The role of socio-cognitive and emotional impairments in young children with emerging symptoms of neurodevelopmental disorders

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Summary of thesis

Symptoms of neurodevelopmental disorders (NDDs) that are established in early childhood often exacerbate, if left untreated, and continue into adulthood. There is increasing evidence that underlying socio-cognitive and emotional processes contribute to the development, persistence and severity of NDDs. Theory of mind (ToM), empathy and facial mimicry, in particular are thought to play a causal role in the development of psychopathology. Based on this, it is possible that early ToM, empathy and facial mimicry assessment may help to identify risk for future NDDs. However, research has not yet explored their roles in young, pre-diagnostic children at risk of developing NDDs. Having a better understanding of the processes and mechanisms underlying symptoms of NDDs early in childhood will lead to the development of early interventions that promote a more positive developmental trajectory.

Chapters 2, 3 and 5 of this thesis aimed to examine the roles of socio-cognitive and emotional processes in children with early signs of NDDs and understand how they relate to specific emotional and behavioural problem profiles. More specifically, Chapter 2 examined ToM in children with broad-ranging symptoms of NDDs compared to TD controls; Chapter 3 compared ToM and empathy in those with high levels of anxiety compared to those with low levels of anxiety and explored their relationships with anxiety severity; and Chapter 5 examined the role of facial mimicry in children's peer relations by comparing facial mimicry responses in those with and without peer problems and exploring its relationship with peer problem severity. Given the causal role an impairment in facial mimicry is thought to play in empathic responding, Chapter 4 investigated the relationship between facial mimicry and cognitive and affective empathy.

We found that ToM, empathy, and facial mimicry are all important processes that are implicated in the development, and explain variation in, severity of symptoms of NDDs. In addition, we found that ToM was differentially affected across different symptom clusters; while low levels of cognitive ToM were associated with broad-ranging symptoms of NDDs, high levels of cognitive ToM were specifically related to anxiety symptomatology. Finally, we demonstrated that facial mimicry for sadness was positively related to children's ability to understand and experience other people's sadness, suggesting that impaired facial mimicry may be responsible for the impaired empathic responding for negative emotions demonstrated by children with psychopathology. This thesis suggests that interventions targeting children's ToM, empathy and facial mimicry should be considered as a preventative effort to reduce risk for NDDs before the onset of clinical symptoms and significant maladjustment.

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List of abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ANOVA	Analysis of Variance
ASD	Autism Spectrum Disorder
CD	Conduct Disorder
CU	Callous-Unemotional
DAWBA	Development and Wellbeing Assessment
DSM	Diagnostic and Statistical Manual
DBD	Disruptive Behaviour Disorder
EBDs	Emotional and Behavioural Disorders
EBPs	Emotional and Behavioural Problems
EMG	Electromyography
FB	False Belief
FSIQ	Full Scale Intelligence Quotient
HA	High Anxiety
ICD	International Classification of Diseases
IQ	Intelligence Quotient
LA	Low Anxiety
MNS	Mirror Neuron System
NDAU	Neurodevelopment Assessment Unit
NDDs	Neurodevelopmental Disorders
NHS	National Health Service
NOS	Not Otherwise Specified
OCD	Obsessive Compulsive Disorder
ODD	Oppositional Defiant Disorder
PAM	Perception Action Model
RDoC	Research Domain Criteria
SAD	Social Anxiety Disorder
SDQ	Strengths and Difficulties Questionnaire
TD	Typically Developing
ToM	Theory of Mind
VMA	Verbal Mental Ability

1. General Introduction

1.1 Neurodevelopmental problems in childhood

Early emerging symptoms of neurodevelopmental disorders (NDDs), including externalising (e.g., aggression, disruption, attention and concentration problems) and internalising behaviours (e.g., social withdrawal, low mood), represent a growing concern for early childhood professionals (Poulou, 2013). The reason is that NDDs cause immediate difficulty for parents, teachers, the society and the children themselves and if left untreated, they also pose a risk for children in later life (Campbell, 1995; Moffitt, 1993; Moffitt, Caspi, Dickson, Silva, & Stanton, 1996). Both externalising and internalising behaviour profiles have been linked to later learning problems, school failure and difficulties in relationships with other people (Cole, 1990; Doumen, Verschueren, & Buyse, 2009; Miech et al., 1999; Rutter et al., 1998). Children with chronic levels of externalising behaviours are also at increased risk of substance abuse, criminality and physical violence in adulthood (Bardone et al., 1998; Eley, Lichtenstein, & Moffitt, 2003; Fombonne et al., 2001; Huesmann, Eron, & Dubow, 2002), consequently placing a substantial financial burden on public services (Scott, Knapp, Henderson, & Maughan, 2001). Indeed, Scott and colleagues (2001) demonstrated that by the age of 28, individuals with childhood-onset externalising disorders cost ten times more than individuals without, due to the excessive need of NHS, criminal justice and social service involvement. The literature has also consistently confirmed a strong relationship between symptoms of NDDs in childhood and future mental health outcomes (Copeland, Shanahan, Costello & Angold, 2009; Fine et al., 2003; Fombonne et al., 2001; Hofstra, van der Ende & Verhulst, 2002; Kim-Cohen et al., 2003; Odgers et al., 2008; Rutter, 1995); more than half of all adults with diagnosed mental health difficulties retrospectively report that first symptoms occurred during childhood and adolescence and that there was a chronic progression into adulthood (Kessler et al., 2007; Kim-Cohen et al., 2003).

Despite the negative impact of childhood symptoms of NDDs on current and future educational, social and psychological functioning, 65-75% of children and young people who experience significant mental health difficulties do not access the support that they need (Chavira, Stein, Bailey & Stein, 2004; Dvorsky, Girio-Herrera & Owens, 2014; Kelvin, 2014; Merikangas et al., 2011; Sawyer et al., 2001; Zwaanswijk et al., 2005). This is in part due to barriers that limit service accessibility (e.g., availability of services; Owens et al., 2002) and flawed approaches in referral for intervention. Traditional mental health services have operated under a 'refer-test-place' model that primarily focuses on treatment services for children and young people at the highest level of risk (Dowdy, Ritchey & Kamphaus, 2010). Similarly, the 'wait-to-fail' model encourages the treatment of NDDs only when symptoms have reached 'crisis point'. Based on these approaches, children and young people with mental health difficulties may not be recognised until after their symptoms have intensified and become deeply entrenched and more resistant to intervention efforts (Dvorsky, Girio-Herrera & Owens, 2014).

An alternative approach is to examine early emotional and behavioural problems, such as social withdrawal and disruptive behaviour, which are indicative of future NDDs. Indeed, in addition to the children with established NDDs, there are children who are at high-risk of developing such disorders (Children's Commissioner for England, 2018) but currently show subclinical characteristics. Interventions targeting early and emerging problems in childhood address problems at their source, and thus have the greatest potential for preventing this developmental trajectory to long-term psychopathology (Department of Health, 2015; Department of Health & Department of Education, 2017; House of Commons, 2019; Shonkoff & Fisher, 2013). However, the current assessment criteria used to assess NDDs prevent early detection.

1.2 Assessment and diagnosis of childhood NDDs

The Diagnostic and Statistical Manual of Mental Disorders (DSM-V) is the universally accepted standard criteria for the classification of NDDs. This framework is based on a categorical conceptualization of psychopathology, whereby psychiatric disorders are presumed to constitute largely discrete entities. This classification approach was first systematized in the 19th century by psychiatrist Emile Kraepelin and continues to play an extensive role in guiding clinical and research practice in psychopathology.

The DSM approach relies on assessing overt phenotypic or behavioural symptoms that emerge later in childhood to diagnose NDDs (Sheldrick, Maye & Carter, 2017), whereas the critical windows for very early intervention often occur before the behavioural symptoms to meet diagnostic criteria emerge (Inguaggiato, Sgandurra & Cioni, 2017). Other limitations with the DSM classification are heterogeneity within single diagnoses; individuals with the same diagnosis can exhibit widely different symptoms. For example, according to the criteria outlined in the DSM there are 15 symptoms for CD and to receive a diagnosis of CD children must have at least 3 CD symptoms, plus impairment (Hudziak, Achenbach, Althoff & Pine, 2007). According to these criteria, there are 32,647 different symptom profiles that would qualify for a diagnosis of CD (Nock, Kazdin, Hiripi, & Kessler, 2006). Given that two people with the same disorder can differ considerably in their expression, it seems likely that their symptoms would stem from different causal influences and would therefore require different interventions (Cuthbert & Insel, 2013). Another limitation of the DSM refers to comorbidity. An ideal taxonomy produces categories that are mutually exclusive. However, the DSM has consistently failed to demonstrate clear boundaries between diagnoses, with multiple diagnoses having overlapping symptoms. In a population sample of 1420 children, aged 9 to 13 years, Costello and colleagues (2003) found that 25.5% of

children with one DSM disorder met criteria for another 2 or more. For example, children and adolescents with anxiety disorders have the comorbidity of attention deficit hyperactivity disorder in 15-50% of cases, depression in 25-50% of cases and disruptive disorders in 20-63% of cases (Angold et al., 1999; Axelson & Birmaher, 2001; Biederman et al., 1996; Costello et al., 2003; Curry & Murphy, 1995; Garland & Garland, 2001; Masi et al., 2004). Similarly, in children diagnosed with ADHD, 25-30% have comorbid depression and 45-84% meet full diagnostic criteria for ODD either alone or with CD (Barkley, 2006; Barkley & Biederman, 1997; Barkley, DuPaul, & McMurray, 1990; Biederman, Newcorn & Sprich, 1991; Biederman et al., 1992; Faraone & Biederman, 1997; Fischer, Barkley, Edelbrock, & Smallish, 1990; Pfiffner et al., 1999; Spencer, Wilens, Biederman, Wozniak, & Harding-Crawford, 2000; Wilens, Biederman & Spencer, 2002). In addition to providing mutually exclusive categories, an optimal classification system also consists of categories that yield few intermediate cases (Frances, 1980). However, for the many classes of psychopathology, one of the most frequent diagnoses is “not otherwise specified” (NOS), meaning that individuals do not fit into a clear category (Stein, Black & Pienaar, 2000; Westen, 2012).

In response to these limitations, researchers have posed a real shift in paradigm; in addition to examining signs of NDDs early in childhood, the early emerging symptoms of psychopathology also need to be considered from a translational point of view. Rather than taking the traditional view of disorders as symptom clusters based largely on clinical descriptions, it has been argued that researchers need to consider psychopathology in terms of dysfunction in particular systems and processes (Cuthbert & Insel, 2013). Understanding the processes and mechanisms influencing the developmental trajectory of emotional and behavioural problems will enable further understanding of the etiological pathways to NDDs. However, for this to be achieved, the implementation of a conceptual

framework that is able to identify risk factors underlying various forms of psychopathology across different levels of severity is necessary (Cuthbert, 2014; Insel, 2014).

1.2.1 Transdiagnostic theory

In support of this, the transdiagnostic theory aims to identify transdiagnostic processes or factors that contribute to the onset and maintenance of numerous disorders (Fairburn, Cooper, & Shafran, 2003). Typically, risk factors have been studied within the context of a particular disorder. For example, factors that increase the risk of developing social anxiety disorders have been investigated within individuals diagnosed with social anxiety. However, there is evidence that risk factors for one specific disorder may also present a risk for other disorders, particularly disorders that are highly comorbid. One example would be impairments in regulating negative emotions. Negative emotionality has consistently been identified as a major risk factor for a range of internalising and externalising problem behaviours, including depressive disorders, anxiety, psychopathy and ADHD (Boschloo et al., 2013; Cole, Zahn-Waxler, Fox, Usher, & Welsh, 1996; Eisenberg, Fabes, Guthrie, & Reiser, 2000; Gilliom & Shaw, 2004; Hicks & Patrick, 2006; Rothbart, Posner, & Kieras, 2006; Wernicke et al., 2019). Consequently, instead of examining risk factors for each specific disorder, a better approach to understanding psychopathology would be to focus on transdiagnostic factors that contribute to the development and maintenance of various forms of mental illness (e.g., Aldao, Nolen-Hoeksema, & Schweizer, 2010; Buckholtz & Meyer-Lindenberg, 2012). Having a better understanding of the transdiagnostic factors that contribute to various forms of psychopathology will allow the development of treatments and interventions that target shared features of multiple disorders. A transdiagnostic approach to developmental risks aligns with the National Institute of Mental Health's Research Domain Criteria framework (Casey, Oliveri & Insel, 2014).

1.2.2 The Research Domain Criteria (RDoC)

The Research Domain Criteria (RDoC) is a new classification framework for conducting research into mental health disorders (Cuthbert & Insel, 2013; Insel, 2013). In contrast to the usual approaches to psychiatric classification, the RDoC advocates studying the underlying processes in mental health problems. This enables the development of personalised intervention and treatment options for psychopathology, which are targeted at a specific phenotype, rather than a diagnostic group (Cuthburt & Insel, 2013). The framework also adopts a fully dimensional approach, allowing the assessment of disorder severity and subclinical presentations of disorders (Lebeau et al., 2012).

The RDoC is constructed around six 'domains' of human functioning, each of which is made up of transdiagnostic 'constructs', encompassing behavioural elements, processes, mechanisms and responses proposed to underlie a number of NDDs (Insel et al., 2010). The six domains of RDoc are: (1) negative valence systems (processes that respond to aversive situations); (2) positive valence systems (processes that respond to rewards); (3) cognitive systems; (4) systems for social processes; (5) arousal/regulatory systems; and (6) sensorimotor systems (Cuthbert, 2014).

1.3 Socio-cognitive and emotional functioning

A promising line of research towards gaining further understanding of the mechanisms underlying psychopathology focuses on individuals' differences in socio-cognitive and emotional functioning (Denham & Brown, 2010; Gillies, 2011; Greenberg et al., 2003). Socio-cognitive and emotional characteristics in the early years have implications for the development of social behaviours and impairments in these abilities play a central role in various domains of psychopathology (Bierman & Welsh, 1997). Successful socio-cognitive and emotional functioning is reliant on partial mutual dependence of a number of brain

regions (e.g., amygdala, anterior insula, superior temporal sulcus, ventral and medial prefrontal cortex, and temporoparietal junction; Adolphs, 2009; Dunbar, 2009; Porcelli et al., 2019; van Overwalle, 2009) and a number of constructs across multiple domains of functioning (Fonagy & Luyten, 2018; Gur & Gur, 2016). Given the complexity of socio-cognitive and emotional processes, impairments in any of the constructs associated with it, will result in significant impairment. In RDoC terms, it has been proposed that difficulties with negative valence systems, positive valence systems, cognitive systems, systems for social processes and arousal and regulatory systems are all key in children with diagnosed NDDs and early signs of psychopathology more generally. Specified constructs include: (1) the ability to respond to fear, loss and anxiety-provoking situations or contexts appropriately (negative valence systems, arousal systems); (2) the ability to learn which actions or stimuli are associated with positive outcomes and respond to positive motivational situations or contexts appropriately (positive valence systems, arousal systems); (3) the ability to construct and transform representations of the external environment, acquire information from, and make predictions about, the external world, including perception and interpretation of others' psychological states (cognitive systems, systems for social processes); and (4) the ability to perceive someone's emotional state and convey one's own emotional state non-verbally via facial expression (cognitive systems, systems for social processes, arousal systems). Consistent with the RDoC approach, this thesis focuses on examining three key aspects of socio-cognitive and emotional processes that are hypothesized to play a key role in a range of emotional and behavioural problems and could inform transdiagnostic early identification and intervention approaches for psychopathology: Theory of Mind, empathy and facial mimicry.

1.4 A case for Theory of Mind

1.4.1 What is Theory of Mind?

An essential aspect of socio-cognitive and emotional functioning is the ability to make inferences about the psychological states of others (Adolphs, 2001). This function, known as Theory of Mind (ToM), enables an individual to understand or predict other people's behaviour in social situations (Premack & Woodruff, 1978). As children develop, so does their ToM understanding; they increasingly see human beings as individuals with beliefs, desires, intentions and feelings that are separate to their own. ToM is also often referred to as *folk psychology, mindreading* and *mentalising* (Stitch & Nichols, 1995; Whiten, 1991). Recently, ToM has been further conceptualised as having both cognitive and affective components which are supported by partial dependence upon separate anatomical substrates (Dvash & Shamay-Tsoory, 2014). When participating in cognitive ToM tasks, activation in the medial prefrontal cortex (mPFC), superior temporal sulcus (STS), temporoparietal junction (TPJ), and temporal poles are significantly pronounced. Engagement in affective ToM tasks, however, is associated with areas in ventromedial (vmPFC) prefrontal cortex. Affective ToM refers to the inferences made regarding other people's emotions, while cognitive ToM refers to the ability to make assumptions about people's thoughts (De la Osa, et al., 2016).

1.4.2 Why is ToM important?

The ability to develop accurate accounts of what people are thinking and feeling enables individuals to respond accordingly. Consequently, the development of ToM has important implications for children's social communication, interaction and behaviour (Szumski, Smogorzewlka, Grygiel & Orlando, 2019). For example, Weimer and Guajardo (2005) examined pre-schoolers' social behaviours, as assessed by both parents and teachers. They

found that performance on ToM tasks was significantly associated with ratings of prosocial behaviour. The relationship between ToM and social competence is also present in older children, with a meta-analytic review demonstrating positive correlations between ToM and different subtypes of prosocial behaviour (helping, cooperating, comforting) in children aged 6-12 years (Imuta, Henry, Slaughter, Selcuk & Ruffman, 2016).

1.4.3 When does ToM develop?

Most research has suggested that the largest developmental shift in ToM understanding occurs during early childhood (Wellman, Cross & Watson, 2001), when typically developing children attain ToM understanding of mistaken belief, or *false belief,* between the ages of 4-5. In a classic paradigm, known as the Sally Anne location task (Baron-Cohen, Leslie & Frith, 1985), children are shown a doll who puts her marble in a box. When she is out of the room, another doll enters, takes the marble from the box, and hides it in a basket. Children are then asked where the first doll will look for her marble when she comes back. Children pass this task if they acknowledge that people act upon their own beliefs, even if those beliefs are incorrect. For a long time, the Sally Anne location task was the gold standard measure for assessing ToM in young children. However, researchers now belief that equating ToM understanding to comprehension of a single task is too simplistic, arguing that developing a ToM involves understanding a number of concepts acquired in a series of developmental accomplishments (Wellman & Lui, 2004). Indeed, prior to being able to pass the Sally Anne Location Task, infants demonstrate success on a number of ToM precursors such as joint attention (Scaife & Bruner, 1975) and preschool children are able to understand pre-false belief ToM concepts, such as desires and intentions (Meltzoff, 1995; O'Reilly & Peterson, 2014; Poulin-Dubois & Yott, 2017; Wellman & Lui, 2004; Wellman & Woolley, 1990). Conversely, more advanced aspects of ToM develop after success on the Sally Anne task.

For example, second-order false-belief understanding (i.e., the capacity to conclude what someone thinks about a third person) is often not achieved until 7 to 9 years (Peterson, Slaughter & Wellman, 2018).

1.4.4 How is ToM measured?

The problems with using a single ToM task has led psychologists to recommend the use of comprehensive ToM measures composed of multiple tasks to assess a wide range of ToM components that both precede and succeed the mentalizing ability captured in the Sally-Anne task (Wellman & Lagattuta, 2000). The total score of such tests is a compound score, which is an accumulative score made up of different parts. ToM research has demonstrated that a compound score is more stable, leading to a more accurate measurement of the ability (Hughes et al., 2000). These types of tests also allow researchers to study ToM as a multidimensional construct; investigators can compare ToM components in the same child and discover how these components are related throughout development (Blijd-Hoogewys, van Geert, Serra & Minderaa, 2008).

In current ToM research, a number of comprehensive ToM test batteries have been used. Examples include the ToM Test (Steerneman, Meesters & Muris, 2002), the ToM scale (Wellman & Liu, 2004) and the ToM storybooks (Blijd-Hoogewys, van Geert, Serra & Minderaa, 2008). The ToM test by Steerneman and colleagues consists of three subscales tapping ToM precursors (e.g., emotion recognition), simple ToM and more advanced ToM. While simple ToM refers to the ability to understand someone's mental states ("John thinks that…"), the latter is defined as the understanding of complex social situations, including the ability to reason about second and higher-order beliefs (Białecka-Pikul, Kołodziejczyk, Bosacki, 2017). The Wellman and Liu (2004) ToM scale incorporates simple ToM tasks only. The measures assess various desires, diverse beliefs, knowledge access, false belief

understanding, belief-emotion and real-apparent emotion. The last ToM comprehensive test, the ToM storybooks, also confines itself to simple ToM measures. The instrument includes 34 tasks tapping core aspects like emotions, beliefs, desires and also associated aspects, like mental-physical distinctions and ToM precursors. In contrast to the other ToM batteries, the majority of tasks in the ToM storybooks include justification questions (for instance, why will Sally look for her marble in the box?). Asking children to justify their responses eliminates the possibility that children pass the task based on chance, and consequently better reflects ToM knowledge (Blijd-Hoogewys, van Geert, Serra & Minderaa, 2008). Moreover, there is some indication that individuals with autism use fewer mental state terms in their narrative explanations of social interactions (Begeer, Malle, Nieuwland & Keysar, 2010; Klin, 2000; Klin et al., 2003). This led researchers to propose that even when individuals with social impairments are able to understand and accurately predict other people's behaviour in social situations, they may not rely on their ToM ability to do so but rather their experience and general cognitive abilities. However, to date the use of language in justification responses has only been investigated in samples of individuals with autism. Consequently, it is not known if compensatory strategies are being utilized by children with a range of other emotional and behaviour problems.

1.4.5 Clinical correlates of ToM impairments

The previous section of this Chapter has shown the importance of successfully understanding the mental states of others and its' relationship with social competence. However, the reverse process also exists; children who exhibit poor ToM skills engage in inappropriate interpersonal behaviour associated with a range of psychopathology. In 1985, Baron-Cohen, Leslie and Frith found that 80% of high functioning children and adolescents with autism failed a standard ToM task which was passed by nearly all typically developing

(TD) children and a Down's syndrome control group. These results have been widely replicated (e.g., Baron-Cohen & Wheelwright, 2004; Baron-Cohen, 1993, 1995, Eisenmajer & Prior, 1991; Happé, 1995; Jones, Happé, Gilbert, Burnett, & Viding, 2010; Leslie & Frith, 1988; Reed & Peterson, 1990).

Almost 30 years later, empirical studies have investigated and documented ToM impairments in several other childhood mental health disorders. The work exploring the relationship between ToM and externalising disorders has found poor ToM performance to be associated with disruptive disorders, ADHD and early callous-unemotional (CU) traits (e.g., Anastassiou-Hadjicharalambous & Warden, 2008a; Hughes, Dunn & White, 1998; Hughes & Ensor, 2006; Maoz, Gvirtz, Sheffer & Bloch, 2017; Song, Waller, Hyde & Olsen, 2016). Few studies aiming to further elucidate the ToM impairments associated with externalising problems have differentiated between cognitive and affective ToM. They demonstrated that while both children with conduct problems and adults with psychopathy show no deficits on tests of cognitive ToM (Jones, Happé, Gilbert, Burnett & Viding, 2010; Sebastian et al., 2012; Shamay-Tsoory, Harari, Aharon-Peretz & Levkovitz, 2010), their affective ToM performance is impaired compared with TD controls (Anastassiou-Hadjicharalambous & Warden, 2008a; Sebastian et al., 2012). For example, Sebastian and colleagues (2012) found that relative to TD children, children with CD showed reduced activation in the brain regions associated with affective ToM performance (amygdala, anterior insula).

Low levels of ToM have also been found in clinical and TD samples of middle-school-aged children, adolescents and adults with internalising behaviours, particularly depressive symptoms (Bora & Berk, 2016; Caputi, Pantaleo & Scaini, 2017; Kerr, Dunbar & Bentall, 2003; Ladegaard, Lysaker, Larsen & Videbech, 2014; Lee, Harkness, Sabbagh & Jacobson,

2005; Manstead, Dosmukhambetova, Shearn & Clifton, 2013; Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008; Wang, Wang, Chen, Zhu & Wang, 2008; Zobel et al., 2010). Cognitive models of depression suggest that altered social information processing may account for these relations (Banerjee, 2008). Similarly, theoretical models of anxiety propose that dysfunctional schemata which rapidly orientate and allocate attentional resources to social stimuli, contribute to the aetiology and maintenance of anxiety (Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011). Tibi-Elhanany and Shamay-Tsoory (2011) argue that these dysfunctional schemata result in an enhanced vigilance towards socially relevant information. However, studies on the link between ToM and anxiety are sparse and results are conflicting; while some anxiety research suggests that hypervigilance results in increased ToM tendencies (Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018), due to a tendency to more accurately obtain insight into others' state of mind, others have found reduced ToM performance (Hezel & McNally, 2014; Tibi-Elhanay & Shamay-Tsoory, 2011), due to a tendency to attribute stronger emotions and more meaning to what others are thinking and feeling. More inconsistencies in the research relate to which aspects of ToM are associated with anxiety symptomatology; some studies have demonstrated an association between anxiety and affective ToM, whereas others have shown a relationship between anxiety and cognitive ToM. Despite the contrasting results, the possible elevated ToM abilities in individuals with anxiety disorders and the specific impairments in affective ToM demonstrated in children and adolescents with disruptive disorders highlight the possibility that ToM may be differentially characterised across different emotional and behavioural profiles. However, further studies are needed to confirm this.

Although a lot of research has found ToM to be associated with a range of externalising and internalising behavioural profiles, a number of studies have not reported significant between-group differences between those with diagnosed psychopathology and healthy controls (Bertoux et al., 2012; Dziobek et al., 2006; O'Nions et al., 2014; Sarfati, Hardy-Baylé, Brunet & Widlöcher, 1999; Steenhuis et al., 2019; Szanto et al., 2012). For example, O'Nions and colleagues (2014) compared the neural bases of ToM in children with autism spectrum disorder (ASD), CD and TD controls. While children with ASD were found to exhibit reduced activation compared to both the CD and TD groups, children with CD were found to display similar levels of activation in the regions associated with ToM to TD children. Findings suggest that although both ASD and CD are characterised by social difficulties, only children with ASD exhibit atypical neural processing associated with ToM. Moreover, in a longitudinal, dimensional study of 157 children, Steenhuis and colleagues (2019) failed to find an association between ToM ability at 12-13 years and depression and anxiety six years later, leading authors to conclude that ToM is not a vulnerability factor for internalising symptomatology. A wide variety of operational definitions may account for the differing results. For example, in the aforementioned studies ToM has been operationalised in nine ways: (a) the detection of faux pas (Banerjee & Henderson, 2001; Maoz, Gvirtz, Sheffer & Bloch, 2017; Steenhuis et al., 2019); (b) the detection of deception (Hughes, Dunn & White, 1998; Hughes & Ensor, 2006); (c) the ability to understand first-order cognitive false belief (Anastassiou-Hadjicharalambous & Warden, 2008a; Hughes, Dunn & Whire, 1998; Hughes & Ensor, 2006; Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008; Song, Waller, Hyde & Olsen, 2016; Steenhuis et al., 2019); (d) the ability to understand first-order affective false-belief (Anastassiou-Hadjicharalambous & Warden, 2008a); (e) the capacity to understand second-order cognitive ToM (Banerjee & Henderson, 2001; Hughes,

Dunn & White, 1998; Steenhuis et al., 2019); (f) the ability to engage in pretend play (Hughes & Ensor, 2006); (g) the capacity to infer others' true intentions from indirect speech (Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008); (h) the ability to understand thoughts and feeling based on eye gaze (O'Nions et al., 2014); and (i) the capacity to understand a number of components essential to social communication, including, pretence, joking, figure of speech, white lie, misunderstanding and irony (Caputi, Pantaleo & Scaini, 2017, 2018; Steenhuis et al., 2019). These studies were also heterogenous in terms of the samples utilized; while some studies investigated ToM in samples of pre- to middle-school aged children, others examined the construct in adolescents and adults. The adoption of different tasks and different aged samples hampers a clear comparison of findings in terms of ToM impairments.

In conclusion, ToM may be a transdiagnostic construct associated with a range of externalising and internalising behavioural profiles. However, more research is needed to confirm this. Moreover, given that impairments in ToM have been documented in a range of childhood psychopathology it is also possible that ToM is a construct indicative of early identification of risk for NDDs. Despite this possibility, only two studies to date have investigated the role of ToM in high-risk children (Banerjee & Henderson, 2001; Song, Waller, Hyde & Olsen, 2016), and neither investigated the relations between psychopathology and affective and cognitive ToM separately. When considering ToM impairments shown by individuals with psychopathology, the distinction between the two components is important, given that cognitive and affective ToM have been shown to be differentially affected across different emotional and behavioural profiles (Anastassiou-Hadjicharalambous & Warden, 2008a; Sebastian et al., 2012; Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018).

1.5 A case for empathy

1.5.1 What is empathy and why is it important?

Empathy, generally defined as the ability to understand and share the emotions of others, comprises both cognitive and affective processes. Cognitive empathy is the ability to identify the emotional state and take the perspective of another, while affective empathy refers to the capacity to experience the same emotional state as another (Decety & Moriguchi, 2007). Being able to understand and appropriately respond to the feelings of others' is crucial for adequate social interaction (Corden, Critchley, Skuse, & Dolan, 2009; Fridlund, 1991). Indeed, the ability to empathise motivates positive factors, such as prosocial behaviour, social competence and the maintenance of meaningful relationships. Similarly, empathy deficits are negatively associated with undesirable factors, such as aggressive and antisocial behaviours and impairments in moral judgments (Batson, 2011; Decety & Svetlova, 2012; Eisenberg, Tracy & Knafo, 2016; Marsh & Cardinale, 2012).

1.5.2 When does empathy develop?

Numerous studies indicate that the affective component of empathy develops before the cognitive component. Affective responsiveness is present at an early age and is largely automatic and involuntary. For instance, as early as eighteen to seventy-two hours after birth, new-borns display distress reactions when exposed to the sounds of another infant crying (Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971). Moreover, they respond more strongly to another infant's cry than a range of control stimuli, including synthetic cry sounds, non-human cry sounds, and their own cry (Martin & Clark, 1982; Sagi & Hoffman, 1976; Simner, 1971). These results suggest that the display of distress in infants is not due to the aversive sound of crying but rather appears to be a prerequisite of empathic responding.

With development, the cognitive capacity begins to emerge. By the second year of life children use emotion labels for facial expressions (e.g., Denham & Couchoud, 1990; MacDonald, Kirkpatrick & Sullivan, 1996; Reichenbach & Masters, 1983; Russell & Widen, 2002; Wellman, Harris, Banerjee & Sinclair, 1995; Wellman, Phillips & Rodriguez, 2000), and by 4-years children can accurately assess situational cues and actively imagine what it would be like to be another person in a particular situation (Wellman, Cross & Watson, 2001). The ability to recognise and identify with another's emotional experience enables children to engage in effective helping strategies. For example, over the second year of life, as cognitive empathy begins to develop, children also become increasingly capable of a wide variety of helping behaviours, such as verbal comfort and advice (Zahn-Waxler et al., 1992). The development of these later cognitive abilities allows children to attach their own empathetic feelings to the experiences of others, reconstructing the early developing affective experience of empathy into an 'other-focused' experience.

1.5.3 Contributors to empathy development

A large body of literature suggests that social interactions are critical to the development of empathy. Given that caregivers have a significant influence on children's socialisation, it is not surprising that parenting influences the early development of empathic responding. Research has shown that children's empathy is most likely to develop when parents: (1) are more accepting of their emotions (Brophy-Herb et al., 2011; Gottman, Katz & Hooven, 1996), (2) display more warmth (Robinson, Zahn-Waxler & Emde, 1994; Zhou et al., 2002); and (3) provide explanations concerning the causes and consequences of emotions and direct their children to label emotions (Garner, 2003). Parent-child relationship quality has also been associated with empathic development. Secure attachment and high levels of

parent-child synchrony have been found to be positively related to empathic responding (Feldman, 2007; Kestenbaum, Farber & Sroufe, 1989; Mikulincer et al., 2001).

1.5.4 Clinical correlates of childhood empathy impairments

Empathy impairments are associated with a wide range of psychopathology. In terms of externalising behaviours, specific impairments in affective empathic responding have consistently been demonstrated in children with CD (Schwenck et al., 2012; van Goozen et al., 2016), in children with CD and high levels of CU-traits (Pasalich, Dadds & Hawes, 2014), in children with ADHD (Maoz, Gvirtz, Sheffer & Bloch, 2017), in pre-diagnostic children with psychopathic tendencies (Jones, Happe , Gilbert, Burnett, & Viding, 2010) and in children at high-risk of developing criminal behaviour (van Zonneveld et al., 2017). A number of studies have also demonstrated that children with disruptive behaviour disorders report feeling less affective empathy to negative, but not positive, emotions (de Wied, Goudena & Matthys, 2005; de Wied, van Boxtel, Posthumus, Goudena, & Matthys, 2009; van Zonneveld et al., 2017).

Empathy impairments have also been found to play a role in a range of internalising problems, including social anxiety, generalised anxiety and symptoms of depression in both clinical and subclinical populations of adolescents and adults (Auyeung & Alden, 2016; Ekinci & Ekinci, 2016; Gambin & Sharp, 2018; Morrison et al., 2016; Schreiter, Pijnenborg & aan het Rot, 2013; Thoma et al., 2011; Tibi-Elhanany & Shamay-Tsoory, 2011). Like ToM theorists, empathy researchers propose that impaired empathic responding in individuals with internalising behaviours is associated with their impairments in cognitive processes, such as attentional biases (e.g., Thoma et al., 2011; Tibi-Elhanany & Shamay-Tsoory, 2011). More specifically, the relationship between anxiety and empathy is hypothesized to be a result of dysfunctional schemata which rapidly orientate and allocate attentional resources

to social stimuli, resulting in an enhanced vigilance towards socially relevant information (Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011). However, also consistent with research on ToM, there are inconsistencies regarding the direction of empathy impairments caused by hypervigilance. While some studies have demonstrated that anxiety disorders are associated with elevated levels of empathic responding (Auyeung & Alden, 2016; Gambin & Sharp, 2018; Tibi-Elhanany and Shamay-Tsoory; 2011), due to a tendency to more accurately obtain insight into others' state of mind, others provide evidence that those with anxiety problems have reduced empathic abilities (Gambin & Sharp, 2018; Morrison et al., 2016), due to a tendency to attribute stronger emotions and more meaning to what others are feeling. The same inconsistencies are apparent in the literature on empathy and depression, with researchers proposing that low empathy reflects an increase in preoccupation with one's self (Ekinci & Ekinci, 2016) and enhanced empathic abilities reflects a hypervigilance to the social environment (Schreiter, Pijnenborg & aan het Rot, 2013; Thoma et al., 2011). More inconsistencies relate to which aspects of empathy are associated with anxiety; some studies have demonstrated an association between anxiety symptomatology and affective empathy, whereas others have shown a relationship between anxiety and cognitive empathic responding. The results regarding the nature of empathy impairments in those with depressive symptoms are more homogenous; all studies established a relationship between depression and affective empathic responding (Ekinci & Ekinci, 2016; Schreiter, Pijnenborg & aan het Rot, 2013; Thoma et al., 2011), with only one study additionally finding an association between depression and cognitive empathy (Ekinci & Ekinci, 2016).

Other theorists propose that, rather than a general hypervigilance towards all social stimuli, individuals with internalising disorders display a selective vigilance towards threat

(Beck & Clark, 1997; Beck, Emery & Greeberg, 1985; Disner, Beevers, Haigh & Beck, 2011; Eysenck, 1992; Eysenck, 1997; Mogg & Bradley, 1998; Mogg et al., 1997; Williams et al., 1988; Williams et al., 1997). However, only two studies have examined the relationship between internalising disorders and empathy according to valence. In a sample of 20 participants with depression and 20 demographically matched controls, Thoma et al., (2011) demonstrated that depressed patients had higher self-reported dispositional empathy scores but there were no differences between the groups in their empathy performance according to valence. Morrison and colleagues (2016) also failed to find evidence of a hypervigilance towards threat, demonstrating that social anxiety was associated with reduced affective empathy for positive affect. That is, individuals with social anxiety were less able to share in others' positive emotions. Indirect evidence investigating the role of facial emotion recognition in individuals with anxiety, however, has found contrasting results. In line with the theory that hypervigilance is specifically related to threatening stimuli, anxiety symptomatology has consistently been associated with the processing of negative facial displays of emotions. In facial recognition research, the hypervigilance towards threat is manifested by both impaired and enhanced recognition of negative facial displays (Doty, Japee, Ingvar & Ungerleider, 2013; Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Gutiérrez-García & Calvo, 2017; Jarros et al., 2012; Joormann & Gotlib, 2006; Lau et al., 2012; Lee, Herbert & Manassis, 2014; Montagne et al., 2007; Richards et al., 2002; Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006; Yoon, Yang, Chong & Oh, 2014). Facial emotion recognition is a contributing factor in the ability to empathise with others and has been theorised to be a precursor to empathy (Blair, 2005; Marshall & Marshall, 2011; Marshall, Hudson, Jones & Fernandez, 1995). Thus, if

children with anxiety are impaired in recognising negative emotions, we would expect them to also display an impairment in empathic responding for negative emotions.

