Understanding, expressing, and interacting: the development of emotional functioning in young children with autism

Li, B.

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Promotore

Prof. dr. C. J. Rieffe

Co-promotores

Dr. K. Greaves-Lord

Dr. E. M. A. Blijd-Hoogewys

Leden promotiecommissie

Prof. dr. W. G. Staal

Prof. dr. R. R. J. M. Vermeiren

Dr. Li Yi (Peking University)

Dr. A. C. Miers

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CHAPTER 1.

General introduction

Before the COVID-19 pandemic and the implementation of restrictions on social contact, every day a person could have contact with about 10 to 25 people (Del Valle et al., 2007). Some contacts include only a simple greeting, whereas others involve meaningful and complex exchanges of emotions, thoughts, and perspectives. Navigating smoothly in the social world can be testing for any child. However, this is particularly challenging for children who have autism. Autism, traditionally known as autism spectrum disorder (ASD), is a life-long condition characterized by difficulties in social communication and social interaction, and by restricted and repetitive behaviors (see Box 1 for information on the diagnosis and prevalence). It affects how people experience and relate to the world around them. They see, feel and understand the world differently to people without autism. The everyday encounter of people, interactions and events which makes good sense to people without autism do not always make sense to people with autism. To get around in social interactions, every child needs to learn from a young age how to orient promptly, interpret accurately and respond appropriately to social cues. For young children, such development takes place often times through unplanned and unintended learning, by observing and overhearing how adults and people around deal with a social situation (Calderon et al., 2003). Autistic children miss out on many opportunities for such incidental learning, as they may not notice the nuances of communication such as the tone of voice and body languages or they may be absorbed by their own special interests and not attend to a social situation voluntarily (Attwood, 2015; Dawson et al., 2004; Klin et al., 2007; Loukusa et al., 2007). As stated above, social communication and social interaction fall in one of the most difficult areas for children on the spectrum (American Psychiatric Association, 2013). Some autistic children may not have a strong interest in connecting with others and prefer to spend time alone with their own imaginations and thoughts. Not participating in social interactions fits the needs of these children and their choices should be accepted and respected. However, still, many other autistic children do have the desire to interact with others, to make friends, and to lead a meaningful and fulfilling social life (Lawson, 2006; Jones & Meldal, 2001), whereas interacting with others can be incredibly difficult for these children, causing them tremendous stress, anxiety and negatively affecting their mental health (Corbett et al., 2010; Shroeder et al., 2014).

BOX 1. THE DIAGNOSIS AND PREVALENCE

DSM-5 ASD Diagnostic Criteria

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history (examples are illustrative, not exhaustive):

1. **Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.**
2. **Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.**
3. **Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.**

B. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive):

1. **Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).**
2. **Insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat food every day).**
3. **Highly restricted, fixated interests that are abnormal in intensity or focus (e.g, strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interest).**

BOX 1 continued

4. **Hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).**

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities or may be masked by learned strategies in later life).

D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual disability (intellectual developmental disorder) or global developmental delay. Intellectual disability and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual disability, social communication should be below that expected for general developmental level.

<u>The estimated prevalence rates of autism</u>

According to the World Health Organization, one in 160 children has a diagnosis of autism. However, the prevalence rates vary by country. For example, the estimation in the U.S. in 2016 is that 18.5 per 1000 children aged 8 years have a diagnosis of autism (Maenner et al., 2020), in the U.K. the prevalence estimate is 10 per 1000 children (The British Medical Association, 2020), in Canada 15.2 per 1000 children (Schendel & Thorsteinsson, 2018), and in Denmark 12 per 1000 children (Imm et al., 2019). In the Netherlands, where the sample of children examined in this study came from, 28 per 1000 children were reported by their parents to have autism, according to Statistics Netherlands (Centraal Bureau voor de Statistiek, 2011). An explanation for the seemingly high prevalence rates in the Netherlands is that Statistics Netherlands did not explicitly ask parents for an official diagnosis. Therefore, the estimation may have included children who did not have an official diagnosis but the diagnosis was suspected by their parents. In a follow-up survey, Statistics Netherlands found that 70% of the 2.8% children were receiving treatment related to the diagnosis of autism. This results

BOX 1 continued

in a rate of 19 per 1000, which is in accordance with the current international prevalence rates of autism (Geurt et al., 2014).

Noteworthy, the prevalence rates have been increasing rapidly over the past 30 years worldwide. The prevalence rate of 2016 (18.5 per 1000) is about 10% higher than the prevalence estimation in 2014 (16.8 per 1000) and about 175% higher than the estimate in 2000 (Maenner et al., 2020). This increase is partly due to an increased awareness of autism in the general population, changes to the diagnostic criteria, early detection, and diagnosis of autism in children at a much younger age (Elsabbagh et al., 2012; Kim et al., 2011; Saemundsen et al., 2013).

Traditionally, autistic people are held responsible for the difficulties they encounter in social situations. However, successful interaction requires efforts from both interacting parties. As accurately pointed out by "the double empathy problem" (Milton, 2012), when it comes to understand and communicate with autistic people, non-autistic people are not doing any better. Instead of putting all the responsibilities on autistic people for the predicament, finding a suitable way to interact with them, preventing social exclusion and reducing the negative impacts on their mental health is an ineluctable responsibility of everyone living in the society. To achieve this, an important pathway is to increase the awareness of autism. This thesis is motivated by such a goal, endeavoring to make a positive step towards strengthening our understanding of the unique challenges that autistic children face at a young age in the social and emotional domain. Knowledge in this regard of young children can be especially important, helping parents as well as everyone around finding the right way to communicate with autistic children and to support them to achieve their full potential.

In particular, this thesis puts autistic children's emotional functioning under a magnifying glass. Emotion plays a key role in guiding and facilitating social interactions. From the functionalistic perspective (see Box 2), emotion is inherently informative and communicative. Towards the self, experiencing an emotion signals to us that something that matters is at stake (Frijda, 1986). It makes us focused, motivated, and prepared to initiate an action as a response to the situational change, either to give a hug or to swing a punch (Scherer, 2000). Towards others, expressing an emotion conveys to people what we want to achieve (Horstmann, 2003). A happy face signals to others that we like the situation and welcome further interaction, whereas an angry face warns others to back off and signals that

we want to reinstate our goal and status. Because of the powerful message that an emotional expression can convey, children need to learn from a young age how to keep their emotional arousal at an optimal level and to express their emotions in an appropriate way, so that they can achieve instead of sabotaging their goal (Rieffe, 2014). In the same vein, it is important for children to learn to read the emotional cues expressed by others. Only when a child knows what emotion another person expresses and understands why the person feels that way, can the child respond to that person appropriately and adaptively (Elfenbein et al., 2007).

Given the essential role of emotion in facilitating social interaction and establishing social relationships, it is not surprising that the abilities to express and to understand emotions start from infancy. The expressions of the basic emotions such as happiness, anger, fear and sadness are observed in infants from the first year of life. For example, by the third month of life, infants start to exhibit social smiles, i.e., expressions of happiness directed towards people, which strengthens the bonding between the infant and the caregiver (Wörmann et al., 2012). Typically developing children's ability to understand facial emotion expressions also grow rapidly during infancy. Infants that are a few months old show awareness that a happy face looks different from a surprised face (Grossmann, 2010). By the end of the first year, children can use adults' facial emotional expressions to guide their behaviors. A 12-month-old child would approach a novel person or object when the mother shows happiness, whereas the child would hesitate to move and stay closer with the mother when the mother shows fear (Carver & Vaccaro, 2007). Children's knowledge of emotion is further strengthened by associating verbal labels to emotional expressions. Being able to use emotion vocabulary to communicate about emotions with adults opens a new learning channel for emotion socialization (Streubel et al., 2020).

While the basic emotions are present from the beginning of life, it is not until the end of the second year of life that moral emotions such as shame, guilt, and pride start to emerge. Moral emotions are more complex than basic emotions in that they are provoked when children evaluate themselves (Tracy & Robins, 2004). To experience moral emotions, children need to have advanced cognitive abilities including an awareness of the self (Lewis, 2000), as well as understandings of other people's thoughts and the prevailing social norms. This is because the self-evaluation is most often built upon the extent to which one thinks his or her behavior meets the expectations of others and of the society (Leary, 2004). The unique feature of moral emotions defines their unique role in regulating and shaping people's behaviors in accordance to the moral standards. Children who are prone to feeling guilty exhibit fewer aggressive behaviors (e.g., Colasante et al., 2016), whereas children who

display little embarrassment when misbehaving have a higher tendency to behave in antisocial ways (e.g., Keltner et al., 1995). Furthermore, as mentioned before, emotion has a communicative function. Moral emotions are no exception. Imagine a child who damages his/her friend's toy but does not show a hint of shame or guilt. How would this lack of emotional expression make his/her friend feel? When a social relationship is threatened by a misbehavior, the expression of shame or guilt illustrates to the other that one is aware of his transgression and regrets it, which can help restore the relationship (Leach, 2017).

Another complex and advanced emotional capacity that emerges and develops substantially in early childhood is empathy. To experience empathy, children need to mobilize and coordinate a group of emotional abilities. The ability to co-experience and feel for others' emotions is present early in life and prompts a baby to cry when hearing other babies cry (Dondi et al., 1999). At this stage, children can become overwhelmed by the emotional display of another due to a lack of self-other distinction (Hoffman, 2000). As they grow older, children become more able to distinguish the distress of others from their own. Through regulating the emotional arousals in themselves and attending to the emotions of others as separate, children's understanding of others' emotions grows with age, so does their prosocial motivation to comfort and help others (Lockwood et al., 2014). Empathy is a highly valued human capacity. For the self, it motivates prosocial actions and pushes one to dive in and help others in need (Morelli et al., 2014). Towards others, to empathize with another person makes that person feel heard and understood. This in turn nurtures and strengthens social relationships with other people (Anderson, 2018).

As discussed so far, emotion permeates into every aspect of our social lives. It is therefore not surprising that disturbances in the above-mentioned emotional processes not only lead to the breakdown of social interactions, but can also contribute to social and personal maladjustments (Keltner & Kring, 1998). What does this mean for people with autism? A plethora of research has investigated emotional functioning of autistic people (e.g., Harms et al., 2010, Lartseva et al., 2015; Nuske et al., 2013), revealing a very different profile of them to that of non-autistic people. These studies contributed greatly to our understanding of the difficulties and challenges that autistic individuals face in the emotional domain. Nonetheless, some important issues need further clarification and elaboration. First, relatively little is known about the emergence and development of emotional functioning in autistic children at the early life stage. Informing parents, educators and clinical professionals of the challenges that autistic children face at a young age is essential for parents and professionals

BOX 2. THE FUNCTIONALISTIC PERSPECTIVE OF EMOTION

From the functionalistic perspective, emotion is viewed as an attempt by an individual to adjust the relation between oneself and the environment (Campos et al., 1994; Saarni et al., 2006). Different from the discrete emotion theory, which asserts that emotions are innate and each emotion is associated with a fixed and distinguished set of facial expressions and neurophysiological reactions (Ekman & Cordaro, 2011; Izard et al., 2010), the functionalistic approach emphasizes that emotions are flexible, contextually bound and goal driven. Within this framework, every emotional episode is provoked by a specific event which is of importance to the person (Frijda, 1986). An emotion arises when the situation that matters to the person has changed. A desired change of the situation evokes positive emotion, whereas an unwanted change of the situation evokes negative emotion (Rieffe, 2014). Experiencing an emotion alerts the person of the change, and motivates the person to take an action to deal with the change (Moors et al., 2013). Therefore, emotions and emotion expressions are goal driven: when a person's goal is hampered and the person wants to reinstate his or her goal and status, anger is experienced and expressed; when a person is satisfied with the situation and wants the situation to continue, happiness is experienced and expressed.

to adjust their strategies promptly and to help autistic children in the most efficient way. Second, emotional research on autistic people tends to focus on their abilities to recognize and understand emotions in others, whereas relatively fewer studies examined their own emotional expressions and emotional reactions (Mazefsky et al., 2012). Applying a broader approach to studying both aspects of emotional functioning in autistic children allows us to gain a more complete profile of their socioemotional functioning. Third, despite the important social function of moral emotions, compared to basic emotions, the experience and expression of moral emotions in autistic children is understudied. However, it can be a great challenge for autistic children to develop moral emotions, because one prerequisite for experiencing moral emotions is to be aware of and have a good understanding of others' thoughts and perspectives. Yet, struggles in Theory of Mind are a hallmark of autism (Baron-Cohen, 2000). Fourth, to date most research on the emotional functioning of autistic children used a cross-sectional design. Cross-sectional studies are informative in helping identify the differences between autistic and non-autistic children at the moment of assessment. However, they cannot tell us how these alterations change over time. Do the differences disappear with age or do

they enlarge? What are the factors that promote or hinder the development of emotional functioning in autistic children? Such questions can only be answered by longitudinal studies. They have the unique potential to improve our understanding of the dynamic processes of child development and can contribute to understanding the drivers and determinants of the developmental outcomes.

The central aim of this thesis is to contribute to a comprehensive understanding of the early development of emotional functioning in preschool children with autism. To achieve this, a multidimensional approach is applied. Four studies are conducted to examine a group of key emotional abilities in preschool autistic children from both (1) the horizontal dimension: investigating the interpersonal differences by comparing autistic children to non-autistic peers, and (2) the vertical dimension: investigating the intrapersonal variations by following children's development over a period of two to three years.

First, a group of essential and diverse emotional abilities are selected for the investigation, ranging from basic emotions to more advanced moral emotions and empathy, and ranging from emotion recognition and emotion understanding to emotion expression and emotion vocabulary. Second, a longitudinal approach is applied to observe changes and continuities of various emotional abilities in autistic children over a period of two to three years, in comparison to the development of non-autistic children without autism. Furthermore, having emotional functioning as the focus of the research, this thesis also explores what factors contribute to the development of emotional functioning, and what impact the development of emotional functioning has on children's psychosocial wellbeing.

This thesis is arranged in the following way: it starts with examining the recognition of four basic emotions, i.e., happiness, anger, fear, and sadness. **Chapter 2** explores how the recognition of basic emotions develops in autistic and non-autistic children, and how the development is associated with the change of symptom severity in autistic children. Next, the focus is shifted to a group of more complex emotions, i.e., shame, guilt and pride. **Chapter 3** examines the experience and expression of moral emotions in autistic and non-autistic children, and the contributing role of Theory of Mind to the development of moral emotions. **Chapter 4** examines another complex emotional ability, i.e., empathy, which emerges from the interaction of multiple emotional and cognitive processes. The development of empathy is compared between autistic and non-autistic children. Besides, it is explored whether empathy contributes to the development of externalizing problems and social competence in autistic and non-autistic children. **Chapter 5** focuses on the impacts of emotional functioning on the development of psychopathology in children with and without autism. In doing so, first, the

development of internalizing and externalizing problems is compared between children with and without autism. Next, the longitudinal associations between emotion recognition, emotion expression, emotion vocabulary and behavioral problems are examined. The last chapter, Chapter 6, summarizes and integrates the findings of the above-mentioned research, and discusses the implications for the direction of future research.

