcome variable. Fixed effects were tested for difference from 0 using a Type II Wald Chi-Square test.

Strategy when using social information

Strategy use was assessed by examining how participants used social information to adjust estimates on individual rounds (Table 2, Model 2 of main manuscript). Strategies were classified as ‘compromising’ if participants’ second estimate fell between their initial estimate and the social information ($0<s<1$). Strategies were classified as all-or-nothing if participants second estimate was the same as their original estimate ($s=0$) or a direct copy of the social information ($s=1$). A Generalised Linear Mixed Effects model was used to compare strategy use between groups, including group as a fixed factor, subject as a random factor, and likelihood of all-or-nothing responding (1 = copy/stay response, 0 = compromising response) as the outcome variable. Fixed effects were tested for difference from 0 using a Type II Wald Chi-Square test.

Appendix S7 Main Experimental Models: Specification and Assumption Checks

Model 1 – Social information use: Mixed model regression analyses were designed using the *lmer* function of the *lme4* package in R, version 4.0.0 (R Core Team, 2020). Model 1. tested whether social information use (*s*) was influenced by group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits, typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. The model was specified in R as follows:

s ~ group + (1|ID)

Model 2 – Strategy use: A logistic regression analysis model was designed using the *glmer* function of the *lme4* package in R, version 4.0.0. Model 2. tested whether participants' strategy use (coded as all-or-nothing; 1 or compromising: 0) was influenced by group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits (CP/LCU), typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. The model was specified in R as follows:

strategy use ~ group + (1 | ID), family='binomial')

Optimiser: 'bobyqa'.

Appendix S8 Additional covariate analysis

Appendix S8a - Methods and statistics

Cognitive and affective empathy were assessed using subscales of the Basic Empathy Scale (BES; Jolliffe & Farrington, 2006). This scale contains 20 items, scored on a five-point scale from 'strongly disagree' to 'strongly agree', nine items measuring cognitive empathy, eleven items measuring affective empathy. The cognitive and affective empathy subscales of the BES showed good internal reliability, with αs of 0.701 and 0.713 respectively.

Cognitive perspective taking was assessed using the Interpersonal Reactivity Index perspective taking scale (IRI-PT; Davis, 1980). This scale contains seven items, scored on a five-point scale from 'does not describe me well' to 'describes me very well'. The measure showed a fairly low reliability in our sample (α = 0.67).

Appendix S8b – Model specification:

Social information use: Three mixed model regression analyses were designed using the *lmer* function of the *lme4* package in R, version 4.0.0 (R Core Team, 2020). These models tested whether social information use (*s*) was influenced by group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits, typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. Each model then included a covariate: model 1 – cognitive empathy, model 3 – affective empathy, model 5 – cognitive perspective taking. The models were specified in R as follows:

Model 3: s ~ group + cognitive empathy + (1|ID)

Model 5: s ~ group + affective empathy + (1|ID)

Model 7: s ~ group + affective perspective taking + (1|ID)

Strategy use: Three logistic regression analysis models were designed using the *glmer* function of the *lme4* package in R, version 4.0.0. Model 2. tested whether participants' strategy use (coded as all-or-nothing; 1 or compromising: 0) was influenced and group (conduct problems with high callous-unemotional (CP/HCU) traits, CP with low CU traits (CP/LCU), typically developing (TD) coded as TD:0, CP/LCU:1, CP/HCU:2) as a fixed factor, and a subject level random intercept. Each model then included a covariate: model 2 – cognitive empathy, model 4 – affective empathy, model 6 – cognitive perspective taking. The models were specified in R as follows:

Model 4: extreme ~ group + cognitive empathy + (1|ID)

Model 6: extreme ~ group + affective empathy + (1|ID)

Model 8: extreme ~ group + cognitive perspective taking + (1|ID)

Optimiser: Bobyqa

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Appendix 3 – The Development and Validation of the Adolescent HEXACO and an Exploration of its Relationship with Conduct Problems and Callous-Unemotional Traits.

This section is an exact copy of the supplementary materials that have been submitted for review at the 'Journal of Psychopathology and Behavioral Assessment'.

S1 Data Cleaning and Management

Data were manually entered into a spreadsheet by four different researchers. Inputted data were checked for consistency and the proportion of incorrectly entered data was <1%. The data was vetted for out-of-range values and these were either corrected or due to administrative errors, recoded as missing.

The Adolescent HEXACO:

In line with the original HEXACO-60 29 items were reverse coded before any further analyses were carried out.

Factor analysis

From our initial sample of participants who gave informed assent (N == 1200), we removed participants with any missing items for the Adolescent HEXACO questionnaire (N=295), or a SD of 0 in their responses (N=1) for Exploratory and Confirmatory factor analyses.

Construct validity analyses

As scale properties of the Adolescent HEXACO had now been established, we went back to our sample of participants who gave informed assent (N=1200), and removed any participant with 3 or more missing items. This left 188 participants with 1 or 2 missing items on this questionnaire. Missing data were then imputed based on the average scores of the other items of the factor in question.