The consistent associations between empathy impairments and a range of psychopathological symptoms supports the transdiagnostic relevance of the construct in research and assessment and the possibility that the construct is indicative of early identification of risk for NDDs. However, while impairments in affective empathy for negative emotions have been well documented in children with externalising problems, the role of empathy in young children's internalising behaviours is yet to be examined. Indeed, the relationship between empathy and internalising disorders has only been investigated in adults. This significantly limits our conclusions, given that risk factors do not confer risk in the same way for an individual across the lifespan; it has been suggested that clusters of behavioural and psychological features may be associated with different psychopathological symptoms across time (Cicchetti, 1993; Rutter & Sroufe, 2000). Consequently, more research is needed to better understand empathy's potential as a protective factor in pre-diagnostic high risk samples of children with internalising problems.

1.5.5 The relationship between ToM and empathy

ToM is very closely linked to empathy. Some researchers argue that both affective and cognitive ToM form cognitive empathy, and thus ToM and cognitive empathy are conceptually interchangeable (Baron-Cohen & Wheelwright, 2004). This is based on neuroanatomical research (e.g., Abu-Akel & Shamay-Tsoory, 2011; Dvash & Shamay-Tsoory 2014; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Harari, Aharon-Peretz, & Lev-kovitz, 2010; Shamay-Tsoory, Tibi-Elhanany, & Aharon-Peretz, 2007) that demonstrates when a cognitive empathic response is generated, the cognitive ToM network (medial prefrontal cortex, superior temporal sulcus, temporal poles) and the affective ToM network

(ventromedial prefrontal cortex) are typically involved. In contrast, the affective empathic response is driven mainly by regions that mediate emotional experiences, such as the amygdala and the insula (Figure 1.1).

However, other researchers propose that ToM is a prerequisite of cognitive empathy; while ToM is the ability to infer the psychological states of others, cognitive empathy additionally requires the ability to adopt another's psychological point of view (Davis, 1994; de Wied, Goudena & Matthys, 2005; Dvash & Shamay-Tsoory, 2014). Consequently, without first being able to understand another person's beliefs, intentions and emotions, one would be unable to successfully take the perspective of that person. Although there is debate regarding how the constructs are related, overall researchers are in agreement that ToM and empathy are two related processes (Baron-Cohen & Wheelwright, 2004; Davis, 1994; de Wied, Goudena & Matthys, 2005; Dvash & Shamay-Tsoory, 2014).

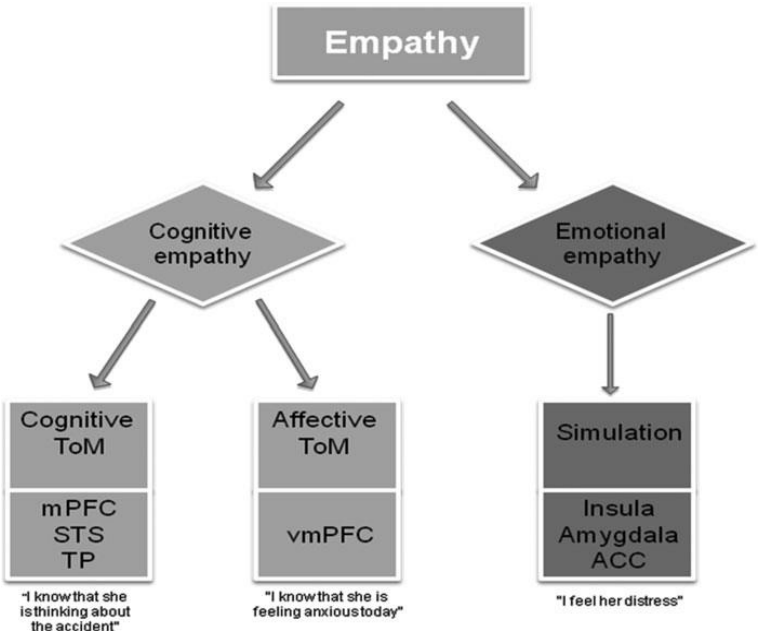

Figure 1.1 Dvash and Shamay-Tsoory's (2014) illustration representing the relationship between cognitive and affective empathy and cognitive and affective ToM. mPFC, medial prefrontal cortex; STS, superior temporal sulcus; TP, temporal poles; vmPFC, ventromedial prefrontal cortex; ACC, anterior cingulate cortex.

1.6 Facial mimicry

Another construct associated with empathic responding is facial mimicry. It is assumed that emotional understanding is initiated by the observation of another's emotional state. Seeing a person display an emotional facial expression often elicits the same expression in the observer. For example, a common response to seeing someone smile is to smile ourselves. The process of imitating another's facial expression has been termed facial mimicry, and its existence has been established in studies of both adults (Bernieri et al., 1988; Cappella & Planalp, 1981; Dimberg, 1990) and children (Chisholm & Strayer, 1995; de Wied et al., 2006, 2009; Haviland & Lelwica, 1987).

Positive emotions typically evoke an increase in zygomaticus major activation (which pulls up the corners of the mouth) and negative emotions are typically associated with

increased corrugator activity (which knits the brows; e.g., De Wied, van Boxtel, Matthys, & Meeus, 2012; Larsen, Norris, & Cacioppo, 2003; Lundqvist & Dimberg, 1995). More recent evidence indicates that there are specific facial muscle response patterns for specific emotions. In successive samples of 61 and 33 TD children, aged 6-7 years, Deschamps and colleagues (2012, 2014) examined children's facial Electromyography (EMG) activity in response to the presentation of dynamic sad and fearful facial expressions. Sad faces were found to be related to a combination of corrugator, depressor (pulls down corners of the lips) and frontalis activation (raising inner brows), and fearful faces were found to be related to frontalis activation. Studies using facial recognition paradigms in adults show that facial expressions judged to be fear involve a combination of raised and drawn in inner eyebrows, stretching the lips (risorius) and widening the eyes (Ekman & Friesen, 1978; Kohler et al., 2004). In facial EMG studies of children, frontalis activation has been shown (Deschamps et al., 2012; 2014), but activation of the risorius, corrugator and eye widen has not yet been demonstrated, because EMG studies have not investigated risorius activity or eye widening in response to fearful facial expressions. Consequently, there is a need for further research on facial mimicry in young children which focuses on additional sites of muscle activation. Figure 1.2 shows the muscles associated with facial expressions of happiness, fear and sadness.

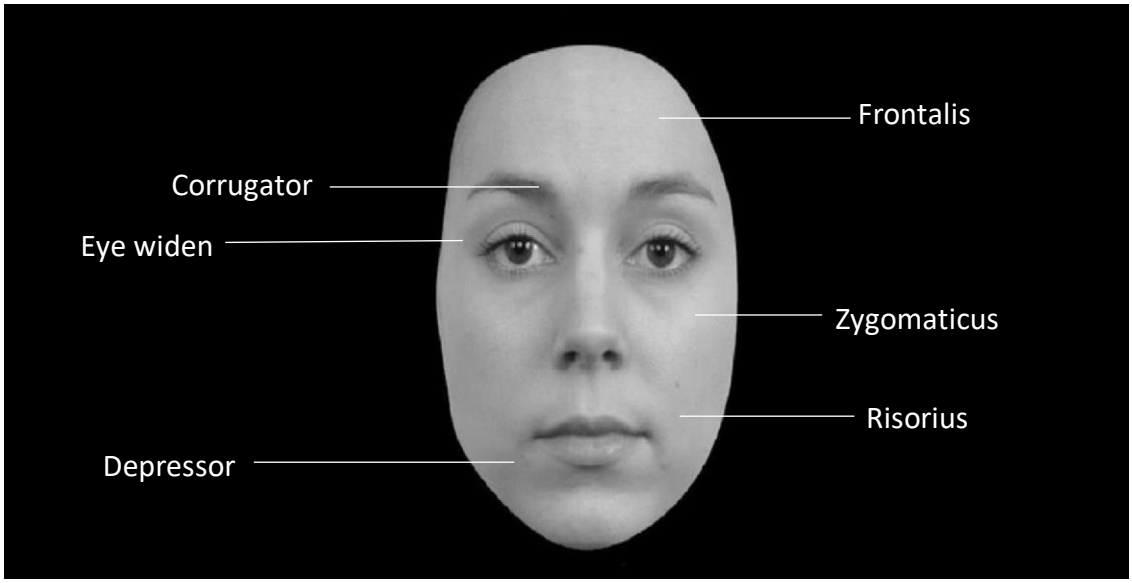

Figure 1.2 Muscles associated with facial expressions of happiness, fear and sadness

1.6.1 The role of facial mimicry in empathy impairments

The literature proposes two main claims regarding the function of mimicry; (1) it facilitates emotion recognition and perspective taking (cognitive empathy; e.g., Niedenthal, Brauer, Halberstadt, & Innes-Ker, 2001; Oberman, Winkielman & Ramachandran, 2007); (2) it enables emotion contagion (affective empathy; Hatfield, Cacioppo & Rapson, 1994; Hess & Fischer, 2013; Laird et al., 1994). However, the precise mechanism of how mimicry is related to the development of individual differences in empathy, remains unclear. According to the staged multicomponent model of empathy (Marshall et al., 1995), observing the emotions of others firstly facilitates emotion recognition, which results in perspective taking and subsequently facilitates an emotional response. Marshall and colleagues (1995) argue that without first being able to recognise the emotion and adopt the perspective of that person, how is one expected to experience a vicarious emotional response? However, other models of empathy propose that facial mimicry specifically underlies affective empathy, given that both processes are relatively automatic and non-cognitive (Hoffman, 1984). Indeed, facial

expressions are proposed to generate concordant changes in the autonomic nervous system (ANS), associated with feeling the corresponding emotion (Levenson, Ekman & Friesen, 1990). Consistent with this notion, the perception-action model (PAM; Preston & De Waal, 2002) proposes that when people perceive an emotion in others, they automatically mimic this emotion, which firstly results in an affective empathic response and then a cognitive one. Similarly, the facial feedback hypothesis (Adelmann & Zajonc, 1989) suggests that muscle activation in response to others' emotional facial expressions generates neural feedback, inducing a corresponding and congruent emotional response (affective empathy). This congruent emotional reaction facilitates emotion understanding, and thus cognitive empathy (Hatfield, Cacioppo & Rapson, 1994; Hoffman, 1984; Lipps, 1907). Empirical research conducted in samples of healthy adolescents and adults has found positive relations between facial mimicry, cognitive empathy and affective empathy (Drimalla, Landwehr, Hess & Dziobek, 2019; Sato et al., 2013; van der Graff et al., 2016) and supported the mediating relationship of affective empathy (Sato et al., 2013; van der Graff et al., 2016). Despite these promising findings, no study has yet investigated these relationships in young children, at a time when empathic and facial responses are less likely to be influenced by social desirability factors.

The link between mimicry and empathy more generally has been supported by several brain systems. In typically developing individuals, neuroanatomical research points to the involvement of the Mirror Neuron System (MNS). The MNS includes neural circuits that activate when an individual performs an action and perceives the same action being performed by others (Buccino et al., 2001, 2004; Rizzolatti & Arbib, 1998). This research indicates that the MNS is the connecting link between cognition and action. When observers see an action, they internally repeat (simulate) and often times externally repeat (mimic),

which ensures understanding of that action. This notion raises an important question: if people engage in facial mimicry to understand the emotions of others, do those with impaired emotional understanding display facial mimicry impairments?

1.6.2 Mimicry impairments in children with psychopathology

Impaired facial mimicry responses have been demonstrated in adolescents and adults with major depressive disorder, dysphoria, ASD, generalised anxiety disorder and symptoms of social anxiety (Dimberg, 1997; Dimberg & Christmanson, 1991; Dimberg & Thunberg, 2007; Heerey & Kring, 2007; McIntosh, 2006; Sloan et al., 2002; Vrana & Gross, 2004; Wexler et al., 1994). This has led researchers to theorize that impaired facial responsiveness plays a role in the empathy impairments consistently exhibited within these disorders. However, research investigating the role of facial mimicry in childhood emotional and behavioural problems have only utilized samples of children with Disruptive Behaviour Disorder (DBD) and ASD. While children with DBD have been found to display specific facial mimicry impairments for negatively valenced facial expressions (de Wied et al., 2006, 2009), children with ASD display impaired mimicry for both negative and positive faces (Beall et al., 2008; Oberman et al., 2009). A reason for the different findings for impaired facial mimicry could be attributed to the different stimulus materials used. In the field of ASD research, only static pictures of faces have been used; static pictures of posed emotions are weaker stimuli (Drimalla, Landwehr, Hess & Dziobek, 2019; McLellan, Johnston, Dalrymple-Alford & Porter, 2010; van der Graff et al., 2016), leading to suboptimal recognition rates and lower intensity and realism ratings compared to dynamic stimuli (Weyers et al. 2006).

Further support for potential mimicry impairments in children with psychopathology comes from emotion recognition studies. Facial emotion recognition deficits for negative (but not positive) emotions have been found in children, adolescents and adults with both

externalising and internalising behavioural profiles, particularly those with DBD (Blair & Coles, 2000; Blair et al., 2001; Bowen, Morgan, Moore & van Goozen, 2014; Dadds et al., 2006; Fairchild et al., 2009; Hunnikin et al., 2019; Wells et al., under review) and anxiety symptomatology (e.g., Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Gutiérrez-García & Calvo, 2017; Jarros et al., 2012; Lau et al., 2012; Lee, Herbert & Manassis, 2014). In line with empathy models proposing that mimicry facilitates emotion recognition, perspective taking and emotion contagion, if children are impaired in emotion recognition for negative emotions, we would also expect them to be impaired in their facial responsiveness to negative emotions.

Despite these findings, there are issues concerning facial mimicry responses in children with social impairments that need further exploration. For example, at what stage in development do atypical responses to facial expressions emerge? Deschamps and colleagues (2014) investigated EMG activity in response to emotional faces in 6- to 7-year-old TD children, children with conduct problems and children with ADHD. They found that all groups displayed significant facial mimicry in response to the emotional expressions of others and that there were no significant differences in mimicry response between the groups. The authors concluded that responses to others' facial expressions are intact in children and that mimicry may not be impaired until later in development. However, further investigation of mimicry in young children with symptoms of NDDs is necessary.

1.7 The importance of identifying socio-cognitive and emotional impairments early

Identifying the socio-cognitive and emotional impairments that underly emotional and behavioural problems at a young age is important for a number of reasons. The first being that, psychological wellbeing, defined as a state in which children realise their own potential and can cope with the typical stressors of life, develops early in life (The Children's Society,

2018; Fattore, Mason & Watson, 2007). According to Public Health England (2015a) the key psychological factors that influence a child's sense of wellbeing are learning and development, emotional functioning, living conditions and life events. The Social Services and Well-Being (Wales) Act (2014) similarly describes wellbeing in relation to children as "physical, intellectual, emotional and behavioural development". Psychological wellbeing is essential if children are to flourish and lead rich and fulfilling lives. Cognitive development through learning, including language and communication acquisition, is associated with a range of wellbeing benefits; it promotes self-confidence, social inclusion and cohesion, and builds resilience to stress through the ability to manage emotions, communicate feelings and think symbolically (Department of Health, 2014; Fattore, Mason & Watson, 2007, 2009; Public Health England, 2015b). Equally, the ability to recognise and regulate emotions is associated with empathy, effective social functioning, self-esteem, and positive outcomes (e.g., Besel & Yuille, 2010; Ciarrochi et al., 2001; Corden, Critchley, Skuse & Dolan, 2009; Eisenberg, Spinrad & Smith, 2004; Eisenberg, Wentzel & Harris, 1998; Fischer & Manstead, 2016; Fridlund, 1991; Gery, Miljkovitch, Berthoz & Soussignan, 2009; Martin, Berry, Dobranski, Horne & Dodgson, 1996; Rey, Extremera & Pena, 2011; Schutte et al, 2002). Finally, an environment that is sensitive and supportive is critical in the development of systems that underpin cognitive and emotional development (Fattore, Mason & Watson, 2007; Institute of Medicine and National Research Council, 2015; Raby et al., 2018). Consequently, there are clear opportunities for early promotion of cognitive and socio-emotional skills to support children's wellbeing and readiness for life.

Secondly, individuals with externalising and internalising disorders often start showing emotional and behavioural problems early in life, and once established such problems continue into later childhood, adolescence and adulthood, resulting in significant

maladjustment. For example, in a longitudinal study of 1273 participants, Copeland and colleagues (2015) demonstrated that compared to children without a history of psychiatric problems, those with a childhood disorder between the ages of 9 and 13 had 9 times higher odds of two or more adverse adult outcomes related to mental and/or physical health, the legal system, personal finances or social functioning. However, if those at risk can be identified and assessed earlier, the systems that underpin socio-cognitive and emotional development can be better understood, creating opportunities for early interventions to promote positive developmental trajectories. Indeed, interventions that target individuals at risk for emotional and behavioural difficulties early in childhood lead to better outcomes than those delivered later in childhood and adolescence (Humphrey & Wigelsworth, 2016; Skeem et al., 2014). The beginning of school age is a crucial time for the development of emotional, cognitive and social skills (Maguire, Niens, McCann & Connolly, 2016) and offers a window of opportunity to intervene (Dvorsky et al., 2014; House of Commons, 2019).

1.8 The Neurodevelopment Assessment Unit

The Neurodevelopment Assessment Unit (NDAU; https://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit) at Cardiff University is a project that targets children aged 4-7 years at risk of future psychopathology. The NDAU aims to provide support to the teachers and parents of children who are showing emotional and behavioural problems, ultimately aiming to play a preventative role via early intervention.

Consistent with the RDoC approach, the NDAU has adopted a transdiagnostic approach to assessment, concentrating on socio-cognitive, emotional and behavioural dimensions. The outcomes of the NDAU assessment are used to produce a report that profiles the child's strengths and needs and informs the formulation of tailored

interventions that are delivered by school staff. This helps those who work with the child at school or home to understand the nature of the child's difficulties, select appropriate educational provision, prioritise interventions and inform later referrals to clinical services.

Referrals into the NDAU are done through the child's classroom teacher or the school's Special Education Needs Coordinator (SENCO). Typically, the children referred to the NDAU display a range of emotional and behavioural problems that render them at high risk of future neurodevelopmental disorders.

The children who are referred to the NDAU have no formal emotional or behavioural diagnoses, but they do show disordered behaviour. However, because these children have not yet reached 'crisis point' they are considered a blind spot for clinical and educational services. The purpose of the NDAU is to help these children before they reach an escalation point.

1.8.1 Sample

The participants in the research presented in this thesis were primary school aged children aged 4-7 years, referred to the NDAU from schools across South Wales. As part of the referral process, the child's teacher completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) to confirm the child's behavioural and/or emotional problems for the last 6 months. Given the dimensional nature of the study, all children referred by their schoolteachers were eligible to take part. Investigation of the teacher SDQ total scores indicates that 55.5% of the NDAU sample (n = 238) was rated as high or very high risk of future psychopathology (a score of ≥ 16 out of 40) (Goodman, 1997). Consequently, whilst all children are referred and accepted, 44.1% of the sample referred are not high-risk. Similarly, only 60.1% of the sample reached diagnostic criteria for a neurodevelopmental or mental health disorder, as assessed by the Development and Wellbeing Assessment

(DAWBA; Goodman, 1997), a semi-structured research diagnostic interview administered in the NDAU. Consequently, the overall sample consisted of children with varying levels of emotional and behavioural difficulties. This finding further highlights the importance of using a dimensional approach to psychopathology; although around 40% of the NDAU sample did not meet the criteria for clinical levels of psychopathology they did experience emotional and behavioural problems that impacted on their daily life, causing difficulty for their teachers and parents. Consequently, they could benefit from an early, tailored intervention. Children referred to NDAU also exhibited a wide range of emotional and behavioural problems; 16.8% met DSM-IV-TR or International Classification of Diseases (ICD-10) criteria for separation anxiety, 2.5% for social phobia, 2.5% for OCD, 3.8% for generalised anxiety, 2.9% for depression, 39.9% for ADHD, 46.6% for ODD and 10.9% CD.

Once referred children and their families were invited to the NDAU to take part in two testing sessions, lasting around 4 and 2 hours respectively. During the testing sessions, children completed a number of tasks assessing a broad range of socio-cognitive and emotional abilities, while parents completed a battery of questionnaires and interviews regarding their child's behaviour over the last 6 months. Table 1.1 provides an outline of the two testing days for the children.

Table 1.1 Order of task presentation

Day 1		
Task	***Description***	***Duration***
Stranger approach	Observation of child's interaction during a novel introduction with researcher	5 minutes
Lucid ability	Computer based cognitive ability task	20 minutes
BPVS	Picture book receptive language task	20 minutes
ANT ROO	Computer based attention and inhibitory control task	10 minutes

Pupil task	Assessment of pupil-size (arousal), via eye-tracking, in response to positive, negative and neutral pictures	10 minutes
Empathy task	Self-report assessment of cognitive and affective empathy in response to film clips and facial mimicry recording	30 minutes
False belief tasks	Verbally administered belief-emotion and explicit false belief tasks	10 minutes
Harter	Verbally administered self-perception/self-esteem task	10 minutes
FER	Computer-based emotion recognition task	15 minutes
False belief tasks	Verbally administered contents false belief and second-order false belief tasks	10 minutes
Renfrew	Picture book expressive language task	10 minutes
AWMA	Computer based working memory task	20 minutes
BELT	Computer based task assessing response to threat and reward	10 minutes
Height & weight	Physical development	2 minutes
Collaboration task	Observation of parent-child dynamic during a collaboration task	5 minutes
Day 2		
Task	***Description***	***Duration***
ANT Pursuit	Computer based task assessing motor coordination & sustained attention	5 minutes
NIH Toolbox – picture sequence memory	Computer based episodic memory task	10 minutes
NIH Toolbox - DCCS	Computer based cognitive flexibility task	10 minutes
ANT Tapping	Computer based coordination task	5 minutes
ANT Tracking	Computer based coordination task	5 minutes
Hungry Donkey	Computer based risk aversion/impulsivity task	10 minutes
NIH Toolbox – flanker	Computer based attention & inhibitory control task	10 minutes
Perfect blue circle	Observational frustrative non-reward task	5 minutes
Saliva sample	Genetic information	10 minutes

Due to the continuation of data collection throughout the undertaking of this research, sample sizes for each chapter vary. Chapter 2 was the first to be written, hence the sample in this chapter is the smallest. Chapter 3 was the last to be written and therefore has a larger sample compared to the other chapters. With regard to the samples it is also important to note that there is large but not complete overlap between each sample in each chapter. Participants who were used in the first study (Chapter 2) were also used in the second study (Chapter 5) if they had mimicry data. Likewise, participants from Chapters 2 and 5 were used in Chapter 4 if they had mimicry and empathy data; and participants from Chapters 2, 5 and 4 were used in Chapter 3 if they had empathy and ToM data.

For Chapter 2, a TD control sample was recruited from primary schools in South Wales. Teachers of these children also completed the SDQ to confirm that participants in this group had low levels of problem behaviours. TD children were assessed individually in a quiet room at school.

In Chapter 2, it is also worth noting that I refer to the NDAU children as a Neurodevelopmental Disorders (NDD) group. While these children do not have a diagnosis of an NDD, they have been referred to the NDAU as they display emotional and behavioural problems indicative of future NDDs and are consequently at risk of developing NDDs.

1.9 Thesis aim and objectives

This chapter has reviewed key literature suggesting that impairments in ToM, empathy and facial mimicry underly a range of psychological problems and therefore are potential mechanisms that may increase risk of NDDs in young, pre-diagnostic children. It has also outlined the argument that impairments in facial mimicry may be important in explaining impaired empathic responding in young children with early signs of NDDs. However, research to date has failed to investigate the role of both affective and cognitive ToM, in

addition to the role of mental state language, in young children's pre-diagnostic emotional and behavioural difficulties. Moreover, it is clear that there are still areas of uncertainty with regards to the specificity of ToM and empathy impairments across different emotional and behavioural profiles, particularly in individuals with anxiety, and whether impairments in ToM and empathy are observed in young children showing early signs of internalising symptomatology. Finally, it is uncertain whether facial mimicry impairments are a feature of childhood emotional and behavioural problems, and if such impairments are associated with impaired empathic responding in young children.

As a result of current uncertainties in the literature, the overarching objective of the thesis was to examine the role of ToM, empathy and facial mimicry in children with early signs of NDDs, to understand how these processes relate to each other and to specific emotional and behavioural problem profiles. The thesis comprises four empirical Chapters, all of which use participants from the sample described in section 1.8.1 (p. 31).

Chapter two will assess ToM performance in a sample of children with symptoms of NDDs and a comparison sample of age-matched typically developing controls. The chapter had three primary aims: to examine whether children with early emerging symptoms of NDDs present with impairments in ToM understanding compared with typically developing (TD) controls, and use less mental state terminology in their justifications compared to TD controls; and whether children with varying profiles of emotional and behavioural problems perform differently across a range of ToM tasks. As a secondary aim, we explored the relationship between ToM, age and verbal mental ability for NDD and TD groups separately.

It was hypothesised that children displaying symptoms of NDDs would display impaired cognitive and affective ToM performance in comparison to TD controls and use fewer mental state terms in their justifications compared with controls. It was also

predicted that children with a disruptive behavioural profile would exhibit a specific impairment in affective ToM. However, given the inconsistent findings regarding the direction and nature of impairments in individuals with anxiety-related problems, we had no specific predictions about the pattern of ToM impairments in those with anxiety symptomatology.

Chapter 3 reports of a study examining and comparing cognitive and affective empathy and cognitive and affective ToM in children with high and low levels of anxiety symptomatology. The aim was also to characterise the specific nature of the empathy impairments underlying anxiety, in terms of emotion-type, and to explore the contribution of empathy and ToM in explaining anxiety. As a secondary aim, we explored the role of gender and age in moderating the associations between empathy, ToM and anxiety.

It was predicted that children with high levels of anxiety would differ from those with low anxiety in their ToM and empathic responding. However, evidence from the limited available research is inconsistent and consequently we were unable to predict the pattern of socio-cognitive and emotional responding in children with anxiety. We also predicted that highly anxious children would exhibit a specific impairment in empathic responding for negative affect compared to children with low levels of anxiety. However, once again, due to the inconsistent findings of previous research we were unable to predict the direction of impairment. Finally, it was hypothesised that empathy and ToM would both be independently associated with the severity of anxiety symptomatology.

Chapter 4 explored the relationship between facial mimicry and cognitive and affective empathy in those with symptoms of NDDs. Two secondary aims were to establish the feasibility of using the software package Affectiva to study facial mimicry responses in

young children (aged between 4 and 7 years) and to explore the role of gender in moderating the association between mimicry and empathy.

Based on the perception action model (Preston & De Waal, 2002), the facial feedback hypothesis (Adelmann & Zajonc, 1989) and previous studies of adults and adolescents (Sato et al., 2013; van der Graff et al., 2016), we expected to find mimicry, cognitive empathy, and affective empathy to be interrelated. Moreover, it was predicted that affective empathy would mediate the relationship between mimicry and cognitive empathic responding. Secondly, we predicted an increase in zygomatic activity in response to happy faces; an increase in frontalis, corrugator, risorius and eye widen activity in response to fearful faces; and an increase in corrugator, depressor and frontalis activity in response to sad faces (Deschamps et al., 2012; 2014; Ekman & Friesen, 1978; Kohler et al., 2004).

Finally, in Chapter 5 we examined facial mimicry in response to empathy eliciting dynamic film clips in children with and without teacher confirmed (SDQ) peer problems, given that peer problems are associated with a wide range of internalising and externalising disorders. In line with mimicry and emotion recognition studies of children with externalising and internalising problem behaviours, it was predicted that children with significant peer problems would display an impaired facial mimicry response in response to negative emotions but be unimpaired in response to positive emotions relative to children without peer problems. We also expected impairments in facial mimicry for negative emotions to be associated with severity of teacher-reported peer problems.

The four empirical Chapters are currently in the process of being submitted or have been submitted as journal papers. They have therefore been presented in paper format.

Because of this, there may be some repetition in the introductions of the Chapters.

However, the hypotheses and results are unique to the individual Chapters.

2. The nature and extent of Theory of Mind impairments in children with emerging neurodevelopmental problems

2.1 Abstract

Background. Research indicates that Theory of Mind (ToM) impairments may underlie a range of psychological problems in childhood, highlighting the possibility that ToM could be a useful construct when studying risk for neurodevelopmental disorders (NDDs). This study investigated ToM in young children with emerging NDDs. We also investigated whether different patterns of ToM impairments were associated with specific clusters of emotional and behavioural symptoms.

Method. Eighty-seven 4-7-year-old children with teacher-reported emotional and behavioural problems (NDD group) and 30 typically developing children without emotional and behavioural difficulties (TD group) took part. A comprehensive assessment tapping into a number of elements of false belief understanding was used to assess cognitive and affective ToM.

Results. The NDD group did not differ from the TD group in affective ToM ability but exhibited specific impairments in cognitive ToM understanding. Children with symptoms of NDDs also used less mental state terminology to justify how others were feeling. However, despite the significant difference in ToM performance between the two groups, poor ToM comprehension within the NDD group was predicted by age and verbal mental ability and not by emotional and behavioural problems. Within the NDD group there were no differences in ToM performance between children with or without disruptive behaviours or anxiety-related problems.

Conclusions. Impaired cognitive, but not affective, ToM comprehension is present in 4-7-year old pre-diagnostic children with a range of emotional and behavioural problems. Amongst these children, ToM performance is predicted by age and language ability. These findings suggest that ToM is a transdiagnostic construct underlying a range of emotional and

behavioural problems, and that fostering young children's language ability may enhance their comprehension of mental states. Consequently, both ToM and language ability need to be included in future research and intervention efforts.

2.2 Introduction

Early emerging symptoms of neurodevelopmental disorders (NDDs), including externalising (e.g., aggression, disruption, attention and concentration problems) and internalising behaviours (e.g., social withdrawal, low mood), represent a growing concern for early childhood professionals (Poulou, 2013). The reason is that young children with NDDs do not make the same developmental progress as typically developing children. These children have poor academic performance (Hinshaw, 1992) and inadequate social skills (Ogundele, 2018; Poulou, 2014), which impact negatively on their relationships with friends, peers, family members and teachers (Botha, Myburgh & Poggenpoel, 2012; Botha & Wolhuter, 2015; Dalton, 2010; Kourkoutas, Vitalaki & Fowler, 2015). Additionally, for a significant proportion of school-aged children, NDDs persist into adolescence and adulthood, causing significant maladjustment, including criminal activity, relational instability, unemployment, drug and alcohol misuse and physical ill health (Caspi et al., 1997; Miner & Clarke-Stewart, 2008; Moffitt, 2003; Moffitt & Scott, 2008; Petitclerc & Tremblay, 2009; Petitclerc et al., 2009; Rutter & Giller, 1983; Shaw, Gilliom, Ingoldsby & Nagin, 2003). It is possible that targeting children with early emerging signs of NDDs may prevent the escalation of problem behaviour. Indeed, early interventions for children with symptoms of neurodevelopmental problems lead to better outcomes than interventions delivered later in childhood or adolescence (Skeem, Scott & Mulvey, 2014). The beginning of school age is a crucial time for the development of emotional, cognitive and social skills, creating a window of opportunity

to intervene at a time when emotional and behavioural problems are not entrenched (House of Commons, 2018).

Theoretical models of emotional and behavioural problems in childhood suggest that impaired social functioning plays a significant role in these difficulties (Bierman & Welsh, 1997; Goodman, Lamping & Ploubidis, 2010; Osher, Bear, Sprague, & Doyle, 2010). Social impairments persist over time and are significantly associated with a range of NDDs. However, there is substantial heterogeneity in social impairments within single diagnoses and significant overlap of social impairments across mental health disorders (Uljarević et al., 2019). That is, individuals with the same diagnosis often exhibit different social functioning deficits, while patients classified under distinct diagnostic categories often exhibit the similar deficits. These limitations of the current classification system are obstacles in the identification of the mechanisms and processes underlying social impairments across multiple disorders and thus the development of personalised intervention and treatment options for psychopathology (Cuthburt & Insel, 2013).

An alternative method to the categorically based diagnostic systems is the Research Domain Criteria (RDoC) approach; a dimensional approach to psychopathology introduced by the National Institute of Mental Health in 2009 (Casey, Oliveri & Insel, 2014). The RDoC approach proposes that research is conducted around six major domains of human functioning that underpin psychopathology: (1) negative valence systems (processes that respond to aversive situations); (2) positive valence systems (processes that respond to rewards); (3) cognitive systems; (4) systems for social processes; (5) arousal/regulatory systems; and (6) sensorimotor systems (Cuthbert, 2014). Each domain is made up of transdiagnostic 'constructs', encompassing behavioural elements, processes, mechanisms and responses proposed to underlie a number of NDDs (Insel et al., 2010). In terms of

impaired social functioning, difficulties with negative valence systems, positive valence systems, cognitive systems, systems for social processes and arousal systems are all key. Indeed, adequate social functioning includes the ability to perceive, correctly interpret and adequately respond to social information, in addition to having the emotional processing and social communication skills necessary to initiate and maintain relationships (Uljarević et al., 2019). Each of these abilities involves partial mutual dependence on each of the aforementioned RDoC domains and consequently, impairments in any of the domains can result in social impairment.

A component essential for successful social interaction is Theory of Mind (ToM), the ability to make inferences about the psychological states of others. This function enables an individual to understand or predict other people's behaviour in social situations (Premack & Woodruff, 1978). Developmental research on ToM has demonstrated that the ability begins to evolve during the first year of life (Bosco, Friedman & Leslie, 2006; Onishi & Baillargeon, 2005), and continues to develop throughout childhood, adolescent and adulthood (Bosacki, 2000, 2003; Choudhury, Blakemore & Charman, 2006; Goldstein & Winner, 2012; Maylor, Moulson, Muncer & Taylor, 2002). Recently, ToM has been further conceptualised as having both cognitive and affective components. Affective ToM refers to the inferences made regarding other people's emotions, while cognitive ToM refers to the ability to make assumptions about people's thoughts (De la Osa, et al., 2016). The ability to develop accurate accounts of what people are thinking and feeling enables individuals to respond accordingly and consequently has important implications for children's social communication, interaction and behaviour. More specifically, a healthy presence of ToM has been associated with global social competence, empathy and the ability to resolve conflict and maintain harmonious friendships (Astington, 2003; Fink et al., 2015; Jenkins &

Astington, 2000).

The reverse process also exists; children who exhibit poor ToM skills engage in inappropriate interpersonal behaviour associated with NDDs, such as autism. Early research by Baron-Cohen, Leslie and Frith (1985) found that 80% of high functioning children and adolescents with autism failed a standard ToM task which was passed by nearly all typically developing (TD) children and a Down's syndrome control group. These results have since been widely replicated (e.g., Baron-Cohen & Wheelwright, 2004; Baron-Cohen, 1993, 1995, Eisenmajer & Prior, 1991; Happé, 1995; Jones, Happé, Gilbert, Burnett, & Viding, 2010; Leslie & Frith, 1988; Reed & Peterson, 1990). Happé (1995) conducted a comprehensive review of 28 studies, which included more than 300 participants with autism spectrum disorder (ASD) aged 4-30 years. Most high-functioning children with autism continued to fail ToM tests into their teens. It was concluded that a chronological age of 13 years and/or a verbal mental age of 9 are needed for the majority of those with ASD to pass. The deficits in understanding the mental state of others appear to be related to the difficulties with interpersonal relationships, such as conversation (de Rosnay et al., 2014; Frith, Happé, & Siddons, 1994; Peterson et al., 2009) and peer interaction (Dissanayake & Macintosh, 2003) that are prevalent in those with ASD.

Marked social impairments are also present amongst children with other mental health disorders and ToM impairments may be responsible for these. Indeed, individuals characterised by externalising behavioural profiles show reduced ToM abilities. This has been reported in different externalising samples, including children with disruptive disorders, children with ADHD and children with callous-unemotional (CU) traits (e.g., Anastassiou-Hadjicharalambous & Warden, 2008a; Hughes, Dunn & White, 1998; Hughes & Ensor, 2006; Maoz, Gvirtz, Sheffer & Bloch, 2017; Song, Waller, Hyde & Olsen,

2016). Research suggests that displays of externalising behaviours may be due to the misinterpretation of another's psychological state which then may lead to inappropriate acts (e.g., aggression; Deneault & Ricard, 2013; Mohammadzadeh et al., 2016; Nader-Grosbois, et al., 2013; Wellman, et al., 2011). Few studies have aimed to further elucidate the ToM impairments associated with externalising problems and have differentiated between cognitive and affective ToM. They demonstrated that while both children with conduct problems and adults with psychopathy show no deficits on tests of cognitive ToM (Jones, Happe´, Gilbert, Burnett & Viding, 2010; Sebastian et al., 2012; Shamay-Tsoory, Harari, Aharon-Peretz & Levkovitz, 2010), their affective ToM performance is impaired compared with TD controls (Anastassiou-Hadjicharalambous & Warden, 2008a; de la Osa et al., 2016; Satlof-Bedrick, 2017; Sebastian et al., 2012).