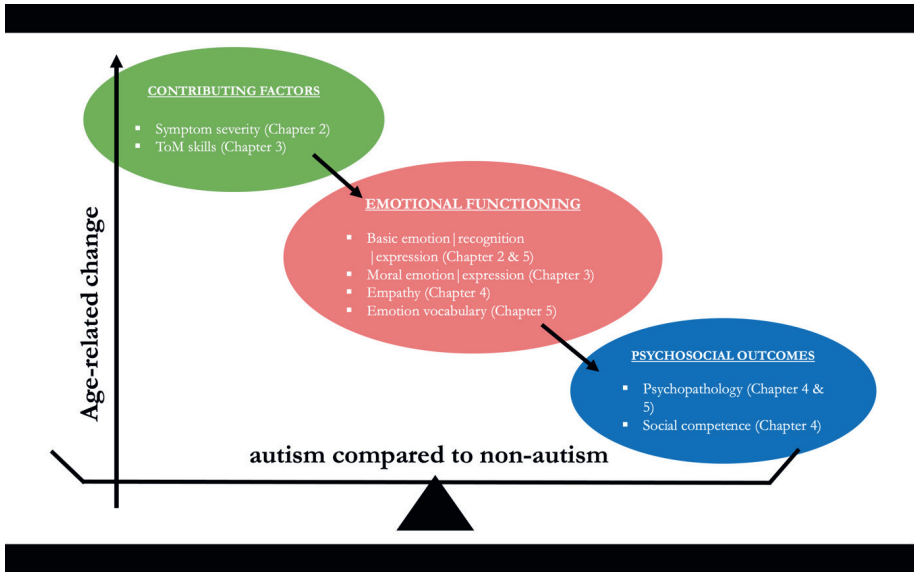

Figure 1. Graphic presentation of the multidimensional approach adopted by this thesis. The red panel displays the core variables examined in this thesis, i.e., the emotional abilities. The green panel and the blue panel display the variables, of which the associations with emotional abilities are examined in this thesis. The horizonal dimension compares between autistic and non-autistic children. The vertical dimension examines the age-related changes of emotional functioning in children.

It should be mentioned that, first, in this thesis, both person-first and identity-first language are used. In Chapter 1 and 6 both languages are used; in Chapter 3, 5, and 7 person-first language is used; in Chapter 2 and 4 identity-first language is used. Both types of language endeavor to remove the stigma of autism but through two different pathways. See Box 3 for the justifications of using both languages. Second, this thesis focuses on the emotional domain, which presents many challenges for people with autism. However, any challenges discovered by this thesis should not be used to label them. Like non-autistic

children, every autistic child is a unique human being with his or her own strengths and difficulties.

BOX 3. PERSON-FIRST LANGUAGE AND IDENTITY-FIRST LANGUAGE

What is the most appropriate way to address people with a diagnosis of autism, using person-first language (i.e., individuals with autism) or using identity-first language (i.e., autistic individuals)? In recent years, there is an increasing discussion on this topic.

Person-first language which places the person before the disability advocates that a person with disability is first and foremost 'a person' and thus deserves all the human rights, opportunities and due respects as assigned to any other human being (Vivanti, 2020). Person-first language emphasizes the value, autonomy and uniqueness of the person, of which the disability is only one feature and by no means the defining feature (Wright, 1983). Person-first language was originally proposed in the context of the broader disability rights movement (Kenny et al., 2016). Proponents of the movement argued that the traditional view of considering disability as a medical condition which needs to be cured or even prevented perpetuates a negative image of people with disabilities (Williams, 1996). Person-first language was proposed to facilitate more positive descriptions, and create more positive identities of people with disability (Bailey, 1991; Blaska, 1993). A survey in the Netherlands involving about 500 adults diagnosed with autism showed that the majority preferred the person-first language (Wevers, 2020).

However, not all members of the autistic communities support the use of person-first language (Gernsbacher, 2017; Sinclair, 1999). As shown by a recent survey in UK, a large percentage of autistic adults, family members, friends, and parents endorse the term "autistic" instead of "with autism" (Kenny et al., 2016). There are two major arguments against using person-first language and supporting using identity-first language (Kenny et al., 2016; Vivanti, 2020). First, using person-first language could belittle the experience of living with autism, downplay the inseparable relation between the person and the diagnosis, and deny the possibility that a person can have pride in his or her identification. Second, person-first language contradicts the common principle that positive and desirable features should precede the nouns. For example, we say "intelligent people" instead of "people with intelligence", "smart children" instead of "children who are smart". In this sense, person-first language is not only cumbersome but also paints the image with a negative tint. These arguments are consistent with the

BOX3 continued

perspective that autism is an expression of neurodiversity rather than pathology, and that the autism culture should be recognized, valued, and celebrated (Altman, 2001; Robertson & Ne'eman, 2008).

Person-first language and identity-first language, both endeavoring to remove the stigma of autism and disability in general, represent two different pathways. The former emphasizes the value of the person above and beyond the disability, and the latter posits that the disability itself can be the reason for pride and celebration (Vivanti, 2020). Which language to choose requires careful weighing of the situation and respecting the preferences of the individual and the group that are being described. This thesis used both languages, following the recommendation proposed by Dunn and Andrews (2015, page 262):

"Although a definitive mandate for writing and speaking about disability might be desirable, we suggest that flexibility is an appropriate, respectful response. Sufficient research focused on the preferences of disabled people for terminology and language use has not been conducted. We hope that the issue raised in this article will spur interest so that the needed research will be done. Until then, we believe that psychologists should broaden their cultural competence by using both person-first and identity-first language when working on disability issues or interacting with people with disabilities."

Below the content of each chapter is discussed in greater detail:

Emotion recognition is the very first step for initiating successful social interaction. According to the functionalistic view of emotion, emotion has an important communicative function. When a person expresses an emotion, it signals to the interactive partner what he or she wants to achieve (Horstmann, 2003). Imagine an autistic child who does not attend to or is confused about the emotion expression of his or her peer. This will hinder the child from responding 'properly' to the emotional signal sent by the other. Over time, difficulties in emotion recognition can obstruct the autistic child from establishing and maintaining positive social relationships (Dede et al., 2021).

In typical development, emotion recognition begins with discriminating emotions. Children first learn to differentiate between different facial expressions (*Emotion*

Differentiation) (Heck et al., 2018). Together with growing cognitive ability, especially language ability, children learn to assign verbal labels to emotion expressions (*Emotion Identification*). Labeling emotions is an important ability which enables children to categorize emotions and to acquire the scripted knowledge of emotions, which includes not only facial expressions, but also bodily reactions, conscious feelings, action tendencies, and importantly, the eliciting events associated with the emotion (Widen & Russell, 2008). Understanding that every emotion is associated with an emotion-provoking situation and being able to predict another's emotion based on situational cues marks further progress towards matured emotion recognition (*Emotion Attribution*). While toddlers and preschoolers rely primarily on facial expressions, school-aged children reply more often on situational cues for processing emotional information (Herba & Phillips, 2004).

So far, a plethora of research has investigated emotion recognition in autistic individuals across a range of contexts and age groups. Although the findings are not always consistent due to the heterogeneity of participant characteristics and task demands (for a review, see Harms et al., 2010), overall, emotion recognition is found to be more challenging for autistic individuals when the emotions are of a negative valence such as fear and disgust (e.g., Ashwin et al., 2006; Balconi et al., 2012; Humphreys et al., 2007; Wright et al., 2008), has a more complex nature such as shame and guilt (e.g., Heerey et al., 2003; Kotroni et al., 2019), is presented with a lower intensity (e.g., Greimel et al., 2014; Law Smith et al., 2010) and for a shorter duration (e.g., Clark et al., 2008). Furthermore, difficulties in recognizing emotions of other people are present at young ages in autistic children. There is evidence that emotion differentiation, emotion identification, and emotion attribution do not develop in autistic children to the same extent as in non-autistic peers (e.g., Evers et al., 2015; Tardif et al., 2007; Xavier et al., 2015). In contrast to the abundance of research on the intergroup differences in emotion recognition, to the best of our knowledge, there is only one longitudinal study, which followed the development of emotion recognition in autistic adolescents, showing that their emotion recognition improved over a period of 18 weeks (Rosen & Lerner, 2016). On the other hand, a recent meta-analysis which amalgamated 43 cross-sectional studies of different age groups, revealed that the discrepancies between autistic and non-autistic individuals in emotion recognition did not narrow down but rather expanded with age (Lozier et al., 2014). This emphasizes the importance of understanding the developmental course of emotion recognition in autistic individuals at different life stages. This gap of knowledge has motivated the first study in this thesis.

STUDY 1 (Chapter 2) aims to examine the levels and follow the development of three emotion recognition abilities (i.e., emotion differentiation, emotion identification, and emotion attribution) in regard to four basic emotions (i.e., happiness, anger, sadness and fear) in preschool autistic children, as compared to non-autistic peers. Besides, the longitudinal association between symptom severity and emotion recognition is explored in autistic children.

Moral emotions are distinguished from basic emotions and refer to a group of emotions with a more complex nature which emerge later in childhood than basic emotions. A key feature that distinguishes moral emotions such as guilt, shame, and pride from basic emotions such as fear, anger, and happiness is that the former involve self-evaluation (Tracy & Robins, 2004). A child who breaks his mother's favorite vase will feel scared if he is concerned about the punishment. However, the child will feel ashamed or guilty if he ascribes the negative outcome to his personal attributes (e.g., 'I am clumsy') or action (e.g., 'I did a bad thing'). Implementing self-evaluation is a complex cognitive process, which requires advanced cognitive abilities such as Theory of Mind. Theory of Mind is considered to play a key role in the evaluative process that provokes moral emotions (Harris, 2008; Lagattuta & Thompson, 2007; Lewis, 2000). As noted by Leary (2004), the self-evaluation that elicits moral emotions is not simply how people evaluate themselves, but often how they establish a self-evaluation based on others' view of them. If one thinks that others hold a positive view of himself, the person may feel proud; if one thinks that others have a negative view of himself, the person usually feels guilty or ashamed (Muris & Meesters, 2014).

Given that the experience of moral emotions relies on the extent to which a child is able to evaluate himself or herself based on his or her understanding of others' thoughts and emotions, the question arises: would autism affect children's experience and development of moral emotions, considering that autism has long been associated with difficulties in Theory of Mind and emotion understanding? To date only a small body of literature has examined moral emotions in children and adolescents with autism, and even fewer have looked into the relation between Theory of Mind and moral emotions. Overall, compared to children without autism, studies reported children and adolescents with autism to score lower in tasks measuring the recognition of moral emotions. Autistic children also scored lower in questionnaires which asked them to rate their own experience of moral emotions (e.g., Davidson et al., 2018; Hobson et al., 2006; Losh & Capps, 2006). Besides, Theory of Mind abilities seem to indeed relate to the experience and recognition of moral emotions in autistic children (Davidson et al., 2018; Heerey et al., 2003). Albeit informative, the extant studies

examined school-aged children and adolescents using a cross-sectional design, and thus it remains unanswered whether the differences are already present at a young age. Nor do we know how moral emotions develop in early childhood in children with autism. This gap of knowledge has motivated the second study in this thesis.

STUDY 2 (Chapter 3) aims to examine the levels and developments of moral emotions and the contributing role of Theory of Mind to the moral emotion developments in preschool children with autism, as compared to typically developing peers.

Empathy refers to the ability to perceive and understand others' emotions, and to react adaptively to others' needs, e.g., to comfort, support or spare the other person (Ketelaar et al., 2013). From a developmental perspective, empathy can be divided into several layers (Netten et al., 2015). *Affective empathy* is the process where the emotions of another person cause arousal in the observer. This is already observed in infants, e.g., when one baby cries, other babies start crying as well. These early automatic responses upon witnessing others' distress indicate that the predisposition to experiencing empathy is hardwired in the human brain (Decety & Meyer, 2008). *Cognitive empathy* occurs at an older age than affective empathy, which involves a more sophisticated conscious comprehension of others' emotional state and is acquired through social learning (Decety et al., 2018). Note that a precursor of cognitive empathy is to pay attention to the other person and understand that it is the other person who is experiencing the distress. *Attention to others* not only facilitates better understanding of others' emotions, but also helps alleviate the stress felt in oneself (Rieffe et al., 2010). With age children show a growing attention to the affected other and an improved cognitive empathy. Children start to understand not only what the other feels but also why the other feels so. This prepares the child to react appropriately to the other's emotions, and triggers prosocial action (Eisenberg et al., 2010). *Prosocial action*, namely, taking the action to support and help others is crucial for maintaining good social relationships.

While empathy seems to develop naturally and without much effort in most typically developing children, it can be challenging for autistic children. First, empathy development in autistic children can be hindered by their diminished social attention. Reduced attention to social stimuli such as people, faces, and body movements is observed in autistic individuals at different stages in life (Chita-Tegmark, 2016). Some researchers ascribed this to a diminished social motivation, positing that social interactions are less rewarding for autistic individuals, and therefore they orient less often and less spontaneously towards other people (Chevallier et al., 2012). However, other researchers posit that many autistic people are also longing for friendship and love, and yet due to difficulties in social-information processing, social

interactions often lead to overarousal, exhaustion, and frustration. Therefore, autistic people may avert their attention as a regulating strategy to avoid being overwhelmed by the intense and perplexing social input (Markram & Markram, 2010; Tanaka & Sung, 2016).

Another possible obstacle for autistic children to develop empathy is their struggles in emotion recognition. Understanding the emotion of others is the core component of cognitive empathy. Decades of research provide converging evidence that autism is associated with difficulties in understanding other people's minds (Baron-Cohen, 2001). Difficulties in emotion understanding are observed already in the first years of life in autistic children and the problem persists into adulthood (Harms et al., 2010; Lozier et al., 2014). Not surprisingly, autistic children and adults often scored lower than non-autistic peers when cognitive empathy was measured (e.g., Deschamps et al., 2014; Mul et al., 2018; Pouw et al., 2013). Furthermore, with reduced attention to others and inefficient emotion understanding, it is not surprising that autistic children were observed to initiate prosocial actions less frequently than non-autistic children (Hudry & Slaughter, 2009; Russell et al., 2013). Note, however, the findings on affective empathy are less consistent than the findings on the other empathy components. While observational studies often reported less affective empathy in autistic children (Dawson et al., 2004; Hutman et al., 2010), studies using parent reports and self-reports usually found no group difference in affective empathy (Hudry & Slaughter., 2009; Deschamps et al., 2014; Pouw et al., 2013).

Although the extant studies provided valuable information on empathy in autistic children and adults, they focused on one or two aspects of empathy, such as cognitive empathy and prosocial actions. The four empathy components, i.e., affective empathy, cognitive empathy, attention to others, and prosocial action, were rarely studied simultaneously. Besides, some questions remain unanswered. First, due to the cross-sectional nature of the extant studies, little is known about how empathy develops in early childhood. Do autistic children develop their empathy skills at the same rate as non-autistic children or do they develop differently? These questions can be answered only by longitudinal studies. Second, past studies on young autistic children often used observational tasks. In these tasks, children needed to interact with an adult stranger. This could present an extra challenge to autistic children and thus interfere with their performance. Adding insight from parents and using a multimethod approach can contribute to a more comprehensive understanding of empathy development in autistic children. Third, empathy has long been associated with positive psychosocial outcomes in typical development (Eisenberg et al., 2010). Yet, whether

the same associations exist in autistic children remains largely unknown. The third study is conducted to address these questions.

STUDY 3 (Chapter 4) aims to examine the development of four empathy components (i.e., affective empathy, attention to others, cognitive empathy and prosocial actions) in preschool autistic children using parent reports and observational tasks. Besides, it examines the extent to which the development of empathy contributes to the change of externalizing problems and social competence in autistic and non-autistic children.