SDQ, ICU, and TIPI measures

Missing data were imputed in line with criteria set by scale developers. For the ICU (Frick, Cornell, Barry, et al., 2003), if participants had answered 12 questions out of 24, missing data were replaced with the mean of the remaining data. Similarly, for the SDQ CP subscale (Goodman, 1997), if 4/5 responses were present, missing data were replaced with the mean. Missing data for the TIPI questionnaire were not imputed as there were only two items per scale (Gosling et al., 2003). If a participant missed an item on any scale, they were not given a total score for this scale.

S2 Rotated Component Matrix of the Adolescent HEXACO

Factor	Item	Communalities	1	2	3	4	5	6
1. Emotionality	Question 17	0.55	0.71					
	Question 23	0.49	0.68					
	Question 29	0.44	0.63					
	Question 59 (Reversed)	0.40	0.63					
	Question 41 (Reversed)	0.37	0.60					
	Question 53 (Reversed)	0.35	0.57					
	Question 47	0.36	0.57					
	Question 11	0.48	0.56					
	Question 35 (Reversed)	0.46	0.52		-0.39			
	Question 5	0.26	0.48					
2. Openness-to-Experience	Question 55 (Reversed)	0.43		0.64				
	Question 1 (Reversed)	0.46		0.63				
	Question 13	0.41		0.55				
	Question 49 (Reversed)	0.37		0.54				
	Question 37	0.40		0.53				
	Question 7	0.29		0.53				
	Question 25	0.30		0.52				
	Question 43	0.36		0.51				
	Question 31 (Reversed)	0.25		0.40				
	Question 19 (Reversed)	0.25		0.36				
3. eXtraversion	Question 46 (Reversed)	0.46			0.66			
	Question 22	0.51			0.64			
	Question 4	0.52			0.62			

	Question 40	0.39			0.60			
	Question 34	0.37			0.57			
	Question 10 (Reversed)	0.40			0.53			
	Question 28 (Reversed)	0.39			0.53			
	Question 58	0.41			0.43	-0.38		
	Question 16	0.25			0.41			
	Question 52 (Reversed)	0.52	-0.48		0.40			
4. Agreeableness	Question 21 (Reversed)	0.61				0.73		
	Question 45	0.50				0.60		
	Question 15 (Reversed)	0.39				0.60		
	Question 9 (Reversed)	0.36				0.54		
	Question 57 (Reversed)	0.35				0.52		
	Question 3	0.27				0.51		
	Question 51	0.38				0.50		
	Question 27	0.26				0.42		
	Question 39	0.31				0.40		
	Question 33	0.20						-0.35
5. Honesty-Humility	Question 60 (Reversed)	0.52					0.65	
	Question 36	0.41					0.62	
	Question 12 (Reversed)	0.48					0.61	
	Question 18	0.40					0.61	
	Question 30 (Reversed)	0.26					0.49	
	Question 42 (Reversed)	0.30					0.47	
	Question 24 (Reversed)	0.30					0.47	
	Question 48 (Reversed)	0.38			-0.32		0.45	

	Question 54	0.22					0.40	
	Question 6	0.09						
6. Conscientiousness	Question 26 (Reversed)	0.40						0.60
	Question 2	0.37						0.53
	Question 44 (Reversed)	0.42				0.35		0.49
	Question 56 (Reversed)	0.22						0.47
	Question 50	0.41		0.33				0.46
	Question 32 (Reversed)	0.38						0.45
	Question 38	0.46		0.42				0.42
	Question 20 (Reversed)	0.44	-0.32					0.40
	Question 8	0.30			0.31			0.36
	Question 14 (Reversed)	0.36		0.51				0.32

Appendix 4 - Assessing the Relationship between Mind Representation and Callous Unemotional Traits

Appendix 4.1 Adolescent PPT Task Instructions.

Imagine a typical person your age:

Continue

We are going to ask you to think about their **personality** and ask you some questions

Continue

For example, we might want to know whether you think someone who is **happy most of the time** is also likely to be **very optimistic.**

You can respond by telling us whether you think this is very likely or very unlikely by clicking a scale under the question.

Please click next to try out an example.

Continue

How likely is it that someone who:

Is happy most of the time

ALSO

is very optimistic?

Very **Unlikely** to be both **Happy** and **Optimistic** -1

Neither likely nor unlikely
0

1 Very **Likely** to be both **Happy** and **Optimistic**

NOTE: Textboxes 1-4 came up as an animation and were illustrated by the

1. Clicking on this end of the scale means that you think it is very likely someone would be both happy and optimistic

2. Clicking on this end of the scale means that you think it is very unlikely someone would be both happy and optimistic

3. Clicking in the middle of the scale means that you think someone is neither likely nor unlikely to be both happy and optimistic

4. And you can click or tap **anywhere along the scale**, depending on what you think!

Continue

All you have to do is say whether you think **the two personality traits normally go together.**

Continue

Important to remember:

1. We want you to think about how much the two traits go together in the average person your age
2. There are no right or wrong answers! We just want your opinion.