Low levels of ToM have also been found in clinical and TD samples of middle-school-aged children, adolescents and adults with depressive symptoms (Bora & Berk, 2016; Caputi, Pantaleo & Scaini, 2017; Kerr, Dunbar & Bentall, 2003; Ladegaard, Lysaker, Larsen & Videbech, 2014; Lee, Harkness, Sabbagh & Jacobson, 2005; Manstead, Dosmukhambetova, Shearn & Clifton, 2013; Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008; Wang, Wang, Chen, Zhu & Wang, 2008; Zobel et al., 2010). Cognitive models of depression suggest that altered social information processing may account for these relations (Banerjee, 2008). Similarly, theoretical models of anxiety propose that dysfunctional schemata which rapidly orientate and allocate attentional resources to social stimuli, contribute to the aetiology and maintenance of anxiety (Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011). Tibi-Elhanany and Shamay-Tsoory (2011) argue that these dysfunctional schemata result in an enhanced vigilance towards socially relevant information. However, studies on the link between ToM and anxiety are sparse and results

are conflicting; while some anxiety research suggests that hypervigilance results in increased ToM tendencies (Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018), due to a tendency to more accurately obtain insight into others' state of mind, others have found reduced ToM performance (Hezel & McNally, 2014; Tibi-Elhanay & Shamay-Tsoory, 2011), due to a tendency to attribute stronger emotions and more meaning to what others are thinking and feeling. More inconsistencies in the research relate to which aspects of ToM are associated with anxiety symptomatology; some studies have demonstrated an association between anxiety and affective ToM, whereas others have shown a relationship between anxiety and cognitive empathic responding.

The specific impairments in affective ToM demonstrated in children and adolescents with disruptive disorders and the possible elevated ToM abilities in individuals with anxiety disorders highlight the possibility that ToM may be differentially characterised across different emotional and behavioural profiles. However, further studies are needed to confirm this. The link between ToM impairments and different types of psychological problems more generally, provides some support for the transdiagnostic relevance of this construct and suggests that early ToM assessment may help to identify risk for future neurodevelopmental disorders. However, only two studies have investigated the role of ToM in children at high-risk of developing psychopathology and findings were mixed (Banerjee & Henderson, 2001; Song, Waller, Hyde & Olsen, 2016). While Banerjee and Henderson (2001) demonstrated a negative association between symptoms of anxiety and ToM in a sample of 6-11-year-old children, Song and colleagues (2016) found that poor ToM was only related to externalising problems in children with high levels of CU traits. They concluded that impaired ToM alone is not sufficient for explaining increased risk for

externalising behaviours but could have social consequences for children who experience other risk factors (e.g., CU traits).

It is also important to note that not all research has found evidence to support an association between ToM performance and diagnosed psychopathology (Bertoux et al., 2012; Dziobek et al., 2006; O'Nions et al., 2014; Sarfati, Hardy-Baylé, Brunet & Widlöcher, 1999; Steenhuis et al., 2019; Szanto et al., 2012). For example, O'Nions and colleagues (2014) compared the neural bases of ToM in children with ASD, conduct disorder (CD) and TD controls. While children with ASD were found to exhibit reduced activation compared to both the CD and TD groups, children with CD were found to display similar levels of activation in the regions associated with ToM to TD children. Findings suggest that although both ASD and CD are characterised by social difficulties, only children with ASD exhibit atypical neural processing associated with ToM. Similarly, in a longitudinal, dimensional study of 157 children, Steenhuis and colleagues (2019) failed to find an association between ToM ability at 12-13 years and depression and anxiety six years later, leading authors to conclude that ToM is not a vulnerability factor for internalising symptomatology.

The use of different samples (children vs. adolescents vs. adults) could account for the discrepant results across the aforementioned studies. For example, researchers have demonstrated that risk factors may not manifest themselves in the same way throughout the lifespan (Cicchetti, 1993; Rutter & Sroufe, 2000). In addition, a wide variety of definitions and meanings of ToM may be responsible for inconsistent and unclear results. Indeed, ToM has consistently been shown to be a multidimensional construct, with individuals acquiring different components of ToM across development (Blijd-Hoogewys, van Geert, Serra & Minderaa, 2008; Steele et al., 2003; Wellman & Lagattuta, 2000; Wellman & Lui, 2004). ToM involves simple concepts, such as understanding the intentions,

beliefs, desires and emotions of others and more advanced aspects of mental state comprehension, including the understanding of faux pas, humour and second-order false belief (i.e., the ability to understand what someone thinks about a third person). In addition, as previously mentioned, the construct has recently been further conceptualised as having both cognitive and affective components. The multidimensional nature of ToM has resulted in the use of indefinite and varying measures. Moreover, most measures are limited in scope, only measuring one dimension of the complex construct. Thus, they are limited in their ability to provide valid and reliable data.

The shortcomings associated with previously used measures have led psychologists to recommend the use of comprehensive ToM measures composed of multiple tasks to assess a wide range of ToM components that develop throughout childhood (Wellman & Lagattuta, 2000). These types of tests also allow researchers to study ToM as a multidimensional construct; investigators can compare ToM components in the same child and discover how these components are related throughout development (Blijd-Hoogewys, van Geert, Serra & Minderaa, 2008). Despite these recommendations, only one study to date has utilized a multidimensional assessment measure of ToM to investigate the role of ToM in high-risk children (Banerjee & Henderson, 2001). While this study used a series of tasks tapping the understanding of intentions, beliefs and emotions, the authors did not investigate the relations between psychopathology and affective and cognitive ToM separately.

The investigation of children's language during ToM tasks has also become particularly relevant in recent years. Studies have demonstrated that individuals with autism use fewer mental state terms in their narrative explanations of social interactions (Begeer, Malle, Nieuwland & Keysar, 2010; Klin, 2000; Klin, Jones, Schultz & Volkmar, 2003). This has

led researchers to propose that even when individuals with social impairments are able to understand and accurately predict other people's behaviour in social situations, they may not rely on their ToM ability to do so but rather use their experience and general cognitive abilities. The role of language in ToM tasks has only been studied in samples of individuals with autism. Consequently, it is not known if compensatory strategies are being utilized by children with a range of neurodevelopmental problems.

In summary, the evidence presented above suggests that ToM may be a transdiagnostic construct associated with a range of externalising and internalising problem profiles. However, more research is needed to confirm this, especially in samples of pre-diagnostic children at risk of psychopathology. It is also not known whether children with a range of early emerging neurodevelopmental disorders are impaired or delayed across multiple areas of mental state understanding or only specific aspects. Finally, there are no data to determine if the lack of mental state terminology used in autistic individuals' narrative of social situations extends to children with a broader range of neurodevelopmental difficulties.

The current study took place in the context of a broader project that targets children at risk of future psychopathology. Children were referred by their schoolteachers to the Neurodevelopment Assessment Unit (NDAU; https://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit) at Cardiff University because of behavioural and/or emotional problems. Using a comprehensive ToM battery, the current study had three objectives: To examine whether children with early emerging symptoms of neurodevelopmental problems (a) present with impairments in ToM understanding compared with typically developing (TD) controls; (b) use less mental state terminology in their justifications compared to TD

controls; and (c) with varying profiles of disruptive behavioural problems and anxiety-related problems perform differently across a range of ToM tasks. Further, previous research in childhood suggests that the relations between ToM, age and verbal mental ability may differ between control and clinical groups (Happé, 1991, 1995; Yirmiya, Sigman, Kasari & Mundy, 1992). Since it is unclear whether this is the case in young children with emerging NDDs, we explored these associations within TD and NDD children separately. Based on the existing literature, we hypothesised that children displaying emotional and behavioural difficulties would exhibit poorer ToM performance in comparison to TD controls and use fewer mental state terms in their justifications compared with controls. Given the previously reported relationships between conduct disorder and affective ToM reasoning, it was also predicted that children with disruptive behaviour profiles would exhibit specific impairments in affective ToM. However, given the inconsistent findings regarding the direction and nature of impairments in individuals with anxiety, we did not make specific predictions about the pattern of ToM impairments in those with anxiety symptoms.

2.3 Method

2.3.1 Ethical statement

The study was approved by the relevant university ethics committee and all parents or legal guardians gave signed, voluntary consent for their children to participate.

2.3.2 Participants

In total, 117 children between the ages of 4 and 7 participated in the study and were assigned to a neurodevelopmental disorder group (NDD) or a typically developing (TD) control group. The NDD group included 87 children with emotional and behavioural difficulties recruited via primary schools in South Wales (mean age = 72.74 months; SD= 12.58). These children were identified by schoolteachers and referred to the

Neurodevelopment Assessment Unit (NDAU) at Cardiff University, where they completed a battery of assessments. The TD group included 30 children also recruited from mainstream primary schools in South Wales (mean age = 70.43 months; SD = 12.03). TD children were visited at school by a trained researcher and individually assessed in a quiet room. For all children, the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) was completed by the individual child's class teacher to confirm behavioural and emotional status for the last 6 months. This measure is described in greater detail below.

To assess differences in ToM performance across different emotional and behavioural profiles, children within the NDD group were further grouped as children with and without disruptive behavioural problems and children with and without anxiety-related problems. These groups were selected based on the established norm scores of the SDQ scoring guidelines (retrieved from http:// www.sdqinfo.org/py/sdqinfo/b3.py?language=Englishqz(UK)). To be eligible to be assigned to the anxiety problems group children were required to score in the high/very high range for emotional problems on the SDQ (≥ 4 out of 10). Although this subscale assesses children's emotional problems generally and is not specific to anxiety, scores on the SDQ emotional subscale correlate significantly with anxiety symptoms as assessed by other measures of childhood anxiety, such the parent version of the Revised Children's Manifest Anxiety Scale (RCMAS; Muris et al., 2003). To be eligible to be assigned to the disruptive behavioural problems group, children needed to obtain a score in the high/very high range for conduct problems (≥ 4 out of 10) or in the low/very low range for prosocial behaviour (≤4 out of 10). Participants only needed to reach the threshold for one of these two subscales to be assigned to this group. Raised scores on the conduct problems subscale are indicative of disruptive behaviour, while lowered scores on the prosocial subscale provides

an indirect measure of callous unemotional traits (Blair, Leibenluft & Pine, 2014; Kimonis et al., 2016). The hyperactivity subscale was not used to assign groups as research has only demonstrated lower levels of affective ToM in those with disruptive behavioural problems and psychopathy (Anastassiou-Hadjicharalambous & Warden, 2008a; de la Osa et al., 2016; Satlof-Bedrick, 2017; Sebastian et al., 2012). Similarly, the peer problems subscale was not used as research has shown that problems with peer relations are associated with both externalising and internalising behavioural profiles (Campbell, 2006; Ladd & Troop-Gordon, 2003; Lynam, 1996; Sturaro, van Lier, Cuijpers, & Koot, 2011).

2.3.3 Materials

2.3.3.1 Strengths and Difficulties Questionnaire (SDQ)

The Strengths and Difficulties Questionnaire (SDQ) is a behavioural screening questionnaire for children and young people aged 3-16 years. Teachers are asked to rate 25 items on a 3-point Likert scale based on how true they are of the child's behaviour over the last 6 months (0 = not true; 1 = somewhat true; 2 certainly true).

The 25 items comprise 5 subscales; four assess negative behaviours (emotional symptoms, conduct problems, hyperactivity/inattention and peer relationship problems) and one assesses positive behaviours (prosocial behaviour). In addition to subscale scores, the SDQ also provides a Total Difficulties score, made up of all negative behaviour scale scores. This score is indicative of the total amount of emotional and behavioural difficulties that a child presents with. The SDQ has been found to discriminate well between children with and without psychological problems (Goodman, 1999; Klasen et al., 2000; Mullick & Goodman, 2001) and is a proven effective tool to screen for child psychiatric disorders in community samples (Goodman, 2001; Goodman et al., 2000). Consequently, the SDQ has been used for a variety of purposes, including clinical assessment and research.

2.3.3.2 Language ability

To assess verbal mental ability (VMA), Lucid Ability, a standardised receptive vocabulary test, was administered (Singleton, 2001). Children aged 4-6 years were assessed by the means of a picture vocabulary task. Five pictures appeared on the screen in random positions. One was the target picture, four were distractions. Children were given audio instructions to choose a picture that went best with a given word. Children aged 7 were administered a conceptual similarities task. Children were presented with two pictures on the screen. The pictures were separated by 6 words. One was the target word, the other five were distractions. The child was asked to choose the word that provided a conceptual link between the two pictures. The validity of Lucid Ability is comparable to a range of conventional IQ measures, including the Wechsler Intelligence Scale for Children (WISC-III), the British Ability Scales (Second Edition) and the British Picture Vocabulary Scale (Second Edition; Lucid Ability Administrator's Manual, 2015; Singleton, 2001).

2.3.3.3 ToM comprehension

ToM understanding was assessed with a four-item ToM scale. These four tasks were presented in a fixed order as follows. The first item was an adaptation of Wellman and Lui's (2004) Contents False Belief (FB) task. The child saw a clearly identifiable 'Smarties' tube, with pencils inside the closed tube. After being shown the contents of the tube, they were introduced to Tiger, who had been sleeping. They were asked: "What does Tiger think is in the tube?" (target question) and "Did Tiger see inside this tube?" (memory question). Children were also asked to justify their response: "Why does Tiger think there are Smarties inside the tube?". To be correct children had to answer "Smarties" to the target question, answer "No" to the memory question, and provide an appropriate justification.

The second item was Baron-Cohen and colleagues' (1985) Explicit FB measure, known as the "Sally-Anne" task. It was presented in full and scored exactly as originally described, with one exception. In the present study, Anne was substituted for a boy named Max to avoid confusion. Max put his ball into a covered basket and leaves the room. Sally then moves the ball into a box. Max returns, and the test question was asked: "Where will Max look for his ball?" Two control questions followed, both of which has to be answered correctly, along with the test question, to pass the task. A justification question was not asked for this item in order to prevent carry-over effects with the later administered second-order task.

The third item was a Belief-Emotion task, presented similarly to the one described by Wellman and Lui (2004). Children saw an identifiable box of 'Coco-Pops' with rocks inside the closed box. Children were introduced to Teddy who says: "I love Coco-Pops. Coco-Pops are my favourite snack. Now I'll go play.'' Teddy was then put away and out of sight. Next, the Coco-Pops box was opened, and the contents were shown to the child. Teddy comes back: ''Teddy has never ever seen inside this box. Now here comes Teddy. Teddy's back and it's snack time. Let's give Teddy this box. So, how does Teddy feel when he gets this box?" (the target question). The researcher opened the Coco-Pops box and let Teddy look inside: ''How does Teddy feel after he looks inside the box?" (the emotion-control question). Children were also asked to justify their responses. To be correct, the child had to answer the target question ''happy'', answer the emotion-control question ''sad" and provide an appropriate justification to the question: "Why was Teddy happy?".

The final ToM item in the scale was an adapted version of Coull, Leekam, and Bennett (2006) and Perner and Wimmer's (1985) second-order FB task. Participants were shown a doll, named Nick, hiding his teddy in his bed. When Nick leaves the room to brush his teeth,

another doll named Alex, takes the teddy and hides it in the cupboard. Nick comes back and sees Alex hiding the teddy, but Alex doesn't see Nick. Participants were asked "Where does Alex think Nick will look for the teddy?" (test question) and asked to justify their response. Three comprehension questions followed. Participants needed to answer all three comprehension questions correctly, as well as the test question, and provide an appropriate justification to pass.

A total ToM score, ranging from 0 to 4, consists of the sum of scores on the four ToM items; a total affective ToM score ranging from 0 to 1 consists of the score on the belief-emotion task; and a total cognitive score, ranging from 0-3, consists of the sum of scores on the contents FB, the explicit FB and the second-order FB tasks. When participants passed the contest FB, the belief-emotion and/or the second-order FB task, their justification for that task was also transcribed and scored for the use of mental-state terms. A randomly selected subset of transcripts (15%) were independently coded by two trained coders; the interrater agreement was 98.4% and inter-scorer reliabilities (Cohen's kappa) between the two coders ranged from 0.89 to 1.00 (mean $\kappa = .97$).

2.3.4 Statistical analyses

Preliminary analyses investigated differences between the NDD and TD groups in gender, age, verbal mental ability and SDQ scores. We performed an independent samples t-test (two-tailed) and chi-square analysis to investigate differences between groups in cognitive and affective ToM respectively. Chi-square analysis also examined differences between groups in the use of mental state terminology in justification responses. The use of *t*-test and chi-square analysis was employed again to examine differences in cognitive and affective ToM between those with and without disruptive behavioural problems and those with and without anxiety-related problems within the NDD group. We then investigated the

relationships between ToM and age, and ToM and verbal mental ability using univariate and correlational analysis respectively. Finally, a linear regression was performed to assess emotional and behavioural problems, age and verbal mental ability as predictors of ToM performance. All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS 24) software and significance level was set at $\alpha < .05$.

2.4 Results

2.4.1 Preliminary analyses

Descriptive characteristics of the NDD and TD groups are included in Table 2.1. The groups did not differ in age or estimated intellectual ability. However, significant group differences were evident for gender, and for internalising and externalising (SDQ) difficulties.

Table 2.1 Descriptive statistics for age, gender, estimated intellectual ability and symptomatology measures for the NDD and TD groups

	NDD (n = 87)		TD (n =30)		NDD vs TD	
	Mean	SD	Mean	SD	Statistic	*p*
Age (months)	72.89	12.57	70.43	12.03	$t(115) = .931$	.354
Gender (% males)	76.14%		56.67%		$X^2(1) = 3.987$	.046
VMA	55.26	29.20	65.57	23.13	$t(112) = -1.746$	.084
SDQ						
Emotional	3.16	2.66	2.00	2.49	$t(114) = 2.097$	.038
Hyperactive	7.83	2.13	3.27	3.18	$t(38.47) = 7.294$	< .001
Conduct	3.76	2.68	1.07	1.77	$t(73.57) = 6.133$	< .001
Peer	3.64	2.44	1.10	1.24	$t(98.81) = 7.305$	< .001
Prosocial	3.87	2.74	8.27	2.02	$t(68.77) = -9.307$	< .001
Total	18.38	6.63	7.41	6.90	$t(113) = 7.624$	< .001

Note: VMA, verbal mental ability; SDQ, Strengths and Difficulties Questionnaire, SD; standard deviation; NDD, neurodevelopmental disorders group; TD, typically developing group

2.4.2 Covariates

T-test analyses were used to investigate the relationship between gender and ToM. Whilst results revealed a significant sex difference in cognitive ToM (see Table 2.2), it was decided not to include gender as a covariate in subsequent analyses. First, whereas NDD boys performed significantly worse on the measure of cognitive ToM than boys in the TD group, [NDD: mean = 1.10, SD = 1.03; TD: mean = 1.71, SD = 0.85, $t(78) = -2.25$, $p < .05$, $d = 0.65$, 95% CI [0.07, 1.15]], there was no gender difference in cognitive ToM within the NDD group, [NDD_{males}: mean = 1.13, SD = 1.05; $NDD_{females}$: mean = 1.62, SD = 1.07, $t(83) = -1.87$, $p > .05$, $d = 0.46$, 95% CI [-0.04, 1.02]], nor were there any differences in affective ToM [$X^2(1) = .06$, $p = .81$]. Together, these results rule out a key role for gender in (cognitive) ToM performance. Secondly, in childhood, boys consistently show higher levels of emotional and behavioural problems than girls (Bulotsky-Shearer et al., 2008; Fantuzzo et al., 2001; Hulle et al., 2007; Lutz et al., 2002; Pianta & Caldwell, 1990; Rubin et al., 2003; Wichstrom et al., 2011). Consistent with these previous findings, boys in the present study demonstrated significantly higher levels of inattentive and hyperactive behaviour and lower levels of prosocial behaviour (Table 2.2). Given that psychological problems appear to be more prominent in boys, matching for gender in this case may eradicate significant group differences. Indeed, it has been suggested that controlling for confounding variables can produce overcorrected and counterintuitive findings (Rothman, Greenland & Lash 2008).

Table 2.2 Gender differences in mean ToM and SDQ scores across NDD and TD groups

	Boys (n = 83)		Girls (n = 34)		Boys vs girls	
	Mean	SD	Mean	SD	Statistic	*p*
Cognitive ToM	1.23	1.02	1.71	0.97	*t*(113) = -2.388	.021
Affective ToM	0.59	0.50	0.58	0.50	*t*(113) = .094	.926
Total ToM	1.80	1.28	2.31	1.29	*t*(109) = -1.925	.057
SDQ Emotional	2.87	2.56	2.85	2.91	*t*(114) = .024	.981
SDQ Conduct	3.32	2.75	2.48	2.67	*t*(113) = 1.481	.141
SDQ Hyperactivity	7.18	3.03	5.35	3.11	*t*(114) = 2.939	.044
SDQ Peer	3.06	2.42	2.79	2.58	*t*(114) = .530	.597
SDQ Prosocial	4.57	3.11	6.06	3.26	*t*(114) = -2.309	.023
SDQ Total	16.43	7.64	13.61	9.30	*t*(113) = 1.680	.096

Notes: ToM, theory of mind; SDQ, Strengths and Difficulties Questionnaire, SD, standard deviation

2.4.3 Main analyses

2.4.3.1 ToM performance in NDD and TD samples

First, we compared ToM performance of the NDD group and the TD group. Results of the univariate comparison revealed that the NDD group scored significantly lower than TD participants for total ToM, $t(109) = -2.121$, $p = .036$, $d = 0.47$, 95% CI [0.04, 1.12]]. However, further t-test and chi-square analyses revealed that while the NDD group was significantly outperformed by the TD group on measures of cognitive ToM, $t(65.79) = -2.866$, $p = .006$, $d = 0.57$, 95% CI [0.12, 1.00], there was no significant difference between the groups for affective ToM, $X^2(1) = 0.05$, $p = .822$ (Table 2.3). In Table 2.4, the proportions of children in the NDD and TD groups who passed each task are shown. As evidenced, more children in the TD group than in the NDD group passed each cognitive task.

Table 2.3 Differences in ToM performance between NDD and TD groups

	NDD/MHD (n = 87)		TD (n =30)		NDD/MHD vs TD	
	Mean	SD	Mean	SD	Statistic	*p*
Total ToM	1.79	1.31	2.37	1.16	$t(109) = -2.121$	.036
Cognitive ToM	1.23	1.06	1.77	0.82	$t(112) = -2.540$	.012
Affective ToM (pass)	57.6%		57.6%		$X^2(1) = 0.05$	.822

Notes: ToM, theory of mind; SD, standard deviations; TD, typically developing group; NDD, neurodevelopmental disorders group

Table 2.4 Proportion of NDD children correct on each task in comparison to TD children

	Contents FB	Explicit FB	Belief-emotion	Second-order FB
TD (n = 30)	63.3%	86.7%	60.0%	26.7%
NDD (n = 87)	43.7%	59.8%	57.5%	16.1%

Notes: FB, false belief; TD, typically developing group; NDD, neurodevelopmental disorders group

The NDD group also reported significantly fewer mental-state references than the TD group for the belief-emotion task, $X^2(1, 70) = 9.05$, $p = .003$. There were no significant differences in the use of mental state terms for either the contents FB or second-order FB tasks (all *p* values > .05; Figure 2.1).

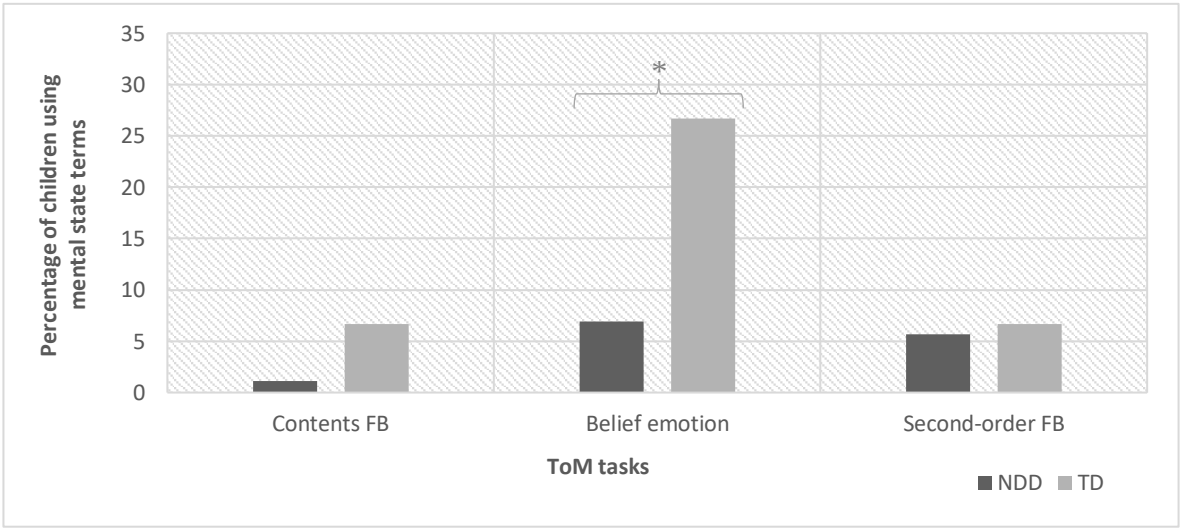

Figure 2.1 Proportion of NDD and TD children using mental-state terms in their justifications. * $p = < .05$. NDD, neurodevelopmental disorders groups; TD, typically developing group; FB, false belief; ToM, theory of mind

2.4.3.2 Theory of mind in relation to distinct emotional and behavioural profiles

Further post hoc tests within the NDD group investigating whether subgroups of those with and without anxiety or disruptive behavioural profiles performed differently on the ToM tasks showed this not to be the case. (Table 2.5).

Table 2.5 Differences in ToM scores between children with and without disruptive behavioural problems (Disruptive+/Disruptive-) and with and without anxiety-related problems (Anxiety+/Anxiety-) within the NDD group

	Disruptive+ (n = 61)		Disruptive- (n = 25)		Disruptive+ vs Disruptive-	
	Mean	SD	Mean	SD	Statistic	*p*
Total ToM	1.80	1.37	1.72	1.21	$t(78) = -.251$	.802
Cognitive ToM	1.24	1.07	1.12	1.01	$t(81) = -.483$	.630
Affective ToM (pass)	57.6%		60.0%		$X^2(1) = .041$	.840
	Anxiety+ (n = 27)		Anxiety- (n = 59)		Anxiety+ vs Anxiety-	
	Mean	SD	Mean	SD	Statistic	*p*
Total ToM	1.88	1.48	1.73	1.24	$t(78) = -.480$	.632
Cognitive ToM	1.31	1.16	1.16	1.00	$t(81) = -.603$	.548
Affective ToM (pass)	51.9%		61.4%		$X^2(1) = .688$	.407

Note: ToM, theory of mind; SD, standard deviation

2.4.3.3 The effect of age on ToM

We next assessed whether there were differences in total ToM performance across ages within TD and NDD children separately. The means and standard deviations for ToM understanding as a function of group and age are shown numerically in Table 2.6 and graphically in Figure 2.2. Univariate analyses revealed a main effect of group, $F(1, 103) = 6.84$, $p = .010$, $\eta_p^2 = .06$, and age, $F(3, 103) = 5.13$, $p = .002$, $\eta_p^2 = .13$, on ToM performance; but there was no group by age interaction, $F(3, 103) = .594$, $p = .621$, $\eta_p^2 = .02$, indicating that the differences in ToM performance between groups across age were consistent. Post

hoc pairwise comparisons revealed that while there were marginally significant differences in ToM understanding between NDD and TD children aged 4 and 6 years, the difference was no longer evident at age 7.

Table 2.6 Mean ToM total scores by group and age

	NDD		TD		
	Mean	SD	Mean	SD	*p*
4-year olds (n = 19)	0.91	1.22	1.88	1.13	.077
5-year olds (n = 34)	1.41	1.22	2.14	1.22	.140
6-year olds (n = 31)	1.77	1.19	2.67	1.23	.055
7-year olds (n = 27)	2.76	1.04	2.83	0.98	.895

Note: SD, standard deviation; NDD, neurodevelopmental disorders group; TD, typically developing group

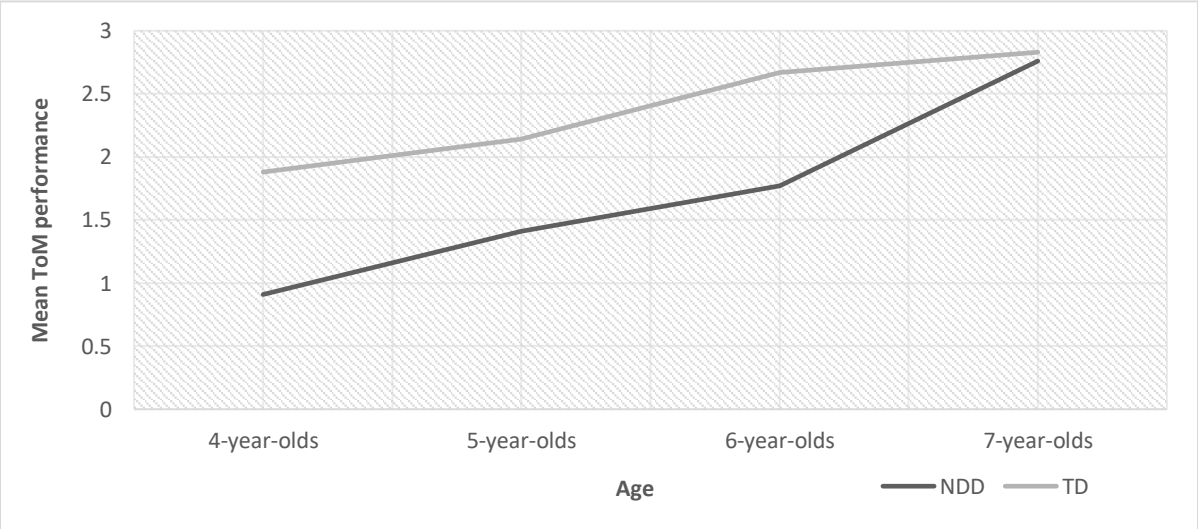

Figure 2.2 Estimated marginal means of total ToM scores across age for NDD and TD children. NDD; neurodevelopmental disorders group; TD, typically developing group; ToM, theory of mind

2.4.3.4 The relationship between ToM and verbal mental ability in high-risk and TD children

Analyses were conducted to examine the relationship between total ToM scores and verbal mental ability (VMA) for NDD and TD groups separately. Pearson's correlations revealed that VMA was significantly associated with ToM in the NDD group, $r = .469$, n = 79, $p < .001$, but not in the TD group, $r = .117$, n = 30, $p = .539$. The relationship between VMA and ToM in the NDD group remained significant after controlling for age, $r = .507$, n = 76, $p < .001$.

To determine the relative contribution of emotional and behavioural problems (as indicated by the total SDQ score), age and VMA in explaining ToM understanding in children with early signs on NDDs, we performed a linear regression analysis. In the NDD group VMA and age were not correlated ($r = .047$, n = 84, $p = .668$), consequently all variables were entered into step 1 of the regression. The multiple regression model significantly predicted ToM understanding $F(3,77) = 18.29$, $p < .001$, adjusted $R^2 = .42$. However, while both age and VMA significantly added to the prediction, $p < .05$, emotional and behavioural problems did not, $p > .05$ (see Table 2.7).

Table 2.7 Summary of multiple regression analysis

	B	**SE_B**	**β**	**CI**
Intercept	-2.868	.777		
Age	.046	.009	.462*	.028-.064
VMA	.019	.004	.432*	.011-.027
SDQ total	.014	.018	.069	-.022-.049

Notes: B = unstandardized regression coefficient, SE_B = standard error of the coefficient, β = standardized coefficient, CI = confidence intervals, * = p < .001. VMA, verbal mental ability.

2.5 Discussion

The current study examined the nature and extent of ToM impairments in young children with emerging neurodevelopmental disorders (NDDs). To the authors knowledge, this is the first study that examined the role of both cognitive and affective ToM understanding in a sample of pre-diagnostic children at risk of developing psychopathology. The study has made a number of important and novel contributions to the literature on ToM and childhood development. First, in line with previous studies on ToM, our results revealed significant differences in ToM ability between children with symptoms of NDDs and typically developing (TD) controls. More specifically, the findings indicate that NDD children are impaired in their ToM understanding. Problems in ToM comprehension have been observed before in children with confirmed neurodevelopmental and mental health diagnoses (e.g., Anastassiou-Hadjicharalambous & Warden, 2008a; Hughes, Dunn & White, 1998; Hughes & Ensor, 2006; Maoz, Gvirtz, Sheffer & Bloch, 2017; Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008) and older children with pre-diagnostic symptoms of anxiety and depression (Banerjee & Henderson, 2001; Caputi, Schoenborn & Walla, 2018; Caputi, Pantaleo & Scaini, 2017). In the current study, we observed similar impairments in pre-diagnostic and younger children with emerging and broad-ranging neurodevelopmental problems. Consistent with the RDoC approach, these findings support the notion that impairments in ToM are transdiagnostic, underlying a large range of psychological problems.

Secondly, results revealed that while NDD children were impaired on measures of cognitive ToM compared to TD controls, there were no differences between the groups on measures of affective ToM. These findings provide support for a multidimensional model of ToM, one in which affective ToM processing operates and develops distinctly from cognitive ToM. This is consistent with neuroanatomical evidence which suggests that the two

processes are supported by distinct anatomical structures (e.g., Abu-Akel & Shamay-Tsoory, 2011; Dvash & Shamay-Tsoory, 2014; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Harari, Aharon-Peretz, & Lev- kovitz, 2010; Shamay-Tsoory, Tibi-Elhanany, & Aharon-Peretz, 2007). However, it is important to note that not all studies support the notion of two independent components of ToM. For example, in a TD sample, Wellman and Lui (2004) found that earlier developing ToM abilities broaden and generalise to encompass later, more advanced mental state understanding. In particular, an understanding of desires precedes an understanding of diverse beliefs. In turn, an understanding of diverse beliefs develops before an understanding of false belief. Finally, children's comprehension of emotion, particularly how emotions connect with beliefs and desires is a late-developing understanding within early childhood. Wellman and Lui (2004) proclaim that the later developing abilities cannot develop until the preceding abilities have been acquired, suggesting that all ToM facets are related and reliant upon one another. Moreover, following a study of advanced ToM in adolescents, Białecka-Pikul, Kołodziejczyk and Bosacki (2017) proposed that cognitive ToM is a developmental prerequisite for affective ToM comprehension. The contrast in findings may suggest that differential development of ToM abilities underlies typical and aberrant development in childhood. Indeed, in our TD sample we found that more children used mental state terminology in their narrative justifications of other people's emotions compared to the sample with NDDs. Based on these findings it possible that while TD children rely on their ability to infer the thoughts and beliefs of others to understand what people are feeling, children with emotional and behavioural difficulties are less able to do so, given their poor ability to understand the cognitive mental states of others. Consequently, they may rely on different processes, such as general cognitive ability and past experience, as suggested by Begeer and colleagues (2010).

In contrast to studies that have demonstrated specific impairments in affective ToM amongst children and adults with disruptive behaviours (Anastassiou-Hadjicharalambous & Warden, 2008a; de la Osa et al., 2016; Satlof-Bedrick, 2017; Sebastian et al., 2012) and elevated ToM performance amongst individuals with anxiety disorders (Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018), we failed to observe any differences in ToM performance across these behavioural profiles. The lack of significant findings may be explained by the dichotomous nature of the measures used. Researchers have suggested that while a pass/fail approach is appropriate for differentiating between extreme cases (healthy or typically developing controls vs clinical cases), ToM tasks that can distinguish degrees of impairment are probably more appropriate for the study of ToM within samples that may display more subtle differences in ToM comprehension (Poletti & Adenzato, 2013). Consequently, future studies utilizing a dimensional approach to assess ToM performance specifically, or social cognition more broadly, would provide us with a better understanding of how distinct ToM constructs relate to different profiles of emotional and behavioural problems in children.

In the present analysis, verbal mental ability (VMA) was associated with ToM performance in the NDD group but not in the TD group. This pattern of performance has previously been demonstrated in studies of autistic children (Happé, 1991, 1995; Yirmiya, Sigman, Kasari & Mundy, 1992), leading authors to conclude that children with autism use cognitive strategies reliant on general ability rather than mentalizing abilities to pass ToM tasks. Based on the current findings it is possible that the same processes underlie ToM comprehension in children with a wider range of emotional and behavioural difficulties.

Although relations between ToM and VMA differed between the two groups, the relation between ToM and age was consistent; in both groups, ToM understanding

improved with age. Therefore, it appears that children with emotional and behavioural problems do not have ToM impairments but are instead delayed in their ability to mentalize. This was particularly evidenced by the finding that while 4- and 6- year old NDD children performed worse than controls on ToM measures, there was no difference in performance between the two groups for 7-year-olds. However, it is important to note that the null result may be due to ceiling effects, given that typically developing children pass first- and second-order FB tasks aged 4-5 and aged 6-7 respectively (Permer & Wimmer, 1985). Consequently, utilizing more advanced ToM tasks with 7-year olds may result in detecting significant differences between typical children and those with NDDs. With that being said, the non-significant differences between TD and NDD children demonstrate that even if 7-year-olds in the TD group did perform at ceiling, 7-year-olds in the NDD group are not far behind. Similar conclusions have been reached by other empirical investigations using samples of children and adolescents with autism spectrum disorder (ASD). While it is well-established that children with high-functioning autism perform worse than TD controls on false belief tests, Happè (1995) demonstrated that by the time they reach their teens, the majority of individuals with ASD also perform at ceiling. Based on these findings, it is possible that as children with emotional and behavioural problems get older, they develop compensatory strategies, as previously mentioned, enabling satisfactory responses without being able to infer the mental states of others.