Research on typically developing children shows that problems in emotional functioning not only hinder implementing smooth and positive social interactions, but can also contribute to the development of psychopathology (Cole & Deater-Deckard, 2009; Keenan, 2000). As asserted by the functionalistic perspective, emotions are functional, even negative emotions. They prepare us to deal efficiently with environmental demands, e.g., anger and fear prepare us to fight or flight in challenging situations. However, emotions are functional only when the level of arousal and duration are under control or manageable. Being overwhelmed by emotions, as indicated by elevated levels of *negative emotion expressions*, puts children at risk of developing internalizing and externalizing behavior problems (Horwitz & Wakefield, 2007; Zeman et al., 2002). In addition to unregulated emotion expression, impaired *emotion recognition* is also related to the development of behavioral problems. Correctly identifying others' emotions is prerequisite to establishing and maintaining positive interpersonal relations. Frequently experiencing unpleasant and stressful social interactions can contribute to social exclusion and the development of internalized feelings such as anxiety, loneliness, and sadness (Fine et al., 2003). Besides, misunderstanding others' emotions can lead to a hostile perception of others' intention and in turn provoke aggressive reactions (Martin et al., 2010; Schultz et al., 2000). Finally, *emotion vocabulary*, namely, children's knowledge of emotion words, enables them to identify their own emotional state and to communicate their emotions with other people (Streubel et al., 2020). This creates a channel which helps children deal with their emotional arousal and thus prevents behavioral problems. Importantly, the knowledge of emotional words enables children to carry out discussions with others on emotions. Such emotion talk promotes in the long run the development of emotional competence in children (Gentzler et al., 2005).

Children diagnosed with autism are at a high risk of comorbid conditions including internalizing problems, such as anxiety and depression, and externalizing problems, such as hyperactivity and aggression (Bauminger et al., 2010; Salazar et al., 2015). The prevalence rates of having at least one psychiatric condition in addition to their core syndrome range

from 70% to 90% (De Bruin et al., 2007; Simonoff et al., 2008), about 3 to 10 times higher than in the general population (Costello et al., 2003). Although internalizing and externalizing problems are well recognized in the mental health profiles of children with autism, information on their developmental trajectories, especially in early childhood, is scarce. Besides, little is known about the contribution of emotional functioning to the development of internalizing and externalizing problems in young children with autism, although the relation has been established in typically developing children. The gap of knowledge has motivated the fourth study of this thesis.

STUDY 4 (Chapter 5) aims to examine the development of psychopathology and the contributing role of emotion functioning in preschool children with and without autism.

Chapter 6 summarizes the findings of the aforementioned four studies, provides an overview of the findings on the early development of various aspects of emotional functioning in autistic children, and discusses the implications and recommendations for future research.

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CHAPTER 2.

The early development of emotion recognition in autistic children: Decoding basic emotions from facial expressions and emotion-provoking situations

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ABSTRACT

Autism has long been associated with struggles in emotion recognition. This four-wave longitudinal study followed the development of three key emotion recognition abilities regarding four basic emotions in preschool autistic and non-autistic children aged 2.5 to 6 years over a period of three years. Behavioral tasks were used to examine whether children could differentiate facial emotion expressions (emotion differentiation), to associate facial emotion expressions to verbal labels (emotion identification), and to attribute emotions to emotion-provoking situations (emotion attribution). The results showed that autistic children experienced more difficulties in discriminating, identifying and attributing emotions than non-autistic peers. These challenges were present early and persistent over time. Remarkably, autistic children showed comparable age-related improvements as non-autistic children. Despite the early presence of difficulties in emotion recognition, autistic children showed the capacity for learning and potential for improvement.

Introduction

Emotions have important communicating functions. A happy face signals to another that one is satisfied with the situation and welcomes further interaction, whereas an angry face signals to another that one dislikes the situation and wants to reinstate goals and status (Nikitin & Freund., 2019; Taylor & Barton, 2015). Correctly interpreting the emotional signals of others is crucial for establishing and maintaining positive relationships (Dede et al., 2021). Social communication and social interaction constitute one of the most challenging areas for people with autism (American Psychiatric Association, 2013). The predicament is partly related to their struggles in recognizing others' emotions. There is a plethora of research investigating emotion recognition in autistic individuals (for reviews, see Harms et al. (2010), Uljarevic & Hamilton (2012), Lozier et al. (2014)). They contributed greatly to our knowledge of the intergroup differences. However, due to their cross-sectional designs, little is known about how emotion recognition abilities develop within autistic individuals over time (Rosen & Lerner, 2016). To address this gap and to start from an early life stage, this study examined the development of emotion recognition over a three-year time course in autistic children aged 2.5 to 6 years, in comparison to non-autistic peers.

In typical development, perceiving and discriminating facial expressions marks the first step towards emotion recognition. A-few-month-old infants already show awareness that a happy face is different from an angry face (Grossmann, 2010; Kobiella et al., 2008). By the end of the first year, they can use facial expressions as social references to guide behaviors (Camras & Shutter, 2010; Hertenstein & Campos, 2004). Along with the language development, children start to produce verbal labels for emotions in the second year of life (Dunn et al., 1987; Ridgeway et al., 1985). Labeling emotions enables children to categorize emotions and acquire the scripted knowledge of emotions, which includes not only facial expressions, but also bodily reactions, action tendencies, and importantly, the eliciting events associated with the emotion (Widen & Russell, 2008). Understanding that every emotion is associated with an emotion-provoking situation and being able to predict another's emotion based on situational cues marks another progress towards matured emotion recognition (Rieffe et al., 2017). While toddlers and preschoolers rely primarily on facial expressions, school-aged children reply more often on situational cues for processing emotional information (Herba & Phillips, 2004).

The above-mentioned abilities usually develop without much effort in typically developing children. However, it can be challenging for autistic children. Research showed that autistic children aged between 4 and 17 years encountered more difficulties than non-

autistic peers in discriminating facial expressions (e.g., Evers et al., 2015; Fridenson-Hayo et al., 2016; Tardif et al., 2007; Wieckowski et al., 2019; Xavier et al., 2015), labeling facial expressions (e.g., Balconi et al., 2012; Fink et al., 2014; Griffiths et al., 2017; Peterson et al., 2015; Shanok et al., 2019), and attributing emotions to emotion-provoking situations (e.g., Balconi et al., 2012; Fridenson-Hayo et al., 2016; Tell et al., 2014). It was especially challenging when the emotions were of the negative valence such as fear and anger (e.g., Akechi et al., 2010; Wright et al., 2008), with a more complex nature such as shame and guilt (e.g., Heerey et al., 2003; Kotroni et al., 2019), presented in a low intensity (e.g., Song & Hakoda, 2018) or for a short duration (e.g., Clark et al., 2008). Some studies did not find group differences (e.g., Castelli, 2005; Lacroix et al., 2014; Tracy et al., 2011). They usually had groups matched on cognitive abilities such as verbal and global IQ. As pointed out by Harms and colleagues (2010), an uneven IQ profile is phenotypically linked with autism. Removing the effect of IQ might also remove some essential attributes linked with autism. Besides, group differences often disappeared when the recognition of basic emotions were examined in prototypical situations in middle-school-aged autistic children and older (e.g., Jones et al., 2011; Tracy et al., 2011). Possibly, autistic children catch up non-autistic peers in their basic-emotion recognition at older ages.

In contrast to the abundant research on the intergroup differences, there is a dearth of developmental data, preventing us from delineating the developmental course of emotion recognition in autism. To the best of our knowledge, only one study used a longitudinal approach. Rosen and Lerner (2016) found that the ability to label basic emotions from facial expressions improved in 11- to 17-year-old autistic children and adolescents over a period of 18 weeks. The age-related improvement was also supported by some correlation studies, which found a positive relation between age and emotion recognition in autistic children aged between 4 to 13 years (Fridenson et al., 2016; Lacroix et al., 2014; Williams et al., 2013; Xavier et al., 2015). Note, however, when looking across the life span, evidence suggests that emotion recognition may develop with a smaller magnitude in autistic people than in non-autistic people. A few cross-sections studies found that non-autistic adults and adolescents outperformed non-autistic children in some emotion-recognition tasks, whereas such age differences were not found in autism (Greimel et al., 2014; O'Connor et al., 2005; Rump et al., 2009). Besides, two meta-analyses, each amalgamating more than 40 cross-sectional studies on emotion recognition in autistic individuals of various ages, found that the difficulties in emotion recognition for autistic individuals did not diminish or disappear with

age (Uljarevic & Hamilton, 2012); rather, the intergroup differences in emotion recognition seem to become greater from childhood to adolescence and adulthood (Lozier et al., 2014).

To find out how emotion recognition develops in autistic people and whether their development follows a different trajectory, longitudinal investigations are needed (Harms et al., 2010). Hoping to address this gap, this four-wave longitudinal study examined emotion recognition and its development in 2.5- to 6-year-old children with and without autism. In particular, we examined emotion recognition at three levels: (1) differentiating facial emotion expressions, (2) identifying facial emotion expressions with verbal labels, and (3) attributing emotions to emotion-provoking situations. Based on the previously mentioned literature, we expected that autistic children had more difficulties than non-autistic peers in differentiating, identifying, and attributing emotions. We assumed that all three emotion-recognition abilities improved with age in non-autistic children (Widen & Russell, 2004; Herba & Phillips, 2004). Due to the scarcity of longitudinal data in autism, our hypotheses regarding their development were explorative. We expected that, similar to non-autistic children, autistic children's abilities would improve with age, but probably with a smaller magnitude.

In addition to the effect of age, we also examined the influence of autistic traits on the development of emotion recognition in autistic children. Previous correlational studies found that more accentuated autistic traits were related to more difficulties in emotion recognition (Brosnan et al., 2015; Evers et al., 2015; Xavier et al., 2015; Tell et al., 2014; Williams & Gray, 2013). We explored whether the associations were also present longitudinally.

Methods

Participants and procedure

This study was part of a larger-scaled longitudinal research on the social and emotional development of preschool children with limited access to the social world, including children with hearing loss, developmental language disorder and autism. The total sample of the larger-scaled research included 73 autistic children (65 boys) and 418 non-autistic children (226 boys). Autistic children met the following inclusion criteria: (1) the child received an autism diagnosis according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.) (American Psychiatric Association, 2000) based on the *Autism Diagnostic Interview-Revised* (Lord, Rutter, & Lecouteur, 1994) set by a qualified child psychologist or psychiatrist at Time 1, (2) parents confirmed three years later that the child retained the autism diagnosis, (3) the child had IQ scores above 70 and no additional clinical diagnoses.

Inclusion criteria for non-autistic children were (1) IQ scores above 70, and (2) no clinical diagnoses or disabilities.

Autistic children were recruited via a specialized institution for diagnosis and treatment of autism, i.e., Center for Autism, Leiden, the Netherlands. Non-autistic children were recruited from day-care centers and mainstream primary schools in the same region. Since the IQ profiles of autistic children were either retrieved from school or collected by the institution, various intelligence tests were used, including the Snijders-Oomen Nonverbal Intelligence Tests (SON-R), Wechsler Intelligence Scale for Children, Wechsler Preschool and Primary Scale of Intelligence, and Wechsler Nonverbal Scale of Ability. Non-autistic children were tested with the SON-R.

The Ethics Committee of Leiden University and Center for Autism granted permission for the larger-scaled research project. All parents provided written informed consent. Children and their parents participated the research once a year for four consecutive years (mean duration between Time 1 and Time 2 = 13.20 months, *SD* = 3.47; between Time 2 and Time 3 = 12.15 months, *SD* = 1.58; between Time 4 and Time 3 = 12.23, *SD* = 1.05). Children were visited either at school or at the specialized institution (for autistic children only), where they finished a series of tasks under the guidance of a trained psychologist. Parents filled out a group of questionnaires to report on children's development. The Social Responsive Scale (SRS; Constantino & Gruber, 2005) was filled out at Time 1, Time 3 and Time 4, where parents reported on the degree of their children's autistic traits. It consists of 65 items with responses on a 4-point scale, where higher scores indicated more accentuated autistic traits. The raw total scores were calculated, based on which the T-scores were generated using the Dutch SRS manual (Roeyers et al., 2011). Since the Dutch norm applies to children aged between four and 17 years, no T-scores were generated for children who were younger than four years.

Due to time constraints, not all children were administered the full test battery. Participants of the larger research project were included in this study if they had data of the emotion-recognition variables on at least one time point (see Supplementary Table 1, 2 and 3 for available data at each time point). The final sample used in the current study included 62 autistic children (7 girls) and 121 non-autistic children (11 girls), aged 32 to 72 months (Mean = 55.86 months).

Table 1: Demographic characteristics of participants: means and standard deviations of background variables.

		Total participants at Time 1 N = 183			
		Autistic	N	**Non-autistic**	N
			62		121
Age in months	Wave 1	56.57 (10.38)	62	55.45 (11.37)	121
	Wave 2	69.18 (10.57)	44	70.16 (11.01)	51
	Wave 3	82.45 (9.45)	42	81.16 (10.69)	49
	Wave 4	95.05 (9.07)	37	93.21 (10.25)	43
Male%		88.71%	62	90.91%	121
IQ**		99.92 (16.45)	51	110.29 (15.07)	62
SRS T score	Wave 1**	75.24 (10.86)	42	46.07 (4.18)	14
	Wave 3**	78.79 (13.27)	38	47.28 (5.27)	36
	Wave 4**	77.91 (11.30)	23	45.70 (5.11)	27
Education mother[a]*		3.80 (1.13)	55	4.42 (0.90)	48
Education father[a]		3.68 (1.36)	56	4.02 (0.96)	41
Net annual income[b]**		2.98 (1.17)	40	3.85 (1.10)	67

[a] Parental education level: 1 = no/primary education; 2 = lower general secondary education; 3 = middle general secondary education; 4 = higher general secondary education; 5 = college/university.

[b] Net household income: 1 = less than €15,000; 2 = €15,000 – €30,000; 3 = €30,000 – €45,000; 4 = €45,000 – €60,000; 5 = more than €60,000.

* $p < .05$ ** $p < .001$

Table 1 shows the descriptive characteristics of the participants. The autistic and non-autistic group did not differ in age ($-.44 < t\text{s} < .85$, $p\text{s} > .05$) or gender distribution (χ^2 (1) = .22, $p = .636$). Autistic children had on average lower IQ than non-autistic children ($t(117) = 3.49$, $p < .001$). They had higher SRS T-scores at Time 1: ($t(52.71) = 14.49$, $p < .001$), Time 3($t(48.92) = 13.55$, $p < .001$, and Time 4 ($t(29.57) = 12.61$, $p < .001$). Mothers of autistic children had on average lower education levels than mothers of non-autistic children ($t(100.13) = 3.09$, $p = .003$). The average education levels of fathers did not differ between

groups ($t(94.89) = 1.47$, $p = .146$). Families of autistic children had lower average income than families of non-autistic children ($t(105) = 3.89$, $p < .001$).

Measures

Considering the young ages of the participants, the emotion recognition tasks were designed to place minimal verbal demand on children and involved only four basic emotions, i.e., happiness, anger, sadness, and fear. These tasks were used previously to measure emotion recognition in children with hearing loss (Wiefferink et al., 2012) and with developmental language disorder (Rieffe & Wiefferink, 2017).