Continue

Let's have a go!

If you finish this game, you will be entered into a lottery to win **£50** of amazon or Love2Shop vouchers!

Continue

Appendix 4.2 Supplemental Analyses

Table of descriptive statistics for Adolescent PPT difference scores with and without inclusion of items that contained unvalidated Adolescent HEXACO items.

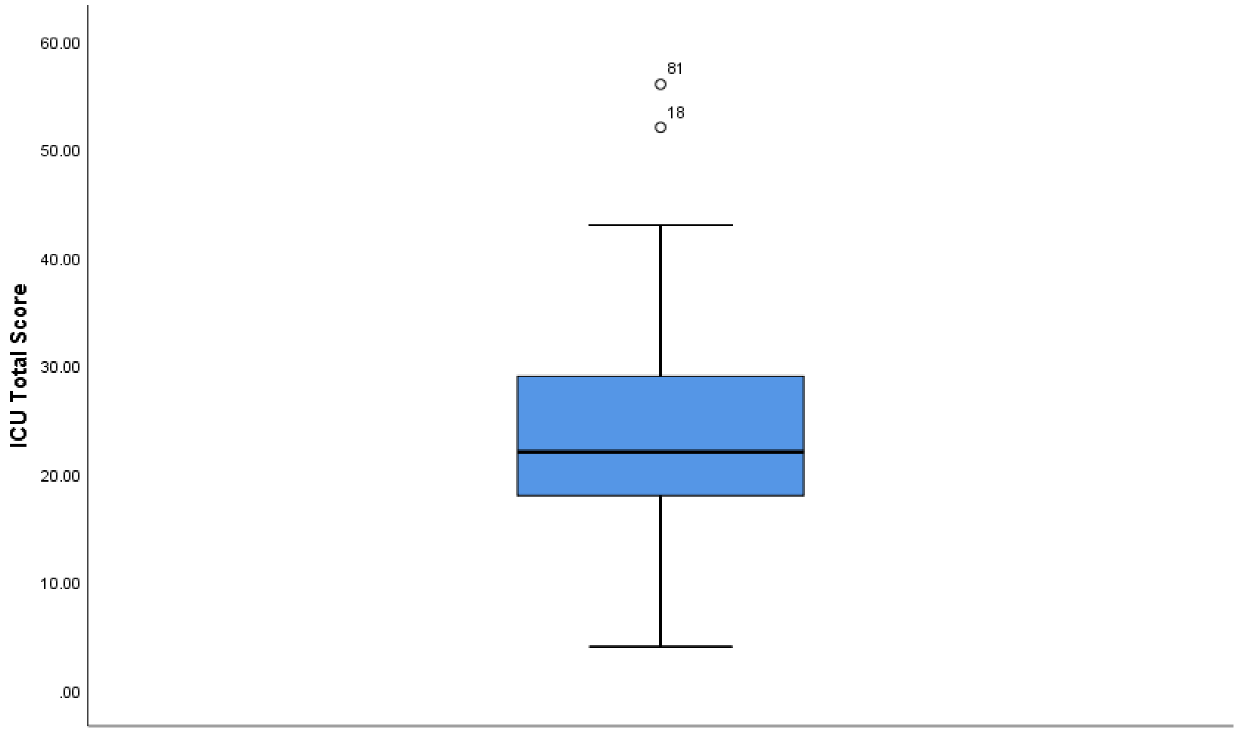
	Adolescent PPT Difference Scores including unvalidated Adolescent HEXACO items	Adolescent PPT Difference Scores excluding unvalidated Adolescent HEXACO items[1]
N	101	101
Mean	0.39	0.39
SD	0.13	0.12
Minimum	0.13	0.14
Maximum	0.60	0.73

N = Number of participants; SD = Standard Deviation; PPT = Personality Pairs Task.

[1] Also reported in main text. Included for reference.

Main analyses were carried out with PPT difference scores including and excluding PPT items that contain un-validated Adolescent HEXACO items (N = 6). This led to no change in results (correlation between ICU scores and Adolescent PPT difference scores *including* un-validated Adolescent HEXACO items: $r(1) = -.21$ $p = .04$; correlation between ICU scores and Adolescent PPT difference scores *excluding* un-validated Adolescent HEXACO items: $r(1) = -.20$, $p = .04$

Appendix 4.3 Demonstration of ICU Outliers



Graph representing Median and interquartile range of ICU Total scores in our sample and two outlying data points (removed for final analysis). Outliers identified as values that fall outside 1.5 x the interquartile range. Quartile 1 = 18. Quartile 3 = 29. Interquartile range = 11. Median ICU score = 22. ICU – Inventory of Callous Unemotional Traits.