Last but not least, our study aimed to determine the relative contribution of emotional and behavioural problems, age and VMA in explaining ToM impairments in children with early emerging symptoms of NDDs. Although we observed significant differences between NDD and TD groups in ToM performance, severity of emotional and behavioural difficulties (SDQ total problem score) did not predict ToM understanding in the

NDD group. Indeed, only age and VMA significantly and independently predicted ToM. It is possible that reduced mentalising ability in children with symptoms of NDDs occurs as an indirect effect of language ability. In support of this, while VMA was not associated with ToM in the TD group, the two constructs were significantly related in children with early emerging symptoms of NDDs. Moreover, children with NDDs used less mental state terminology in their justifications of other people's emotions. The notion that impaired ToM in NDDs is an indirect effect of language ability is also in line with previous research demonstrating that children with hearing and language difficulties perform more poorly on tasks that require understanding of others' mental states (Nelson et al., 2011; Slaughter & Peterson, 2011; Peterson et al., 2012; Broekhof et al., 2015; Cavioni et al., 2017; Rieffe & Wiefferink, 2017), and that advanced language skills in young children is predictive of more concern for others and more prosocial behaviour (Conte et al., 2018; Rhee et al., 2013). However, as previously noted, NDD children in the current study did not exhibit any difficulties in understanding others' emotions, only others' thoughts and intentions. It may be the case that NDD children in the current sample displayed greater difficulties in the understanding and production of language related to cognitive mental states. Support for this comes from developmental research stating that children's references to emotions develop before their use of terms describing cognitive states (Wellman, 2014). Consequently, the different developmental trajectories of language acquisition for emotions and language acquisition for cognitive mental states may be responsible for the dissociation between cognitive ToM and affective ToM impairments.

As with any study, there are some limitations to be acknowledged. First, as previously mentioned, the dichotomous nature of the ToM tasks prevented us from investigating the relationship between ToM and emotional and behaviour problems

dimensionally. The RDoC framework advocates the dimensional study of mental health disorders and the processes and mechanisms underlying the disorders. This dimensional approach to psychopathology enables a sufficient mechanism to record variation across individuals in particular traits or capacities, which represents a greater or lesser degree of mental health and adaptation and avoids a substantial loss of valuable information, that is often the case when using categorical approaches (Brown & Barlow, 2005). A meta-analysis investigating the reliability and validity of utilizing a dimensional approach reported a 15% and 37% increase in reliability and validity respectively through the adoption of a dimensional over a categorical measure of psychopathology (Markon, Chmielewski & Miller, 2011). Therefore, in line with the RDoC approach, future studies should aim to assess the relationship between ToM and psychopathology dimensionally. Secondly, despite using reliable and well replicated ToM tasks, future studies should explore the use of ToM paradigms focusing on stimuli that are ecologically more similar to the types of natural stimuli involved in children's social interactions. The Movie for the Assessment of Social Cognition (Dziobek et al., 2006) assesses ToM via participants' understanding of other people's psychological states in response to home videos of real people. This task assesses individuals' ability to determine what other people are thinking and feeling based on a range of factors applicable to real-life social interactions e.g., context, eye gaze, facial expressions. However, this paradigm was designed to assess advanced ToM in adulthood and consequently, is not valid for use in young children. Similar tasks should be developed to assess ToM ability in childhood. The final methodological limitation is that the current study only explored one component of ToM, namely false belief. ToM involves understanding a number of concepts (e.g., intentions and desires) acquired in a series of developmental accomplishments (Wellman & Lui, 2004). However, the development of false

belief understanding is central during the ages of 4 and 7 and consequently, assessing this component of ToM provided us with information on impairments that are highly representative of children in this age group.

Despite the limitations, our findings consolidate and extend previous studies, demonstrating that ToM impairments underlie atypical emotional and behavioural development, even amongst young children who have not yet reached diagnostic levels of mental health problems. Not only was the mean ToM score for the NDD group significantly lower than that for matched controls, but the quantity of cognitive mental state terms used to justify the emotions of others was also lower. From a clinical perspective these findings suggest that differential development of ToM underlies typical and aberrant development in childhood. Secondly, this study found impaired cognitive ToM but intact affective ToM in children at high-risk of future psychopathology. This provides support for a multidimensional model of ToM, one in which affective and cognitive mentalising abilities develop and operate distinctly from one another. Finally, the current findings suggest that language is a crucial factor in the development of ToM for young children with symptoms of NDDs. Therefore, interventions focusing on young children's language acquisition with a view to improve their early development of social cognition skills is recommended. Consistent with this proposition, there is already evidence that stimulating conversations about mental states in young children has positive effects on social and emotional abilities (Agliati, Grazzani & Ornaghi, 2015; Bianco, Lecce & Banerjee, 2016; Giménez-Dasí, Fernández-Sánchez & Quintanilla, 2015; Grazzani, Ornaghi & Brokmeier, 2016; Lecce, Bianco, Devine, Hughes & Banerjee, 2014; Ornaghi et al., 2017), with improvements remaining stable over time (Grazzani, Ornaghi & Brokmeier, 2016).

3. Socio-cognitive and emotional processing in young children with symptoms of anxiety

3.1 Abstract

Background. A growing body of literature suggests that impaired empathy and Theory of Mind (ToM) are risk factors for anxiety symptomatology. Whilst both constructs develop rapidly in childhood, no study before now has simultaneously examined these emotional and social-cognitive skills in relation to anxiety in young children.

Method. Sixty highly anxious (HA) children and 114 children with low to normal anxiety (LA) levels, aged 4-7 years and identified by their schoolteachers as having emotional or behavioural difficulties, took part. Children watched three film clips showing a sad, happy, and scared child, respectively. Questions about the emotions of the children in the clips were asked to assess cognitive empathy, and questions about the participants' own emotions were asked to assess affective empathy. A series of false-belief tasks were used to assess affective and cognitive ToM.

Results. Compared to LA children, HA children exhibited reduced affective empathy to fear and sadness, and elevated cognitive ToM. Multivariate linear regression analyses indicated that reduced affective empathy for negative emotions and increased cognitive ToM predicted severity of anxiety symptomatology.

Conclusions. Children high or low in anxiety did not differ in their understanding of other people's emotions. However, highly anxious children reported markedly higher levels of cognitive theorising and lower levels of affective empathy for others' negative emotions, particularly fear and sadness. The theoretical and clinical implications of these findings for early interventions are discussed.

3.2 Introduction

Anxiety disorders are one of the most common psychiatric disorders in childhood and adolescence. In children younger than 12 years, the prevalence varies between 2.6% and 5.2%, with separation anxiety being the most common disorder (Costello, Egger & Angold, 2004; Ford, Goodman & Meltzer, 2003; Lawrence et al., 2015). Many children with anxiety disorders exhibit significant and persistent impairments in their social and interpersonal functioning (Chansky & Kendall, 1997; Mesa, Beidel & Bunnell, Rao et al., 2007; Strauss et al., 1988). Two components essential for successful social interaction are Theory of Mind (ToM) and empathy; impairments in both have been implicated in the development and maintenance of anxiety disorders. Several models have proposed that individuals with anxiety-related symptomatology display a selective hypervigilance towards threat, as a result of dysfunctional schemata which rapidly orients and allocates attentional resources to threatening stimuli in their environment (Beck et al., 1985; Beck & Clark, 1997; Eysenck, 1992; Eysenck, 1997; Mogg & Bradley, 1998; Mogg et al., 1997; Williams et al., 1988; Williams et al., 1997). In the case of all anxiety disorders, fear is pathological and is related to the presence or anticipation of a particular object, situation or outcome. Consequently, it seems plausible to expect anxious individuals to attend more attention towards stimuli indicating a potential threat. Alternatively, other theorists propose that rather than a selective bias towards threat, individuals with anxiety exhibit an excessive alertness to all social signals (Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011). Since anxious individuals often experience concerns related to their social environment (e.g., fear of being negatively evaluated by others, fear of specific social or performance-related situations, fear of having panic-like reactions in public), they tend to think and care more about what other people think and feel and therefore, excessively scan (and display

hypervigilance for) *all* information in their social environments. In contrast to the hypervigilance to threat theory, this bias will manifest itself in a general impairment in inferring and reasoning about other people's psychological states, including others' thoughts, beliefs, intentions and emotions regardless of emotional valence. It also remains unknown whether hypervigilance results in increased empathic and ToM tendencies, due to a tendency to more accurately obtain insight into others' state of mind, or reduced empathic and ToM performance, due to a tendency to attribute stronger emotions and more meaning to what others are thinking and feeling. Researchers have termed these latter tendencies over-theorising and over-empathising.

Evidence for both general and specific hypervigilance has come from studies of children and adults with a range of anxiety disorders (Bogels & Mansell, 2004; Hirsch & Clark, 2004; Ouimet, Gawronski & Dozois, 2009; Schofield, Johnson, Inhoff, & Coles, 2012; Seefeldt, Kramer, Tuschen-Caffier & Heinrichs, 2014; Sposari & Rapee, 2007). For example, while Seefeldt and colleagues (2014) found that children between 8 and 12 years with social phobia demonstrated a specific hypervigilance towards angry faces, Sposari and Rapee (2007) found that adults diagnosed with generalised social phobia exhibited a preference for attending toward faces than household objects, suggesting an enhanced vigilance for social stimuli in general. Consequently, although empirical evidence for hypervigilance across a range of anxiety disorders is quite prevalent (Bogels & Mansell, 2004; Schofield, Johnson, Inhoff, & Coles, 2012;), there are still uncertainties about its nature and even less is known about its role in empathy and ToM impairments. Studies aimed at further understanding the mechanisms underlying impaired social functioning in anxiety can aid in our understanding of the disorder and help in the development of more effective intervention strategies. Several studies have demonstrated that children's ToM and

empathy dramatically improves at the start of school age (Bartsch & Wellman, 1995; Dadds et al., 2008; Flavell, 1999; Imuta, Henry, Selcuk & Slaughter, 2016; McDonald & Messinger, 2011; Rai & Mitchell, 2004; Uzefovsky & Knafo-Noam, 2017). In this same period, emotional problems, such as anxiety symptomatology and withdrawn behaviours, become increasingly prevalent (Bhatia & Goyal, 2018; Krain et al., 2007; Maguire, Niens, McCann & Connolly, 2016; Pianta & Castaldi, 1990). Consequently, assessing ToM and empathy in this age group will provide us with more information regarding their potential to prevent the development of anxiety.

Empathy

Empathy is generally defined as the ability to understand and share the feelings of another (Cohen & Strayer, 1996). From the second year of life, throughout childhood, adolescence and into adulthood, individuals increasingly begin to understand the emotions of other people (Eisenberg & Miller, 1987; Knafo, Zahn-Waxler, van Hulle, Robinson, & Rhee, 2008; McDonald & Messinger, 2011; Roth-Hanania et al., 2011). The ability to understand and appropriately respond to the feelings of others' forms the basis for prosocial behaviour, social competence and the maintenance of meaningful relationships (Corden, Critchley, Skuse, & Dolan, 2009; Fridlund, 1991). Most researchers acknowledge that empathy is made up of both cognitive and affective components. Cognitive empathy is the ability to identify the emotional state and take the perspective of another, while affective empathy refers to the capacity to experience the same emotional state as another (Decety & Moriguchi, 2007).

Impairments in empathy have been extensively documented in a range of childhood psychological disorders, including autism (e.g., Deschamps, Been & Matthys 2014; McDonald & Messinger, 2012; Yirmiya, Sigman, Kasari & Mundy, 1992), attention hyperactivity disorder (Maoz, Gvirtz, Sheffer & Bloch, 2019) and disruptive disorders (e.g.,

Anastassiou-Hadjicharalambous & Warden, 2008b; Pasalich, Dadds, & Hawes, 2014; Schwenck et al., 2012; van Goozen et al., 2016). The deficits in understanding and responding to the emotional states of others appear to be directly related to the interpersonal and social difficulties that are prevalent in those with such disorders (Groen et al., 2018; Marsh & Blair, 2008; Mul et al., 2018; van Zonneveld et al., 2017). Empathy impairments have also been associated with conduct problems and psychopathic traits in samples of pre-diagnostic children (Jones, Happé, Gilbert, Burnett, & Viding, 2010), suggesting that empathy impairments may begin in the early years of social development, prior to illness onset.

Studies on the link between empathy and anxiety disorders are sparse and have only focused on adolescent and adult samples. In line with the theory that hypervigilance to social stimuli results in increased empathic tendencies, some research has demonstrated positive associations between empathy and anxiety. For example, Auyeung and Alden (2016) found that social anxiety was associated with enhanced cognitive empathy when participants were exposed to social threat. Similarly, Tibi-Elhanany and Shamay-Tsoory (2011) found that adults with high social anxiety and symptoms of generalised anxiety disorder reported elevated affective empathy. However, when controlling for generalised anxiety, social anxiety was related to cognitive rather than affective measures. In contrast, Gambin and Sharp (2018) found support for both enhanced and reduced empathy as a result of hypervigilance. They demonstrated that while affective empathy was positively related to all anxiety dimensions, cognitive empathy was negatively associated with social and separation anxiety. These findings suggest that adolescents with high levels of anxiety have problems with recognising, interpreting and understanding the intense emotions they share with others.

There are different explanations that could account for these conflicting findings. Firstly, empathy is often measured using self-report questionnaires. Such measurements of empathy are subject to demand characteristics (Fiske & Pearson, 1970; Saunders, 1991; Vartanian & Powlishta, 2001), and thus may yield different findings to objective assessments of socio-cognitive and emotional functioning. Secondly, when determining the relationship between anxiety and empathy it is important to consider how empathy was defined. While some researchers determine cognitive empathy as being able to correctly infer the emotions of others, other researchers equate cognitive empathy with perspective-taking. The latter considers one's ability to contemplate another's point of view, which is thought to be essential in differentiating empathy from ToM (Davis, 1994; de Wied, Goudena & Matthys, 2005; Dvash & Shamay-Tsoory, 2014). However, definitions of cognitive empathy state that the construct involves both emotion identification and perspective taking (Bons et al., 2013; Dvash & Shamay-Tsoory, 2014) and thus, measures of cognitive empathy should assess both.

A further critique of the aforementioned studies is that they did not differentiate between empathy for positively valenced emotions and empathy for negatively valenced emotions. As seen in the hypervigilance theory for threat, one of the key processes thought to underpin anxiety is dysfunctional schemata, which allocates excessive attentional resources to threatening stimuli. Theoretically, it is reasonable to expect that this vigilance for threatening stimuli would result in either improved empathy for negative emotions, due to a tendency to more accurately obtain insight into others' negative state, or reduced empathy for negative emotions due to a tendency to attribute stronger emotions and more meaning to what others are feeling in aversive situations. Despite this, only one study to date has investigated the role of empathy for positive and negative emotions in participants

with anxiety. In a sample of adults with social anxiety disorder (SAD) and a demographically matched sample of controls, Morrison and colleagues (2016) demonstrated that social anxiety was only associated with reduced affective empathy for positive affect. That is, socially anxious individuals' display reduced ability to share in others' positive emotions. However, indirect evidence investigating the role of facial emotion recognition in individuals with anxiety, has provided support for the hypervigilance for threat theory, by consistently showing an association between anxiety symptomatology and the processing of negative facial displays of emotions. The hypervigilance is manifested by both impaired and enhanced recognition of negative facial displays (Doty, Japee, Ingvar & Ungerleider, 2013; Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Gutiérrez-García & Calvo, 2017; Jarros et al., 2012; Joormann & Gotlib, 2006; Lau et al., 2012; Lee, Herbert & Manassis, 2014; Montagne et al., 2007; Richards et al., 2002; Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006; Yoon, Yang, Chong & Oh, 2014). Facial emotion recognition is a contributing factor in the ability to empathise with others and has been theorised to be a precursor to empathy (Blair, 2005; Marshall & Marshall, 2011; Marshall, Hudson, Jones, & Fernandez, 1995). Thus, if children with anxiety are impaired in recognising negative emotions, we would expect them to also display an impairment in empathic responding for negative emotions.

Theory of Mind

Theory of mind (ToM) is the ability to make inferences about the psychological states (intentions, desires, beliefs, emotions) of others (Adolphs, 2001). This function enables an individual to understand or predict other people's behaviour in social situations (Premack & Woodruff, 1978). It is closely linked with empathy, as a failure to infer the psychological states of others may result in a failure to see things from another's perspective.

Developmental research on ToM has demonstrated that the ability begins to evolve during the first year of life (Bosco, Friedman, & Leslie, 2006; Onishi & Baillargeon, 2005), and continues to develop throughout childhood, adolescent and adulthood (Bosacki, 2000, 2003; Choudhury, Blakemore & Charman, 2006; Goldstein & Winner, 2012; Maylor, Moulson, Muncer & Taylor, 2002). Similar to empathy, ToM is comprised of two component processes, affective and cognitive ToM. The former refers to the ability to make inferences about other people's emotions, while the latter is the capacity to make assumptions about people's thoughts (De la Osa, et al., 2016). The ability to develop accurate accounts of what people are thinking and feeling enables individuals to respond accordingly. Consequently, the development of ToM has important implications for children's social communication, interaction and behaviour (Szumski, Smogorzewlka, Grygiel & Orlando, 2019).

Similar to empathy, studies investigating the link between ToM and anxiety are rare, mostly focused on adult samples and yield heterogenous findings. While Hezel and McNally (2014) found that individuals with SAD performed worse on measures of ToM, due to a tendency to attribute stronger emotions and more meaning to what others were thinking and feeling, Zainal and Newman (2018) demonstrated that hypervigilance was associated with enhanced cognitive ToM performance. By contrast, other researchers have found support for hypervigilance resulting in both impaired and enhanced theorizing abilities (Tibi-Elhanay & Shamay-Tsoory, 2011). Tibi-Elhanay and Shamay-Tsoory (2011) showed that adults with high levels of social anxiety were more accurate on measures of affective ToM, but less accurate on cognitive measures compared to individuals with low social anxiety. While the authors determined that it was their hypervigilance that led to cognitive ToM inaccuracy due to a tendency to over-theorise, they also suggested that hypervigilance resulted in increased accuracy for the affective measure; the affective section of the ToM

task required increased sensitivity as the social cues were subtle.

Our knowledge of the link between ToM and anxiety in young children is limited to just a couple of studies. One study focused on the role of ToM in a sample of 6-11-year-old children exhibiting symptoms of social anxiety (Banerjee & Henderson, 2001). While the two groups did not differ in their performance on second-order false belief tasks, children with social anxiety performed significantly worse on the Faux Pas task than controls. The Faux Pas task requires an advanced understanding of the links between emotions, intentions and beliefs in social situations, consequently leading authors to suggest that children with social anxiety only demonstrate impairments in advanced ToM tasks. The second study was conducted among typically developing children and young adolescents (mean age = 11.3 years) and showed that participants demonstrating low levels of ToM (assessed through the Strange Stories task) had more symptoms of panic disorder and separation anxiety (Caputi, Schoenborn & Wella, 2018). However, both studies provided limited insight into the role that ToM plays in anxiety symptomatology, as authors did not differentiate between the cognitive and affective components. When considering ToM impairments shown by individuals with anxiety, the distinction between the two constructs is important, given that different impairments in cognitive compared to affective ToM have been demonstrated in adults with social anxiety (Tibi-Elhanay & Shamay-Tsoory, 2011).

In sum, the findings on the relationship between anxiety, empathy and ToM are inconclusive. While some studies suggest that individuals with anxiety have reduced ToM and empathic abilities, others provide evidence that anxiety symptomatology is associated with elevated ToM and empathy. However, taken together these findings do demonstrate a key role of ToM and empathy in symptoms of anxiety. Based on this, it is possible that ToM and empathy function as protective factors for the onset of anxiety. To better understand

their potential as protective factors, more research is needed in pre-diagnostic, high-risk samples. Moreover, the beginning of school age is a crucial time for the development of emotional and social-cognitive skills, due to the increase in social demands (Deschamps et al., 2012). Thus, more research is needed to investigate the potential of empathic and ToM abilities to buffer the development of anxiety in this age group.

The present study

We examined the relationship between cognitive and affective empathy and cognitive and affective ToM in a sample of young children with emerging neurodevelopmental problems. The first aim of the present study was to compare cognitive and affective empathy and cognitive and affective ToM in children with elevated anxiety symptomatology compared to those with low anxiety. Based on prior literature, we expected differences in empathic and ToM responding between high anxiety (HA) and low anxiety (LA) groups. However, evidence from the limited available research is inconsistent and consequently we were unable to predict the pattern of socio-cognitive and emotional responding in children with anxiety.

The second aim was to characterise the specific nature of the empathy impairments underlying anxiety, in terms of emotion-type. Given the previously reported relationship between negative emotion recognition and anxiety, we expected differences in cognitive and affective empathic responding specifically for negative emotions between HA and LA groups. However, once again, due to the inconsistent findings of previous research we were unable to predict the direction of responding.

Next, we sought to examine the extent to which ToM and empathy abilities are able to explain anxiety in young children. In line with previous research, we expected both abilities to predict the severity of anxiety symptomatology.

Finally, some studies have demonstrated that empathy and ToM are strongly influenced by gender and age differences (e.g., Ibanez et al., 2013; Imuta, Henry, Selcuk & Slaughter, 2016; Strayer & Roberts, 2004a; Uzefovsky & Knafo-Noam, 2017; Zhan-Waxler, Cole, Welsh & Fox, 1995). We therefore explored the role of gender and age in moderating the associations between empathy, ToM and anxiety.

3.3 Method

3.3.1 Ethical statement

The study was approved by the relevant university ethics committee and all parents or legal guardians gave signed, voluntary consent for their children to participate.

3.3.2 Participants

Participants (n = 174) were aged between 4 and 7 years and had been referred to the Neurodevelopment Assessment Unit (NDAU; https://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit) at Cardiff University by their teachers because of emotional and/or behavioural difficulties. All children referred by their schoolteachers were eligible to take part in the research and the overall sample consisted of children with varying levels of emotional and behavioural problems. Once at the NDAU parents of all children completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) and the Development and Wellbeing Assessment (DAWBA; Goodman, 1997). The high anxiety (HA) group consisted of 60 children (35 boys) who scored highly on the emotional problems scale of the parent reported SDQ and/or obtained a research diagnosis of an anxiety disorder as determined by the parent version of the DAWBA. The remaining 114 children (81 boys) made up the normal or low anxiety (LA) group; these children had low scores on the SDQ emotional problems subscale and did not have a DAWBA anxiety diagnosis.

Consistent with the SDQ emotional subscale cut-off score, defined by the SDQ scoring guidelines (retrieved from http:// www.sdqinfo.org/py/sdqinfo/b3.py?language=Englishqz(UK)), a score of 5 or more indicated high emotional problems, and scores of 4 or less indicated low emotional problems. DAWBA diagnoses were established according to DSM-IV-TR criteria. Children were characterised as having a research diagnosis of anxiety if they obtained a probability of over 50% of having separation, social and/or generalised anxiety disorder, as a $\geq$50% prediction band can be counted as a positive diagnostic prediction (Goodman, Heiervang, Collishaw & Goodman, 2011). The parent reported SDQ and DAWBA were used because, for younger children, parents are the best informants in rating internalising disorders (Smith, 2007).

3.3.3 Materials

3.3.3.1 Strengths and Difficulties Questionnaire (SDQ)

The parent version of the Strengths and Difficulties Questionnaire (SDQ) is a behavioural screening questionnaire for children and young people aged 3-16 years. Parents are asked to rate 25 items on a 3-point Likert scale based on how true they are of their child's behaviour over the last 6 months (0 = not true; 1 = somewhat true; 2 certainly true).
The 25 items comprise 5 subscales; four assess negative behaviours (emotional symptoms, conduct problems, hyperactivity/inattention and peer relationship problems) and one assesses positive behaviours (prosocial behaviour). In addition to subscale scores, the SDQ also provides a Total Difficulties score, made up of all negative behaviour scale scores. This score is indicative of the amount of psychosocial difficulties that a child presents with. The SDQ has been found to discriminate well between children with and without psychological problems (Goodman, 1999; Klasen et al., 2000; Mullick & Goodman, 2001) and is a proven

effective tool to screen for child psychiatric disorders in community samples (Goodman, 2001; Goodman et al., 2000a). Consequently, the SDQ has been used for a variety of purposes, including clinical assessment and research. Emotional scale scores were used in the data analysis for this study. The emotional subscale consists of 5 items with raw scores ranging from 0-10. Example items include: “Many worries, often seems worried”; “Often unhappy, downhearted”. Although this subscale assesses children’s emotional problems generally and is not specific to anxiety, scores on the SDQ emotional subscale correlate significantly with anxiety symptoms as assessed by other measures of childhood anxiety, such the parent version of the Revised Children’s Manifest Anxiety Scale (RCMAS; Muris et al., 2003). Reliability estimates show moderate to strong internal consistency for the subscale (e.g., Bourdon et al., 2005; Goodman, 2001; Hawes & Dadds, 2004).

3.3.3.2 The Development and Well-Being Assessment

The Development and Wellbeing Assessment (DAWBA) is an in-depth diagnostic interview used to assess children’s psychopathology according to DSM-IV-TR and ICD-10 taxonomy (American Psychiatric Association, 2013). There are multi-informant versions of the DAWBA for parents and young people aged 11-16-years. The current study used the parent version of the DAWBA suitable for primary school-aged children. Respondents initially complete the SDQ before moving on to a more detailed interview that covers a wide range of specific diagnoses. Upon completion, the DAWBA computer programme proposes likely diagnoses, ranging from a probability of less than 0.1% of having the relevant diagnosis to a probability of over 70% of having the relevant diagnosis. The DAWBA is able to reliably and validly discriminate between community and clinic samples in rates of diagnosed disorder (Goodman et al., 2000b) and has been utilised consistently in research on child and adolescent mental health (Meltzer, Gatward, Goodman & Ford, 2000).

Social anxiety, separation anxiety and generalised anxiety data were utilised for the present study. In addition to producing DSM-IV-TR and ICD-10 orientated diagnoses, dimensional scores for each disorder can be calculated. The dimensional scores for separation anxiety, social anxiety and generalised anxiety are made up of the total number of worry areas (e.g., worries about past behaviour, worries about sleeping alone), the total number of symptoms (e.g., worrying leads to concentration difficulties) and the severity of symptoms (a little/a lot).

3.3.3.3 Intellectual ability

To assess cognitive ability the Lucid Ability assessment was administered (Singleton, 2001). The Lucid estimates full-scale IQ (FSIQ), verbal IQ and performance IQ. For children aged 4-6 years verbal IQ is assessed by a picture vocabulary task, and performance IQ by a mental rotation task. For older children, aged 7-16 years, verbal IQ is assessed via a conceptual similarities task, and performance IQ through a matrix problem-solving task. An overall measure of FSIQ is calculated based on the sum of verbal and performance IQ scores. The validity of Lucid Ability is comparable to a range of conventional IQ measures, including the Wechsler Intelligence Scale for Children (WISC-III), the British Ability Scales (Second Edition) and the British Picture Vocabulary Scale (Second Edition; Lucid Ability Administrator's Manual, 2015; Singleton, 2001).

3.3.3.4 Measurement of empathic abilities

To assess empathic ability children were shown three empathy-inducing film clips. The three clips have been used in a study conducted by Noten and colleagues (2019), who demonstrated that three-year-old children were able recognise and understand the emotions presented in these videos. One clip represents happiness (a boy opening a Christmas present), another sadness (a boy flushing his dead goldfish down the toilet), and

another one fear (a girl being scared of being in a car wash). The film clips vary in length between 52 and 56 seconds.

After each clip, participants were asked about the type and intensity of the emotions of the main character in the clip, the type and intensity of their own emotions and the reasons for their emotions. The answers were calculated with a scoring system that takes into account the three elements of empathy: (a) the ability to identify the emotional states of another, (b) the ability to take the perspective of the other, and (c) the capacity to demonstrate a congruent affective response with the protagonist. This scoring system was adapted from Strayer's (1993) Empathy Continuum and has been used in studies of both adults and children (e.g., Braaten & Rosen, 2000; Ricard & Kamberk-Kilicci, 1995; van Rijn et al., 2014; van Zonneveld et al., 2017).

Cognitive empathy scores in this study were calculated as follows. If participants correctly identified the emotion of the main character, they received a point. The responses they gave for their own emotion were then coded on a 4-point scale: 0 = The participant did not answer or gave an irrelevant answer; 1 (egocentric interpretation) = The participant referred only to his or her actual feeling state (e.g., "I feel happy because I like Christmas"); 2 (situation-centered interpretation) = The participant provided an explanation referring to the situation (e.g., "I feel sad because the fish died"); 3 (character-centered interpretation) = The participant provided an explanation that included a direct reference to the character's feelings or experience (e.g., "I feel scared because she was scared"). There were two emotions for each clip that were considered correct and therefore, cognitive empathy scores for each clip ranged from 0-8.

Children's emotions were further coded for affective empathy, assessing an affective match with the protagonist: 0 = child felt no emotion; 1 = child felt an emotion similar in

valence to the protagonist; 2 = child's emotion is the same as the protagonist's, but emotion is of different intensity; 3 = child's emotion and emotion intensity is the same as the protagonist's. There were two emotions for each clip that were considered correct and therefore, affective empathy scores for each clip ranged from 0-6. A randomly selected subset of transcripts (15%) were independently coded by two trained coders; the interrater agreement was 92.2% and inter-scorer reliabilities (Cohen's kappa) between the two coders ranged from .83 (cognitive) and .98 (affective).

3.3.3.5 ToM comprehension

ToM understanding was assessed with a four-item false belief (FB) battery, including three cognitive tasks and one affective task. The cognitive set had an unexpected contents task (Contents FB Task), based on Wellman and Liu (2004); a changed location task, similar to Baron-Cohen and colleagues' (1985) explicit FB measure (The Sally-Anne Location Task); and an adapted version of Coull, Leekam, and Bennett (2006) and Perner and Wimmer's (1985) second-order false FB task. The affective task was an emotion FB test (the Belief-Emotion Task), very similar to the one used by Wellman and Lui (2004). A fixed presentation order was used for the four tasks: (1) belief-emotion, (2) explicit FB, (3) contents FB, and (4) second-order FB[1].

For the scoring of the measures, we drew on Blijd-Hoogewys and colleagues' (2008) reasoning that a better assessment of ToM is obtained when participants are asked to justify their responses (e.g., why does Tiger think there are Smarties in the tube?); justification of responses eliminates the possibility that children pass the task based on chance. Moreover, use of belief-based terms in justifications of FB tasks appear to represent

[1] The ToM tasks used in this chapter are the same as those used in Chapter 2. However, while the tasks in Chapter 2 were scored dichotomously, the tasks in this chapter are scored using a dimensional scoring system.

a more sophisticated ToM ability (Begeer et al., 2010; Clements, Rustin & McCallum, 2000; Hale & Tager-Flusberg, 2003). Thus, for the emotion FB, unexpected contents FB, and second-order FB tasks justification questions were incorporated, and consistent with previous studies, justifications including belief-based terminology were given a superior score (Clements, Rustin & McCallum, 2000; Hale & Tager-Flusberg, 2003). Scores for each of these three tasks ranged from 0-3 (see Table 3.1). Scoring rules from Wellman and Liu (2004) were used to code the explicit FB task; children passed the task if they answered the test and associated control questions correctly. A justification question was not asked for this item in order to prevent carry-over effects with the later administered second-order task. A total ToM score, ranging from 0 to 10, consists of the sum of scores on the four ToM items; a total affective ToM score, ranging from 0-3, consists of the score on the emotion FB task; and a total cognitive score, ranging from 0-7, consists of the sum of scores on the unexpected contents FB, the explicit FB and the second-order FB tasks. A randomly selected subset of transcripts (15%) were independently coded by two trained coders; the interrater agreement was 90.7% and inter-scorer reliabilities (Cohen's kappa) between the two coders ranged from 0.68 to 1.00 (mean $\kappa = .86$).

Table 3.1 Scheme for coding ToM tasks

Unexpected Contents FB
0 = answered test questions incorrectly
1 = answered test questions correctly but did not provide an appropriate justification (*e.g., Because he loves them)*
2 = answered test questions correctly and provided an appropriate non-belief justification e.g.,
The misleading appearance (e.g., It's a Smarties tube)
Non-belief mental state (e.g., He didn't see)
Deception (e.g. He was tricked)

3 = answered test questions correctly and provided an appropriate belief-based justification *(e.g., Because he doesn't know what's really in there)*
Explicit FB
0 = answered test questions incorrectly 1 = answered test questions correctly
Belief-Emotion
0 = answered test questions incorrectly 1 = answered test questions correctly but did not provide an appropriate justification *(e.g., Because he feels happy)* 2 = answered test questions correctly and provided an appropriate non-belief justification e.g., *Apparent contents (e.g., Because he has coco-pops)* *Non-belief mental state (e.g., Because he hasn't seen what's inside)* *Deception (e.g., Someone tricked him)* *Preference (e.g. He likes coco-pops)* 3 = answered test question correctly and provided an appropriate belief-based justification (*e.g., Because he thinks there're coco-pops inside)*
Second-Order FB
0 = answered test questions incorrectly 1 = answered test questions correctly but did not provide an appropriate justification 2 = answered test questions correctly and provided an appropriate non-belief justification e.g., *Original location of object is mentioned (e.g., Because that's where he hid it)* 3 = answered test question correctly and provided an appropriate belief-based justification, e.g., *Nesting of crucial information within another's belief (e.g., Because she hid in the cupboard, and then, and she thinks Nick didn't see her)* *Embedding of mental state (e.g., Because she thinks Nick thinks it is in the bed)*

Note: FB, false belief

3.3.4 Procedure

Children visited the NDAU to participate in an individual testing session, during which empathic ability and ToM comprehension were assessed. At the same time, in a separate room, parents or legal guardians answered a battery of questionnaires and a structured interview about their child's psychological symptoms.

3.3.5 Statistical analysis

Preliminary analyses investigated differences between the LA and HA groups in gender, age, estimated intellectual ability, anxiety symptomatology and externalising problems that are frequently associated with empathy. We performed independent samples *t*-tests (two-tailed) to investigate differences between groups in cognitive and affective empathy and cognitive and affective ToM. We then investigated the relationships between ToM, empathy and anxiety using correlational analysis. Finally, a hierarchical multiple logistic regression was performed to assess empathy and ToM predictors of anxiety symptomatology. All statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS 24) software and significance level was set at $\alpha < .05$.

3.4 Results

3.4.1 Preliminary analyses

Descriptive characteristics of the HA and LA groups are included in Table 3.2. The groups did not differ in age, gender or estimated intellectual ability. Significant group main effects were evident on both measures of anxiety: the parent SDQ emotional subscale and on a combined measure of anxiety that is constructed from the DAWBA separation anxiety, social anxiety and generalised anxiety dimensional scores. In terms of externalising behaviours, there were no group differences in peer problems or prosocial behaviour. However, the HA group scored significantly higher on measures of peer and conduct problems, as assessed by the parent SDQ.

Table 3.2 Descriptive statistics for age, gender, estimated intellectual ability and symptomatology measures for the two groups

	LA (n= 114)		HA (n= 60)			
	M	SD	M	SD	t/X^2 test	*p*
Age (in months)	74.43	12.09	76.78	14.31	*t*(172) = -1.144	.254
Gender (% boys)	69.8%		58.3%		X^2(1) = 2.862	.091
IQ	47.95	27.03	46.20	22.73	*t*(140.05) = .447	.656
SDQ Emotional	2.05	1.30	6.62	1.91	*t*(89.4) = -16.609	<.001
DAWBA Anxiety	5.05	10.60	27.43	21.24	*t*(74.8) = -7.676	<.001
SDQ Peer	2.46	2.17	3.97	2.08	*t*(168) = -4.376	<.001
SDQ Conduct	3.70	2.57	4.97	2.66	*t*(168) = -3.031	.003
SDQ Hyperactivity	7.58	2.66	8.07	2.22	*t*(168) = 1.267	.207
SDQ Prosocial	6.95	2.30	6.25	2.70	*t*(168) = 1.794	.075

Notes: DAWBA Anxiety measure consists of separation anxiety, social anxiety and generalised anxiety dimensional scores; LA, low anxiety group; HA, high anxiety group; IQ, intelligence quotient; SDQ, Strengths and Difficulties Questionnaire

3.4.2 Main analyses

Results of the univariate comparisons between HA and LA children can be seen in Table 3.3. HA children had significantly lower scores on affective empathy, *t*(155) = 2.299, *p* = .023, *d* = 0.39, 95% CI [0.37, 2.71], and marginally higher scores on cognitive ToM, *t*(162) = -1.824, *p* = .070, *d* = 0.29, 95% CI [-0.06, 1.16] than TD children. There were no significant differences between the groups for cognitive empathy or affective ToM.