Children's ability to discriminate between different facial emotion expressions was measured by the ***Emotion Discrimination Task***. First, a sheet was placed in front of them, where the drawing of one category (e.g., a happy face) was printed on the top left corner, and the drawing of another category (e.g., a sad face) was printed on the top right corner. Next, the experimenter demonstrated how to place two cards with drawings of the two different categories on the sheet, accompanied by a simple oral explanation: "Look, this one should be put here, and this one should be put here". Then, children were given six cards (e.g., three drawings of a happy face and three drawings of a sad face) to do the sorting.

Before sorting out cards of facial emotional expressions, children did two practice tasks, where they first sorted out cards of cars and flowers, and then sorted out cards of similar faces, one with glasses and one with a hat. The two practice tasks were used to familiarize children with the intention and procedure of the tasks. In the testing task, children sorted out facial emotion expressions of different emotional valences (condition 1: happy versus sad) and facial emotion expressions of the same emotional valence (condition 2: angry versus sad). Condition 1 was supposed to be easier than condition 2, because the differences are more prominent in facial emotion expressions between valences than within the same valence. Children scored "1" when placing one card under the correct category and scored maximally "3" for each category.

Children's ability to associate verbal labels to facial emotion expressions was measured by the ***Emotion Identification Task***. The experimenter showed children eight drawings of facial emotion expressions for happiness, anger, sadness and fear (two drawings for each emotion) and asked: "Who looks happy?" Children had to point to the drawing of a happy face. Next, the researcher asked: "Is there anyone else who looks happy?" Children had to point to another drawing of a happy face. The same procedure was repeated for anger,

sadness and fear. Children scored "1" for each correctly identified facial emotion expression, and scored maximally "2" for each emotion.

Children's ability to attribute emotions to emotion-provoking situations was tested by the ***Emotion Attribution Task***. Children were shown drawings of eight vignettes, depicting two prototypical emotion-provoking situations for happiness, anger, sadness and fear respectively. Meanwhile the experimenter gave a simple oral explanation, such as "Look, the boy sees a frightening dog" (see Supplementary Table 4 for the descriptions of the eight vignettes). Then the experimenter asked: "How does the boy feel?" This required a verbal answer from children (the verbal condition). Considering that some children might not know the word for the emotion, next, the experimenter showed children a sheet with the drawings of a happy, angry, sad and fearful face and asked: "How does the boy look?" This required the child to point to the corresponding face (the visual condition). For both conditions, children scored "2" when assigning the emotion that was intended by the study, scored "1" when assigning an emotion which was not the intended emotion but of the intended valence, and scored "0" when assigning an emotion of the opposite valence. Children's performances in this task were examined per valence. This was because a prototypical situation might provoke different emotions within the same valence. For example, a child may feel scared when seeing a frightening dog, but it is also possible that the child feels sad. Furthermore, children younger than 3 years tend to mix emotions within the same valence, for example, referring to all the negative emotions as "anger" or "sad" (Widen, 2013).

The drawings used in the tasks were computer generated and in black and white. The facial emotion expressions were drawn based on photos of different four- and five-year-old boys, which were randomly chosen from a large database with photos of various facial emotion expressions. Examples of the drawings can be found in Supplementary Figure 1.

Statistical analyses

R (version 3.3.3; R Core Team 2019) was used to make figures (with the package "ggplot2" (Wickham, 2009)). IBM SPSS Statistics for Macintosh (version 27.0; Armonk, NY: IBM Corp.) were used to conduct Linear Mixed Model (LMM) analyses for examining the developmental trajectories of emotion recognition abilities and their associations with symptom severity. LMM can account for the dependency within the longitudinal data (Hox et al., 2010) and is robust in handing missing data when they miss (completely) at random (Twisk et al., 2017). The current data had missing values at every time point. Little's MCAR

tests indicated that the missing patterns could be completely at random ($422.98 < \chi^2 s < 2570.48$, $ps > .05$).

We followed a formal model-fitting procedure, i.e., fitting increasingly more complex models to the data step by step. Simpler models with a better model fit were selected over the more complex model. To evaluate model fit, for nested models, the preferred model showed significant less deviance, i.e., lower values of -2 Log Likelihood (-2LL). For non-nested models, the preferred model showed lower Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values.

To examine the developmental trajectories of emotion recognition abilities, we started with an unconditional means model which included only a fixed and random intercept. Then, age (centered around 32 months, the youngest age of all participants) was added to the model. We examined two models of change: linear and quadratic, respectively. Next, group (0 = non-autistic, 1 = autistic) was added to examine if the levels of emotion recognition differed between the two groups across time. Fourth, we added the interactions between age and group to the model to examine whether the two groups differed in developmental trajectories.

To investigate the role of autistic traits in predicting of the development of emotion recognition abilities in autistic children, we first calculated four composite scores, i.e., the total score of the emotion discrimination task, the emotion identification task, the emotion attribution task verbal condition and visual condition. Next, we calculated the mean score of SRS, i.e., the mean of SRS raw total score at Time 1, Time 3, and Time 4. Third, we started with four separate models which had only age as the control variable and the composite scores of the four emotion-recognition tasks as the dependent variables. Fourth, we added the SRS mean score as a predicting variable to the age-only models.

Results

Developmental trajectories of emotion discrimination. Table 2 shows the estimates of the fixed and random effects of the best age models for emotion discrimination. The best age models for both conditions were with the fixed effects of linear age and group. As depicted in Figure 1, the abilities to discriminate between facial expressions improved with age in all children, and yet autistic children scored overall lower than non-autistic children in the tasks.

See also Supplementary Table 5 for more information on the model fit of the best age models for emotion discrimination, identification and attribution.

Developmental trajectories of emotion identification. Table 3 provides the estimates of the fixed and random effects of the best age models for emotion identification. For identifying happy and angry facial expressions, the best age models were both with the fixed effects of linear age and group, and their interactions. For both models, adding the random effects of linear age contributed to significant improvements of model fit, indicating that there were substantial unexplained slope variabilities. Autistic children showed greater improvement with age in identifying happy facial expressions (b = .008, p = .006) than non-autistic children (b = .006, p = .002). They also showed greater improvement in identifying angry facial expressions (b = .008, p = .001) than non-autistic children (b = .007, p = .001) (see Figure 2).

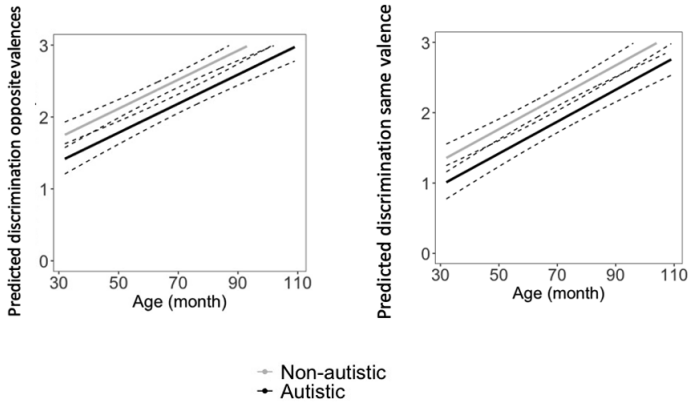

Fig 1. Regression lines depicting the predicted levels of discrimination between emotions of opposite valences (left) and emotions of the same valence (right) with 95% confidence intervals based on the best fitting models with age as the predictor.

Table 2. Fixed and random effects of the best age models for *emotion discrimination*.

	Positive vs. Negative				***Sad vs. Anger***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.75	.09	[1.57, 1.93]		1.35	.10	[1.16, 1.56]	
Age	.02	.002	[.016, .024]		.02	.002	[.02, .03]	
Group	-.34	-.09	[-.51, -.16]		-.34	.10	[-.55, -.14]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.49	.04	[.41, .57]	11.89	.55	.05	[.47, .66]	11.43
Intercept	.11	.04	[.06, .21]	3.01	.18	.05	[.10, .32]	3.45

Table 3. Fixed and random effects of the best age models for *emotion identification*.

	Happy				***Anger***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.67	.09	[1.49, 1.85]		1.67	.09	[1.48, 1.85]	
Age	.006	.002	[.002, .009]		.007	.002	[.003, .01]	
Group	-.55	.15	[-.85, -.25]		-.63	.16	[-.95, -.32]	
*Age*group*	.008	.003	[.002, .014]		.008	.003	[.002, .015]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**

Residual	.10	.01	[.08, .12]	9.33	.09	.01	[.07, .10]	9.61
Intercept	.61	.10	[.45, .85]	6.11	.70	.10	[.53, .93]	6.90
Slope	.0002	.00004	[.0001, .0003]	3.90	.0002	.00005	[.0002, .0003]	5.03
	Sad				***Fear***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.96	.09	[.77, 1.14]		.95	.09	[.77, 1.14]	
Age	.02	.002	[.014, .021]		.02	.001	[.014, .021]	
Group	-.18	.07	[-.32, -.03]		-.17	.07	[-.30, -.03]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.27	.03	[.21, .33]	9.16	.26	.03	[.21, .32]	9.23
Intercept	.63	.18	[.36, 1.09]	3.54	.73	.18	[.44, 1.19]	3.98
Slope	.0001	.00009	[.00003, .0005]	1.32	.0001	.00009	[.00005, .0005]	1.74

Table 4. Fixed and random effects of the best age models for *emotion attribution*.

Positive emotions	***Verbal condition***				***Visual condition***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.01	.09	[.84, 1.19]		1.47	.11	[1.25, 1.68]	
Age	.02	.002	[.01, .02]		.007	.002	[.002, .01]	
Group	-.23	.07	[-.37, -.09]		-.60	.18	[-.95, -.25]	
*Age*group*	-	-	-		.008	.004	[.0002, .01]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.24	.03	[.19, .29]	9.05	.19	.02	[.16, .24]	9.25
Intercept	.65	.15	[.41, 1.03]	4.25	.68	.13	[.46, 1.01]	4.99
Slope	.0002	.00007	[.0001, .0004]	2.80	.0002	.00006	[.0001, .0004]	3.37
Negative emotions	***Verbal condition***				***Visual condition***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.04	.05	[.94, 1.14]		.90	.06	[.77, 1.02]	
Age	.003	.001	[.001, .005]		.009	.001	[.006, .01]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.10	.01	[.08, .11]	11.08	.14	.02	[.11, .17]	9.30
Intercept	.19	.03	[.14, .25]	6.79	.28	.07	[.17, .47]	3.78
Slope	-	-	-	-	.0001	.00004	[.00004, .0002]	2.36

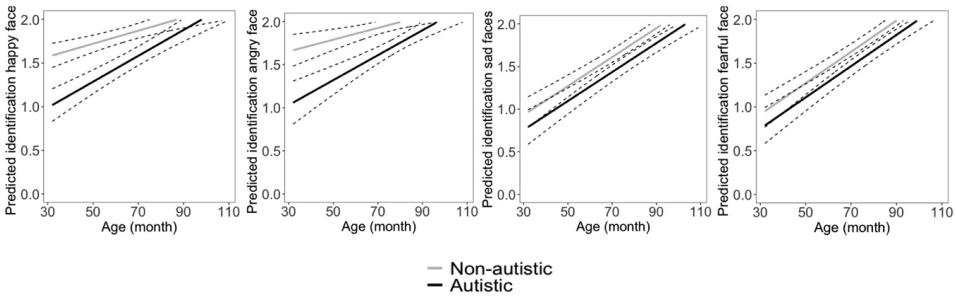

Fig 2. From left to right: regression lines depicting the predicted levels of identifying happy, angry, sad and fearful facial expressions with 95% confidence intervals based on the best fitting models with age as the predictor.

The best age models for identifying sad and fearful facial expressions were both with the fixed effects of linear age and group. Adding the random effects of linear age contributed to significant improvements of model fit, indicating that, for both models, there were substantial unexplained slope variabilities. Autistic children scored overall lower than non-autistic children in these tasks. However, all children showed age-related improvement in identifying sad and fearful facial expressions.

Developmental trajectories of emotion attribution. Table 4 provides the estimates of the best age models for emotion attribution. The best age model for attributing positive emotions in the verbal condition was with the fixed effects of linear age and group, showing that this ability improved in all children, and autistic children scored overall lower in this task. The best age model for attributing positive emotions in the visual condition was with the fixed effect of linear age, group and their interaction. While autistic children had overall lower scores, they showed greater improvement (b = .008, p = .045) than non-autistic children (b = .007, p = .003) (see Figure 3). For both conditions, adding the random effects of linear age contributed to significant improvements of model fit, indicating that there were substantial unexplained slope variabilities.

The best age model for attributing negative emotions in the verbal condition was with the fixed effect of linear age, and in the visual condition was with the fixed and random effect of linear age. This indicates that children's abilities to attribute negative emotions increased

with age. In the visual condition, there was also substantial unexplained slope variability. Adding group did not contribute to a better model fit, showing that autistic children did not differ from non-autistic children in attributing negative emotions.

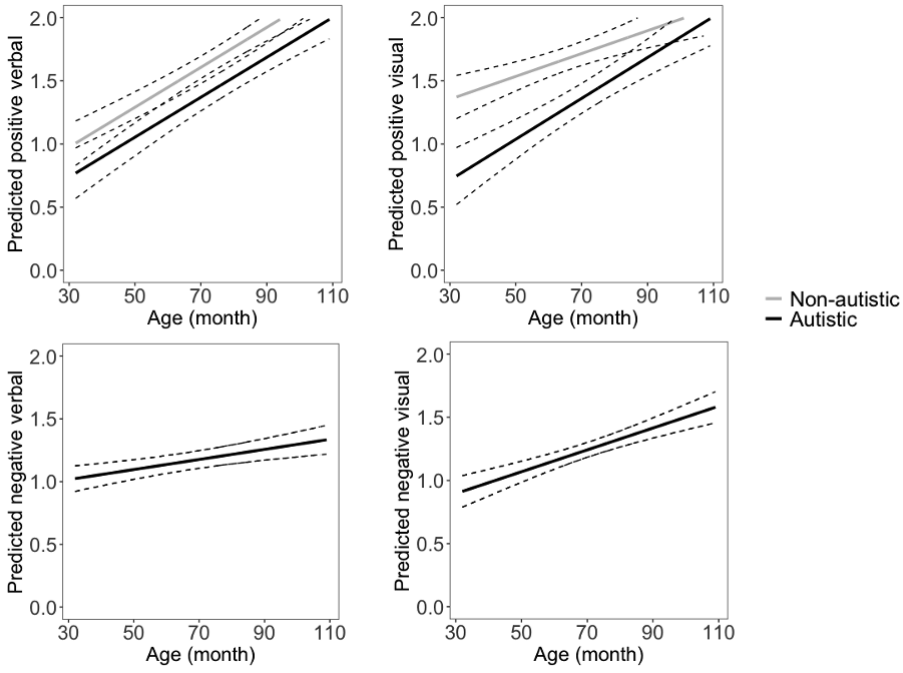

Fig 3. Upper left and right: regression lines depicting the predicted levels of attributing positive emotions in the verbal and visual condition with 95% confidence intervals based on the best fitting models with age as the predictors. Lower left and right: regression lines depicting the predicted levels of attributing negative emotions in the verbal and visual condition with 95% confidence intervals based on the best fitting models with age as the predictor.

Symptom severity and the development of emotion recognition. Table 5 provides the fixed and random effects of the predicting models with the SRS mean score as the predictor. Adding the SRS mean score improved the model fit for all models (see Supplementary Table 6 for detailed information on model comparisons). Nonetheless, none of the fixed effects of the SRS mean for predicting emotion recognition abilites among autistic children was significant.

Table 5. Fixed and random effects of the predicting models with SRS mean as the predictor in the autistic group.

	Emotion discrimination				***Emotion identification***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.94	.36	[1.21, 267]		.91	.31	[.29, 1.54]	
Age	.02	.003	[.01, .03]		.02	.002	[.01, .02]	
Mean SRS	-.006	.003	[-.01, .001]		-.001	.003	[-.006, .005]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.39	.05	[.30, .51]	7.42	.16	.02	[.12, .21]	7.43
Intercept	.16	.06	[.07, .33]	2.57	.16	.05	[.09, .28]	3.51
	Emotion attribution							
	Verbal condition				***Visual condition***			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.55	.30	[-.06, 1.15]		.82	.31	[.19, 1.44]	
Age	.01	.002	[.009, .02]		.01	.002	[.006, .02]	
Mean SRS	.001	.003	[-.004, .007]		.0002	.003	[-.006, .006]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**

Residual	.19	.03	[.15, .25]	7.39	.20	.03	[.15, .26]	7.35
Intercept	.14	.04	[.07, .25]	3.18	.15	.05	[.08, .28]	3.19

Discussion

This study contributed unique insights into the levels and early development of three emotion recognition abilities (i.e., discrimination, identification, and attribution) in 2.5- to 6-year-old autistic children, in comparison to non-autistic children. First, in line with the literature, we found that autistic children had more difficulties than non-autistic children in discriminating, identifying facial emotion expressions and in attributing positive emotions to emotion-provoking situations. The group differences were present throughout the three-year course of measurements. However, autistic did not differ from non-autistic children in attributing negative emotions. Second, it was revealed for the first time that in early childhood, like non-autistic children, autistic children's abilities to recognize basic emotions improved with age. Noteworthy, some abilities increased with greater magnitudes in autistic children than in non-autistic children. Furthermore, we did not find the expected association between autistic traits and emotion recognition in autistic children.

First, we found that the challenges in emotion recognition for autistic children were present across modalities and across emotions. This provides supporting evidence that their struggles in emotion recognition are universal rather than task- or emotion-specific (Uljarevic & Halmilton, 2012; Lozier et al., 2014). Some studies on older autistic children and adults proposed that the challenges were emotion specific, as autistic people had difficulties only in recognizing one or a few negative emotions (Uono et al., 2011; Ashwin et al., 2006; Humphreys et al., 2007). Our findings showed that young autistic children were also less accurate in recognizing positive emotions. Despite the challenges, their abilities to recognize emotions all improved with age. Conceivably, autistic children would catch up non-autistic peers at older ages in some aspects of emotion recognition such as recognizing positive emotions.

We expected that autistic children would develop at slower rates than non-autistic children. However, the magnitudes of development were by and large the same between the groups, and autistic children showed even greater improvements than non-autistic children in identifying happy and angry facial expressions and in attributing positive emotions to emotion-provoking situations. Protracted developments were suggested by cross-sectional and meta-analysis studies (e.g., Greimel et al., 2014; Rump et al., 2009; Lozier et al., 2014), which compared between children, adolescents and adults. Although these studies shed insight into the development of emotion recognition throughout the whole life span, the development within each developmental phase and of each discrete emotion can be dynamic and different. The only longitudinal study we were aware of also found age-related improvement in autistic

children and adolescents (Rosen & Lerner; 2016). However, this study did not involve a control group, so it remains unknown whether non-autistic peers developed at a similar or faster rate. Future research adopting a longitudinal design and involving a control group can provide more information in this regard.

Surprisingly, autistic children did not differ from non-autistic peers in attributing negative emotions to emotion-provoking situations. No group differences were found in the levels nor in the developmental trajectories. This is unexpected, because compared to emotion discrimination and emotion identification where we did find group differences, emotion attribution is a more advanced ability and developed usually at later stages. One possibility is that autistic children were better at recognizing emotions through situational cues than through facial expressions. Past research found that autistic people experience more difficulties in processing facial information (Weigelt et al., 2012). Many autistic people tend to avoid looking at the faces of others, and when they do look at the faces, they often show atypical face scanning patterns (Chawarska & Shic, 2009). To find out whether the task performances of autistic children were indeed influenced by the type of task stimuli, we conducted post-hoc analyses to check children's performances in the two practice tasks of the emotion discrimination task. The first practice task asked children to discriminate between two objects (a car vs. a flower), and the second asked children to discriminate between two faces which did not differ in emotion expressions but in appearances (wearing glasses vs wearing a hat). If autistic children were less skilled in processing facial information, they would be outperformed by non-autistic peers in the face condition but not in the object condition. The post-hoc analyses showed that at wave one autistic children performed less well than non-autistic children in both conditions, and at wave two autistic children performed less well only in the face condition. No group differences were found in either condition in the following two waves (see Supplementary Table 7 for the statistical outcomes). It seems that autistic children caught up non-autistic peers in discriminating both objects and non-emotional facial features. However, the group differences in discriminating and identifying facial emotion expressions did not disappear with age. This suggests that the persistent difficulties in recognizing facial emotion expressions in autistic children might be related to but not limited to their struggles in processing facial information.

Note that autistic children had more difficulties in attributing positive emotions. This again indicates that the absence of group difference in attributing negative emotions was not only due to autistic children's difficulties in processing facial information. Possibly, autistic children were especially sensitive and alert to situations that could provoke negative

emotions, and thus they performed better in attributing negative emotions than positive emotions. Another possibility is that non-autistic children's abilities to attribute negative emotions were still unfolding. In typical development, children first learn to recognize positive emotions and to distinguish situations that provoke positive emotions from those that provoke negative emotions. While toddlers already have the general knowledge that unpleasant events would lead to the arise of negative emotions, fine distinguishments among discrete negative emotions are not well developed until the school age (Widen & Russell, 2008). The emotion-attribution abilities were probably at the starting phase of development, and thus the effect of autistic traits on their development was yet to be seen.

Some correlation studies found that more accentuated autistic traits were related to more difficulties in emotion recognition in autistic children (e.g., Brosnan et al., 2015; Evers et al., 2015). However, we did not find this relation with our longitudinal data. The lack of strong association between symptom levels and the development of emotion recognition might be partly due to the measurement chosen in the study. The Social Responsive Scale (SRS; Constantino & Gruber, 2005) was used to measure the autism symptom severity in autistic children. The SRS is most appropriate for use with children from four to 18 years of age. Yet, many participants of this study were younger than four years. Therefore, the SRS might not be sensitive to detect symptom levels in such a young sample.

This study has the advantages of using a longitudinal approach to unravel the development of multiple emotion recognition abilities in autistic children at a relatively young age. However, limitations should also be noted. First, the testing materials were the drawings of faces with pronounced emotion expressions. The drawings of facial expressions were easier to detect than facial expressions encountered in daily life, where the emotions are expressed often more subtly, with a lower intensity and in a dynamic way. Despite the relatively low ecological validity of the testing materials, autistic children were still outperformed by non-autistic peers, indicating that emotion recognition was a real challenge for them. Second, the autistic sample included in this study did not have intellectual disabilities. Also, the autistic participants and their parents were involved regularly in supporting programs. The positive outcomes found in this study might at least partly result from the supports that the participants received. Caution is warranted when generalizing our findings to other autistic groups. Third, autistic girls were underrepresented in this study, so as in the general population with autism. Although much fewer girls are diagnosed with autism, it does not mean that the predicament is of a lesser extent for autistic girls than for autistic boys. Future research should make more efforts to understand the unique challenges and difficulties that autistic girls face and provide

them gender-tailored support. Last but not least, our findings only reflected the average performances and abilities of autistic children. As indicated by the significant random age effects found in most models, the development of emotion recognition abilities differed greatly among children. Autistic children are as heterogeneous and diverse as non-autistic children. The findings of this study should not be used to label them. Instead, when interacting with an autistic child, we should try to understand his or her characteristics, strengths and needs, and treat each of them as a unique human being.

To conclude, this study confirmed previous findings that challenges in emotion recognition were present already at young ages for autistic children and persisted over time. Nonetheless, autistic children displayed potential for developing emotion recognition skills. Understanding the challenges that autistic children face and acknowledging their potentials can make a positive step towards supporting autistic children in the right way. Future research should look into factors that facilitate and promote emotional development in autistic children, such as the impacts of providing extra supports inside and outside family, and creating an inclusive and respectful social environment, where autistic children can develop at ease and to their full potential.

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CHAPTER 3.

See the self through others' eyes: The development of moral emotions in young children with autism spectrum disorder

Li, B., Tsou, Y., Stockmann, L., Greaves-Lord, K., & Rieffe, C. (In press). See the self through others' eyes: The development of moral emotions in young children with autism spectrum disorder, *Development and Pyschopathology*.

ABSTRACT

Despite the important social functions of moral emotions, they are understudied in the ASD population. This three-wave longitudinal study is among the first to examine the development of moral emotions and their associations with Theory of Mind in 3- to 7-year old children with ASD. 142 children (52 with ASD) were followed over a period of two years. We found that while the expressions of shame and guilt remained stable in non-ASD children, they decreased with age in children with ASD. Besides, better false belief understanding was uniquely related to increased expressions of pride in children with ASD. Our findings highlight the importance of addressing the developmental gap and facilitating the development of moral emotions in children with ASD at the youngest possible age.

Introduction

Moral emotions such as guilt, shame and pride play an important role in regulating behaviors in accordance to moral standards and motivating prosocial actions. The experience and the anticipation of experiencing moral emotions inhibit moral transgressions and encourage socially-appreciated deeds (Eisenberg, 2000; Tangney et al., 2007). Moral emotions are provoked when one evaluates oneself by social norms, and judges oneself through other people's eyes (Leary, 2004; Tangney & Tracy, 2012). Children diagnosed with Autism Spectrum Disorder (ASD) are known for their difficulties in reading others' minds (for reviews, see Baron-Cohen (2001) and Frith (2001)). Presumably, a lack of Theory of Mind (ToM) can compromise their awareness of how other people evaluate them and prevent them from experiencing moral emotions properly. To date, only a handful of studies have examined moral emotions in children with ASD, reporting lower levels of moral emotions as compared to non-ASD peers (Davidson et al., 2018; Heerey et al., 2003; Hobson et al. 2006). Albeit informative, these studies examined school-aged children and adolescents using cross-sectional design, and thus it remains unanswered whether a developmental gap already emerges at a younger age. Nor do we know how moral emotions develop in early childhood. Furthermore, it is barely explored whether the lower levels of moral emotions in children with ASD are related to their deficits in ToM. To address the gap, this three-wave longitudinal study aimed to examine the developmental trajectories of moral emotions and the contributing role of ToM in 3- to 7-year-old children with ASD, as compared to non-ASD peers.

The nature and the development of moral emotions

A key feature that distinguishes moral emotions such as guilt, shame and pride from basic emotions such as fear, anger and happiness is that the former involve self-evaluation (Tracy & Robins, 2004). A child who breaks his mother's favorite vase will feel scared if he is concerned about the punishment. However, the child will feel ashamed or guilty if he ascribes the negative outcome to his personal attributes (I am clumsy) or his own action (I did a bad thing). Implementing self-evaluation is a complex cognitive process, which requires advanced cognitive abilities such as ToM. ToM is considered to play a key role in the evaluative process that provokes moral emotions (Harris, 2008; Lagattuta & Thompson, 2007; Lewis, 2000). As noted by Leary (2004), the self-evaluation that elicits moral emotions is not simply how people evaluate themselves, but often how they establish a self-evaluation based on others' view of them. If one thinks that others hold a positive view of himself, the

person may feel proud; if one thinks that others have a negative view of himself, he usually feels guilty or ashamed (Muris & Meesters, 2014). Prior research using cross-sectional designs found that better ToM abilities were related to higher levels of moral emotions and more advanced moral understanding in children (Dunn et al., 2000; Gavazzi et al., 2011; Lane et al., 2010; Lagattuta & Thompson, 2007; Loureiro & Souza, 2013; Misailidi, 2018; Misailidi, 2020).

Given the complex nature of moral emotions, it is not surprising that unlike basic emotions which are already present in infancy, moral emotions emerge later in child development (Tracy & Robins, 2004). Children show the first manifestations of guilt, shame and pride around the age of 2 (Izard et al., 1999; Lewis, 1995; Stipek, 1995). With a growing understanding that the self is separate from and constantly perceived by others, toddlers start to show distress when realizing they have misbehaved and show contentment when fulfilling a task (Emde et al., 1991; Izard et al., 1999; Kochanska et al., 2002). Throughout childhood children's experience, recognition and understanding of moral emotions increase with age. Studies comparing different age groups among toddlers, preschoolers and school-aged children reported that older children show more regret at their transgressions and more concern for others than younger children (Bafunno & Camodeca, 2013; Kochanska et al., 1994; Zahn-Waxler & Robinson, 1995). While toddlers tend to attribute positive emotions to victimizers who achieved their goals by violating rules, children of age 6 and older usually attribute negative emotions such as shame and guilt to the victimizer, due to their increased concern about moral rules and enhanced ability to take others' perspectives (Arsenio et al., 2006; Krettenauer et al., 2013; Sokol & Chandler, 2003). Older children are also more able to recognize pride and more often attribute pride to situations where the self is responsible for the achievement (Graham & Weiner, 1991; Kornilaki & Chlouverakis, 2004; Tracy et al., 2005).

Moral emotions in children with ASD

One of the greatest challenges for people with ASD is to interpret others' thoughts and emotions (Baron-Cohen, 2001; Frith, 2001; however, see Gernsbacher & Yergeau (2019) for a critical review). Studies on moral cognition showed that although the basic understanding of social rules and moral principles is intact in people with ASD, their moral reasoning and judgement are affected by their impaired ToM abilities (for a review, see Grant et al., 2018). Children with ASD tend to make judgements based on the nature of the action (having or having not violated the rule) and have difficulties in processing and incorporating the mental

information such as the motives of the agent (e.g., unintentional mistake versus intended offence) in their moral reasoning (Fadda et al., 2016; Garcia-Molina et al., 2019; Salvano-Pardieu et al., 2016; Weisberg & Leslie, 2012).

Moral emotions in children with ASD may also be affected by their ToM deficits. However, to date only a small body of literature has examined moral emotions in children with ASD, and even fewer have looked into the relation between ToM and moral emotions. Overall, studies reported lower levels of moral emotions - especially shame and guilt - in children with ASD. Children with ASD aged 7 to 15 reported themselves to experience less shame and guilt than non-ASD peers (Davidson et al., 2018; Novin et al., 2019). When describing their personal experience of shame and guilt, children with ASD aged 8 to 13 provided accounts that were less personalized and less contextually appropriate (Losh & Capps, 2006). Children with ASD aged 8 to 16 were less able to recognize expressions of shame or attribute shame to social events (Heerey et al., 2003; Kotroni et al., 2019). Among these studies, two have examined the relations between ToM and moral emotions. They found that ToM abilities were positively related to self-reported levels of guilt (Davidson et al., 2018) and to the recognition of shame and embarrassment in children with ASD (Heerey et al., 2003).