Table 3.3 Means, standard deviations and t-test analyses of empathy and ToM performance in children with high and low anxiety

	LA (n = 114)	HA (n = 60)		
	M (SD)	M (SD)	*t*	*p*
Affective empathy	8.04 (4.009)	6.50 (3.812)	(155) = 2.299	.023
Cognitive empathy	10.14 (5.020)	9.23 (4.269)	(155) = 1.124	.263
Affective ToM	1.33 (1.025)	1.45 (0.994)	(161) = -.693	.490
Cognitive ToM	2.13 (1.818)	2.68 (1.910)	(162) = -1.824	.070

Notes: M, mean; SD, standard deviation; LA, low anxiety group; HA, high anxiety group

To evaluate the specific nature of participants' affective empathic deficits, we examined children's affective responses to the happy, fearful and sad videos separately. Analysis revealed that the group differences in affective empathy were more pronounced for the negatively valenced emotions: while the HA group scored significantly lower than the LA group on affective empathy for fear [$t(137.05) = 2.098$, $p = .038$, $d = 0.34$, 95% CI [0.03, 1.17]] and marginally lower for sadness [$t(171) = 1.843$, $p = .067$, $d = 0.30$, 95% CI [-0.01, 1.05]], there was no difference for happiness [$t(163) = 1.269$, $p = .206$, $d = 0.21$, 95% CI [-0.26, 1.04]].

The relation between anxiety (measured by SDQ and DAWBA combined dimensional scores) and affective empathy for negative emotions was further supported by correlational analysis, which indicated that anxiety was significantly negatively correlated with affective empathy for fear ($r = -.172$, n = 155, $p = .033$), and marginally correlated with affective empathy for sadness ($r = -.143$, n = 169, $p = .064$). In addition, anxiety was significantly positively correlated with cognitive ToM ($r = .192$, n = 164, $p = .014$).

To investigate the possibility that the correlations between anxiety and cognitive ToM and affective empathy for negative emotions could be explained by individual differences in peer and/or conduct problems, we conducted multiple regression analyses. As affective empathy for fear and affective empathy for sadness were correlated ($r = .4$), a negative affective empathy composite score was calculated on the basis of total affective empathy responses for fear and sadness. Two separate analyses were performed for affective empathy and cognitive ToM as outcome variables. In the first regression analysis (model 1) we entered affective empathy for negative emotions as the outcome variable. When the three predictors (anxiety, conduct and peer problems) were entered into the regression, although the overall model was trending towards significance, $F(3,153) = 2.61$, $p = .054$,

adjusted R^2 = .05, results demonstrated that only anxiety symptomatology significantly predicted affective empathy for negative affect, $p < .05$. In the second analysis (model 2), we entered cognitive ToM as the outcome variable. When the same three predictors were entered into the regression, although the overall model was trending towards significance, $F(3,163) = 2.46$, $p = .065$, adjusted R^2 = .04, once again, only anxiety emerged as a significant predictor of cognitive ToM (Table 3.4).

Table 3.4 Regression analyses of the main effects of anxiety, peer problems and conduct problems on cognitive ToM and affective empathy for negative emotions

	B	**SE_B**	**β**	**CI**
Model 1 (DV: Affective empathy for negative emotions)				
Intercept	3.026	.523		
SDQ/DAWBA Anxiety	-.033	.014	-.199*	-.060- -.006
SDQ Peer	.036	.117	.026	-.194-.267
SDQ Conduct	.146	.097	.125	-.046-.339
Model 2(DV: Cognitive ToM)				
Intercept	2.243	.301		
SDQ/DAWBA Anxiety	.021	.008	.206*	.005 - .037
SDQ Peer	-.009	.068	-.010	-.144 - .127
SDQ Conduct	-.056	.057	-.081	-.168 - .055

Notes: Negative affective empathy is a composite score made up of total affective empathy responses for fear and sadness; B = unstandardized regression coefficient, SE_B = standard error of the coefficient, β = standardized coefficient; CI = confidence intervals, * = $p < .05$. DV, dependent variable; SDQ, Strengths and Difficulties Questionnaire.

To determine the relative contribution of affective empathy and cognitive ToM in explaining anxiety symptomatology we performed a linear regression analysis. Using the negative empathy composite score, the multiple regression model significantly predicted anxiety symptomatology, $F(2,149) = 4.55$, $p < .05$, adjusted R^2 = .06. Both low levels of affective empathy for negatively valenced emotions and high levels of cognitive ToM significantly added to the prediction, $p < .05$ (Table 3.5).

Table 3.5 Regression analyses of the main effects of negative affective empathy and cognitive ToM on children's anxiety symptomatology

	B	**SE_B**	**β**	**CI**
Intercept	15.362	2.952		
Negative affective empathy	-1.003	.481	-.167*	-1.954- -.051
Cognitive ToM	1.599	.800	.161*	-.018 – 3.180

Notes: Negative affective empathy is a composite score made up of total affective empathy responses for fear and sadness; B = unstandardized regression coefficient, SE_B = standard error of the coefficient, β = standardized coefficient, CI = confidence intervals, * = $p < .05$

While there was no significant difference in boys' and girls' empathy performance for sadness, boys were worse in affective empathy for fear than girls [$t(157) = -2.305$, $p = .022$] and had lower scores on cognitive ToM [$t(162) = -2.425$, $p = .016$]. However, a moderation analysis revealed that the relationship between affective empathy for fear and anxiety, and cognitive ToM and anxiety did not differ based on gender [affective empathy: $F(1, 151) = 1.443$, $p = .232$; cognitive ToM: $F(1, 160) = .235$, $p = .628$]. Finally, we examined the relations between affective empathy and cognitive ToM and age. While age was not significantly related to affective empathic performance for either fear or sadness, there was a positive association between age and cognitive ToM [$r = .466$, n = 164, $p < .001$]. However, the relationship between cognitive ToM and anxiety was not moderated by age [$F(1, 160) = .610$, $p = .436$].

3.5 Discussion

The current study focused on empathy and theory of mind (ToM) deficits related to anxiety symptomatology in young children with emerging neurodevelopmental problems. Overall, highly anxious (HA) children demonstrated elevated cognitive ToM abilities and reduced affective empathic tendencies compared to normal or low anxious (LA) children. More specifically, HA children exhibited more pronounced impairments in affective empathy for

fear and sadness. Correlational analysis further supported the presence of a unique social profile in highly anxious children; anxiety was positively correlated with cognitive ToM, but negatively correlated with affective empathy for both fear and sadness. Finally, the results of regression analyses demonstrated that low affective empathy for negative emotions and high cognitive ToM are predictive of anxiety symptomatology in young children. These findings underpin the importance of early detection of at-risk children; in our sample the children were identified by their teachers for exhibiting emotional and behavioural problems and have been found to display impairments in their ToM and empathic abilities. Impairments in empathy and ToM have also been reported in adults with anxiety disorders and implicated in the development and maintenance of adult anxiety symptomatology (Auyeung & Alden, 2016; Gambin & Sharp, 2018; Hezel & McNally, 2014; Tibi-Elhanany & Shamay-Tsoory; Zainal & Newman, 2018).

Cognitive ToM

More accurate performance of HA children on the cognitive ToM tasks supports the notion that anxious individuals exhibit an enhanced vigilance to all social stimuli, even in relation to stimuli devoid of emotional content. These findings are also in line with studies demonstrating that the enhanced sensitivity results in elevated ToM performance (Tibi-Elhanay and Shamay-Tsoory, 2011; Zainal & Newman, 2018).

Typically, individuals with high levels of interpersonal sensitivity think and care more about what others are thinking. Consequently, it is not surprising that these individuals are better at decoding others' mental states. Furthermore, for the first time, the present study demonstrated that enhanced cognitive ToM performance predicts anxiety symptomatology. It is possible that a heightened ability to understand the mental state of others results in paranoid thinking and catastrophising, which in turn causes anxiety.

Some theorists have suggested that aggressive and conduct-disordered children may also display enhanced ToM, given that this skill is necessary to manipulate others (Bjorkvist, Lagerspetz, & Kaukiainen, 1992; Sutton, Smith & Swettenham, 1999). Indeed, ToM superiority has been associated with aggressive and antisocial behaviour (Silvern, 1981, cited in Waterman et al., 1981; Sutton, 1994). However, in our sample, such externalising problems were not responsible for the enhanced performance in cognitive ToM, suggesting that elevated theorising in the current sample is specific to anxiety symptomatology.

Affective ToM

Although HA children demonstrated elevated cognitive ToM, their affective ToM score did not differ from normal or low anxious children. This finding is in contrast to the aforementioned notion, that the hypervigilance demonstrated by highly anxious individuals results in greater mentalising abilities. However, our results are consistent with Zainal and Newman (2018) who found comparable affective ToM among those with and without generalised anxiety when worried. The dissociation between cognitive theorising and affective theorising implies that children's superior understanding of other people's thoughts and beliefs does not extend to their understanding of other people's emotions. According to the Simulation Theory (Gallese & Goldman, 1998), understanding how a person feels depends on the mimicking of that person's feelings. Children in the present study exhibited deficits in affective empathic responding, which may be responsible for their lack of enhanced understanding and identifying of other's emotions.

Cognitive empathy

Consistent with this theory, there were also no significant differences in cognitive empathy between the HA and LA groups. While this is in contrast to some studies, who have observed either enhanced (Auyeung & Alden, 2016; Tibi-Elhanany & Shamay-Tsoory (2011)

or impaired (Gambin & Sharp, 2018) cognitive empathy in adults with anxiety, it is in line with one previous study by Morrison and colleagues (2016). A possibility for this contradiction in results is that the relation between cognitive empathy and anxiety varies as a function of the methodology used. For example, no differences in cognitive empathy were found when performance-based measures of empathy were used (Morrison et al., 2016), whereas clear differences in cognitive empathy were found when using self-report measures (Gambin & Sharp, 2018; Tibi-Elhanany & Shamay-Tsoory, 2011). The behavioural empathy task utilized by Morrison and colleagues (2016) involved watching videos of real people expressing real emotions, and then providing ratings of how they believed the person was feeling. Film clips portraying natural expressions in true-to-life settings aim to elicit an immediate empathy-inducing response and the questions following encourage the immediate evaluation and reporting of emotions. Evaluating and reporting other people's emotions immediately following the visualization of an empathy-inducing stimulus may result in a more accurate measure of empathy than self-report measures, which rely on retrospective and/or hypothetical reporting. In the current study, children's own verbal responses to questions about home-videos displaying authentic emotions indexed cognitive empathy and may explain why no differences in cognitive empathy were found.

However, our null finding with regard to cognitive empathy is also contradictory to studies indicating an association between anxiety and the recognition of negative facial expressions in both children and adults (Doty, Japee, Ingvar & Ungerleider, 2013; Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Gutiérrez-García & Calvo, 2017; Jarros et al., 2012; Joormann & Gotlib, 2006; Lau et al., 2012; Lee, Herbert & Manassis, 2014; Montagne et al., 2007; Surcinelli, Codispoti, Montebarocci, Rossi, & Baldaro, 2006; Richards et al., 2002; Yoon, Yang, Chong & Oh, 2014). Facial emotion recognition is a

contributing factor in the ability to empathise (Blair, 2005; Marshall & Marshall, 2011; Marshall, Hudson, Jones, & Fernandez, 1995). Indeed, in their staged multicomponent model of empathy, Marshall et al. (1995) stated that the empathy process involves four discriminable steps: (1) emotion recognition, (2) perspective taking, (3) emotion sharing, (4) response decision. Thus, if children with anxiety are impaired in recognising negative emotions, we would also expect them to display an impairment in cognitive empathic responding for negative emotions. However, recent evidence has contradicted this hypothesis. Hunnikin and colleagues (2019) found no evidence of an association between emotion recognition and cognitive empathy in a group of 7-11-year olds children at-risk of antisocial behaviour. Similarly, Lui and colleagues (2016) showed that in adolescents with callous unemotional traits, impaired cognitive empathy was not mediated by emotion recognition. This recent line of research suggests that facial emotion recognition performance is not a mechanism for cognitive empathic responding in children with disruptive behaviour disorders. These findings may extend to samples of children with anxiety symptomatology. However, research on the relationship between facial emotion recognition and cognitive empathy in children with anxiety is needed to confirm this.

Affective empathy

Although there were no group differences in cognitive empathy, highly anxious children performed significantly worse, compared to the low anxious group, on measures of affective empathy. More specifically, poor affective empathic responding in HA children was more strongly associated with negatively valenced emotions, particularly fear. Furthermore, low affective empathy for negative emotions was found to directly predict anxiety symptomatology. These findings are in support of theoretical frameworks that propose

that hypervigilance to threat-related stimuli cause and maintain anxious states (Beck et al., 1985; Beck & Clark, 1997; Eysenck, 1992; Eysenck, 1997; Mogg & Bradley, 1998; Mogg et al., 1997; Williams et al., 1988; Williams et al., 1997). More specifically, individuals with anxiety disorders experience pathological fear related to the presence or anticipation of a particular object, situation or outcome, which researchers suggest are maintained by dysfunctional schemata which rapidly orients and allocates attentional resources to threatening stimuli in their environment (Beck et al., 1985; Beck & Clark, 1997; Eysenck, 1992; Eysenck, 1997; Mogg & Bradley, 1998; Mogg et al., 1997; Williams et al., 1988; Williams et al., 1997). Enhanced sensitivity to threatening stimuli in individuals with anxiety leads to emotion regulation difficulties, including emotional reactions to threat that occur more easily, quickly, and intensely than for most other people. Such overwhelming negative feelings in response to perceived threat may result in anxious individuals being unable to understand and identify their emotions (Mennin et al., 2005). Consequently, it is possible that highly anxious children have deficits in affective empathic responding to fear and sadness due to a unique tendency to over-empathise. However, the reverse process may also exist; individuals experiencing more intense emotions to other people's fear and sadness may overly engage with others, resulting in elevated levels of anxiety. Elaborating on these results, if children with anxiety are responding to others' emotions with heightened negative emotional intensity on a regular basis this could have detrimental effects on their interpersonal relationships. Indeed, children with anxiety disorders have fewer friends and are more neglected by peers compared to typically developing controls and children with conduct disorder (CD; Chansky & Kendall, 1997; Strauss et al., 1988). This was supported in our sample with the HA group being reported to have significantly higher levels of peer relationship problems.

Impaired affective empathy for negative emotions has also been documented in children with externalising problems, including children at high-risk of developing antisocial behaviour (van Zonneveld et al., 2017), children with diagnosed disruptive behaviour disorders (de Wied, Goudena & Matthys, 2005) and children with psychopathic tendencies and conduct problems recruited from the community (Jones, Happé, Gilbert, Burnett, & Viding, 2010). Moreover, unique emotional processing deficits for fear have been documented in adolescents with CD (Fairchild, van Goozen, Stollery & Goodyer, 2008) and children with symptoms of psychopathy (Dadds et al., 2006). In our sample, such externalising problems were not responsible for the impairments in affective empathy, suggesting that reduced affective empathy for negative emotions in the current sample is specific to anxiety symptomatology.

Though current findings of impaired affective empathic responding for negative emotions are in support of theoretical models of anxiety and studies of children with other forms of psychopathology, they are in contrast with previous anxiety research. Morrison and colleagues (2016) reported that adults with social anxiety disorder (SAD) only displayed impaired affective empathy for positive emotions compared to LA controls. These results carry several implications. First, they suggest that findings in individuals with a diagnosis of SAD may not extend to those with undifferentiated anxiety symptomatology. Secondly, it is possible that the affective empathic abilities underlying anxiety in adults differ from those in children. Both implications extend to our results more generally. Given the wide range of anxiety symptomatology included in our study we are unable to compare our findings with previous studies that only included individuals with one anxiety disorder. Further research would benefit from examining the overlapping and distinct roles of ToM and empathy in relation to symptoms of anxiety specific to particular anxiety disorders. Moreover, the

young age of our participants and the fact that their ToM and empathic abilities are still developing, limits our comparison with the previous studies conducted in adolescents and adults. More research investigating the relationship between ToM, empathy and anxiety during the same age period is needed in order to further elucidate our findings.

Strengths, limitations and further research

The current study also has several other limitations. First, despite using reliable and well replicated ToM tasks, future studies should explore the use of ToM paradigms focusing on stimuli that are ecologically more similar to the types of natural stimuli involved in children's social interactions. The Movie for the Assessment of Social Cognition (Dziobek et al., 2006) assesses ToM via participants' understanding of other people's psychological states in response to home videos of real people. This task assesses individuals' ability to determine what other people are thinking and feeling based on a range of factors applicable to real-life social interactions e.g., context, eye gaze, facial expressions. However, this paradigm was designed to assess advanced ToM in adulthood and consequently, is not valid for use in young children. Similar tasks should be developed to assess ToM ability during childhood. It is also important to keep in mind that the current study only explored one component of ToM, namely false belief. ToM involves understanding a number of concepts (e.g., intentions and desires) acquired in a series of developmental accomplishments (Wellman & Lui, 2004). However, the development of false belief understanding is central during the ages of 4 and 7 and consequently, assessing this component of ToM provided us with information on impairments that are highly representative of children in this age group. A further limitation of our ToM tasks is the use of a single vignette, assessing only happiness and sadness, to evaluate affective ToM. It would be interesting to establish if children with anxiety symptomatology still exhibit intact affective ToM when presented with tasks

assessing the understanding of other, more complex emotional displays. Based on this, future research should aim to incorporate a more comprehensive measure of affective ToM reasoning. Another limitation relates to the generalisability of our results; our study involved children aged 4-7 years, and therefore findings cannot be extrapolated to other age groups. Even within the period of childhood, results could vary significantly between children aged 4-7 and 8-11 years, given the continued development of emotional and social-cognitive abilities during childhood. Finally, practical limitations prevented the collection of complete empathy and ToM data with the full sample (n = 174) and consequently, a consistent group of the same participants could not be used at all stages of analyses. However, this is a common and unavoidable limitation when collecting vast amounts of data from hard-to-test families and individuals with symptoms of NDDs (e.g., Airdrie, Langley, Thapar, & van Goozen, 2017).

Despite the limitations, the current study advances our understanding of the emotional and social-cognitive processes that underlie anxiety in young children. This is the first study to examine affective empathy, cognitive empathy, affective ToM and cognitive ToM in primary-school aged, pre-diagnostic children within one experimental set up. The utilization of this sample allowed the investigation of ToM and empathic abilities at a time critical for socio-cognitive and emotional development and when emotional and behavioural problems have not yet reached 'crisis point'. In turn, this has enabled a better understanding of the potential role of ToM and empathy as protective factors for the onset of anxiety. A further strength of the sample used is that all participants were referred to NDAU for a range of emotional and behavioural problems. Evidence has consistently demonstrated a high rate of comorbidity for individuals presenting with anxiety disorders (Bernstein, 1991; Borkovec, Abel & Newman, 1995; Brown, Antony & Barlow, 1995; Brown

& Barlow, 1992; Deas-Nesmith, Brady & Campbell 1998; Kendall, 1994; Kessler et al., 1994; Masi et al., 1999; Merikangas et al., 1998). For example, children and adolescents with anxiety disorders have comorbid attention deficit hyperactivity disorder (15-50%), depression (25-50%) and/or disruptive disorders (20-63%) (Angold et al., 1999; Axelson & Birmaher, 2001; Biederman et al., 1996; Costello et al., 2003; Curry & Murphy, 1995; Garland & Garland, 2001; Masi et al., 2004). Results such as these have led researchers to question the current diagnostic categories and begun to instead assess psychopathology dimensionally (e.g., Achenbach, 1995, Caron & Rutter, 1991; Cuthbert & Insel, 2013). Our study, in using a dimensional approach to investigate the role of emotional and social-cognitive processes in the context of emerging emotional and behavioural difficulties is not only relevant to those who already display anxiety symptomatology, but also for those with other types of neurodevelopmental problems.

Conclusions

Our results indicate that lower levels of affective empathy for negative emotions, and higher levels of cognitive ToM are associated with elevated anxiety during early childhood. In particular, affective empathy for negative emotions and cognitive ToM were associated with increased anxiety symptomatology. Therefore, both affective empathy and cognitive ToM are important aspects of behaviour that may need to be considered when it comes to developing early interventions that aim to prevent or reduce anxiety in young children. In line with theories suggesting that hypervigilance towards threat plays a central role in anxiety disorders, we propose that highly anxious children experience negative emotions with greater intensity, impairing their ability to interpret their own negative emotions. Therefore, interventions that focus on promoting emotional awareness, may help young children to better understand why they experience emotions so intensely (Hannesdottir &

Ollendick, 2007; Mennin, Heimberg, Turk, & Fresco, 2005). In turn, we propose that enhanced vigilance towards social stimuli can help to explain the superior cognitive ToM performance exhibited by the current sample. Cognitive models of anxiety suggest that hypervigilance is a result of dysfunctional schemata which rapidly orientate and allocate attentional resources to social stimuli (Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011) and consequently, interventions targeting maladaptive cognitive schemata, such as cognitive therapy, may help reduce anxiety symptomatology in children (Beck et al., 1990; Beck & Clark, 1997; Clark & Beck, 2011; Padesky, 1994). In line with this proposition, there is already evidence that cognitive restructuring aimed at changing dysfunctional schemata is an effective treatment for childhood anxiety disorders (e.g., Hogendoorn et al., 2014; Nauta, Scholing, Emmelkamp & Minderaa, 2001; James, James, Cowdrey, Soler & Choke, 2013).

4. The contribution of facial mimicry to cognitive and affective empathy in 4- to 7-year-old children

4.1 Abstract

Background. Research conducted in adolescents and adults indicates that observing another's emotion spontaneously activates the same emotional expression in the observer, inducing a corresponding and congruent emotional response (affective empathy) and subsequently facilitating emotion understanding and perspective taking (cognitive empathy). In the present study, we investigated the relationship between mimicry and cognitive and affective empathy in school-aged children, a period when empathic responding is less likely to be influenced by social factors, such as display rules and social desirability.

Method. One hundred and forty-four 4- to 7-year old children watched three film clips showing a sad, happy and scared child, respectively, while facial mimicry was assessed using iMotions software. Questions about the emotions of the children in the clips were asked to assess cognitive empathy, and questions about the emotions the participants felt whilst watching the clips were asked to assess affective empathy.

Results. We first confirmed that the film clips elicited differential facial responses that were in line with the presented emotions. We found that children who exhibited stronger facial mimicry in response to sadness reported higher recognised and experienced sadness. However, in contrast to previous studies demonstrating that facial mimicry is related to cognitive empathy indirectly via affective empathy, we found stronger support for a mediating role of cognitive empathy. Similar relations between mimicry and empathy could not be confirmed for happiness or fear.

Conclusions. The study provides support for the notion that mimicry facilitates empathic responding, especially in the case of sadness. Impaired facial reactivity in response to

distress may be responsible for some empathy problems in children with neurodevelopmental problems.

4.2 Introduction

Empathy, defined as the ability to understand and share the emotions of others, consists of both cognitive and affective processes. Cognitive empathy is the ability to identify the emotional state and take the perspective of another, while affective empathy refers to the capacity to experience a vicarious response to another (Davis, 1996). Empathy is an essential aspect of children's social and emotional competence; it motivates prosocial behaviour and inhibits aggressive and antisocial behaviour (Batson, 2011; Decety & Svetlova, 2012; Eisenberg, Tracy & Knafo, 2016). It is assumed that empathy is initiated by the observation of another's emotional state. Seeing a person display an emotional facial expression often elicits the same expression in the observer. For example, a common response to seeing someone smile is to smile ourselves. The process of imitating another's facial expression has been termed facial mimicry, and its existence has been established in studies of both adults (Bernieri et al., 1988; Cappella & Planalp, 1981; Dimberg, 1990) and children (Chisholm & Strayer, 1995; de Wied et al., 2006, 2009; Haviland & Lelwica, 1987). However, the process by which mimicry is related to empathic responding remains unclear.

The main aim of the current study was to examine the interrelations between mimicry and cognitive and affective empathy in children of primary school age. To date, the only studies investigating the relationship between the three constructs simultaneously have been conducted in adolescents and adults. Adolescents' and adults' facial expressions do not always match their true feelings. In social situations, they are likely to follow emotion display rules, which lead people to modify (intensify, neutralise, hide) their emotional responses in accordance with context-specific expectations (Ekman, 1972; Ekman & Friesen,

1975; Saarni, 1982). Children's knowledge of when to modify emotional displays does not fully develop until 10-11 years (Gnepp & Hess, 1986). Consequently, children are more likely to show significant convergence between their feelings and their facial expressions, enabling us to establish the underlying relationship between mimicry and empathy.

The relationship between mimicry and cognitive and affective empathy

The literature proposes two main claims regarding the function of mimicry; (1) it facilitates emotion recognition and perspective taking (cognitive empathy; e.g., Niedenthal, Brauer, Halberstadt & Innes-Ker, 2001; Oberman, Winkielman & Ramachandran, 2007); (2) it enables emotion contagion (affective empathy; Hatfield, Cacioppo & Rapson, 1994; Hess & Fischer, 2013; Laird et al., 1994). Theoretically, it is reasonable to expect that facial mimicry specifically underlies affective empathy, given that both processes are relatively automatic and non-cognitive (Hoffman, 1984). According to the perception-action model (PAM; Preston & De Waal, 2002), when people perceive an emotion in others, they automatically mimic this emotion, which firstly results in an affective empathic response and then a cognitive one. Similarly, the facial feedback hypothesis (Adelmann & Zajonc, 1989) suggests that muscle activation in response to others' emotional facial expressions generates neural feedback, inducing a corresponding and congruent emotional response (affective empathy). This congruent emotional reaction facilitates emotion understanding, and thus cognitive empathy (Hatfield, Cacioppo & Rapson, 1994; Hoffman, 1984; Lipps, 1907). However, other models of empathy, for example Marshall and colleagues' (1995) staged multicomponent model of empathy, suggests that observing the emotions of others facilitates emotion recognition, which results in perspective taking, and subsequently facilitates an emotional response, indicating a different order of events. They argue that without first being able to recognise the emotion and adopt the perspective of that person, how is one expected to

experience a vicarious emotional response? Therefore, while positive associations can be expected between mimicry and cognitive and affective empathy, the order of the relationships remains largely unknown.

The relation between mimicry and cognitive empathy has predominantly been investigated via mimicry blocking. This paradigm involves comparing two conditions, one in which participants' facial muscles are restricted via mimicry-interfering manipulations (e.g., being asked to bite on a pen) and one in which participants can freely move their facial muscles. Such studies provide some evidence for a positive relationship between mimicry and cognitive empathy (Niedenthal et al., 2001; Oberman, Winkielman, & Ramachandran, 2007; Ponari et al., 2012; Rychlowska et al., 2014). For example, Niedenthal and colleagues (2001) found that participants who were free to mimic detected expression changes for happiness and sadness more rapidly than did participants who were inhibited from mimicking. Utilising the same method, Oberman, Winkielman, and Ramachandran (2007) demonstrated that blocking muscles in the observer's face interfered with the recognition of happiness and disgust, although the recognition of fear and sadness was not affected. Somewhat similar results were found by Ponari and colleagues (2012): although blocking muscles negatively affected the recognition of happiness, disgust, anger and fear, no effect was found for sadness and surprise. The authors suggested that the lack of association between mimicry and cognitive empathy for certain emotions might be due to the associated muscle sites not being successfully blocked by their manipulations. Thus, more effective paradigms for investigating the relationship between facial mimicry and cognitive empathic responding are needed. Moreover, in all the aforementioned studies the relationship between mimicry and cognitive empathy was investigated in adolescent and adult participants, and cognitive empathy was consistently conceptualised as emotion

recognition, which is only one aspect of cognitive empathy. As a result, these results cannot be generalised to explain the relationship between mimicry and cognitive empathic responding in young children.

Regarding the relationship between mimicry and affective empathy, associations have frequently been demonstrated between these constructs (Anastassiou-Hadjicharalambous & Warden, 2007; Chisholm & Strayer, 1995; Eisenberg et al., 1989; Eisenberg et al., 1994; Stel, van Bareen & Vank, 2008; Zhou et al., 2002). For example, Rymarczyk and colleagues (2016; 2019) showed that individuals high in affective empathy reacted with greater activity in the corrugator supercilii and levator labii muscles in response to pictures of fearful and disgusted faces, compared to individuals low in affective empathy. In addition, affective empathy has also been found to mediate the relationship between mimicry and prosocial behaviour. In a sample of 46 adults, mimicry facilitated an affective empathic response, which activated prosocial behaviours directed toward others (Stel, van Baaren & Vonk, 2008).

Despite the importance of mimicry for adequate emotional and social responding, only one study has investigated the relationship between mimicry and affective empathy in children of primary school age. Anastassiou-Hadjicharalambous and Warden (2007) found that there was significant convergence between facial expressions and self-reported affective empathy in 8- to 10-year-olds who were exposed to an emotion eliciting film clip. However, a limitation of this study is that the authors used behavioural coding techniques to assess facial mimicry. Such measures are less sensitive than facial electromyography (EMG), which can identify motor responses that cannot be detected by the naked eye (van Boxtel, 2010).

To date, five studies have simultaneously examined mimicry, cognitive empathy, and affective empathy. Two studies investigating the relationship between the three constructs in response to static emotional stimuli failed to find any association (Blairy, Herrera & Hess, 1999; Hess & Blairy, 2001). However, it has been argued that the lack of significant findings is due to the fact that static pictures of posed emotions are weaker stimuli (Drimalla, Landwehr, Hess & Dziobek, 2019; McLellan, Johnston, Dalrymple-Alford & Porter, 2010; van der Graff et al., 2016). In everyday social interactions, emotions are often complex, subtle, and contextual (Drimalla, Landwehr, Hess & Dziobek, 2019). Recent studies have begun to address this limitation. In response to dynamic pictures of facial expressions, Sato and colleagues (2013) found that facial EMG activity consistently predicted the valence ratings for the emotions experienced and that the experienced valence ratings in turn predicted recognized valence ratings. Further, van der Graff and colleagues (2016) assessed facial mimicry and self-reported cognitive and affective empathy in response to emotion-inducing film clips. Adolescents who responded with higher levels of zygomaticus activity during the presentation of happy stimuli reported higher levels of cognitive and affective empathy for happiness; and adolescents who responded with higher levels of corrugator activity during the presentation of sad stimuli reported higher levels of cognitive and affective empathy for sadness. Results also demonstrated that affective empathy fully mediated the relationship between mimicry and cognitive empathic responding. Similarly, in a sample of 70 adults, Drimalla and colleagues (2019) found positive relations between mimicry and cognitive and affective empathy when using realistic stimuli, including complex and contextually embedded emotions. They additionally demonstrated that mimicry was more strongly related to affective empathy than cognitive empathy. The results of these three studies are largely in line with the PAM and facial feedback hypothesis, which suggest that mimicry

underlies affective empathy, which in turn facilitates cognitive empathic responding. However, no study to date has investigated the alternative model, that observing the emotions of others facilitates emotion recognition, which results in perspective taking and subsequently facilitates an emotional response (Marshall et al., 1995).

Facial mimicry

Focusing on facial imitation, studies have consistently demonstrated that exposure to happy and angry faces elicits distinct facial EMG responses (Beall et al., 2008; Deschamps et al., 2012, 2014; de Wied et al., 2006, 2009; Oberman, Winkielman & Ramachandran, 2009). Children react with increased zygomaticus major activation (which pulls up the corners of the mouth) when exposed to happy faces, whereas observing others' angry faces elicits an increase in the corrugator muscle activation (which knits the brows). More recently there is some evidence emerging for specific facial muscle response patterns for other emotions. In a sample of 61 and 33 typically developing (TD) children, aged 6-7 years, Deschamps and colleagues (2012, 2014) examined children's facial responses to sad and fearful facial expressions. Sad faces were found to be related to a combination of corrugator, depressor (pulls down corners of the lips) and frontalis activation (raising inner brows), and fearful faces were found to be related to frontalis activation.

Studies using facial recognition paradigms in adults show that facial expressions judged to be fear involve a combination of raised and drawn in inner eyebrows, stretching the lips (risorius) and widening the eyes (Ekman & Friesen, 1978; Kohler et al., 2004). In facial EMG studies of children, frontalis activation was shown (Deschamps et al., 2012; 2014), but activation of the risorius, corrugator and eye widen has not yet been demonstrated, because EMG studies to date have not investigated risorius activity or eye widening in response to fearful facial expressions. Consequently, there is a need for further

research on facial mimicry in young children which focuses on additional sites of muscle activation.

A new way of measuring mimicry

Recently, software solutions have been developed to code the movement of facial muscles automatically. For example, iMotions (2016) includes a facial expression analysis engine called Affectiva AFFDEX. Affectiva enables the analysis of previously recorded faces. The software identifies the main landmarks on the face, such as eyes and mouth, and assesses movement, shape and texture of the face at a pixel level. The main outputs include 7 basic emotions (joy, anger, surprise, fear, contempt, sadness, disgust), valence (positive, negative and neutral sentiments) and expression channels (e.g. smile, brow furrow, brow raise). The reliability of the software has been confirmed by Kulke, Feyerabend and Schacht (2020). They demonstrated that happy and angry facial expressions could reliably be detected by both Affectiva and EMG, but that Affectiva was more reliable than EMG in identifying neutral expressions. To our knowledge Affectiva has not yet been used to assess facial behavior in young children.

The present study

Prior to our main objective, we aimed to determine the feasibility of using Affectiva as a method of studying facial mimicry responses in children aged between 4 and 7 years, in response to dynamic emotional facial expressions of other children. Based on previous studies using facial EMG or facial recognition paradigms, we hypothesized an increase in zygomatic activity in response to happy faces (de Wied et al., 2006, 2009; Oberman et al., 2009). In response to fearful faces, we hypothesized an increase in frontalis, corrugator, risorius and eye widen activity (Ekman and Friesen, 1978; Kohler et al., 2004). In response to

sad faces, we hypothesized an increase in corrugator, depressor and frontalis activity (Deschamps et al., 2012; 2014; Ekman and Friesen, 1978; Kohler et al., 2004).

Our primary objective was to examine facial mimicry, cognitive empathy and affective empathy using context-embedded naturalistic stimuli. Based on theory and previous studies of adults and adolescents, we expected to find mimicry, cognitive empathy and affective empathy to be interrelated. Moreover, in line with van der Graff and colleagues (2016), it was predicted that affective empathy would mediate the relationship between mimicry and cognitive empathic responding. However, given the contradiction between empathy models, we also aimed to test the alternative model, that there is an indirect relationship between mimicry and affective empathy via cognitive empathy.

Finally, although some studies have demonstrated that the relations between empathy-related components differ based on gender (e.g., Anastassiou- Hadjicharalambous & Warden, 2007; Eisenberg et al., 1988a), the lack of research on the relationship between mimicry and cognitive and affective empathy in young children means that we do not know whether gender differences are evident in this age group. We therefore explored the role of gender in moderating the association between mimicry and empathy.

4.3 Method

4.3.1 Ethical statement

The study was approved by the relevant university ethics committee and all parents or legal guardians gave signed, voluntary consent for their children to participate.

4.3.2 Participants

Data were collected from 144 participants aged 4 to 7 years (98 males and 46 females; mean age, 75.06 months). They had been referred to the Neurodevelopment Assessment Unit (NDAU; https://www.cardiff.ac.uk/research/explore/research-

units/neurodevelopment-assessment-unit) at Cardiff University by teachers due to emotional and/or behavioural problems. All children referred were eligible to take part in the research and the overall sample consisted of children with varying levels of emotional and behavioural difficulties. All participants were individually assessed.

4.3.3 Materials

4.3.3.1 Facial mimicry

During the testing session children were shown three empathy-inducing film clips. These clips have been used in a study by Noten and colleagues (2019), who demonstrated that 3-year-olds recognized and understood the emotions presented in each video. The happiness clip showed a boy opening a Christmas present, the sadness clip showed a boy flushing his dead goldfish down the toilet, and the fear clip showed a girl being scared in a car wash. The length of the clips varied between 52s and 56s. Facial expressions of participants were recorded with a Dell laptop (Precision 7710) integrated webcam from stimulus onset until stimulus offset. The sections of each clip in which the child protagonist displayed peak expressions of happiness, sadness and fear were used as target scenes. Neutral sections elsewhere in the clip were used as a baseline. Target scenes varied in length between 9s and 15s. Baseline scenes varied between 8s and 10s. The sad video was always shown first, the happy video second and the fearful video last. Webcam footage of participants viewing the target and baseline scenes were later imported into the iMotions Biometric Research Platform 6.0 software (www.imotions.com) and processed using the Affectiva AFFDEX facial expression recognition engine.