In keeping with the above-mentioned studies on children with ASD who did not have intellectual disabilities, lower levels of shame and guilt were also found in intellectually disabled children with ASD. Hobson et al. (2006) found that compared to non-ASD children and adolescents who had general learning disabilities, 6- to 19-year-old children and adolescents with ASD and with intellectual disabilities less often used personal examples when describing their experience of guilt, expressed less guilt in guilt-provoking situations and were evaluated by their parents as displaying less shame and guilt (Hobson et al., 2006). Also comparing intellectually disabled children with and without ASD, Williams and Happé (2010) found no group difference when evaluating children's accounts of personal experience of guilt. However, it should be noted that the average evaluations on both groups were very low, indicating that all participants were poor in providing contextually appropriate descriptions of guilt.

Compared to shame and guilt, pride seems to be less affected by ASD. Most studies reported comparable levels of pride in children with and without ASD (Davidson et al., 2018; Hobson et al., 2006; Kotroni et al., 2019; Losh & Capps, 2006; Tracy et al., 2011; Williams & Happé, 2010). As pointed out by Hobson et al. (2006), while interpersonal engagement was quintessential for experiencing moral emotions such as shame and guilt, one can

experience pride without having acute awareness of another person's attitudes. Possibly, to experience pride, children do not need to relate to others' feelings or thoughts to the same extent as required for experiencing shame and guilt.

Present study

To the best of our knowledge, this longitudinal study is the first to examine the development of moral emotions in children with ASD. Our goal was two-fold. First, we aimed to investigate the levels and developmental trajectories of moral emotions in children with ASD aged 3 to 7 years, in comparison to non-ASD peers. In particular, we evaluated the expressions of positive (pride) and negative moral emotions (shame and guilt) in young children by observing their reactions in emotion-provoking situations. Based on previous findings on older children and adolescents, we expected children with ASD to display less shame and guilt, whereas they might not differ from non-ASD peers in their expressions of pride. We expected the expressions of moral emotions to increase with age in the non-ASD group (Bafunno & Camodeca, 2013; Kochanska et al., 1994; Kornilaki & Chlouverakis, 2004; Tracy et al., 2005; Zahn-Waxler & Robinson, 1995). Since we were not aware of any research that examined the age effect in children with ASD, we did not make directional hypotheses regarding their developmental trajectories.

Second, we investigated whether children's ToM abilities contributed to the prediction of moral emotion development. Although the literature has long been emphasizing the important role of ToM in moral emotions (Leary, 2004; Lewis, 2000), this view is argued mainly from a theoretical perspective and supported by empirical evidence from correlational studies (Beer et al., 2003; Davidson et al., 2018; Heerey et al., 2003; Misailidi, 2018; Misailidi, 2020; Treeby et al., 2016). To the best of our knowledge, the relation between ToM and moral emotions has not been examined longitudinally, and it is rarely investigated in the ASD population. Because people's mental states include both thoughts and emotions, we checked two ToM abilities: children's understanding of false beliefs, and their understanding of other people's emotions. We expected that higher average levels of the ToM abilities (false belief and emotion understanding) across time, and larger increases in the ToM abilities over time, would contribute to higher levels of moral emotions in children. Additionally, we explored whether the relations between ToM abilities and moral emotions were moderated by having the diagnosis of ASD. Due to lack of empirical evidence, we did not make hypothesis regarding different moral emotions or the moderating effect.

Methods

Participants and procedure

This study was part of a larger-scaled longitudinal research project on the social and emotional development of preschool children with limited access to a social learning environment, including children with hearing loss (Ketelaar et al., 2012), with developmental language disorder (Rieffe & Wiefferink, 2017) and with ASD (Broekhof et al., 2015; Li et al., 2020).

The total sample of the larger-scaled research project included 73 children with ASD (65 boys) and 418 non-ASD children (226 boys) from the Netherlands. However, due to the time limit, not all children were administered the full battery of tasks. Participants of the larger research project were included in this study if they had data of measures on at least one time point (see Table 2 for available data at each time point). The final sample used in the current study included 52 children with ASD (6 girls; aged 33 to 85 months at Time 1) and 90 non-ASD children (13 girls; aged 34 to 88 months at Time 1). See Supplementary Table 1 for our sample size justification.

Children with ASD were recruited via a specialized institution for diagnosis and treatment of ASD, Center for Autism, Leiden, The Netherlands. Non-ASD children were recruited from day-care centers and mainstream primary schools in the same region. Inclusion criteria for the ASD group were: (1) the child received an ASD diagnosis according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., *DSM-IV-TR*; American Psychiatric Association, 2000) based on the *Autism Diagnostic Interview-Revised* (Lord et al., 1994) set by a qualified child psychologist or psychiatrist at Time 1, (2) the parents confirmed two years later that the child retained the ASD diagnosis, (3) the child had IQ scores above 70 and no additional *DSM-IV-TR* diagnoses or disabilities, besides their ASD diagnosis. Inclusion criteria for the non-ASD group were (1) IQ scores above 70, and (2) no clinical diagnoses or disabilities.

Since the IQ profiles of the ASD group were retrieved from school files or collected through testing at the institution, various intelligence tests were used, including the Snijders-Oomen Nonverbal Intelligence Tests (SON-R), Wechsler Intelligence Scale for Children (WISC III), Wechsler Preschool and Primary Scale of Intelligence (WPPSI), and Wechsler Nonverbal Scale of Ability (WNV). Non-ASD children were tested with the SON-R. Parents also filled out Social Responsive Scale (SRS; Constantino & Gruber, 2005) at Time 3, to report on the degree of ASD symptoms in their children. The SRS consists of 65 items with responses on a 4-point scale, where higher scores indicated greater severity of ASD traits.

First, raw total scores were calculated. Then the raw scores were converted to T scores according to the Dutch SRS manual (Roeyers et al., 2011).

Table 1 shows the descriptive characteristics of the two groups. The ASD and non-ASD group did not differ in age ($1.17 < t\text{s} < 1.78$, $p\text{s} > .05$) or gender distribution (χ^2 (1) = .240, p = .624). Children with ASD on average had a lower IQ than non-ASD children, $t(118) = 5.14$, $p < .001$. Children with ASD were given higher rates by parents than non-ASD children on the SRS scale at Time 3, $t(38.12) = 10.27$, $p < .001$. Mothers of children with ASD had lower education levels than mothers of non-ASD children, $t(81.37) = -3.66$, $p < .001$. The education levels of fathers did not differ between groups, $t(88.34) = -1.12$, $p = .268$. Families of children with ASD had lower income than families of non-ASD children, $t(91) = -5.16$, $p < .001$.

During the year 2010 and 2016, children and their parents participated the study once a year for 3 consecutive years (mean duration between Time 1 and Time 2 = 12.06 months, *SD* = 1.92; between Time 2 and Time 3 = 12.16 months, *SD* = 1.02). Children were visited once a year either at school or at the specialized institution (for ASD group only), where they finished a series of tasks under the guidance of a psychologist who had received training for administering the tasks and for coding children's behaviors. Parents provided family background information and filled out various questionnaires about their children's social and emotional development. The Ethics Committee of Leiden University and Center for Autism granted permission for the larger-scaled research project (P08.140/SH/sh). All parents provided written informed consent. Below we reported the measures that were used in the current study.

Materials

Moral emotions. At each time point, three tasks were used to provoke shame and guilt and two to provoke pride in children (Ketelaar et al., 2015). These tasks were designed based on previous research (Alessandri & Lewis, 1993; Barrett, 1995; Lewis et al., 1992). To avoid that children remembered the tasks from the last time, the content of the tasks varied each year, yet the nature of the tasks remained unchanged. During these tasks, children's reactions were rated by the psychologist who administered the tasks. All the participating psychologists followed the same script for giving instructions during the tasks. The instructions were designed to be simple and short with a minimal demand on language communication. The participating psychologists received intensive training on administering the tasks and coding the behaviors. They had achieved a suitably high inter-rater reliability before they went to

work independently on coding their participants' behaviors. Besides, the first author of this study took a random selection of 10% participants (9 children with ASD and 7 non-ASD children) and rated their behaviors from video recordings. Cohen's kappa ranged from 0.91 to 1.00, showing good agreement between the two raters. Although there was disagreement on a few individual items, the mean scores calculated from the ratings of the first rater did not differ from the mean scores calculated from the ratings of the second rater. Therefore, the original ratings were reported and used in the current study.

Table 1: Demographic characteristics of participants: means (standard deviations) of background variables.

		Total participants at Time 1 N = 142			
		ASD	N	**Non-ASD**	N
			52		90
Age in months	Time 1	66.90 (13.19)	49	63.80 (16.54)	79
	Time 2	80.67 (11.80)	46	76.22 (16.03)	82
	Time 3	93.07 (11.83).	40	88.38 (15.77)	71
Male%		88.5%	52	85.6%	90
IQ*		98.51 (16.63)	45	113.57 (14.88)	75
SRS T score at Time 3*		78.23 (15.77)	31	47.28 (7.59)	54
Education mother[a*]		3.90 (1.10)	49	4.57 (0.79)	70
Education father[a]		3.81 (1.33)	48	4.01 (1.03)	48
Net annual income[b*]		2.94 (1.21)	31	4.15 (0.99)	62

[a] Parental education level: 1 = no/primary education; 2 = lower general secondary education; 3 = middle general secondary education; 4 = higher general secondary education; 5 = college/university. [b] Net household income: 1 = less than €15,000; 2 = €15,000 – €30,000; 3 = €30,000 – €45,000; 4 = €45,000 – €60,000; 5 = more than €60,000. * $p < .001$

In the shame/guilt-provoking tasks, the child was made believe that either he or she had misbehaved (e.g., having damaged a property of the experimenter), or he or she had failed a task which was supposed to be easy to accomplish (e.g., failing to copy a drawing). One and the same pre-designed checklist which consisted of 11 items was used to rate children's reactions during each task on a three-point scale (0 = not at all, 1 = a little, 2 = a

lot), which coded the occurrence of reactions such as “negative response to the situation”, “looking away from the experimenter”, “looking down”, “frowning”, “facial expressions changing towards negative”, “collapsed body”, “pouting”, etc. (Ketelaar et al., 2015). The final score of shame/guilt expression of a child was calculated by averaging the scores the child received from the three shame/guilt-provoking tasks. The original scale showed acceptable to satisfactory reliabilities across time for the two groups except for the reliability of the ASD group at Time 2 ($\alpha = 0.63$). A closer examination showed that two items of the checklist (“fidgeting on the face”, and “showing repairing behaviors”) had poor fit and thus were removed. The final scale showed improved reliabilities across time for both groups (non-ASD: $0.79 \leq \alpha \leq 0.83$; ASD: $0.71 \leq \alpha \leq 0.97$; measure reliabilities at three time points were reported in Supplementary Table 2).

The pride-provoking tasks succeeded the shame/guilt-provoking tasks, where the child was given a second chance to finish the tasks that he had just failed. For example, the child was asked to copy the drawing again and this time received positive feedback from the experimenter. The pride-provoking tasks were arranged directly after the shame- and guilt-provoking tasks for two reasons: first, to assure children that they had not done anything wrong and to show them that the final outcome was positive. Second, letting children fail at the first time was to prime them with the belief that the task was difficult to accomplish. When children accomplished the task at the second try, this was supposed to provoke pride in them. A separate checklist for pride consisting of 7 items on a three-point scale (0 = not at all, 1 = a little, 2 = a lot) was used to code children’s reactions during the pride-provoking tasks, such as “positive response to the situation”, “uplifted chin”, “smiling/laughing”, “eye contact with the experimenter”, “erect posture”, etc. (Ketelaar et al., 2015). The final score of pride expression of a child was calculated by averaging the scores the child received from the two tasks. The scale showed satisfactory reliability across time for both groups (non-ASD: $0.78 \leq \alpha \leq 0.81$; ASD: $0.79 \leq \alpha \leq 0.88$).

ToM. Children’s understanding of people’s thoughts was measured by false-belief tasks. At each time point, a task adapted from the Sally-Anne task (Baron-Cohen et al., 1985) was used to measure children’s understanding of false belief (Broekhof et al., 2015; Ketelaar et al., 2012). For example, at Time 1, the experimenter told the child a story (also presented with picture illustrations) about a boy who left his toy at one location, and while he was away, a girl came in and hid his toy at another location. Later on, the boy returned and looked for his toy. Children were asked three questions about the story: 1) the test question: “Where will the

boy look for his toy?", and 2) two control questions: "Where is the toy actually?", and "Where did the boy put his toy when he went away?". Only when a child answered all three questions correctly did he or she receive a score of "1", otherwise "0". Before the testing, the experimenter had checked with the child whether he or she understood the words that were used in the tasks. Like the moral-emotion tasks, the content of the false-belief tasks varied every year, but the nature of the tasks remained unchanged.

Children's understanding of peoples' emotional state was measured by parental reports. The Emotion Expression Questionnaire is a 35-item parent-report questionnaire that measures a child's emotion expressions and emotion acknowledgement (Rieffe et al., 2010). We used the Emotion Acknowledgment Scale (6 items) of the questionnaire. Parents reported the extent to which children recognized and understood happiness, anger, fear, sadness and joy in their parents (example item: "Does your child understand when you are happy?"). Parents rated each item on a 5-point scale ranging from "1 = (almost) never" to "5 = (almost) always". For both groups, the internal consistency of the Emotion Acknowledgment Scale was satisfactory across time ($\alpha \geq 0.74$).

A correlation matrix of moral emotions, age and ToM abilities at the three timepoints can be found in Supplementary Table 3.

Statistical analyses

Statistical analyses were performed using IBM SPSS Statistics for Macintosh, Version 26.0 (Armonk, NY: IBM Corp.). Figures were produced using R (R Core Team 2019) with the package ggplot2 (Wickham, 2009). First, independent *t*-tests were conducted to explore group differences in demographic characteristics and the predicting and outcome variables at the three time points. Second, Linear Mixed Models (LMMs) were used to examine how moral emotions developed with age and how ToM abilities contributed to the prediction of moral emotions over time.

LMMs have the advantages of accounting for the dependency within the longitudinal data where the data of time points are nested within the participants (Hox et al., 2017). Besides, LMMs are robust in handling missing data when they miss (completely) at random (Twisk et al., 2013). The current data had missing values at every time point. Little's MCAR tests indicated that the missing patterns could be completely at random (Time 1: $\chi^2 = 1900.72$, $df = 1983$, $p = .906$; Time 2: $\chi^2 = 794.71$, $df = 887$, $p = .988$; Time 3: $\chi^2 = 840.46$, $df = 857$, $p = .650$).

We followed a formal model-fitting procedure of LMMs, i.e., fitting increasingly more complex models to the data step by step. Simpler models with better model fit were selected over more complex model. To evaluate model fit, for nested models, the preferred model showed significant less deviance (i.e., lower values of -2 log-likelihood (-2LL)) tested by a likelihood ratio test. For non-nested models, the preferred model showed lower Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values.

To examine the developmental trajectories of moral emotions, we started with an unconditional means model which included only a fixed and random intercept. Then, age (centered around 33 months, the youngest age of all participants) was added to the model to examine how moral emotions changed over time, and diagnosis (0 = non-ASD, 1 = ASD) was added to the model to examine whether the levels of moral emotions across three times points differed between children with and without ASD. Note that while *t*-tests compared the mean of the ASD group to the mean of the non-ASD group at Time 1, 2, and 3 respectively, fitting LMM models allowed for comparing the two groups longitudinally across the three times points. Considering that the measurements took place at three time points, we examined two models of change: linear and quadratic, respectively. Third, we added the interactions between age and diagnosis to the model to examine whether the two groups differed in developmental trajectories. We also added IQ to the best age-model, but it did not improve the model fit and thus not reported here.