4.3.3.2 Cognitive and affective empathy

After each clip children were asked a series of questions concerning the emotions of the main character and their own emotions while viewing the clip. Children indicated how the

main character felt, how they felt, and identified the intensity of each emotion as ‘a little’ or ‘a lot’. A coding system adapted from Strayer's (1993) empathy continuum was used to score children’s affective and cognitive responses. Affective empathy was based on feeling emotions concurrent with the emotions of the main character (there were two emotions for each clip that were considered correct). Answers were coded on a 4-point scale: Children were given a score of 0 if they felt no emotion or answered using a different valence (e.g., felt happiness when the protagonist was sad); a score of 1 was given if the participant's and the protagonist’s emotions were of similar valence but had different content (e.g., the participant felt angry in response to the protagonist feeling sad); a score of 2 was given if the participant’s emotion was the same as the protagonist’s but of different intensity; and a score of 3 was given if the participant’s and the protagonist's emotions were exactly alike. Cognitive empathy was based on two components: recognizing the emotions of the main character (there were two emotions for each clip that were considered correct) and the quality of the reason given for their own emotions. Emotion recognition was coded as 0 when the emotion was not recognized, and 1 when the emotion was recognized. The coding of the quality of the explanation for their emotion ranged from 0 to 3. Answers were coded as 0 when the participant did not answer or gave an irrelevant answer; answers were coded as 1 if the participant referred only to his or her actual feeling state, with no regard to the episode itself or to the character's experience; answers were coded as 2 if the participant provided an explanation referring to the situation but not to the character's inner feelings; and answers were coded as 3 if the participant provided an explanation that included a direct reference to the character's feelings or experience. Cognitive empathy scores ranged from 0-8 whereas affective empathy scores ranged from 0-6 for each clip. For both scales a higher score was indicative of greater empathy. A randomly selected subset of transcripts

(15%) were independently coded by two trained coders; the interrater agreement was 92.3% and inter-scorer reliabilities (Cohen's kappa) between the two coders ranged from .82 (cognitive) and .98 (affective).

4.3.4 Procedure

Facial mimicry data were collected while the child was seated in a dimly lit room in front of a computer. Prior to the task children were informed about what would happen and were asked to watch the videos carefully and minimize their movements. Between each video the experimenter ensured that the child was motivated and reminded them to watch the next video carefully. The experimenter encouraged the children to pay attention and noted if a participant was inattentive.

4.3.5 Facial mimicry data processing

iMotions provides probability-like values for all basic emotions and the muscle sites associated with each emotion. Probability data were exported for all subjects. Mean facial probability values for 7 muscle sites were calculated for baseline and target scenes of each clip. The 7 muscle sites were zygomaticus, corrugator, frontalis, depressor, orbicularis, risorius and eye widen. Trials containing less than 50% data were removed prior to data analysis, and anomalies in the data (+/- 3 standard deviations away from the mean) were replaced with the highest/lowest value that remained within 2 standard deviations of the mean of that variable.

4.3.6 Statistical analyses

Prior to conducting the main analyses, we tested for gender differences in measures of facial mimicry, cognitive empathy and affective empathy, using independent samples t-tests. To analyze children's facial activity in response to the emotional clips, paired samples *t*-tests examined changes in zygomaticus, corrugator, depressor, frontalis, risorius,

orbicularis and eye widen activity from baseline level to stimulus presentation for each clip. Next, we examined the associations among mimicry, cognitive empathy and affective empathy for each clip with Pearson's correlation coefficients. Finally, we conducted mediation analyses using the PROCESS macro (version 3.4; Hayes, 2013), to test separately for each clip whether affective empathy mediated the relationship between mimicry and cognitive empathy. Preacher and Hayes' (2004; 2008) bootstrapping procedure was utilized to examine the statistical significance of the indirect effect.

4.4 Results

4.4.1 Preliminary analyses

4.4.1.1 Sex differences in mean scores

There were no significant sex differences in mean facial activity in response to the happy, sad or fearful clips. T-tests performed on the empathy scores also revealed no sex differences in mean levels of affective or cognitive empathy for any of the clips. Gender differences were therefore not investigated in further analyses.

4.4.2 Main analyses

4.4.2.1 Facial responses to dynamic emotional facial expressions

First, we assessed whether children display a distinct pattern of facial activity in response to different emotional stimuli. Paired-samples *t*-tests compared mean facial activation during stimulus presentation to mean facial activation during baseline. The relevant summary statistics are shown in Table 4.1. Happy faces elicited the expected increase in zygomaticus activity, $t(101) = -3.665$, $p < .001$, $d = 0.36$, 95% CI [3.33, 11.19], but also an increase in frontalis activity, $t(102) = -3.748$, $p < .001$, $d = 0.38$, 95% CI [1.59, 5.17], and a decrease in orbicularis activity, $t(101) = 4.705$, $p < .001$, $d = 0.48$, 95% CI [1.93, 4.75], compared to

baseline. Sad facial expressions elicited a significant increase in frontalis, $t(110) = -4.223$, $p < .001$, $d = 0.39$, 95% CI [3.74, 10.38], corrugator, $t(110) = -3.880$, $p < .001$, $d = 0.36$, 95% CI [0.10, 1.42], and depressor activity, $t(110) = -4.990$, $p < .001$, $d = 0.48$, 95% CI [2.39, 5.53], and a significant increase in zygomaticus activation, $t(110) = -2.430$, $p = .017$, $d = 0.23$, 95% CI [0.89, 8.79]. Fearful facial expressions led to the predicted increase in risorius, $t(97) = -4.467$, $p < .001$, $d = 0.45$, 95% CI [2.62, 6.82], and eye widen activity, $t(97) = -2.514$, $p = .014$, $d = 0.26$, 95% CI [0.04, 0.36], compared to baseline. Children also showed a decrease in depressor activity, $t(97) = 1.980$, $p = .050$, $d = 0.20$, 95% CI [-0.01, 2.53], and an increase in zygomaticus activity, $t(97) = -3.817$, $p < .001$, $d = 0.40$, 95% CI [3.69, 11.73]. Taken together, these results indicate that young children exhibited differential facial behavior in response to different emotions, and that the facial expressivity they engaged in was congruent with the target children's facial expressions.

Table 4.1 Facial activation following emotional expressions compared to a non-emotive baseline condition in a sample of 4- to 7-year-old children

Presented emotion	Baseline		Emotive		Baseline vs emotive	
	Mean	*SD*	*Mean*	*SD*	*t*	*p*
Happy						
Zygomaticus	9.02	15.50	16.28	23.12	-3.665	<.000
Frontalis	5.80	7.22	9.18	11.26	-3.748	<.000
Corrugator	1.15	2.13	1.02	2.15	.490	.625
Depressor	2.37	4.23	1.62	3.28	1.472	.144
Orbicularis oculi	6.53	8.70	3.31	4.45	4.705	<.000
Risorius	2.13	5.03	3.15	6.10	-1.466	.146
Eye widen	0.08	0.28	0.10	0.35	-.416	.678
Sad						
Zygomaticus	8.12	12.77	12.96	19.04	-2.430	.017
Frontalis	6.00	7.65	13.06	19.55	-4.223	<.000
Corrugator	0.41	0.80	1.35	2.71	-3.800	<.000

Depressor	0.39	1.05	4.35	8.49	-4.990	<.000
Orbicularis oculi	5.57	6.73	6.09	7.61	-.710	.479
Risorius	2.45	4.92	3.99	6.88	-1.888	.062
Eye widen	0.20	0.65	0.25	0.80	-.563	.575
Fear						
Zygomaticus	7.97	16.23	15.67	23.94	-3.817	<.000
Frontalis	12.12	15.64	9.88	11.90	1.694	.093
Corrugator	4.63	9.20	3.23	6.42	1.517	.132
Depressor	3.13	6.28	1.87	3.17	1.980	.050
Orbicularis oculi	6.45	10.48	8.18	11.70	-1.542	.126
Risorius	0.97	1.89	5.69	10.84	-4.467	<.000
Eye widen	0.14	0.46	0.35	0.82	-2.514	.014

Note: SD, standard deviation

4.4.4.2 The relationship between cognitive and affective empathy

There were significant positive correlations between affective and cognitive empathy for all three clips (happiness: r = .404, n = 131, p = < .001; sadness: r = .636, n = 136, p = < .001; fear: r = .667, n = 128, p < .001; see Table 4.2 for participant mean scores on measures of cognitive and affective empathy).

Table 4.2 Mean scores and standard deviations on self-report measures of cognitive and affective empathy

	Mean	*SD*
Cognitive empathy happiness	4.42	*2.36*
Affective empathy happiness	4.37	*1.82*
Cognitive empathy sadness	2.82	*1.95*
Affective empathy sadness	1.68	*1.65*
Cognitive empathy fear	2.46	*1.77*
Affective empathy fear	1.40	*1.91*

Note: SD, standard deviation

4.4.4.3 The relationship between mimicry and cognitive and affective empathy

Children's average facial mimicry score (aggregated over happy, sad and fearful stimuli) positively correlated with children's cognitive and affective empathy scores (cognitive: r = .267, n = 79, p = .017; affective: r = .230, n = 79, p = .041). However, further analyses indicated that the relationships between mimicry and cognitive and affective empathy was only significant for sadness. More specifically, higher corrugator activity was associated with greater levels of experienced and recognized sadness [affective empathy: r = .215, n = 111, p = .023; cognitive empathy: r = .343, n = 111, p = < .001]. Mimicry responses to the happy video were not significantly correlated with children's cognitive and affective empathy scores for happiness (all p values > .05). Mimicry responses to the fear video were also not associated with children's cognitive and affective scores for fear (all p values > .05; see Appendix A for the relationships between mimicry, cognitive empathy and affective empathy for happiness, sadness and fear).

4.4.4.3.1 Sadness

To further understand the order of the relationship between mimicry, cognitive empathy and affective empathy, two mediation models were tested. In the first model, mediation analysis was conducted using facial mimicry (corrugator activity) as the predictor and cognitive empathy scores as the outcome and included in the model a) a direct pathway between predictor and outcome and b) an indirect pathway via the "intermediate" variable of affective empathy. The indirect effect of mimicry on cognitive empathy via affective empathy was estimated using bootstrapping procedures and tested for significance by examining the 95% confidence intervals. The upper and lower limits of the confidence interval did not include zero, indicating that for sadness, affective empathy significantly

mediated the relationship between mimicry and cognitive empathy (β = .10, 95% bootstrap CI [.016-.174]).

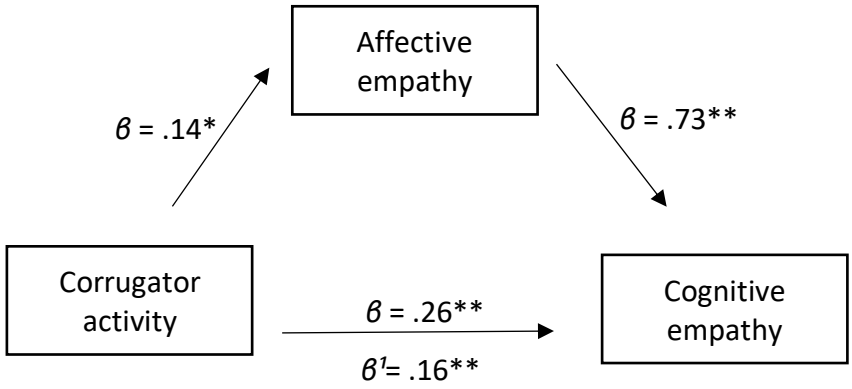

Figure 4.1 The indirect effect of facial mimicry (corrugator activity) on cognitive empathy through affective empathy.

In the second model, the mediation analysis used facial mimicry (corrugator activity) as the predictor, affective empathy as the outcome and cognitive empathy as the "intermediate" variable. The upper and lower limits of the confidence interval did not include zero, indicating that this model was also significant, and for sadness, cognitive empathy also significantly mediated the relationship between mimicry and affective empathy (β = .14, 95% bootstrap CI [.061-.224]).

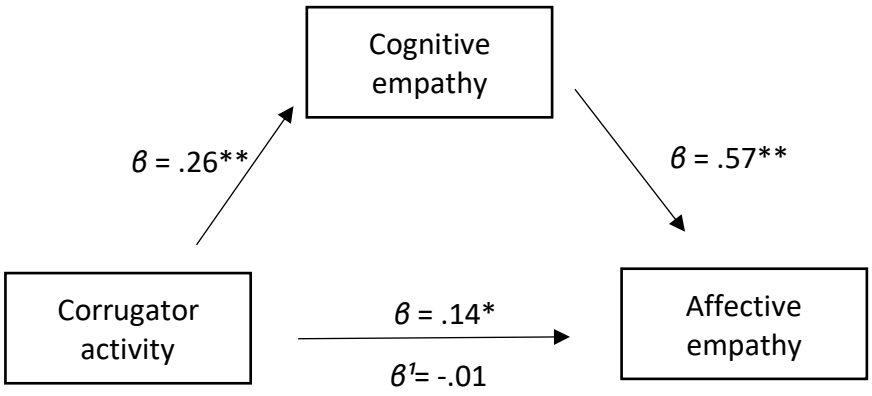

Figure 4.2 The indirect effect of facial mimicry (corrugator activity) affective empathy through cognitive empathy.

Although both mediation models were significant, the latter model was more compelling; the indirect effect was slightly stronger when cognitive empathy served as the mediator and affective empathy as the outcome. This finding was also implied by our correlational analysis, which found a stronger correlation between mimicry and cognitive empathy than between mimicry and affective empathy.

4.5 Discussion

Prior to our principle objective, we aimed to determine the feasibility of using Affectiva as a method to study facial mimicry responses in young children. We expected happy, sad and fearful faces to elicit different patterns of facial activity. The primary objective aimed to examine the interrelations between mimicry and cognitive and affective empathy in young children. We expected facial mimicry to be positively associated with both cognitive and affective empathy. Affective empathy was expected to mediate the relationship between mimicry and cognitive empathic responding. In addition, the role of gender in the association between mimicry and empathy was explored. To the authors knowledge, this is

the first study to examine the associations between mimicry and cognitive and affective empathy simultaneously in young children.

Facial mimicry

We demonstrated that happy, sad and fearful faces elicit different facial patterns. Children aged 4-7 years displayed increased zygomaticus and frontalis activity and decreased orbicularis oculi activity in the happy condition. The present study is the first to demonstrate frontalis activation and orbicularis oculi relaxation in response to happy faces. Consistent with facial emotion recognition literature, an increase in frontalis activity is associated with surprise, while a decrease in orbicularis oculi activity is associated with a reduction in anger and/or confusion (Ekman & Friesen, 1978; Kohler et al., 2004).

In line with our predictions, the presentation of sad facial expressions led to an increase in corrugator, frontalis and depressor activity. These results are consistent with previous facial EMG studies in older children (Deschamps et al., 2012; 2014).

The presentation of fearful faces resulted in risorius and eye widen activation, in line with the facial activation literature (Ekman & Friesen, 1978; Kohler et al., 2004). Fearful faces also led to a decrease in depressor activity. These results indicate that in response to fearful faces children demonstrate a reduction in facial activity associated with sadness and an increase in facial activation congruent with fear. We did not find increased frontalis or corrugator activity in response to fearful faces. These results contrast with some other studies; for example, Deschamps et al., (2012; 2014) showed that the presentation of fearful facial expressions was associated with brow raising activity. However, Beall and colleagues (2008) found no EMG responses in the frontalis or corrugator muscles following the presentation of fearful faces in a sample of 15 TD children aged 7-12 years. Surprisingly, both the fearful and sad clips also increased activation of the zygomaticus major. It is

possible that this increase in zygomaticus muscle site activity was because some children found the content of the clips rather funny or smiled because they found the content awkward. Taken together, these findings demonstrate that young children exhibit facial expressivity that is mostly congruent with the target children's facial expressions, and that Affectiva can be used to reliably examine facial responsiveness children aged 4-7 years.

The relationship between cognitive and affective empathy

The results further showed that cognitive empathy was positively associated with affective empathy. Specifically, children who reported higher levels of experienced happiness in the happy condition were better able to recognize and understand that the target was happy; children who reported higher levels of experienced sadness following the sad video were better able to recognize and understand that the target was sad; and children who reported higher levels of experienced fear in the fear condition were better able to recognize and understand that the target was scared. Thus, consistent with previous literature, the present study demonstrates convergence between the understanding of others' emotional state and vicarious affective responsiveness (Batson, Fultz, & Schoenrade, 1987; Decety & Moriguchi, 2007; Eisenberg & Strayer, 1987; Feshbach, 1987; Hoffman, 2000).

The relationship between mimicry and cognitive and affective empathy

In line with previous studies, our results provide evidence of a positive relationship between facial mimicry and self-reported affective empathy. More specifically, children who demonstrated stronger corrugator activity in response to sadness reported stronger experienced sadness. Children's corrugator activity in response to the sad film clip was also associated with their self-reported cognitive empathy, indicating that facial mimicry and cognitive and affective empathy are positively associated constructs in young children.

This study also aimed to understand the order of the relations between mimicry for sadness (corrugator activity) and cognitive and affective empathy for sadness, by firstly examining the indirect relationship between facial mimicry and cognitive empathy via affective empathy and secondly by examining the indirect relationship between facial mimicry and affective empathy via cognitive empathy. Although both mediation models were significant, the model in which affective empathy was the outcome rather the mediator was slightly more compelling, given that the relationship between facial mimicry and affective empathy was no longer significant when controlling for cognitive empathy. These findings indicate that facial mimicry helps people to successfully identify and understand the emotions of others, which in turn enables vicarious responding. While these findings contradict our hypothesis and are inconsistent with some studies investigating these relationships in adolescents and adults (Sato et al., 2013; van der Graff et al., 2016), they are in support of the staged multicomponent model of empathy (Marshall et al., 1995), which argues that observing the emotions of others facilitates emotion recognition, resulting in perspective taking and subsequently facilitating a vicarious emotional response. The staged multicomponent model of empathy was developed in relation to literature examining empathy deficits in offenders and studies providing support for the model were also found in offending samples (Fernandez & Marshall, 2003; Fernandez, Marshall, Lightbody, & O'Sullivan, 1999). Individuals with histories of offending often meet clinical diagnostic criteria for antisocial personality disorder, conduct disorder (CD) and/or oppositional defiant disorder (ODD). Consequently, it is possible that individuals with psychopathological symptoms exhibit a different relationship between mimicry and empathy than those without psychopathology. This in turn may explain the different relations between facial mimicry and empathy in our sample of children with early emerging symptoms of

neurodevelopmental disorders and previous studies conducted in samples of typically developing individuals. However, due to the lack of a typically developing control group we can only speculate that this is the case. Future research should aim to compare the relationship between facial mimicry and empathy in young children with symptoms of NDDs with typically developing controls.

Although we found significant associations between mimicry and cognitive and affective empathy for sadness, we did not find evidence of a relationship between facial mimicry and reported experienced and recognised fear. This finding is surprising given that sadness and fear have the same underlying functionality. Theorists argue that both sad and fearful facial expressions are distress cues and that mimicking these emotions is essential to signal understanding of other's suffering (Blair, 1995, 2001; Blair et al. 1997; Decety & Chaminade, 2003; Hess & Fischer, 2014; Marsh & Ambady, 2007). A possible explanation is that the fear clip used (a young girl crying and screaming loudly because she's stuck in a carwash) resulted in strong emotional involvement which led to a reactive response, a problem identified in previous mimicry research (Drimalla, Landwehr, Hess & Dziobek, 2019; Hess & Fischer, 2014). Consequently, the mimicry response may be confounded by the reactive response to the clip, resulting in a dissociation between empathic responding and facial muscle responses. Moreover, even though participants were encouraged to watch each video carefully it is possible that children who responded reactively did not attend to the presented stimuli. Stimulus avoidance will result in reduced attention to the social cues that aid mimicry, congruent emotional responses, and correct identification of emotions. Indeed, perception and correct interpretation of distress cues are essential to facilitate an empathic response (Blair, 1995; Hoffman, 1987; Marsh & Ambady, 2007). In contrast, the clip portraying sadness was less loud and startling, therefore less likely to elicit an

overwhelming emotional response, resulting in a more authentic representation of the relationship between mimicry and empathy.

In the present study, we did not find a positive relationship between facial mimicry and cognitive and affective empathy for happiness. Several factors may underlie these findings. Firstly, in contrast to fear and sadness, smiling signals a range of emotions. Not only does it act as an expression of happiness, but it also often serves as an expression of pride, love, pity, arrogance, contempt, shame, embarrassment, and uncertainty (Niedenthal, Mermillod, Maringer & Hess, 2010). Due to the multiple functionality of the zygomaticus, its activation could be less sensitive in facilitating emotional responding than other muscle sites. Secondly, positive facial expressions are visually simpler to recognise than negative facial expressions (Leppanen & Hietanen, 2004). Happiness is associated with a single facial feature (smiling), whereas negative facial features are associated with various muscle sites that often overlap (e.g., corrugator activity is associated with both sadness and anger; Adolphs, 2002). Therefore, while the ability to successfully distinguish between different negative emotions involves being able to differentiate between very subtle facial differences, a single salient feature can be used to recognise happiness. Consequently, the recognition and experience of vicarious happiness may be less dependent on mimicry than other emotions. This notion appears to be supported by the means shown in Table 4.2, where the cognitive and affective empathy scores for happiness are noticeably higher than those for sadness and fear.

The results of previous studies have consistently demonstrated that boys are less empathetic and less facially expressive than girls, even in infancy (Berenbaum & Rotter, 1992; Buck, Savin, Miller & Caul, 1972; Card, Stucky, Sawalani, & Little, 2008; Carlo, Raffaelli, Laible, & Meyer, 1999; Christov-Moore et al., 2014; Dimberg & Lundquist, 1990; Eisenberg

et al., 1988b; Findley & Ojanen, 2013; Karniol, Gabay, Ochion, & Harari, 1998; Mayberry & Espelage, 2007; Strayer & Roberts, 2004b). However, more recent research has failed to establish gender differences in cognitive and affective empathy among preschool children (Noten et al., 2019). Moreover, in a sample of adolescents, van der Graff and colleagues (2017) were unable to find differences between males and females in facial mimicry responses to happy and sad empathy-inducing film clips. Our findings are consistent with the latter studies and fail to confirm the idea of gender differences in empathy-related responding.

Limitations and conclusions

As with any study, there are some limitations to be acknowledged. Firstly, given the nature of our design, we are unable to draw firm conclusions about the direction of the observed relationships. Although the results are consistent with the idea that observation of the sad stimuli evoked facial mimicry, which in turn facilitated cognitive and affective empathy, we cannot rule out the possibility that the stimuli evoked an emotive response in the observer which led to a congruent emotional expression. Secondly, research has shown that mimicry is influenced by several contextual factors. More specifically, mimicry is more likely to occur when individuals are personally involved in a situation and when there is a form of affiliation or bond between them and the target (Swan, 1984; Thibault, Bourgeois & Hess, 2006). Given that our findings were obtained within a laboratory setting, in which children were passive observers with no affiliation with the observed, the results cannot necessarily be generalised to situations in which children are active participants who have a bond with the target. Thirdly, practical limitations prevented the collection of complete empathy and facial mimicry data with the full sample (n = 144) and consequently, a consistent group of the same participants could not be used at all stages of analyses. However, this is a common

and unavoidable limitation when collecting vast amounts of data from hard-to-test families and individuals with symptoms of NDDs (e.g., Airdrie, Langley, Thapar, & van Goozen, 2017). Finally, due to not having a typically developing control group, we cannot determine if the relationship between facial mimicry and empathy differs across groups with and without symptoms of NDDs. Consequently, results cannot be generalised to all in the same age range.

Even with these limitations, the current study adds to our understanding of the relationship between mimicry and cognitive and affective empathy. To our knowledge, this is the first study to examine the three constructs simultaneously in school-age children, a period when empathic understanding and responding is developing and less likely to be influenced by social constructs, such as display rules and social desirability. We demonstrated that facial mimicry has an important role in both the understanding and experiencing of sadness. The investigation of facial mimicry and empathy in the current sample of children with emerging neurodevelopmental problems also enabled us to further understand the relationship in a population that has consistently demonstrated impaired empathic responding (e.g., Auyeung & Alden, 2016; Ekinci & Ekinci, 2016; Gambin & Sharp, 2018; Maoz, Gvirtz, Sheffer & Bloch, 2017; Pasalich, Dadds, & Hawes, 2014; Schwenck et al., 2012; Thoma et al., 2011; Tibi-Elhanany & Shamay-Tsoory, 2011; van Goozen et al., 2016; van Zonneveld et al., 2017). For example, reduced empathic responsiveness to other people's sadness has been linked to disruptive behaviour problems in children (de Wied, Goudena & Matthys, 2005). Given the significant relationship between mimicry and empathy for sadness within this population of children, impairments in facial reactivity may be partly responsible for the emotional and behavioural problems they have been referred for. While future research is needed to confirm and extend current findings, the study does

provide more food for thought about the role of mimicry in children's cognitive and affective empathic responding.

5. The role of facial mimicry in children with problematic peer relations

5.1 Abstract

Background. Peer problems have frequently been associated with difficulties in recognizing, understanding and interpreting the emotions of others. It has been argued that facial mimicry is an important precursor of emotion processing skills. Although facial mimicry impairments have been observed in studies of older children with social difficulties, it is not yet known whether impairments are present at a much earlier age when children begin to develop peer relationships and show disordered behaviour.

Method. A group of 45 4- to 7-year-old children with high/very high levels of teacher-reported peer problems and a group of 46 children without peer problems watched three film clips showing a sad, happy and scared child, respectively, while facial mimicry was assessed using iMotions software.

Results. All children displayed facial expressivity that was congruent with the emotional expressions in the clips. The group with peer problems did not differ from the group without peer problems in facial muscle responses to happy faces but exhibited subnormal facial mimicry responses to the two negative emotional clips. Impaired facial mimicry responses to happiness, sadness and fear were all associated with severity of peer problems; impairments in facial responses to happiness and sadness predicted peer problems, independently of one another.

Conclusions. Atypical facial responsivity to others' positive and negative facial expressions is associated with problematic peer relations in 4-7-year-old children. The implications for early identification and interventions for these children are discussed. We also highlight directions for future research.

5.2 Introduction

Peer problems in childhood are associated with mental health impairments that can continue throughout development (Ladd, 2006; Ladd & Troop-Gordon, 2003; Prinstein & Aikins, 2004). For example, chronic peer rejection in early childhood is related to increased incidence of both externalising and internalising behaviors that remain stable through to adolescence and adulthood (Campbell, 2006; Ladd & Troop-Gordon, 2003; Lynam, 1996; Sturaro, van Lier, Cuijpers, & Koot, 2011). A mechanism that may be responsible for the link between childhood peer problems and psychopathology is impaired emotion processing. Indeed, difficulties in recognising, understanding and interpreting the emotions of others have frequently been associated with peer rejection, greater peer victimisation, and exclusion by peers (Miller et al., 2005; Schultz, Izard, Ackerman, & Youngstrom, 2001; Snyder et al., 2003; Sterba, Prinstein, & Cox, 2007). The reasoning is that if one cannot correctly identify the emotions of others, one is more likely to respond to others in an inappropriate way (van Goozen, 2015). For example, an inability to recognize peer distress can result in behavior that continues to upset or harm (Hunnikin et al., 2019). These same emotional processing skills can also predispose children to encounter future psychological problems: schizophrenia, social anxiety, bipolar disorder, psychopathy and autism are all associated with or mediated by emotion processing abilities (Blair et al., 2004; Brotman et al., 2008; Easter et al., 2005; Penn & Combs, 2000; Russell, Chu & Phillips, 2006; Silver, Goodman, Knoll, & Isakov, 2004; van Beek & Dubas, 2008).

Numerous studies indicate that emotion development begins early in life (Saarni, Mumme, & Campos, 1998; Thompson, 1994; Thompson, & Lagattuta, 2006). Emotion processing skills evident at primary-school age are the best predictors of later social and emotional competencies (Blair & Diamond, 2008; Halle et al., 2012; Herbert-Myers et al.,

2006; Konold & Pianta, 2005). For example, the same emotional processing skills learned in childhood are essential in adulthood for effective parenting, maintaining meaningful relationships, working well with others and upholding a job (Berscheid, & Reis, 1998; Reis, Collins, & Berscheid, 2000). Therefore, being able to better understand the emotion processing impairments that underlie problems in peer relations will allow the development of interventions that target the problems early and prevent any adverse outcome. Observing another's emotional state presumably initiates emotion processing. Seeing a person display an emotional facial expression typically elicits a similar expression in the observer. Thus, smiling is a common response to seeing someone else smile. Adequately responding to others' emotional expressions facilitates a cascade of emotional skills, such as empathy and emotional reciprocity, and consequently plays an important role in the development of appropriate social behavior (Eisenberg, Eggum & Di Giunta, 2010). Similarly, impairments in facial responding early in life could restrict a child's prosocial development, in particular their ability to understand others' emotions and to form friendly, reciprocal relationships with others.

The process of imitating another's facial expression has been termed facial mimicry, and its existence has been established in studies of both adults (Bernieri, Reznick, & Rosenthal, 1988; Cappella & Planalp, 1981; Dimberg, 1990) and children (Chisholm & Strayer, 1995; de Wied et al., 2006, 2009; Haviland & Lelwica, 1987).

Facial mimicry in children

Studies utilizing facial electromyography (EMG) paradigms to assess facial mimicry have consistently demonstrated that children react with increased zygomaticus major activation (which pulls up the corners of the mouth) when exposed to happy faces (Beall et al., 2008; Deschamps et al., 2012, 2014; de Wied et al., 2006, 2009; Oberman, Winkielman &

Ramachandran, 2009), whereas observing others' angry faces elicits an increase in the corrugator muscle activation (which frowns the brows; Deschamps et al., 2012, 2014; de Wied et al., 2006, 2009; Oberman, Winkielman & Ramachandran, 2009). There is also some evidence emerging for specific facial muscle response patterns for other emotions. In a sample of 61 and 33 typically developing (TD) children, aged 6-7 years, Deschamps and colleagues (2012; 2014) examined children's facial responses to sad and fearful facial expressions. Results demonstrated that sad faces were related to a combination of corrugator, depressor (pulls down corners of the lips) and frontalis activation (raising inner brows) and fearful faces with frontalis activation.

Recently, software solutions have been developed to code the movement of facial muscles automatically. For example, iMotions (2016) includes a facial expression analysis engine called Affectiva AFFDEX. Affectiva enables the analysis of previously recorded faces. The software identifies the main landmarks on the face, such as eyes and mouth, and assesses movement, shape and texture of the face at a pixel level. The main outputs include 7 basic emotions (joy, anger, surprise, fear, contempt, sadness, disgust), valence (positive, negative and neutral sentiments) and expression channels (e.g. smile, brow furrow, brow raise). The reliability of the software in young children has been confirmed by Howe-Davies and colleagues (under review), who demonstrated that happy, sad and fearful facial expressions could reliably be detected by the software. In the same study the researchers focused on additional muscle sites that may be activated during displays of happiness, sadness and fear. Results demonstrated that in addition to zygomaticus activation, happy faces elicited increased frontalis and decreased orbicularis activity (tightening of the eye lids). Moreover, consistent with facial recognition paradigms fearful facial expressions led to

increased risorius (stretching of the lips) and eye widen activation (Ekman & Friesen, 1978; Kohler et al., 2004).

Facial mimicry and atypical social skills

Studies investigating how mimicry relates to peer problems in childhood have primarily focused on children with Disruptive Behaviour Disorders (DBD) and Autism Spectrum Disorder (ASD), due to their significant impairments in peer relations. De Wied and colleagues (2006) compared facial EMG responses in 22 TD children with those in 22 boys with DBD (average age 10 years). When exposed to dynamic facial expressions, both groups showed increased zygomaticus activity to happy faces and increased corrugator response to angry facial expressions. However, boys with DBD showed a significantly smaller increase in corrugator response to anger, compared to TD children. A similar study by de Wied and colleagues (2009) also demonstrated that children with DBD displayed significantly smaller increases in corrugator activity in response to both sad and angry facial expressions, compared to a TD sample. These results suggest that mimicry responses to negatively valenced facial expressions are less intense in boys with DBD. In contrast, children with ASD appear to display impaired mimicry for both negative and positive facial expressions (Beall et al., 2008; Oberman et al., 2009). For example, Oberman and colleagues (2009) found that 8-12-year-olds with ASD displayed delayed facial mimicry responses across expressions of happiness, anger, disgust, fear and sadness. Similarly, Beall and colleagues (2008) showed that 11 children with ASD, aged 8-13 years, did not display facial expressions that were congruent with the fearful and angry faces they observed and did not produce any EMG activity for happy faces. However, differences in results between DBD and ASD groups could be attributed to the different stimulus materials used. In the field of ASD research, only static pictures of faces have been utilized; static pictures of posed emotions are weaker

stimuli (Drimalla, Landwehr, Hess & Dziobek, 2019; McLellan, Johnston, Dalrymple-Alford & Porter, 2010; van der Graff et al., 2016), leading to suboptimal recognition rates and lower intensity and realism ratings compared to dynamic stimuli (Weyers et al. 2006).

Further support for potential mimicry impairments in children with peer problems comes from emotion recognition studies. Facial emotion recognition deficits have been found in children, adolescents and adults with both externalising and internalising behavioural profiles, particularly those with disruptive behaviour disorders (Blair & Coles, 2000; Blair et al., 2001; Bowen, Morgan, Moore & van Goozen, 2014; Dadds et al., 2006; Fairchild et al., 2009; Hunnikin et al., 2019; Wells et al., under review) and anxiety symptomatology (e.g., Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Gutiérrez-García & Calvo, 2017; Jarros et al., 2012; Lau et al., 2012; Lee, Herbert & Manassis, 2014). More specifically, researchers have consistently found impaired emotion recognition for negative emotions but unimpaired emotion recognition for positive emotions in these groups of children and adolescents. Facial mimicry deficits may explain why children with peer problems demonstrate difficulties in recognizing the emotions of others. The Perception Action Model (PAM; Decety & Moriguchi, 2007) proposes that observing others' emotions activates neural circuits, which results in an emotional state congruent with that of the target person, and this facilitates emotion recognition and perspective taking (cognitive empathy). Empirical findings have supported this theory. For example, typically developing adults have consistently shown reductions in emotion recognition abilities when facial mimicry is blocked (Oberman, Winkielman & Ramachandran, 2007; Ponari et al., 2012; Rychlowska et al., 2014).

Despite these findings, there are issues concerning facial mimicry responses in children with social impairments that need further exploration. For example, at what stage

in development do atypical responses to facial expressions emerge? Deschamps and colleagues (2014) investigated EMG activity in response to emotional faces in 6- to 7-year-old TD children, children with conduct problems and children with ADHD. They found that all groups displayed significant facial mimicry in response to the emotional expressions of others, and there were no significant differences in mimicry response between the groups. The authors concluded that responses to others' facial expressions are intact in children aged 6-7 years, and that mimicry may not be impaired until later in development. However, this study used black and white dynamic pictures of posed facial expressions to assess mimicry. As previously mentioned, posed emotional stimuli are both less representative of everyday facial expressions and weaker in terms of eliciting mimicry (McLellan, Johnston, Dalrymple-Alford, & Porter, 2010; Wehrle, Kaiser, Schmidt & Scherer, 2000). In the current research we therefore aimed to extend the literature by investigating facial mimicry in young children with impaired peer relations via empathy-eliciting film clips portraying natural expressions in naturalistic settings. The objective was to compare facial mimicry responses in a sample of 4- to 7-year-old children with and without teacher-confirmed problems in interactions with peers. Facial activation was assessed via the Affectiva AFFDEX facial expression recognition engine, during exposure to emotion-inducing film clips. In line with mimicry and emotion recognition studies of children with externalising and internalising problem behaviours, it was predicted that children with peer problems would have impaired facial mimicry responses in relation to negative emotions, but unimpaired mimicry response to positive emotions relative to children without peer problems. We also expected impairments in facial mimicry for negative emotions to be associated with severity of peer problems. True facial mimicry involves a lack of activation at incongruent muscle sites, in addition to activation of the muscles matching the observed emotion. Therefore, as

in all previous facial mimicry studies, we examined expression-inappropriate muscle activation as well as activation of expression-appropriate muscles.

5.3 Method

5.3.1 Ethical statement

The university ethics committee granted permission for the study and all parents or legal guardians gave signed, voluntary consent for their children to participate.

5.3.2 Participants

Participants (n = 91) were aged between 4 and 7 years and had been referred to the Neurodevelopment Assessment Unit (NDAU; https://www.cardiff.ac.uk/research/explore/research-units/neurodevelopment-assessment-unit) at Cardiff University by their teachers because of emotional and/or behavioral difficulties observed at school. All children referred were eligible to take part in the research and the sample selected for this study consisted of children with varying levels of emotional and behavioural difficulties. The children's teachers completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). This measure is described in greater detail below.

The high peer problems group was selected based on the established norm scores of the SDQ scoring guidelines (retrieved from http:// www.sdqinfo.org/py/sdqinfo/b3.py?language=Englishqz(UK)); 45 children (32 boys) who had a score of 5 or more on the peer problems subscale of the SDQ were classified as being high/very high risk of peer problems; 46 children (35 boys) made up the low peer problems group; these children had a score of 4 or less on the peer problems subscale which is indicative of having a close to average or only slightly raised risk of peer problems (Goodman, 1997). A breakdown of SDQ items in the peer problems subscale shows that

participants in the high peer problems group were more likely to play alone and less likely to have at least one good friend than children in the low peer problems group (Figure 5.1).