To explore whether ToM abilities contributed to the prediction of the levels of moral emotions over time, first, a mean variable and a change variable were created for each ToM ability. The ToM mean variables checked the between-person effects of the predicting variables, informing us whether participants who had better ToM abilities had higher levels of moral emotions. The ToM change variables checked the within-person effects of the predicting variables, informing us whether larger increases of ToM within participants contributed to higher levels of moral emotions.

The mean variable of false belief understanding ("FB (mean)" in Table 3) and the mean variable of emotion understanding ("EU (mean)") were created by averaging the scores at Time 1, 2 and 3. The change variable of false-belief understanding ("FB (change)" in Table 3) and the change variable of emotion understanding ("EU (change)") were created by subtracting the scores at each time point by the initial score at Time 1, i.e., Time 1 - Time 1, Time 2 – Time 1, Time 3 – Time 1. In the long data format, the mean variables had one value per participant across timepoints, whereas the change variables were time-varying and had three values per participant.

Then we fitted the model with only age and diagnosis as the control variables. Next, we fitted all the predicting variables (i.e., the mean score and the change score of each ToM ability) to the model. Fourth, we added the interactions of the ToM abilities (mean and change scores) with diagnosis to the model, to explore whether the groups differed in the relations. Non-significant interactions were removed during the procedure.

The above-mentioned models were first fitted with the raw scores of the predicting variables, i.e., the raw mean and change scores of false belief and emotion understanding. The unstandardized coefficients of predicting variables provide intuitive and easily interpretable information on the predicting effects. However, it is not possible to directly compare the effect sizes among different predicting variables. To check the effect sizes, we also fitted models with the standardized *z*-scores of the predicting variables. For multilevel models, the standardized coefficients of predicting variables provide a good indication of effect sizes of the fixed effects (Lorah, 2018).

Results

Table 2 shows the mean scores and standard deviations of the outcome and predicting variables at three time points. *T*-tests showed that ASD group did not differ from non-ASD group in their expressions of shame and guilt at Time 1: $t(137) = 1.74$, $p = .084$. However, ASD group displayed fewer expressions of shame and guilt at Time 2: $t(126.99) = -3.86$, $p < .001$, and Time 3: $t(114.74) = -6.94$, $p < .001$. As for pride, ASD group did not differ from non-ASD group in expressions of pride at the first two time points, but they showed less pride at Time 3: $t(116) = 3.17$, $p = .002$.

At all three time points, ASD group showed lower ToM abilities: they received lower scores of the false-belief tasks ($2.23 \leq t\text{s} \leq 4.33$, $p\text{s} < .05$), and they received lower ratings from parents on Emotion Acknowledgment Scale as compared to non-ASD group ($5.09 \leq t\text{s} \leq 7.36$, $p\text{s} < .001$).

Developmental trajectories of moral emotions. Table 3 shows the estimates of the fixed and random effects in the best fitting models for predicting the developmental trends of moral emotions.

As for shame and guilt, compared to the unconditional means model (-2LL = 82.32), adding linear age and diagnosis (-2LL = 62.58) contributed to increasing model fit ($\chi^2 = 19.74$, $df = 2$, $p < .001$). The fixed effect of linear age did not reach the significant level ($t(255.69) = .00004$, $p = .963$). The significant effect of diagnosis ($t(138.46) = -4.05$, $p < .001$) indicated

that when holding the value of age constant, children with ASD showed less shame and guilt as compared to children without ASD.

Table 2. Mean scores, standard deviations (SD) and statistics (group comparisons) of outcome and predictor variables for ASD and non-ASD group at three time points.

	ASD			**Non-ASD**				
	Mean	SD	N	Mean	SD	N	*t*-value	*p*-*value*
Shame/guilt								
Time 1	0.44	0.26	52	0.37	0.23	87	1.74	.084
Time 2	0.22	0.15	47	0.37	0.27	82	-3.86	.000
Time 3	0.18	0.19	42	0.50	0.31	76	-6.94	.000
Pride								
Time 1	0.99	0.56	50	0.93	0.43	87	0.78	.462
Time 2	1.11	0.45	47	1.11	0.43	82	-0.06	.956
Time 3	0.84	0.45	42	1.12	0.44	76	3.17	.002
False belief								
Time 1	0.37	0.49	52	0.72	0.45	90	4.19	.000
Time 2	0.62	0.49	47	0.80	0.40	82	2.36	.028
Time 3	0.66	0.48	41	0.93	0.25	76	4.09	.001
Emotion understanding								
Time 1	2.94	0.90	50	4.07	0.72	73	7.78	.000
Time 2	2.97	*0.96*	45	4.11	0.51	67	8.21	.000
Time 3	3.14	0.98	31	4.10	0.54	56	5.95	.000

To examine whether children with and without ASD differed in their developmental trajectories, the interaction of age and diagnosis was added to the model. The interaction model (-2LL = 53.22) with the fixed effects of linear age ($t(230.09) = 1.80$, $p = .074$), diagnosis ($t(278.17) = 1.53$, $p = .128$) and their interaction ($t(297.92) = -3.19$, $p = .002$) showed the best model fit: compared to the unconditional means model: $\chi^2 = 29.1$, $df = 3$, $p < .001$; compared to the model with only the main effects of age and diagnosis: $\chi^2 = 9.36$, $df = 1$, $p < .001$. While the expressions of shame and guilt did not change over time in non-ASD group ($b = .002$,

$t(230.09) = 1.80$, $p = .074$), they decreased with age in ASD group ($b = -.005$, $t(297.92) = -3.19$, $p = .002$) (see also Figure 1). In addition to the fixed effect of age, we also checked the random effect of age, which could inform us whether the age slopes varied significantly among participants. In the model for shame and guilt, adding the random effect of linear age did not contribute to a better model fit, indicating that there was no substantial slope variability.

As for the development of pride, the best fitting model was with the fixed effects of linear age and diagnosis and with a random slope of linear age (-2LL = 444.96): compared to the unconditional means model (-2LL = 478.61): $\chi^2 = 29.1$, $df = 4$, $p < .001$). None of the fixed effects was significant. The insignificant age effect ($t(115.51) = 1.68$, $p = .096$) indicates that pride did not change over time. The insignificant effect of diagnosis ($t(111.95) = -1.11$, $p = .268$) indicates that the two groups did not differ in the overall levels of pride when holding the value of age constant. Adding the interaction of age and diagnosis did not improve the model, indicating that the two groups did not differ in the overall developmental trajectories. Yet, the significant random slope of age indicated that that there were great individual differences in the developmental trends among participants (see also Fig 1).

ToM abilities and the development of moral **emotions.** To explore whether ToM abilities contributed to the development of shame and guilt, the mean and change variables of ToM were fitted to the baseline model with age and diagnosis. Although adding the ToM variables showed a significant improvement in model fit, the Hessian matrix was not positive definite, indicating redundant covariance parameters (West et al., 2007). By removing the ToM variables one by one from the full model, we found that the problem was caused by the change variable of emotion understanding. However, fitting the simpler model without the change variable of emotion understanding did not show a better model fit than the baseline model with diagnosis and age: -2LL of the baseline model was 62.58; -2LL of the simpler model without the change variable of emotion understanding was 56.36, $\chi^2 = 6.21$, $df = 3$, $p > .05$. Adding interactions of ToM variables and diagnosis did not improve the model fit either. The results showed that the mean levels and changes of ToM abilities were not related to the levels of shame and guilt in all children.

Table 3. Fixed and random effects of the best age models for moral emotions.

	Shame/guilt				Pride			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.34	.04	[.25, .42]		.94	.08	[.78, 1.10]	
Age	.002	.001	[-.0002, .004]		.003	.002	[-.001, .006]	
Diagnosis	.13	.08	[-.04, .29]		-.06	.06	[-.18, .05]	
Age*diagnosis	-.005	.002	[-.01, -.002]					
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.06	.006	[.05, .08]	10.61	.137	.02	[.11, .17]	9.47
Intercept	.005	.004	[.001, .03]	1.17	.254	.090	[.13, .51]	2.81
Age					.0001	.00005	[.0001, .0003]	2.42

NOTE. SE: standard error. CI: confidence interval.

Table 4. Fixed and random effects of the best predicting models for pride with ToM abilities as the predictors.

Fixed effects	**Raw estimates (s.e.)**	**CI [low, high]**	**Standardized estimates (s.e.)**	**CI [low, high]**
Intercept	1.11 (.21)	[.70, 1.52]	1.08 (.05)	[.99, 1.17]
Age	.003 (.002)	[-.001, .007]	.05 (.04)	[-.02, .12]
Diagnosis	-.46 (.15)	[-.77, -.16]	.01 (.08)	[-.15, .17]
FB (mean)	-.11 (.14)	[-.39, .17]	-.04 (.05)	[-.14, .06]
FB (change)	.11 (.06)	[-.02, .23]	.04 (.03)	[-.01, .10]

EU (mean)	-.03 (.05)	[-.12, .07]	-.02 (.04)	[-.10, .06]
EU (change)	-.07 (.05)	[-.18, .04]	-.04 (.03)	[-.09, .02]
Diagnosis * FB (mean)	.68 (.18)	[.32, 1.05]	.25 (.07)	[.12, .38]
Random effects	**Estimates (s.e.)**	**CI [low, high]**	**Wald Z**	
Residual	.16 (.02)	[.13, .20]	8.70	
Intercept	.03 (.02)	[.01, .09]	2.07	

NOTE. S.e.: standard error. CI: confidence interval. FB: false belief. EU: emotion understanding.

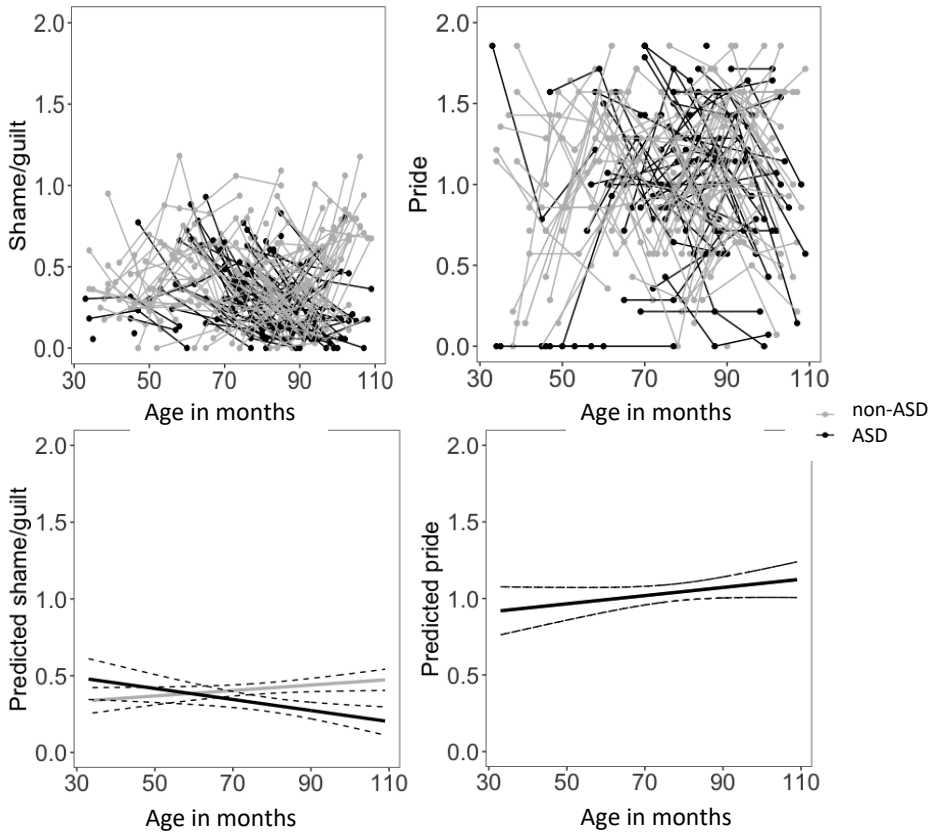

Fig 1. Upper left and right: graphic representations of the levels of shame/guilt and pride of all participants at three time points. The points were connected in lines, each line representing one participant. Participants had data at one time point are presented by points. Lower left and right: regression lines depicting predicted levels of shame/guilt and pride with 95% CI's based on the best fitting models.

As for pride, adding the mean and change variables of ToM abilities contributed to a significant improvement of the model fit: -2LL with age and diagnosis only was 453.60; -2LL when ToM variables were added was 332.23, $\chi^2 = 121.37$, $df = 5$, $p < .001$. The best fitting model showed a significant main effect of diagnosis ($t(124.03) = -3$, $p = .003$) and a significant interaction effect of diagnosis and the mean variable of false belief understanding ($t(120.05) = 3.69$, $p < .001$). The standardized coefficients for comparing the effect sizes showed that the size of the diagnosis effect was relatively small, and the interaction had the largest effect (see Table 4). While the average levels of false belief understanding were not

longitudinally associated with the development of pride in non-ASD group (b = -.11, t(147.71) = -.76, p = .448), they were longitudinally associated with an increase of pride in ASD group (b = .58, t(125.53) = 4.05, p < .001). See Table 4 for the fixed and random effects of the best predicting model for pride with unstandardized and standardized ToM predictors.

Discussion

Moral emotions keep people attuned to the society and getting along with others (Tangney et al., 2007; Muris & Meesters, 2014; Muris et al., 2016). Despite their important social functions, moral emotions are understudied in the ASD population. This longitudinal study is among the first to examine the development and contributing factors of moral emotions in young children with ASD. Our main findings are the following: First, the expressions of shame and guilt stayed stable in non-ASD children, whereas the expressions of shame and guilt decreased in children with ASD. Second, the overall trend of pride did not differ between groups and the expression of pride remained stable over time in all children. Third, ToM abilities (i.e., false belief and emotion understanding) were not associated with the expressions of shame and guilt in all children. Fourth, better false belief understanding was uniquely related to an increased expression of pride in children with ASD. Below we discuss these findings in more detail.

First, we did not find the expected age effect on the expressions of moral emotions in non-ASD children. This seems to diverge from the literature, which suggests that moral emotions develop throughout childhood. This may have to do with our focus on the expressive component of moral emotions. While past research found that children's concerns for others and their understanding of moral emotions grow with age (Bafunno & Camodeca, 2013; Kornilaki & Chlouverakis, 2004; Tracy et al., 2005), their external emotion expressions as measured in the current study may remain stable, because children's ability to regulate emotions also grow with age (Kochanska et al., 2002). When a child transgresses or misbehaves, expressing shame and/or guilt is socially expected, because it signals to others that the child is aware of the mistakes and feels regretful. Nonetheless, excessive expression of distress does not help correct the wrong or amend the relationship, and thus needs to be regulated (Tangney & Dearing, 2002). Likewise, although pride expression is expected when a child does a right thing, excessive expression of pride can distance oneself from others and harm the social relations (Kitayama et al., 2006; Oveis et al., 2010).