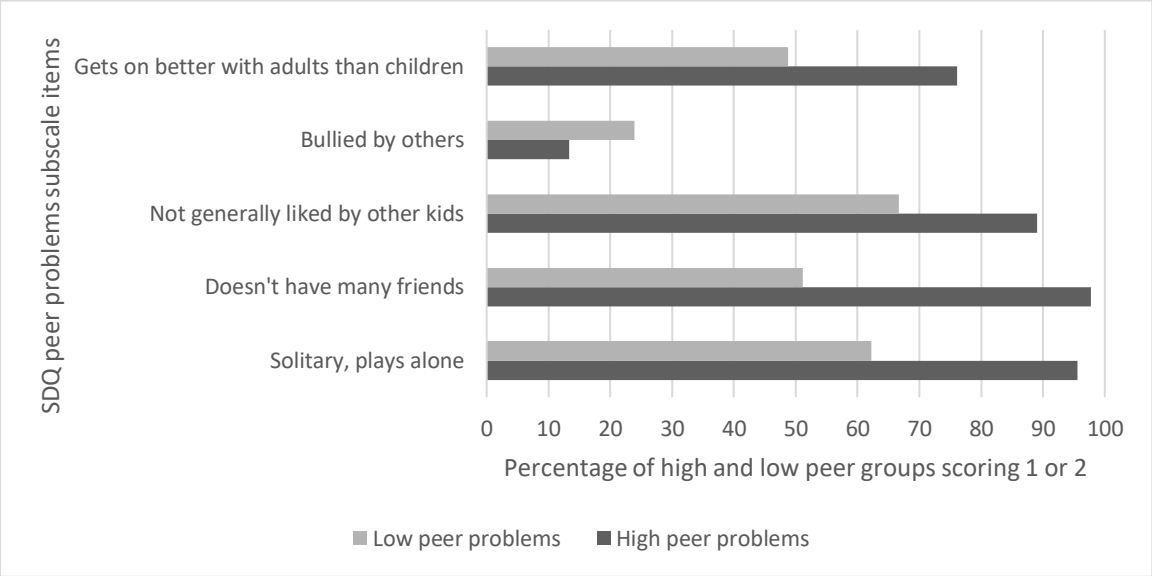

Figure 5.1. Percentage of participants in high and low peer groups scoring one or two on each item of the peer problem SDQ subscale

5.3.3 Materials

5.3.3.1 Strengths and Difficulties Questionnaire (SDQ)

The teacher version of the Strengths and Difficulties Questionnaire (SDQ) is a behavioral screening questionnaire for children and young people aged 3-16 years. Teachers are asked to rate 25 items on a 3-point Likert scale based on how true they are of the child's behavior over the last 6 months (0 = not true; 1 = somewhat true; 2 certainly true). The 25 items comprise 5 subscales; four assess negative behaviors (emotional symptoms, conduct problems, hyperactivity/inattention and peer relationship problems) and one assesses positive behavior (prosocial behavior). In addition to subscale scores, the SDQ also provides a Total Difficulties score, made up of all negative behavior scale scores. This score is indicative of the amount of psychosocial difficulties that a child presents with. The SDQ has

been found to discriminate well between children with and without psychological problems (Goodman, 1999; Klasen et al., 2000; Mullick & Goodman, 2001) and is a proven screening tool for child psychiatric disorders in community samples (Goodman, 2001; Goodman, Renfrew & Mullick, 2000).

5.3.3.2 Intellectual ability

To assess cognitive ability the Lucid Ability assessment was administered (Singleton, 2001). This estimates FSIQ, verbal IQ and performance IQ. For children aged 4-6 years verbal IQ is assessed by the means of a picture vocabulary task, and performance IQ by the means of a mental rotation task. For older children, aged 7-16 years, verbal IQ is assessed via a conceptual similarities task, and performance IQ through a matrix problem-solving task. An overall measure of FSIQ is calculated based on the sum of verbal and performance IQ scores. The validity of Lucid Ability is comparable to a range of conventional IQ measures, including the Wechsler Intelligence Scale for Children (WISC-III), the British Ability Scales (Second Edition) and the British Picture Vocabulary Scale (Second Edition; Lucid Ability Administrator's Manual, 2015; Singleton, 2001).

5.3.3.3 Measurement of facial mimicry

Children were shown three empathy-inducing film clips. The clips have been used in a study conducted by Noten and colleagues (2019), who demonstrated that three-year-old children recognized and understood the emotions presented in each video. One clip represented happiness (a boy opening a Christmas present), another clip represented sadness (a boy flushing his dead goldfish down the toilet), and another clip represented fear (a girl who is scared of being in a car wash). The film clips varied in length between 52 and 56 s. Facial expressions of participants were recorded with a Dell laptop (Precision 7710) integrated webcam from stimulus onset until stimulus offset. The most emotional sections of the clip in

which the child protagonist was expressing maximum facial expressions of happiness, sadness and fear were used as target scenes. Neutral sections at the opening or closing of the clip were used as a baseline. Webcam footage of the participants viewing the target and baseline sections of the clip were later imported into iMotions Biometric Research Platform 6.0 software (www.imotions.com) and processed using the Affectiva AFFDEX facial expression recognition engine. Target scenes varied in length between 9 and 15s. Baseline sections varied between 8 and 10s.

5.3.4 Procedure

Facial mimicry data were collected while the child was seated in front of a computer. Prior to the task children were informed about what to do and instructed to watch the videos carefully. After each video children rated how the protagonist felt, how intense these emotions were and why these emotions were expressed. Children were also asked how they felt themselves, how intensely they felt those emotions and why they felt those emotions. In between the presentation of each video the experimenter ensured the child was motivated and reminded them to watch the next video carefully. During the task, the experimenter encouraged the children to pay attention and noted whether a participant was inattentive. Total duration of the facial mimicry task was approximately 20 minutes.

5.3.5 Facial mimicry data processing

iMotions provides probability-like values for all basic emotions and the muscle sites associated with each emotion. Probability data were exported for all subjects. Mean facial probability values for 7 muscle sites were then calculated for baseline and target periods of each clip. The 7 muscle sites were zygomaticus, corrugator, frontalis, depressor, risorius, orbicularis oculi and eye widen. Trials containing less than 50% data were removed prior to data analysis, and anomalies in the data (+/- 3 standard deviations away from the mean)

were replaced with the highest/lowest value that remained within 2 standard deviations of the mean of that variable.

5.3.6 Statistical analysis

To address our first hypothesis, mixed model analyses of variance (ANOVAs) were conducted to examine whether changes in facial activation from baseline differed in children with high peer problems compared to children with low peer problems. Dependent variables were the seven facial mimicry muscle sites in response to each emotion (e.g., zygomaticus for happiness, zygomaticus for sadness, zygomaticus for fear, corrugator for happiness, corrugator for sadness, corrugator for fear). Mimicry was entered as a within subjects' factor with two group levels (facial activation during baseline and facial activation during stimulus presentation). Group was entered as a between subjects' variable with two levels (high peer problems and low peer problems). Independent samples *t*-tests were also used to examine differences in facial mimicry between the groups during stimulus presentation. To address our second hypothesis, Pearson's correlations examined relationships between key facial mimicry variables and severity of peer problems and a multiple regression analysis was used to determine whether impaired facial mimicry responses predict problems with peer relations. In all tests a significance level of .05 was employed.

5.4 Results

5.4.1 Preliminary analyses

Descriptive characteristics of the high peer and low peer problems samples are included in Table 5.1. The groups did not differ in age, gender or estimated full-scale IQ (FSIQ). Analyses of the SDQ subscales and total score revealed differences between groups in their peer,

prosocial and total SDQ scores. However, the high peer problems group did not differ from those with low peer problems on emotional, hyperactive or conduct problems.

Table 5.1 Characteristics of children with and without peer problems

	Low peer problems (n = 45)		High peer problems (n = 46)		Low vs high	
	Mean	SD	Mean	SD	Statistic	*p*
Age (months)	76.36	10.77	72.17	13.83	$t(89) = 1.605$	.112
Gender (% males)	71.1%		77.8%		$X^2(1) = 0.526$	.468
FSIQ	96.62	17.60	101.02	12.14	$t(85) = -1.366$	.176
SDQ						
Emotional	4.40	2.38	3.98	2.39	$t(89) = .844$	.401
Hyperactive	8.69	1.56	8.24	1.73	$t(89) = 1.301$	.197
Conduct	4.84	2.31	4.39	2.26	$t(89) = .948$	.346
Peer	2.69	1.18	5.91	1.01	$t(89) = -14.005$	<.001*
Prosocial	3.80	2.39	2.57	2.34	$t(89) = 2.488$	.015*
Total	20.62	3.18	22.52	4.38	$t(89) = -2.373$	.020*

Notes: FSIQ, Full Scale Intelligence Quotient; SDQ, Strengths and Difficulties Questionnaire

Given that children with peer problems also differed in their prosocial scores, the relation between the two subscales was further investigated. Scores on the peer problems subscale were significantly inversely associated with prosocial scores ($r = -.325$; Table 5.2). However, while scores on the peer problems subscale were significantly correlated with key mimicry variables, the same was not true for the low prosocial scores (see Table 5.2). In addition, combined peer problems and reversed prosocial scores also did not correlate with key mimicry variables (all *p* values > .05).

Table 5.2 Relationships between facial mimicry, peer problems and prosocial problems across happy, sad and fear clips

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. ZM happy	-																						
2. OO happy	.069	-																					
3. R happy	.401**	.005	-																				
4. CS happy	-.105	-.101	-.141	-																			
5. EW happy	.189	-.204	.049	-.143	-																		
6. F happy	.010	.109	.150	-.005	.026	-																	
7. DAO happy	-.086	-.030	.110	.024	.093	.198	-																
8. ZM sad	.179	.083	.232	-.195	.125	.089	.243	-															
9. OO sad	.091	.378**	-.053	-.190	-.154	.076	.297*	.369**	-														
10. R sad	.071	-.197	-.037	-.099	.079	-.023	.029	.149	-.026	-													
11. CS sad	-.179	-.092	-.065	.283*	-.166	-.124	-.069	-.165	-.068	-.104	-												
12. EW sad	.123	-.024	.317*	-.137	.488**	.267*	.224	.314*	.024	.070	-.129	-											
13. F sad	-.126	-.094	-.055	-.011	.122	.350**	.013	.020	.039	-.158	-.117	.253*	-										
14. DAO sad	.310*	.109	.192	-.133	.096	.033	.210	.072	.246*	-.046	-.090	.317**	.053	-									
15. ZM fear	.251	.204	.104	-.192	.162	.156	-.117	.212	-.072	-.003	.124	.366**	.145	.163	-								
16. OO fear	.164	.378**	-.123	.148	-.158	.069	-.015	.209	.252	.025	-.161	-.166	.001	-.107	.078	-							
17. R fear	.175	-.009	.040	-.126	.191	-.018	-.063	.238	.056	-.135	-.022	.368**	.055	.083	.622**	.078	-						
18. CS fear	.063	-.120	.054	.186	-.168	-.004	.092	-.138	.287*	-.256*	.171	-.184	.003	.122	-.082	.032	-.069	-					
19. EW fear	.055	-.121	-.080	-.212	.425**	-.024	-.081	.090	-.047	.120	-.069	.168	.233	-.015	-.073	-.203	-.003	-.213	-				
20. F fear	.037	-.170	-.017	-.110	.208	.305*	-.023	-.002	-.016	.114	-.182	.390**	.522**	.087	.129	.219	.069	-.075	.151	-			
21. DAO fear	.103	-.214	-.048	.06	.075	.212	.132	-.030	-.021	.135	.001	.000	.215	-.011	-.011	-.083	.135	-.146	.307*	.061	-		
22. SDQ Peer	.131	.261*	.225	-.092	.015	.033	.115	.214	.248*	.016	-.049	.066	-.228*	.176	.067	.184	.024	-.110	-.287*	-.141	-.168	-	
23. SDQ Prosocial	.176	.087	.051	.200	-.125	.048	-.039	-.084	.030	-.057	.128	-.053	-.017	.130	.010	.238	-.144	.235	-0.145	.17	-.050	-.325**	-

Notes: Values represent Pearson's rho. * = correlation is significant at the 0.05 level, ** = correlation is significant at the 0.01 level. ZM, zygomaticus major; OO; orbicularis oculi; R, Risorius; CS, corrugator supercilii; EW, eye widen; F, frontalis; D, depressor anguli oris.

5.4.2 Main analyses

5.4.2.1 Facial mimicry in children with high vs low peer problems

We assessed whether there were differences in facial mimicry between groups with high and low peer problems. Univariate analyses assessed changes from baseline.

Results demonstrated statistically significant main effects of mimicry in response to happiness. Specifically, happy faces elicited the expected increase in zygomaticus, $F(1, 68) = 5.499$, $p = .022$, $\eta_p^2 = .06$], and frontalis activity, $F(1, 68) = 4.852$, $p = .031$, $\eta_p^2 = .07$, and a decrease in orbicularis activity, $F(1, 68) = 17.413$, $p < .001$, $\eta_p^2 = .20$, compared to baseline. There were no main effects of group nor were there mimicry by group interactions, indicating that children with high and low peer problems did not differ in facial mimicry for happiness.

In response to sadness the ANOVAs yielded significant main effects of mimicry. Sad facial expressions elicited a significant increase in frontalis, $F(1, 73) = 13.776$, $p < .001$, $\eta p^2 = .16$, corrugator, $F(1, 73) = 13.597$, $p < .001$, $\eta_p^2 = .16$, depressor, $F(1, 73) = 19.544$, $p < .001$, $\eta_p^2 = .21$, and eye widen activity, $F(1, 72) = 5.086$, $p = .019$, $\eta_p^2 = .08$. There were no significant main effects of group, but consistent with predictions there were significant group by mimicry interactions. Zygomaticus, $F(1, 73) = 9.803$, $p = .003$, $\eta_p^2 = .19$, and orbicularis oculi activity, $F(1, 73) = 5.098$, $p = .027$, $\eta_p^2 = .07$, decreased during exposure to sadness in the low peer problems group, whereas in children with high peer problems activation for these muscle sites increased.

Independent samples *t*-tests also showed significantly greater levels of zygomaticus and orbicularis activity in the high peer group compared to the low peer group during the presentation of the emotive section of the sad clip [zygomaticus: low peer: mean = 9.23, SD = 14.24; high peer: mean = 19.30, SD = 25.40, $t(63.5) = -2.200$, $p = .031$, $d = 0.49$, 95% CI

[0.84, 19.30]; lid tighten: low peer: mean = 4.26, SD = 6.70; high peer: mean = 8.23, SD = 7.44, $t(78) = -2.454$, $p = .016$, $d = 0.56$, 95% CI [0.75, 7.19]].

In response to fearful faces we found significant main effects of mimicry. Specifically, fearful facial expressions led to the predicted increase in risorius, $F(1, 59) = 14.370$, $p < .001$, $\eta_p^2 = .20$, and eye widen activity, $F(1, 59) = 4.835$, $p = .032$, $\eta_p^2 = .08$, compared to baseline. Children also showed an unpredicted decrease in frontalis activity, $F(1, 59) = 5.721$, $p = .020$, $\eta_p^2 = .09$, and an unpredicted increase in zygomaticus activation, $F(1\ 59) = 12.334$, $p = .001$, $\eta_p^2 = .17$. There was a significant multivariate main effect of group for the activation of the orbicularis muscle site, $F(1, 59) = 5.931$, $p = .018$, $\eta_p^2 = .09$, and consistent with predictions, a significant group by mimicry interaction. Eye widen activity increased during exposure to fear in the low peer problems group, whereas in children with high peer problems activation for this muscle site decreased, $F(1, 59) = 5.564$, $p = .022$, $\eta_p^2 = .09$.

Also, independent samples *t*-tests revealed significantly lower levels of eye widen activity [low peer: mean = 0.72, SD = 1.30; high peer: mean = 0.20, SD = 0.67, $t(53.5) = 2.110$, $p = .040$, $d = 0.50$, 95% CI [0.01, 1.03]], lower levels of depressor activity [low peer: mean = 2.26, SD = 3.20; high peer: mean = 1.03, SD = 1.68, $t(54.2) = 2.021$, $p = .048$, $d = .48$, 95% CI [-0.03, 2.49] and marginally greater levels of orbicularis activity [low peer: mean = 6.15, SD = 9.61; high peer: mean = 12.01, SD = 14.05, $t(53.9) = -1.982$, $p = .053$, $d = 0.49$, 95% CI [0.09, 11.63]] in the high peer group compared to the low peer group, during the presentation of the emotive section of the fearful clip. Group differences in mimicry responses during stimulus presentation can be illustrated by standardized mean scores (mean mimicry scores transformed into z-scores) as shown in Figure 5.2.

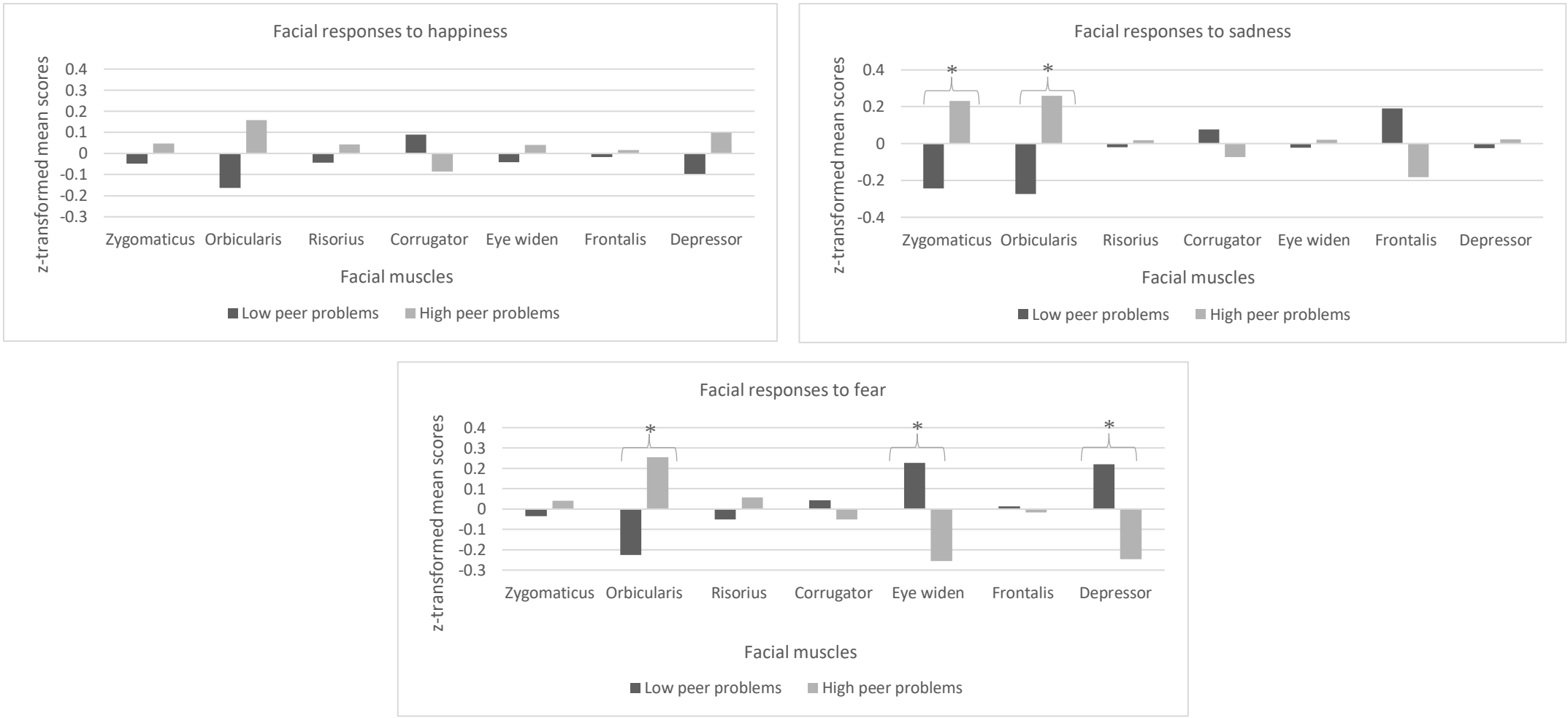

Figure 5.2 Children's facial expressivity in response to happiness, sadness and fear clips as a function of peer problems. For visualization purposes standardized mean scores (z scores) are shown.

5.4.2.2 The relationship between facial mimicry and peer problems

The relation between peer problems and facial mimicry for sadness and fear was further supported by correlational analysis; during the observation of sadness peer problems were positively associated with orbicularis activity, $r = .248$, n = 80, $p < .05$, negatively associated with frontalis activity, $r = -228$, n = 80, $p < .05$, and marginally positively associated with zygomaticus activity, $r = 2.14$, n = 80, $p = .057$. Peer problems were also significantly inversely related to eye widen activity during the observation of fear, $r = .287$, n = 68, $p = < .05$. Finally, in contrast to the above between-group analyses, peer problems were associated with more orbicularis facial activity during the observation of happiness, $r = .261$, n = 73, $p < .05$.

Multiple regression analysis was used to determine whether increased orbicularis and zygomaticus facial activity during sadness, decreased frontalis activity during sadness, reduced eye widen during fear and increased orbicularis activity during happiness predicted peer problems. The multiple regression model significantly predicted severity of problems with peer relations, $F(5,51) = 4.72$, $p < .01$, adjusted $R^2 = .34$. Reduced frontalis activity during the observation of sadness, and increased orbicularis activity during the observation of happiness significantly added to the prediction, $p < .05$ (see Table 5.3).

Table 5.3 Summary of multiple regression analysis

	B	**SE_B**	**β**	**CI**
Intercept	4.004	.409		
Frontalis sad	-.027	.012	-.275*	-.052-.002
Orbicularis sad	.016	.037	.063	-.057-.090
Zygomaticus sad	.022	.013	.223	-.004-.048
Eye widen fear	-.342	.217	-.199	-.779-.095
Orbicularis happy	.160	.073	.288*	.013-.308

Notes: B = unstandardized regression coefficient, SE_B = standard error of the coefficient, β = standardized coefficient, CI = confidence intervals, * = p < .05

5.5 Discussion

Impairments in facial responding have been hypothesized to restrict a child's ability to recognize and understand others' emotions, and in turn, their ability to form friendly, reciprocal relationships with others. We investigated these impairments in a sample of children showing impaired peer relations. Specifically, the first aim of the current study was to measure and compare facial mimicry responses in young children with and without teacher-rated peer problems. Consistent with previous research, our results demonstrate a specific impairment in facial mimicry for negative emotions in children with poor peer relations. The second aim of the study was to explore the relationships between key facial mimicry variables and peer problems. In contrast to our between-group analyses our results indicate that impairments in facial mimicry for both positive and negative emotions are associated with severity of peer problems. Moreover, for the first time, we found that impaired facial responsiveness, particularly increased orbicularis activity during the observation of happiness and reduced frontalis activity during the observation of sadness, predicted peer problems.

Before addressing the principal findings, it is important to note that the present study provides evidence that young children do correctly mimic facial expressions of happiness, sadness, and fear. Children displayed increased zygomaticus and frontalis activity and decreased orbicularis oculi activity during the happy condition. The presentation of sad facial expressions led to an increase in corrugator, frontalis, depressor, and eye widen activity. The presentation of fearful faces resulted in an increase in risorius and eye widen activity and a decrease in frontalis activation. Surprisingly, the fearful clip also increased activation of the zygomaticus major. It is possible that the unexpected findings in the zygomaticus muscle site in the present study are due to the young age of our participants,

given that fearful facial expressions are usually the most difficult to recognize (Ekman & Friesen, 1976).

For the first time, the current study assessed facial mimicry impairments in children aged 4-7-years using facial expression analysis software, iMotions (2016). In response to sad faces, we found that while zygomaticus relaxation was observed in children without peer relation impairments, those with impaired peer problems demonstrated an increase in zygomaticus activity. Moreover, zygomaticus and orbicularis oculi activation were significantly higher in children with peer problems compared to those without. Thus, children with inadequate peer relations exhibited a blended and incongruent expression to the sadness displayed in the film clip. The absence of a congruent response to sad facial expressions suggests that children with impairments in their relationships with peers either respond atypically to sadness or do not understand the sadness display.

Children with peer problems also displayed a different pattern of facial activation compared to the children without peer problems in response to the presentation of fearful facial expressions. The fearful clip significantly enhanced eye widen activity in the low peer problems group, but not in the high peer group. Moreover, eye widen muscle responses were significantly stronger amongst children without peer impairments. During the fear clip children without peer problems also exhibited significantly more depressor activity and significantly less activation of the orbicularis oculi compared to children with peer problems. These findings suggest that while children with healthy peer relations respond to fear with a pattern of facial activation that is associated with both fear and sadness, children with peer relation impairments respond with facial activation associated with confusion and/or anger. In general, the absence of a congruent response to fear amongst children with peer problems suggests they may not be sharing the emotion of the person in the clip. However,

children in both groups demonstrated incongruency in relation to fear; both groups exhibited an increase in zygomaticus activity from baseline, meaning that children of this age may not yet fully understand fear in others, regardless of their social ability.

Correlational analysis further supported the relationship between impaired facial mimicry for negative emotions and peer problems. More specifically, more orbicularis and zygomaticus activity for sadness, less frontalis activity for sadness and less eye widen activity for fear were associated with the severity of peer problems. Previous research has consistently demonstrated that difficulties in recognising, understanding and interpreting the emotions of others is associated with problems in peer relations (Miller et al., 2005; Schultz, Izard, Ackerman & Youngstrom, 2001; Snyder et al., 2003; Sterba, Prinstein & Cox, 2007). The associations between impaired facial mimicry responses and severity of peer problems in the current study extends these findings, by demonstrating that facially responding to other people's emotions incongruently or inappropriately also negatively impacts on relations with peers.

While the present study found no significant differences between children with and without peer problems in facial muscle responses to happiness, correlational analysis demonstrated an inverse association between orbicularis activity during the observation of happiness and peer problem severity. These findings suggest that an atypical response to happiness is associated with impaired or limited peer relations, which contrasts with our hypothesis. Based on previous studies, we expected peer problem severity to only be associated with impaired facial mimicry for negative emotions. However, this is the first study to investigate the relationship between facial mimicry impairments and peer problems dimensionally. The RDoC framework, a new way of classifying psychopathology, advocates the dimensional study of mental health disorders and the processes and

mechanisms underlying these disorders. A dimensional approach to psychopathology assesses or measures variation in relevant underlying processes, capacities or traits across individuals, which represents a greater or lesser degree of mental health and adaptation, and avoids a substantial loss of valuable information, that is often the case when using categorical approaches (Brown & Barlow, 2005). A meta-analysis investigating the reliability and validity of utilizing a dimensional approach reported a 15% and 37% increase in reliability and validity respectively through the adoption of a dimensional over a categorical measure of psychopathology (Markon, Chmielewski & Miller, 2011). Accordingly, dimensional ways of studying psychopathology are on the rise (Fairchild et al., 2009; Marsee et al., 2005; Passamonti et al., 2010). Another reason for the inconsistent findings between the current study and previous research relates to the types of facial muscles investigated during the observation of happiness. Previous studies that failed to find an association between happiness and disordered behaviour only assessed activation of the zygomaticus and corrugator muscles. We did not find any association between zygomaticus or corrugator activity and peer problem severity, but rather an association between orbicularis activity and peer relations. With these critiques in mind, future research should dimensionally investigate the relationship between psychopathology and multiple facial muscle sites during the observation of happiness. Having deeper understanding of the mimicry deficits for positive emotions in populations of children with psychopathology is important, given that happiness is supposed to diffuse hostility and stimulate prosocial behaviour (Becker & Srinivasan, 2014).

Our finding of impaired facial mimicry for happiness is also at odds with studies that report a specific impairment in recognition of negative facial expressions in children and adolescents with a range of psychopathology associated with problematic peer relations.

The Perception Action Model (PAM; Decety & Moriguchi, 2007) proposes that observing others' emotions activates neural circuits, which result in an emotional state congruent with that of the target person, and this facilitates emotion recognition. Thus, if children with peer relationship problems are only impaired in recognizing negative emotions, we would expect them to display an impairment in facial responsiveness for negative emotions. A possible explanation is that positive facial expressions are visually simpler to recognise than negative facial expressions (Leppanen & Hietanen, 2004). Happiness is associated with a single facial feature (smiling), whereas negative facial features are associated with various muscle sites that often overlap (e.g., corrugator activity is associated with both sadness and anger; Adolphs, 2002). Therefore, while the ability to successfully distinguish between different negative emotions involves being able to differentiate between very subtle facial differences, a single salient feature can be used to recognise happiness. Consequently, the recognition and experience of vicarious happiness may be less dependent on mimicry than other emotions and thus, while children with problematic peer relations may exhibit an impairment in their facial responses to happiness, this impairment does not seem to cause difficulties for the recognition of and empathy for happiness.

To our knowledge this is the first study to demonstrate facial mimicry impairments in children as young as 4-7 years. A previous study on facial mimicry in 6-7-year-old children with disruptive behavior disorder and TD controls failed to establish group differences in facial responses (Deschamps et al., 2014). This led the authors to conclude that mimicry is unimpaired until later in development. However, our study points to a different conclusion. There are numerous explanations for these inconsistencies. First, while Deschamps and colleagues (2014) used facial EMG techniques, we introduced the Affectiva AFFDEX facial expression recognition engine, which may be a more precise measure of facial mimicry

(Kulke, Feyerabend & Schacht, 2020). Second, while the previous study used stimuli that consisted of black and white dynamic pictures, the present study used film clips with social content. Our stimuli showed real children experiencing real-life emotions and the target emotion was clearly displayed in a social situation that is familiar to young children. Consequently, the current design is more sensitive to assess facial mimicry in young children.

In summary, this study provides first evidence in support of the feasibility of using Affectiva to detect impairments in facial responsiveness that relate to children's social problems. Atypical facial responsivity to others' facial expressions could be associated with other common difficulties reported in children with social impairments, such as poor emotion recognition, reduced empathy and diminished affect (Aspan, Vida, Gadoros & Halasz, 2013; Blair, 2007; Hunnikin, Wells, Ash & van Goozen, 2019; Noten et al., 2019; Schechtman, 2003; Seltzer et al., 2003, Sutton, Reeves & Keogh, 2000, van Zonneveld et al., 2017; Wells et al., 2019). Our results could have important implications for the development of interventions, which focus on targeting and improving emotion processing in children with inadequate or limited peer relations. This type of approach has already been shown to be effective. For example, emotion comprehension programs for children and young people have been associated with improved behaviour and prosocial skills (Baron-Cohen, Golan & Ashwin, 2009; Dadds et al., 2012; Hubble et al., 2015; Wells et al., under review). Our results suggest that emotion intervention programs aimed at improving social functioning should be administered early in life when key socio-emotional skills are developing. Administering successful interventions during an early, sensitive period may ensure children with peer problems attain a more positive developmental trajectory.

6. General Discussion

Children with diagnosed neurodevelopmental disorders (NDDs) exhibit a high prevalence of co-occurrence across disorders and marked heterogeneity in behavioural presentation within diagnostic groups. In an attempt to reduce the problems associated with traditional categorical approaches to psychopathology, theorists have highlighted the importance of identifying transdiagnostic processes or factors that contribute to the development and maintenance of various forms of mental illness (Cuthbert, 2014; Cuthbert & Insel, 2013; Insel, 2014). Having a better understanding of the transdiagnostic factors that contribute to various forms of psychopathology will allow the development of interventions that target shared features of multiple disorders. A transdiagnostic approach to developmental risk aligns with the National Institute of Mental Health's Research Domain Criteria framework (Casey, Oliveri & Insel, 2014), which advocates studying the processes and mechanisms underlying mental health problems (Insel et al., 2010).

Central to this thesis was the examination of Theory of Mind (ToM), empathy and facial mimicry in children with emerging NDDs. Symptoms of NDDs that develop during early childhood often exacerbate if left untreated and continue into adulthood. In line with the RDoC approach, ToM, empathy and facial mimicry are all essential for successful social and emotional development and thus, impairments in these processes are likely to play a role in the development of childhood NDDs.

A large body of research indicates that impairments in ToM, empathy and facial mimicry play a role in the development and maintenance of both externalising and internalising disorders, supporting the transdiagnostic relevance of the constructs in research and assessment. Based on this, it is also possible that ToM, empathy and facial mimicry are useful constructs when studying risk for NDDs. However, research has not yet explored the roles of ToM, empathy and facial mimicry in young, pre-diagnostic children at

risk of developing psychopathology. Having a better understanding of the processes and mechanisms underlying emotional and behavioural problems early in childhood may lead to the development of interventions that promote a more positive developmental trajectory.

6.2 Overview, aims and key findings

The central aims of this thesis were to examine the roles of ToM, empathy and facial mimicry in children with early signs of NDDs, to understand how these processes relate to each other as well as to specific emotional and behavioural problem profiles.

Chapter 2 examined ToM in children with early emerging symptoms of NDDs compared to TD controls. Impairments in ToM ability have consistently been associated with a range of mental health and neurodevelopmental disorders, including mood disorders, disruptive disorders and ADHD (e.g., Anastassiou-Hadjicharalambous & Warden, 2008a; Banerjee & Henderson, 2001; Schenkel, Marlow-O'Connor, Moss, Sweeney & Pavuluri, 2008; Hughes, Dunn & White, 1998; Maoz, Gvirtz, Sheffer & Bloch, 2017; Song, Waller, Hyde & Olsen, 2016). There is also some suggestion that individuals with autism who perform comparably to TD controls on ToM tasks use significantly fewer mental state terms in their explanations of social interactions (Begeer, Malle, Nieuwland & Keysar, 2010; Klin, 2000; Klin et al., 2003). This has led researchers to propose that even when individuals with social impairments are able to understand and accurately predict other people's behaviour in social situations, they may not rely on their ToM ability to do so but rather their experience and general cognitive abilities. However, little is known about whether ToM impairments are evident in young, pre-diagnostic children with a range of emotional and behavioural problems and even less about the nature of ToM impairments in these children. A further issue was to ascertain whether ToM is differentially characterised across different emotional and behavioural profiles. Indeed, while a specific impairment in affective ToM

has been demonstrated in children and adolescents with disruptive disorders (de la Osa et al., 2016; Satlof-Bedrick, 2017; Sebastian et al., 2012), some studies have indicated that enhanced levels of ToM are associated with anxiety symptomatology (Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018).

Chapter 2 aimed to identify whether impairments in ToM, that have been found in children with diagnosed psychopathology, extends to pre-diagnostic children with early signs of NDDs. The study also aimed to identify whether a specific or general impairment in ToM underlies emotional and behavioural problems in early childhood and whether ToM is differentially affected across disruptive and anxiety-related behavioural profiles. The findings in Chapter 2 extend the literature by showing that participants with NDDs were specifically impaired on measures of cognitive ToM compared with controls. This finding was further supported by the results investigating the use of mental-state language, where it was found that the NDD group also used less mental state terminology when justifying and reasoning about other people's emotions. Together these findings suggest that it is possible that while TD children rely on their ability to infer the thoughts and beliefs of others to understand what people are feeling, children with emotional and behavioural difficulties are less able to do so, given their impaired ability to understand the cognitive mental states of others. Consequently, they may rely on different processes, such as general cognitive ability and past experience, as suggested by Begeer and colleagues (2010). Despite the significant differences between NDD and TD groups in ToM performance, severity of emotional and behavioural difficulties (SDQ total problem score) did not predict ToM understanding in the NDD group. Indeed, only age and verbal mental ability significantly and independently predicted ToM. Based on these findings, it is possible that the reduced

mentalising ability that we observed in our sample of children with symptoms of NDDs was an indirect effect of language ability.

Our final prediction was that children with a disruptive behavioural profile would exhibit a different pattern of ToM impairments compared to children with anxiety symptomatology, but the current study found no evidence of this. It has been suggested that the lack of significant findings may be due to the use of dichotomous measures (Poletti & Adenzato, 2013). Consequently, when comparing ToM and empathy in those with high and low levels of anxiety in Chapter 3, we utilized a dimensional ToM scoring system.

Recent literature has found both empathy and ToM to play a role in the development and maintenance of anxiety disorders (Auyeung & Alden, 2016; Gambin & Sharp, 2018; Hezel & McNally, 2014; Morrison et al., 2016; Tibi-Elhanay & Shamay-Tsoory, 2011; Zainal & Newman, 2018). However, while some research suggests that anxiety symptomatology is associated with elevated ToM and empathic tendencies, other research suggests that levels of ToM and empathy are lower in anxious individuals. Moreover, some studies have found that emotion-processing impairments in individuals with anxiety are specific to negative emotions (e.g., Doty, Japee, Ingvar & Ungerleider, 2013; Frenkel & Bar-Haim, 2011; Jarros et al., 2012; Lau et al., 2012; Lee, Herbert & Manassis, 2014; Montagne et al., 2007; Yoon, Yang, Chong & Oh, 2014). The goal of Chapter 3 was to identify whether children with high levels of anxiety would differ from children with low levels of anxiety in their ToM and empathy performance and whether ToM and empathy were related to anxiety severity.

The results of Chapter 3 expand on previous studies by showing that children with high levels of anxiety symptomatology exhibited elevated ability in inferring the cognitive mental states of others (cognitive ToM) but reduced ability in feeling a congruent emotional

response to others' negative emotions (affective empathy). There was, however, no difference between the high anxiety (HA) and low anxiety (LA) groups in affective ToM and cognitive empathy. When examining relations with the clinical variables we found that elevated cognitive ToM and reduced affective empathy for negative emotions were associated with more severe anxiety and that they, independently of one another, predicted anxiety symptomatology.

In Chapter 4, we examined the relationship between facial mimicry and cognitive and affective empathy in young children with symptoms of NDDs. Previous literature examining the three constructs simultaneously has demonstrated positive associations between mimicry and cognitive and affective empathy (Drimalla, Landwehr, Hess & Dziobek, 2019; Sato et al., 2013; van der Graff et al., 2016). Moreover, in these studies the relationship between mimicry and cognitive empathy was mediated by affective empathy (Sato et al., 2013; van der Graff et al., 2016). However, these studies were conducted in adolescents and adults and adolescents' and adults' facial expressions do not always match their true feelings. In social situations, they are likely to follow emotion display rules, which lead people to modify (intensify, neutralise, hide) their emotional responses in accordance with context-specific expectations (Ekman, 1972; Ekman & Friesen, 1975; Saarni, 1982). Children's knowledge of when to modify emotional displays does not fully develop until 10-11 years (Gnepp & Hess, 1986). Consequently, children are more likely to show significant convergence between their feelings and their facial expressions, enabling us to establish the underlying relationship between mimicry and empathy. The goal of Chapter 4 was to examine the relations between mimicry, cognitive empathy and affective empathy in sample of children aged 4-7 years with early emerging symptoms of NDDs in order to

establish whether impaired facial mimicry was the mechanism underlying the impairments in empathic responding consistently demonstrated by children with diagnosed NDDs.

In partial support of our first hypothesis we found positive relationships between facial mimicry for sadness and affective and cognitive empathy for sadness, but no significant associations between facial mimicry and empathy for either happiness or fear. Against predictions, and in contrast to previous research in samples of adolescents and adults (Drimalla, Landwehr, Hess & Dziobek, 2019; Sato et al., 2013; van der Graff et al., 2016), we also found stronger support for a mediating role of cognitive rather than affective empathy. That is, facial mimicry was found to better predict affective empathy, indirectly via cognitive empathy, rather than predicting cognitive empathy indirectly via affective empathy.

The final experimental chapter in this thesis examined the role of facial mimicry in children's peer relations. Difficulties in recognising, understanding and interpreting the emotions of others have frequently been associated with peer rejection, greater peer victimization and exclusion by peers (Miller et al., 2005; Schultz, Izard, Ackerman, & Youngstrom, 2001; Snyder et al., 2003; Sterba, Prinstein, & Cox, 2007). Given that facial mimicry has been theorised to initiate emotion processing, it seems plausible that children with peer problems would also exhibit impaired facial mimicry responses. Research has shown that children aged 8-12 years with poor peer relations (as indicated by children with disruptive behaviour disorders and ASD) display impaired facial mimicry. However, the exact nature of the impairment is unclear. For example, while boys with oppositional defiant disorder and conduct disorder were less facially reactive to displays of negatively valenced facial expressions (de Wied et al., 2006; 2009), children with ASD appear to display impaired mimicry for both negative and positive facial displays (Beall et al., 2008; Oberman et al.,

2009). Moreover, little is known about whether facial mimicry impairments are evident in younger children with broad-ranging emotional and behavioural problems.

Consistent with the research on children with disruptive behaviour disorders (de Wied et al., 2006; 2009), the study firstly demonstrated that pre-diagnostic children with peer problems showed impairments in facial mimicry compared to children with no peer problems, particularly in response to negative emotions. Interestingly, this pattern of results was not found when exploring the relationships between facial mimicry and peer relations dimensionally. Indeed, our results indicated that impairments in facial mimicry for both positive and negative emotions were associated with severity of peer problems. Moreover, for the first time, we found that impaired facial responsiveness, particularly increased orbicularis activity during the observation of happiness and reduced frontalis activity during the observation of sadness, predicted peer problems.

6.2 Do children with emerging NDDs show problems in their socio-cognitive and emotional processes?

A key aim of this thesis was to explore the roles of ToM, empathy and facial mimicry in young children with early signs of NDDs. While impairments in all three constructs have been observed in older children and in children with diagnosed psychopathology little is known about whether impairments are evident in young, pre-diagnostic children with a range of emotional and behavioural problems and even less about the nature of impairments in these children.

The results taken together extend the literature by showing that pre-diagnostic children with early emerging symptoms of NDDs are impaired in their ToM, empathic and facial mimicry abilities (Chapters 2, 3 and 5 respectively). Chapter 2 showed that children with symptoms of NDDs demonstrated a specific impairment in their ability to infer the

cognitive mental states of others compared to TD controls; Chapter 3 demonstrated that compared to children with low levels of anxiety, children with high anxiety exhibited elevated levels of cognitive theorising and a reduced ability to vicariously share others' negative emotions; and Chapter 5 showed that children with poor peer relations displayed impaired facial mimicry for negative emotions compared to those without. These findings point to the importance of early intervention as these children were exhibiting similar ToM, empathy and facial mimicry impairments to those that have been observed in older children and adolescents with diagnosed psychopathology (e.g., Anastassiou-Hadjicharalambous & Warden, 2008a, 2008b; Beall et al., 2008; Caputi, Pantaleo & Scaini, 2017; de Wied et al., 2006, 2009; Gambin & Sharp, 2018; Maoz, Gvirtz, Sheffer & Bloch, 2017; van Goozen et al., 2016). The results of the current thesis also provide support for the RDoC approach, which advocates studying the processes and mechanisms underlying mental health problems rather than treating mental illnesses and disorders based on labels and diagnoses (Insel et al., 2010). In Chapters 2 and 5 respectively we found an impaired ability to infer others' thoughts and beliefs in children with NDDs compared to TD controls and impaired facial mimicry in children with problematic peer relations compared to those without. The symptoms demonstrated by children with NDDs included a wide variety of emotional and behavioural problems and problematic peer relations are proposed to underlie a number of externalising and internalising disorders (Campbell, 2006; Ladd & Troop-Gordon, 2003; Lynam, 1996; Sturaro, van Lier, Cuijpers, & Koot, 2011). These findings, therefore, support the notion that emotional and socio-cognitive processes, particularly cognitive ToM and facial mimicry, are transdiagnostic factors that underlie a range of difficult behaviours.

With regard to the nature of socio-cognitive and emotional impairments, the findings of the current thesis vary depending on the emotional and behavioural profile being

examined. From Chapter 2 it is clear that children with broad-ranging symptoms of NDDs show a clear deficit in inferring others' thoughts and beliefs; however, the results in Chapter 3 suggest that children with anxiety specific symptomatology show an elevated ability in understanding the thoughts and beliefs of others. These findings highlight the importance of investigating emotional and socio-cognitive processes in relation to specific symptom clusters. Indeed, determining the role of ToM, empathy and facial mimicry in relation to other behavioural profiles is something that further work should explore.

6.3. Does variation in ToM, empathy and facial mimicry explain variation in emotional and behavioural problem severity?

Another central aim of this thesis was to determine how ToM, empathy and facial mimicry relate to one another as well as to specific emotional and behavioural profiles. Therefore, in addition to investigating differences in ToM, empathy and facial mimicry performance between categorical groups, we assessed symptoms and constructs dimensionally via correlational and regression analyses. Investigating psychopathology dimensionally not only increases understanding of the processes underlying NDDs and explains variation in severity but can also better inform the development and implementation of novel treatment options (Brown & Barlow, 2005; Hudziak et al., 2007). Accordingly, dimensional ways of studying psychopathology are on the rise (Fairchild et al., 2009; Marsee et al., 2005; Passamonti et al., 2010).

Our analysis in Chapter 3 showed that elevated levels of cognitive ToM and reduced levels of affective empathy for negative emotions were associated with anxiety symptomatology and that they both, independently of one another explained anxiety severity. This is in line with previous research in samples of adolescents and adults that has found that both ToM and empathy are associated with anxiety severity (Gambin & Sharp,

2018; Tibi-Elhanany & Shamay-Tsoory, 2011) and theories that propose that they contribute to the development and maintenance of the disorder (e.g., Beck et al., 1985; Beck & Clark, 1997; Eysenck, 1992; Eysenck, 1997; Heinrichs & Hofmann, 2001; Tibi-Elhanany & Shamay-Tsoory, 2011). Similarly, our analyses in Chapter 5 showed that impaired facial mimicry for happiness, sadness and fear were all related to peer problems and that impaired facial mimicry for sadness and happiness explained peer problem severity independently of one another. A body of research has found that difficulties in recognising, understanding and interpreting the emotions of others is associated with problems in peer relations (Miller et al., 2005; Schultz, Izard, Ackerman, & Youngstrom, 2001; Snyder et al., 2003; Sterba, Prinstein, & Cox, 2007). The associations between impaired facial mimicry responses and severity of peer problems in the current study extends these findings, by demonstrating that facially responding to other people's emotions incongruently or inappropriately also negatively impacts on relations with peers. Interestingly, our analysis in Chapter 2 showed that SDQ Total score, reflective of a child's total number of difficulties and overall mental health and wellbeing (Beardsmore, 2015), did not predict ToM performance. Indeed, only age and verbal mental ability (VMA) significantly and independently predicted ToM. These findings suggest that reduced mentalising abilities in children with symptoms of NDDs may occur as an indirect effect of language ability. However, in the research presented in this thesis, ToM was assessed using conventional false belief measures, which have been criticised for their linguistic complexity (Lewis & Osborne, 1990). For example, Bloom and German (2000) argue that children fail the tasks not because they lack the conceptual competence, but rather because they have difficulties with the verbal-conversational aspects of the measures. Consequently, while intervention and prevention programmes focusing on young children's language acquisition may improve their performance on highly

verbally dependent ToM tasks, it may not result in better performance on other socio-cognitive measures. Future research should explore the relations between ToM, verbal ability and childhood emotional and behavioural problems using implicit measures of socio-cognitive processes that are not so heavily dependent on language, such as monitoring eye movement and anticipatory-looking during false-belief tasks (e.g., Burnside, Wright & Poulin-Dubois, 2017; Powell et al., 2018; Schneider et al., 2003; Schuwerk, Vuori & Sodian, 2014). In relation to these findings, it is also important to note that even though there was a significant difference in gender ratio between the two groups, with the NDD group having a higher proportion of males compared to the TD group, gender was not controlled for and the relations between gender, VMA and ToM were not explored. Therefore, it is possible that lower levels of cognitive ToM in the NDD group are an artefact of both gender (maleness) and VMA. Further research should aim to explore these associations.

Investigation of the relationships between facial mimicry and empathy in Chapter 4 revealed that facial mimicry for sadness was significantly correlated with both cognitive and affective empathy for sadness, and significantly predicted affective empathy indirectly via cognitive empathy. Similar relations could not be confirmed for happiness or fear. This suggests that while targeting impaired facial mimicry could result in improvements in recognising, understanding, and feeling others' sadness, it would not improve impairments in empathic responding for happiness and fear. Facial mimicry and empathy in this case appear to be related but distinct constructs. Further support for this finding comes from the results in Chapter 5. Previous studies have consistently demonstrated that children with both internalising and externalising problems display specific emotion-processing deficits for negative emotions (e.g., Blair & Coles, 2000; Blair et al., 2001 Fairchild et al., 2009; Frenkel & Bar-Haim, 2011; Garner, Baldwin, Bradley & Mogg, 2009; Hunnikin et al., 2019; Jarros et al.,

2012). If mimicry is associated with emotion processing, as proposed by numerous empathy models (Decety & Moriguchi, 2007; Marshall et al., 1995), then facial mimicry should only be impaired for negative emotions. However, the results of Chapter 5 indicate that impaired facial mimicry for both positive and negative emotions was associated with peer problem severity and that impaired mimicry for happiness and sadness independently of one another predicted poor peer relations. Taken together these findings suggest that while facial mimicry and empathy are related processes, they are distinct risk factors for NDDs.

ToM and empathy also appear to be distinct constructs, as evidenced by the findings in Chapter 3, in which cognitive ToM and affective empathy for negative emotions predicted anxiety symptomatology independently of one another. These findings are in line with Dvash and Shamay-Tsoory's (2014) neuroanatomical model of ToM and empathy, which suggests that cognitive ToM and affective empathy are separate constructs, based on their dependence on different neural systems. While cognitive ToM performance is associated with activation in the medial prefrontal cortex, superior temporal sulcus and the temporal poles, an affective empathic response is driven mainly by regions that mediate emotional experiences, such as the amygdala and the insula (e.g., Abu-Akel & Shamay-Tsoory, 2011; Dvash & Shamay-Tsoory 2014; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Harari, Aharon-Peretz, & Lev- kovitz, 2010; Shamay-Tsoory, Tibi-Elhanany, & Aharon-Peretz, 2007). However, this model also proposes that both affective and cognitive ToM form cognitive empathy, and thus ToM and cognitive empathy are conceptually interchangeable (Baron-Cohen & Wheelwright, 2004). This proposition is also based on neuroanatomical findings; when a cognitive empathic response is generated, the cognitive ToM network (medial prefrontal cortex, superior temporal sulcus, temporal poles) and the affective ToM network (ventromedial prefrontal cortex) are typically involved (e.g., Abu-Akel & Shamay-

Tsoory, 2011; Dvash & Shamay-Tsoory 2014; Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory, Harari, Aharon-Peretz, & Lev- kovitz, 2010; Shamay-Tsoory, Tibi-Elhanany, & Aharon-Peretz, 2007). In line with this model, enhanced cognitive ToM, as evidence in Chapter 3, would extend to an elevated performance in affective ToM and cognitive empathy. In contrast to this, while we found elevated ToM performance in children with high levels of anxiety, we found no differences between the groups in affective ToM or cognitive empathy. These findings suggest that the ability to recognise and understand the thoughts and beliefs of others is dependent from the ability to recognise and understand other people's feelings and emotions. All in all, these findings have important implications when formulating intervention and treatment strategies for children displaying emotional and behavioural problems. Specifically, cognitive ToM, affective empathy and facial mimicry are all independent risk factors for NDDs and need to be considered separately.

Another interesting finding was the contrast in results when utilizing categorical vs dimensional approaches in Chapter 5. While we found differences in facial mimicry for negative emotions between children with and without peer problems, our dimensional results indicated that impairments in facial mimicry for both positive and negative emotions were associated with severity of peer problems. Moreover, for the first time, we found that impaired facial responsiveness, particularly increased orbicularis activity during the observation of happiness and reduced frontalis activity during the observation of sadness, predicted peer problems. Discrepancies in results when using categorical vs dimensional approaches was also evidenced by our findings regarding ToM in chapters 2 and 3; differences in the ability to infer the psychological states of others' between those with and without anxiety symptomatology were not found when using a categorical approach, while elevated cognitive theorising was associated with anxiety when investigating the

relationship dimensionally. A dimensional approach to psychopathology avoids a substantial loss of valuable information (Brown & Barlow, 2005) and thus is more reliable and valid than categorical measures of psychopathology (Markon, Chmielewski & Miller, 2011). With this in mind, future research should continue to dimensionally investigate the relationship between psychopathology and socio-cognitive and emotional processes.

Our findings are consistent with previous research that suggests that impairments in ToM, empathy and facial mimicry play a role in the development and maintenance of NDDs. However, the specificity of ToM and empathy impairments that children with emotional and behavioural problems show is of note and has implications for the development of prevention and intervention programmes. This thesis found evidence of an impaired ability to infer the cognitive mental states of others in children with broad-ranging symptoms of NDDs (Chapter 2) and an enhanced ability to understand others' cognitive states in children with high levels of anxiety (Chapter 3). However, there was no difference between NDD and TD groups nor between high anxiety and low anxiety groups in their ability to understand others' affective mental states. We also found that HA participants exhibited impaired sharing of negative emotions, but there was no difference in their ability to vicariously share others' happiness and no difference in scores on cognitive empathy. Consequently, instead of targeting these constructs as a whole, future intervention and prevention programmes should be tailored to address these specific impairments.

6.3 Strengths, limitations and future directions

6.3.1 Strengths

The current thesis held a number of strengths over previous research. First, by recruiting a sample of young, pre-diagnostic children at risk of future psychopathology, the current thesis was able to identify early risk factors for the development of NDDs. As a result, it

extends and contributes to the literature by identifying that low levels of cognitive ToM, predicted by poor language ability, are present in young pre-diagnostic children with early emerging symptoms of NDDs; that elevated cognitive ToM and reduced affective empathy for negative emotions are risk factors for the development and maintenance of anxiety symptomatology; and that impaired facial mimicry responses for happiness and sadness explain peer problem severity. As well as being associated with the severity of emotional and behavioural problems, this thesis demonstrated that facial mimicry for sadness was positively related to cognitive and affective empathy for sadness. Early interventions can now target these processes early to ensure children obtain a more positive developmental trajectory.

The sample was also strong because it included children with a wide range of overlapping emotional and behavioural difficulties. Epidemiological research has consistently shown that the prevalence of co-occurring symptoms across externalising and internalising behavioural profiles is high, even amongst community samples (Achenbach, 1990; Angold, Costello, & Erkanli, 1999; Beyers & Loeber, 2003). Similarly, the prevalence of pure levels of internalising and externalising symptom trajectories from age 2 to age 12 is low (~2%) relative to children with levels of co-occurring symptoms (Fanti & Henrich, 2010). Consequently, our investigation of socio-cognitive and emotional functioning in a sample of children with a range of overlapping internalising and externalising symptoms is highly representative of children displaying emerging psychopathology.

Despite the previously noted criticisms of false belief measures, a meta-analysis by Wellman, Cross and Watson (2001) demonstrated that false belief tasks are a largely robust measure of ToM. Consequently, a further strength of the current research was its use of well-known, objective, and reliable procedures and experimental tasks to examine socio-

cognitive and emotional functioning in children with emotional and behavioural problems. In addition, this was the first study to utilize iMotions software to assess facial mimicry in a sample of pre-diagnostic children with early emerging signs of NDDs. The inclusion of this methodology allowed us to objectively assess children's facial mimicry responses in a way that is more reliable and less intrusive than facial EMG (Kulke, Feyerabend & Schacht, 2020). On a related note, this thesis also makes a potential significant contribution to the literature by providing first evidence in support of the feasibility of using Affectiva to reliably examine facial responsiveness in children aged 4-7 years and detect impairments in facial responsiveness that relate to children's social problems.

Another strength of this thesis is our collaboration with school practitioners to identify children with disordered behaviour who are at risk of developing future psychopathology. The amount of time children spend in schools makes this an important location for prevention efforts (Domitrovich, Durlak, Staley & Weissberg, 2017). Teachers are familiar with a broad range of children and have expertise regarding normative child development (Viding, Blair, Moffitt & Plomin, 2005). Moreover, children at risk of future psychopathology, particularly those at risk for disruptive behaviours, frequently come from families that operate off the radar from health and social services (Doran, 2018; van Zonneveld et al., 2017), highlighting the importance of outreach processes within schools to help these families and children.

Finally, a key strength of this thesis is the integrated categorical and dimensional approach employed throughout. Previous studies investigating ToM, empathy and facial mimicry in older children, adolescents and adults have employed a categorical approach. Consequently, replicating this approach allowed us to compare our findings, in a sample of young pre-diagnostic children, to those found in older samples with diagnosed

psychopathology. However, due to the heterogenous nature of childhood NDDs, categorical attempts to understand their development have been limited. Consequently, in line with the RDoC approach we also utilised a dimensional approach to study the processes and mechanisms underlying psychopathology. The dimensional approach in the current study has allowed for an understanding of the interrelations between ToM, empathy, facial mimicry and severity of emotional and behavioural problems, demonstrating that these risk factors all add to the explanation of emotional and behavioural problems. Understanding the mechanisms and processes underlying emotional and behavioural difficulties in childhood is essential for the development of effective intervention and treatment options.

6.3.2 Limitations and future research

The results of the thesis also need to be interpreted considering its limitations. Firstly, Chapters 3, 4 and 5 would have been strengthened by the inclusion of a typically developing control group. Although we were able to show specific cognitive ToM and affective empathy impairments for negative emotions in children with high levels of anxiety symptoms, and impaired facial mimicry responses in children with poor peer relations, it is unclear whether ToM, empathy and mimicry performance in children with low levels of anxiety or peer problems would have been similar to those of non-referred children. Indeed, although the low anxious and low peer problems children evidently had low levels of anxiety and peer problems respectively, it is possible they had other emotional and/or behavioural difficulties which could have influenced the findings. Similarly, in contrast to studies investigating the relationship in healthy and typically developing adolescents and adults (Sato et al., 2013; van der Graff et al., 2016), the results of Chapter 4 demonstrated that the relationship between mimicry and affective empathy is mediated by cognitive empathy. Consequently, it is possible that individuals with psychopathological symptoms exhibit a different

relationship between mimicry and empathy than those without psychopathology. Although children in the NDD group exhibited varying levels of emotional and behavioural problems, ranging from low to high risk, it is still possible that symptoms of psychopathology influenced the relations between mimicry and empathy. Consequently, the addition of a control group would have helped us to understand whether the mediating role of cognitive empathy is specific to those with early emerging symptoms of NDDs.

Going forward it would also be beneficial to use more sources of behavioural data. While the SDQ is a commonly used, valid measure of emotional and behavioural problems, it does have its limitations in the context of this thesis. For example, the emotional subscale is not limited to symptoms of anxiety, but rather assesses emotional problems generally. Consequently, it is possible that some of the children in the high anxiety groups in Chapters 2 and 3, were categorised due to low mood rather than elevated anxiety symptomatology. Relatedly, in Chapter 2, we used the reversed prosocial subscale as one of the criteria to categorise children as high or low in disruptive behaviours. The reversed prosocial subscale in this context was used as a measure of callous unemotional traits. While other studies have used this measure for the same purpose (e.g., Wells, Hunnikin, Ash & van Goozen, 2019), it is important to note that it is an indirect, rather than a direct measure of CU traits (Blair, Leibenluft & Pine, 2014; Kimonis et al., 2016). Consideration should be given to these measurement issues when using the labels ‘high anxiety’ and ‘highly disruptive’ to describe the children in this thesis. A similar caveat relates to the grouping of the NDAU children into the NDD group in Chapter 2. While these children were referred by their teachers for emotional and behavioural problems, which are indicative of future NDDs, none of the children in the NDD group had a diagnosis of an NDD.

It is also important to highlight that due to the continuation of data collection throughout the undertaking of this research, sample sizes for each chapter varied. Chapter 5 was the first to be written, hence the sample in this chapter is the smallest. Chapter 3 was the last to be written and therefore has a larger sample compared to the other chapters. Despite the varying sample sizes, there were no differences in age, gender or FSIQ between each of the samples in Chapters 3, 4 and 5 and the remainder of the NDAU sample (see Appendix B). These findings suggest that each sample is representative of the NDAU sample as a whole. In contrast, there were differences in the gender ratio between the sample in Chapter 2 and the remaining NDAU sample. However, we found no differences in ToM performance between males and females, and therefore it seems unlikely that differences in gender ratio are responsible for the difference between NDD and TD groups in ToM.

Similarly, full empathy, ToM and/or facial mimicry data were not available for each sample within each chapter. This was due to a combination of difficulties associated with collecting data from hard-to-test families and young children with symptoms of NDDs. For example, children demonstrating attentional difficulties do not have the concentration levels necessary to complete all tasks and some children from chaotic families failed to return for a second session. Consequently, in each chapter, a consistent group of the same participants could not be used at all stages of analyses. However, this is a common and unavoidable limitation when collecting vast amounts of data from such challenging populations (e.g., Airdrie, Langley, Thapar, & van Goozen, 2017).

Further, given the cross-sectional nature of the study, we are unable to comment on the causal relationship between the impairments and emotional and behavioural problems. For example, while we argue in line with RDoC, that socio-cognitive and emotional processing impairments may cause emotional and behavioural difficulties, it is also possible

that those with early emerging symptoms of NDDs reduce their social contact with others, which negatively impacts on their socio-cognitive and emotional skills. Follow-up studies of our sample are needed to examine how these processes, measured over time, predict changes in emotional and behavioural problems.

The final limitations relate to issues that were beyond the scope of this thesis. We found impaired facial mimicry in children with poor peer relations and found a significant association between facial mimicry and cognitive and affective empathy for sadness. However, we did not directly examine whether children with impaired facial mimicry for sadness also displayed impaired cognitive and affective empathy for sadness. Future research should aim to explore this relationship.

Additionally, one of the challenges for integrating the critical role of early development into RDoC perspectives is the lack of established early behavioural constructs that can be targeted for analyses and intervention. Consequently, the first aim was to identify behavioural constructs. I first selected measures of socio-cognitive and emotional functioning, namely ToM, empathy and facial mimicry, based on theoretical and empirical relevance to the development of both internalising and externalising problem behaviours, and their dependence on multiple RDoC domains. The second aim, using a data-driven approach, was to identify any gaps in the literature, with regard to how these constructs related to specific emotional and behavioural profiles in young children. Based on the review of evidence, I identified children with anxiety, disruptive behaviour and peer problems as subgroups of interest. It now remains for further research to continue to identify further socio-cognitive and emotional processes and explore how these relate to other emotional and behavioural profiles and symptoms of NDDs generally.

Finally, the identification of impairments in ToM, empathy and facial mimicry in this age group should encourage work exploring the presence and nature of socio-cognitive and emotional impairments in younger and older samples. Brain areas associated with the development of ToM, empathy and facial mimicry continue to develop throughout childhood, adolescence and often into adulthood (Casey et al., 1997; Gogtay et al., 2004; Sowell et al., 1999; Durston et al., 2006). For example, the prefrontal cortex (PFC), which is involved in both theorising and cognitive empathic abilities, undergoes considerable maturation during childhood and adolescence. This includes a reduction of synaptic and neuronal density, a growth of dendrites and both growth and then decline in grey matter volume (Musser & Raiker, 2019). Due to these substantial changes in neuroanatomy during this period, we should also expect the nature of these socio-cognitive and emotional impairments to continue to change and develop throughout childhood and adolescence. In addition to the independent development of the PFC, it also develops intensive interconnections with other brain regions during childhood and adolescence, such as the amygdala (Decety, Michalska & Kinzler 2012; Gabard-Durnam et al., 2014; Gabard-Durnam et al., 2016; Silvers et al., 2017; Swartz et al., 2014; Vink et al., 2014; Wu et al., 2016). Communication between the medial prefrontal cortex (mPFC) and the amygdala supports emotional learning and arousal and is consequently important for the development of facial mimicry and affective empathic responding. Studies examining the connectivity between the PFC and the amygdala have demonstrated that the communication between the two brain regions is qualitively different in childhood than in adulthood (Decety, Michalska & Kinzler 2012; Gabard-Durnam et al., 2014; Gabard-Durnam et al., 2016; Silvers et al., 2017; Swartz et al., 2014; Vink et al., 2014; Wu et al., 2016). More specifically, in adulthood, but not earlier, increases in mPFC activity are associated with a decrease in amygdala activity

in relation to emotional stimuli. This suggests early emergence of bottom-up amygdala signalling to the mPFC in children and later development of top-down inhibitory control of mPFC over amygdala in adults (Wu et al., 2016). Based on this it is plausible that the relations between ToM, empathy and facial mimicry may differ over time and development, and thus may provide an explanation as to why we found a different pattern of relationships between facial mimicry and empathy compared to those found in samples of adolescents and adults. In a similar vein, developmental research has revealed important interactions between genetic polymorphisms and adverse life events, and highlighted development as a moderator for these interactions. For example, heritability estimates for a number of emotional and behavioural symptom clusters (e.g., anxiety and depressive symptoms, and externalising behaviours) increase from adolescence into young adulthood (Bergen, Gardner, & Kendler, 2007), indicating moderation by developmental stage. Additionally, research has demonstrated the moderating effect of large-scale environmental factors in gene-environment interactions are particularly dominant among those from disadvantaged environments (Turkheimer, Haley, Waldron, D'Onofrio, & Gottesman, 2003). Studies such as these demonstrate that interactions between variables are complex and that risk factors do not confer the same risk for all people or in the same way for an individual across the lifespan (Cicchetti, 1993; Rutter & Sroufe, 2000). This suggests that a particular RDoC profile may be associated with different emotional and behavioural problems across people and time (Franklin, Jamieson, Glenn & Nock, 2015). Consequently, now that we have identified observable RDoC constructs, additional research is needed to assess how they relate to the development of psychopathology over time using a longitudinal design.

6.4 Implications and conclusions

Theorists have highlighted the importance of examining symptoms of NDDs in early childhood that precede and predict adverse developmental outcomes (Eisenberg, Spinrad, & Eggum, 2010; Gilliom & Shaw, 2004; Olson, Choe, & Sameroff, 2017). Identifying the mechanisms that influence the developmental trajectory of such early emerging symptoms is essential to further understand the etiological pathways to psychopathology (Gilliom & Shaw, 2004). Despite this, research investigating the processes and mechanisms that may contribute to psychopathology over time is still in its infancy (Franklin, Jamieson, Glenn, & Nock, 2015; Insel, 2014). Our study is among the first to integrate RDoC constructs into a developmental psychopathology framework.

The overall findings of this thesis identify ToM, empathy and facial mimicry as important processes that are implicated in the development of and explain the variation in severity of NDDs, supporting the transdiagnostic relevance of these constructs in research and assessment. Current findings also extend and contribute to the literature by identifying that ToM in young, pre-diagnostic children, is differentially affected across different emotional and behaviour profiles; while low levels of cognitive ToM categorise children with emotional and behavioural problems generally, high levels of cognitive ToM were specifically related to anxiety symptomatology. This highlights the importance of not only investigating elements of socio-cognitive and emotional functioning across disorders, but to also assess the constructs in relation to specific symptom clusters. What is now needed is a greater understanding of the role of ToM, empathy, and facial mimicry in relation to specific types of disordered behaviour. Finally, this thesis demonstrates that facial mimicry for sadness was positively related to children's ability to understand and experience other people's sadness, suggesting that impaired facial mimicry may be responsible for the

impaired empathic responding for negative emotions demonstrated by children with psychopathology, particularly disruptive disorders.

This thesis also highlights the importance of early detection and intervention as these children were exhibiting similar impairments to those that have been observed in older children with diagnosed psychopathology. Disordered behaviour in childhood causes immediate difficulty for parents, teachers, the society and the children themselves and also poses a risk for children in later life (Campbell, 1995; Moffitt, 1993; Moffitt, Caspi, Dickson, Silva, & Stanton, 1996). Externalising and internalising behaviour profiles have been linked to poor social functioning, poor academic achievement, future psychopathology, substance abuse, criminality and physical violence (Caspi et al., 1997; Miner & Clarke-Stewart, 2008; Moffit, 2003; Moffitt & Scott, 2008; Petitclerc & Tremblay, 2009; Petitclerc et al., 2009; Rutter & Giller, 1983; Shaw, Gilliom, Ingoldsby & Nagin, 2003). Despite this, traditional mental health services only focus on treatment services for children and young people at the highest level of risk (Dowdy et al., 2010). Moreover, intervention efforts typically focus on targeting symptoms associated with a diagnostic group rather than targeting a specific phenotype (Cuthburt & Insel, 2013). Consequently, when children finally receive support, it is often not appropriately targeted towards their individual needs. The combination of these approaches results in the utilization of generic interventions aiming to target symptomatology long after it has intensified and become deeply entrenched, thus, becoming more resistant to intervention efforts (Dvorsky et al., 2014). The findings of this thesis contradict these traditional approaches to intervention; the transdiagnostic relevance of socio-cognitive and emotional impairments in young pre-diagnostic children highlights that by taking an RDoC approach, mechanisms and processes underlying developmental psychopathology can be identified and targeted early to prevent an aberrant developmental

trajectory. Interventions tailored to the causal processes that influence the development, persistence and severity of NDDs will allow a better chance of achieving beneficial and longer-term outcome for the children (Hunnikin et al., 2019). More specifically, our findings suggest that interventions targeting children's socio-cognitive and emotional functioning, particularly children's ToM, empathy and facial mimicry, should be considered as a preventative effort to reduce risk for both internalising and externalising problems before the onset of clinical symptoms and significant maladjustment.

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Appendix

Appendix A: Relationships between mimicry, cognitive empathy and affective empathy

Relationship between mimicry, cognitive empathy and affective empathy for happiness

	Mimicry						Empathy		
	1. ZM	2. OO	3. R	4. CS	5. EW	6. F	7. DAO	8. Cognitive	9. Affective
1	-								
2	.131	-							
3	.441**	.047	-						
4	-.109	-.106	-.135	-					
5	.188	-.154	-.003	-.118	-				
6	.022	.194*	.150	-.069	-.017	-			
7	-.066	-.089	.048	-.026	.039	.139	-		
8	.036	.125	.088	-.090	-.041	.072	-.093	-	
9	.036	.169	.115	-.089	.059	-.003	-.036	.404**	-

Notes: Values represent Pearson's rho. * = correlation is significant at the 0.05 level, ** = correlations is significant at the 0.01 level. ZM, zygomaticus major; OO; orbicularis oculi; R, Risorius; CS, corrugator supercilii; EW, eye widen; F, frontalis; D, depressor anguli oris.

Relationship between mimicry, cognitive empathy and affective empathy for sadness

	Mimicry						Empathy		
	1. ZM	2. OO	3. R	4. CS	5. EW	6. F	7. DAO	8. Cognitive	9. Affective
1	-								
2	.403**	-							
3	.277**	.167	-						
4	-.105	-.040	-.062	-					
5	.124	-.040	.059	-.070	-				
6	-.032	.040	-.086	-.086	.171	-			
7	.048	.172	-.050	-.090	.270**	.250**	-		
8	-.073	-.073	-.155	.343**	.035	.000	.065	-	
9	-.076	.041	-.126	.215*	.015	.076	.105	.636**	-

Notes: Values represent Pearson's rho. * = correlation is significant at the 0.05 level, ** = correlations is significant at the 0.01 level. ZM, zygomaticus major; OO; orbicularis oculi; R, Risorius; CS, corrugator supercilii; EW, eye widen; F, frontalis; D, depressor anguli oris.

Relationship between mimicry, cognitive empathy and affective empathy for fear

	Mimicry						Empathy		
	1. ZM	2. OO	3. R	4. CS	5. EW	6. F	7. DAO	8. Cognitive	9. Affective
1	-								
2	.143	-							
3	.599**	.076	-						
4	-.134	.053	-.118	-					
5	.063	-.050	.001	-.197*	-				
6	.171	.323**	.000	-.058	.191*	-			
7	-.021	-.082	.139	-.090	.105	.061	-		
8	.033	-.180	.167	-.096	.125	.041	.008	-	
9	.052	-.040	.135	.028	.027	.094	-.031	.667**	-

Notes: Values represent Pearson's rho. * = correlation is significant at the 0.05 level, ** = correlation is significant at the 0.01 level. ZM, zygomaticus major; OO; orbicularis oculi; R, Risorius; CS, corrugator supercilii; EW, eye widen; F, frontalis; D, depressor anguli oris.

Appendix B: Demographic characteristics of samples in Chapters 2, 3, 4 and 5 compared to the remaining NDAU sample

Demographic characteristics of sample in Chapter 2 compared to remaining NDAU sample

	Chapter 2 (n = 87)		NDAU (n = 151)		Chapter 2 vs NDAU	
	Mean	SD	Mean	SD	Statistic	p
Age	72.89	12.57	75.95	13.48	t(236) = -1.792	.085
IQ	48.95	25.46	45.70	25.73	t(223) = .913	.362
Gender (female)	24.14%		38.26%		X^2 (1) = 4.947	.026

Demographic characteristics of sample in Chapter 3 compared to remaining NDAU sample

	Chapter 3 (n = 174)		NDAU (n = 64)		Chapter 3 vs NDAU	
	Mean	SD	Mean	SD	Statistic	p
Age	75.24	12.91	74.47	14.43	t(236) = .397	.692
IQ	47.33	25.54	45.45	26.09	t(223) = .471	.638
Gender (female)	33.33%		30.65%		X^2 (1) = .150	.698

Demographic characteristics of sample in Chapter 4 compared to remaining NDAU sample

	Chapter 4 (n = 144)		NDAU (n = 94)		Chapter 4 vs NDAU	
	Mean	SD	Mean	SD	Statistic	p
Age	74.85	12.57	75.40	14.67	t(236) = -.309	.758
IQ	48.70	25.97	43.80	24.90	t(223) = 1.391	.165
Gender (female)	31.94%		34.78%		X^2 (1) = .204	.651

Demographic characteristics of sample in Chapter 5 compared to remaining NDAU sample

	Chapter 5 (n = 91)		NDAU (n = 147)		Chapter 5 vs NDAU	
	Mean	SD	Mean	SD	Statistic	p
Age	74.24	12.53	75.65	13.86	t(236) = -.788	.432
IQ	50.30	26.67	44.63	24.76	t(223) = .1.631	.104
Gender (female)	26.37%		37.24%		X^2 (1) = 2.984	.084