What is concerning, unlike non-ASD children whose shame and guilt expressions stayed stable, a decreasing trend of shame and guilt expressions was observed in children

with ASD. It should be noted that the two groups did not differ in the expressions of shame and guilt at the initial time point. However, children with ASD expressed less shame and guilt when they grew older. This decreasing trend may not be attributed to the task demand because the tasks were designed to have similar complexity and minimized language requirements at all time points, and the finding remained unchanged when IQ was controlled for. According to Stipek (1995; Stipek et al., 1992), young children first experience moral emotions in an autonomous form. Failing or accomplishing a task gives them the immediate feelings of frustration or efficacy. With age the experience of moral emotions becomes less autonomous. As children grow older, they attend more to other people's reactions, and learn that their failure or accomplishment can affect others and induce social disapproval or approval from others (Hart & Matsuba, 2007). Possibly, while the immediate frustration and distress induced by the outcomes of the tasks faded over time in all children, non-ASD children had grown a concern about how the other person would think of them. However, for children with ASD, who are known to have reduced social interest (for a review, see Chita-Tegmark (2016)), they probably did not develop the sense of relatedness with others to the same extent as non-ASD children. If children with ASD are not aware of or concerned with how other people think of them, this could compromise their experience and expression of shame and guilt. Nonetheless, it remains unclear why children with ASD showed a decreasing trend in their shame and guilt expressions. Some recent research suggested that social attention in children with ASD decreased with age (Fujioka et al., 2020). More future studies on moral emotions and the related factors in children with ASD can help us gain better understandings in this regard.

Although a group difference was found in the development of shame and guilt, as we expected and consistent with the literature (Davidson et al., 2018; Hobson et al., 2006; Kotroni et al., 2019; Losh & Capps, 2006; Tracy et al., 2011; Williams & Happé, 2010), children with ASD did not differ from non-ASD children in the levels or the developing trend of pride expressions. As mentioned before, pride may not require the same magnitude of interpersonal engagement as shame and guilt and thus it is less affected by ASD (Hobson et al., 2006). However, it should be noted that in the pride-provoking tasks, in order to elicit pride in children, the experimenter gave compliments when children finished the tasks. It could be that the positive feedback made it easier for children with ASD to interpret the experimenter's view. Yet, in the shame/guilt-provoking tasks the experimenter did not orally blame the child. Children did not receive explicit prompts informing them that their actions were being evaluated by another person, and this could present extra challenges to children

with ASD. Future studies should check whether children with ASD still express pride to the same extent as non-ASD children when the explicit social cues are absent, and vice versa, whether providing explicit social cues can help children with ASD understand people's view better and hence promote their development of moral emotions. We want to point out that, although our LMM analyses did not confirm group differences regarding the overall trend and levels of pride expressions, children with ASD showed lower levels of pride at Time 3. Follow-up research is needed to inform us whether children with ASD continue keeping up with their non-ASD peers in the development of pride, or they show a decrease in pride expression in the long run. A recent study found that adults with ASD experienced lower levels of pride than non-ASD adults (Davidson et al., 2017).

The literature has assigned an important role of ToM to the occurrence of moral emotions (Leary, 2004; Lewis, 2000). In line with this, we assumed that higher levels and larger increase of ToM abilities such as false belief and emotion understanding would contribute positively to the development of moral emotions in children both with and without ASD. This hypothesis was only partly confirmed regarding the development of pride. Better false belief understanding was related to increased expressions of pride. Note, however, this relation was found only in children with ASD. This finding mirrors previous findings that ToM was related to moral emotions in individuals with ASD whereas not in non-ASD individuals (Davidson et al., 2017; Davidson et al., 2018). A possible explanation is that while non-ASD individuals have a rich reservoir of skills to help them navigate in the social world, individuals with ASD rely more heavily on their ToM skills in social interactions (Davidson et al., 2017; Davidson et al., 2018).

To our surprise, we did not find any relations between ToM abilities and the expressions of shame and guilt. If as suggested by the literature ToM plays an important role in provoking shame and guilt, we would expect to find relatively strong associations between ToM abilities and negative moral emotions, especially in children with ASD. One possibility is that before children with ASD could use their ToM abilities to establish a self-evaluation based on other people's view, the first step is to pay attention to others and be aware that their behaviors are perceived by others. However, this first step might be hindered for children with ASD, as the shame/guilt-provoking tasks did not provide explicit cues indicating that their behaviors were evaluated by another person. This may explain why ToM had little influence on their reactions.

Nonetheless, it still remains unclear why the associations were absent in non-ASD children, who were supposed to have higher levels of social interest and better self-other

awareness. It should be mentioned that the cognitive aspect of ToM was measured only by a single false-belief task. Although this task is widely used and proven valid for measuring false belief in young children with ASD, it might be inadequate to capture the full variance of the construct. Besides, the near-ceiling effect observed in non-ASD children at Time 3 indicates that they might have acquired the first-order cognitive abilities and started developing more advanced ToM abilities (Lane et al., 2010; Liddle & Nettle, 2006). The choice of the task may partly account for the absent longitudinal association between false-belief understanding and moral emotions in this study. Likewise, the emotional aspect of ToM was measured by asking parents whether their children were able to recognize basic emotions. Social interactions in the daily life often involve multiple and complex emotional exchange. Besides, understanding other people's emotional state includes not only recognizing the emotion but also knowing what causes the emotion. A child who breaks his or her mother's favorite vase will feel ashamed or guilty only if he or she understands how this will make the mother feel and why. To understand whether and how ToM abilities relate to and influence the development of moral emotions in early childhood, especially shame and guilt, future research should consider using more comprehensive test batteries for examining ToM abilities in young children.

This study has its advantages of using a longitudinal design and examining moral emotions in an ASD sample at a young age. Nonetheless, there are also limitations, such as focusing on one aspect of moral emotions, i.e., emotion expression. Although the extent to which a child expresses an emotion is related to the extent to which the child experiences that emotion, emotion expression can be influenced by other factors such as emotion regulation. To gain a comprehensive understanding of the early development of moral emotions in children with ASD, future studies should include different informants and use multiple measurements to investigate how other aspects such as the recognition and experience of moral emotions unfold at young ages. Besides, we measured moral emotions only at the global level, without distinguishing between shame and guilt, nor between hubristic and authentic pride. Shame and guilt are a pair of negative moral emotions which often arise in the same situation and co-occur (Tangney et al., 2007). Likewise, the two types of pride are often intertwined (Tracy & Robins, 2007). We decided to examine negative and positive moral emotions at the global level, because pure and mature forms of moral emotions did not develop until middle to late childhood (Muris & Meesters, 2014; Parisette-Sparks et al., 2017), and so far there is little evidence that discrete moral emotions can be reliably distinguished in young children (Baker et al., 2012; Kochanska et al., 2002; Berti et al., 2000;

Olthof et al., 2000). Nonetheless, it would be informative to examine whether children already show higher proneness to one type of moral emotion than the other at a young age. As a hindsight, we could have refined our coding schemes by adding more items to observe children's action tendencies. For example, children who are prone to shame would display more withdrawing behaviors, whereas children who are prone to guilt would display more repairing behaviors (e.g., Bafunno & Camodeca, 2013). Well-designed parental questionnaires and interviews can also help unravel the possibly distinctive and unique development of discrete moral emotions in young children, which may have been masked when analyzing them at a global level. However, given the scarcity of research in moral emotions in young children with ASD, we consider our findings, albeit at the global level, are worth sharing and made the valuable first step towards the understanding of the topic. We should also note that this study included only children without intellectual disabilities. Caution is warranted when generalizing our findings to other ASD groups. Also, moral emotions can be heavily influenced by cultural, ethnic, or religious values (Bear et al., 2009; Furukawa et al., 2012). The outcomes of the current study were based on observations of Dutch children, which may not be simply generalized to children from other cultures. Besides, we did not control for children's language abilities. However, all the tasks were designed with minimal demand of language communication and it was confirmed before the testing that children understood all the words used in the tasks.

This study added valuable new information to the existing knowledge. Our findings showed that the development of pride in young children with ASD was on a par with non-ASD children. However, they displayed lower levels of shame and guilt than non-ASD children already at a young age and this difference enlarged over time. This is alarming given that appropriate experience and expression of shame and guilt play a crucial role in preventing behavioral problems and promoting psychosocial well-being (for a review on typically developing children, see Muris & Meesters (2014); for a review on clinically referred children, see Muris et al. (2016)). Our findings call for more attention to the early development of moral emotions in children with ASD. Importantly, given that moral emotions serve higher-order social needs and develop in interactions with the social world (Miller et al., 2019; Tracy & Robins, 2004), future research should examine how emotion socialization such as emotion communication with parents and peers, and overall how an inclusive social environment can foster the development of moral emotions in children with ASD.

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CHAPTER 4.

Towards feeling, understanding, and caring: The development of empathy in young autistic children

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ABSTRACT

Autistic children face more challenges than non-autistic children in developing empathic skills. To unravel empathy development and pinpoint the source of challenges in early childhood, this four-wave longitudinal study examined the levels and developments of four key empathy components (i.e., affective empathy, attention to others, cognitive empathy, prosocial actions) in Dutch autistic children (N = 61, M_{age} = 55 months, 89% boys), in comparison to non-autistic peers (N = 145, M_{age} = 52 months, 92% boys), using parent questionnaires and on-site observations. Compared to non-autistic children, autistic children experienced more difficulties in cognitive empathy, paid less attention to others and showed fewer prosocial actions, whereas their affective empathy was not different according to parents. Remarkably, autistic children showed great potential for developing empathic abilities. Helping them increase attention to others and improve emotion understanding can benefit their empathy development. Meanwhile, it is important for non-austistic people to enhance their understanding and interact with autistic children in a respectful and empathical way.

Introduction

Empathy is the ability to feel, understand and react prosocially towards the emotions of another person (Overgaauw et al., 2017). It is a highly valued human capacity that is crucial for maintaining social relationships and for motivating moral and compassionate behaviors (Eisenberg et al., 2010). Autism has long been associated with empathy deficits (Baron-Cohen & Wheelwright, 2004). Recent research which examined empathy as a multicomponent construct advocate that, while autistic individuals have difficulties in understanding others' emotions and thereby might be hindered from responding to others' emotions appropriately, they are not indifferent to other people's feelings (Fletcher-Watson & Bird, 2020; Smith, 2009). This multicomponent approach of empathy helps removing the negative and stereotypical view of autism (Santiesteban et al., 2020). More importantly, it facilitates identifying the unique challenges that autistic individuals face in their empathy development (Bons et al., 2013). Information in this regard obtained from early childhood can be of particular importance and benefit effective prevention and intervention (Falck-Ytter et al., 2013).

Hoping to advance our knowledge of empathy development in autistic children, this four-wave longitudinal study examined the development of four key empathy components in young autistic children aged 1 to 6 years, as compared to non-autistic peers. In addition to the commonly acknowledged affective and cognitive empathy, we also examined the extent to which autistic children knew to switch their attention from the self to the affected other, and the extent to which they displayed prosocial behaviors towards others. Furthermore, we examined how the development of empathy influenced children's psychosocial functioning.

Empathy and its development in early childhood

Empathy is a complex construct which emerges from multiple interrelated emotional and cognitive processes (Tousignant et al., 2017). Observing the emotional state of another, especially negative emotions, can induce a similar emotional state in the self ("affective empathy") (Decety & Meyer, 2008; Rieffe et al., 2020). While feeling the self being emotionally aroused, one needs to understand that the emotional state is not about the self. The attentional switch from the self to the affected other ("attention to others") marks a crucial step in the empathy process (Bird & Viding, 2014; Rieffe et al., 2010). Only when the attention is switched to interpret the information relating to another, can the individual evaluate accurately how another feels and why in that way ("cognitive empathy") (Baron-Cohen & Wheelwright, 2004; Dziobek et al., 2008). Furthermore, when one is feeling, paying attention to and understands another's feelings, they are motivated to react prosocially

(Eisenberg et al., 2010). The person is motivated to share another's pleasure or to ease another's distress ("prosocial actions").

Early childhood is the period when empathy undergoes substantial development (Davidov et al., 2013). Infants aged 6 months and above show affective concern when witnessing another in distress. Meanwhile information-seeking behaviors such as attending to another begin to emerge (Roth-Hanania et al., 2011). However, at this stage the self-other distinction is not yet fully established, therefore infants often confuse the distress of another with the distress of their own, and they can become overwhelmed by others' negative emotions (Hoffman, 2000). As children's self- and other-awareness increase with age, they become more aware that the emotional turmoil is not about themselves. The attentional switch from the self to the affected other not only facilitates better understanding of others' emotions, but also helps alleviate the distress provoked in oneself (Bird & Viding, 2014). Accordingly, longitudinal studies found that while attention to others and cognitive empathy kept growing during early childhood, affective empathy increased only slightly or remained stable (Tousignant et al., 2017; Davidov et al., 2013). With enhanced cognitive and motor abilities, children's prosocial actions increase in both quality and quantity. With age children engage more often in prosocial behaviors such as helping and comforting in response to others' distress (Flook et al., 2019; Zahn-Waxler et al., 1992).

Empathy in autistic children

While empathy seems to develop naturally and effortlessly in most typically developing children, it is more challenging for autistic children. First, decades of research provide converging evidence that autism is associated with impaired understanding of other people's minds (Baron-Cohen, 2001). Deficits in emotion understanding are observed already in the first years of life in autistic children and the problem persists into adulthood (Harms et al., 2010; Lozier et al., 2014). Correctly interpreting others' emotional states forms the core of cognitive empathy (Bons et al., 2013). Not surprisingly, lower levels of cognitive empathy are repeatedly reported in autistic children and adults as compared to non-autistic peers (e.g., Deschamps et al., 2014; Mul et al., 2018; Pouw et al., 2013).

Empathy development in autistic children can also be hindered by their diminished social attention. Reduced attention to social stimuli such as people, faces and body movements is observed in autistic individuals at different stages in life (Chita-Tegmark, 2016). Some researchers ascribed this to a diminished social motivation, positing that social interactions are less rewarding for autistic individuals, and therefore they orient less often and less spontaneously towards other people (Chevallier et al., 2012). However, this account

seems to contradict testimonies from autistic individuals, who state that they long for social interactions just as much as everyone else (Jaswal & Akhtar, 2019). Furthermore, recent behavioral and neurophysiological research found that, instead of having hypo-reactivity, autistic individuals might experience hyper-reactivity and overarousal when exposed to social stimuli such as direct gazes and emotional expressions of other people (e.g., Dalton et al., 2005; Kleinhans et al., 2010; Monk et al., 2010). It is proposed that autistic people avert their attention as a regulating strategy to avoid being overwhelmed by the intense social input (Markram & Markram, 2010; Tanaka & Sung, 2016).

Diminished attention to others is also reported by empathy research on autistic children aged from 1 to 7 years (Campell et al., 2015; Corona et al., 1998; Dawson et al., 2004; Hutman et al., 2010). These studies used in vivo tasks, where children's empathic reactions to the emotional display of an adult were observed and evaluated. It is consistently reported that autistic children paid less attention to the affected adult than non-autistic children.

The above-mentioned studies also observed less intense emotional responses such as facial, vocal and gestural concerns in autistic children. This seems to indicate lower levels of affective empathy in autistic children. Worth noting, the findings of observational studies diverge from the findings of studies using parent reports (Hudry et al., 2009; Deschamps et al., 2014) and self-reports (Dziobek et al., 2008; Mul et al., 2018; Pouw et al. 2013; Santiesteban et al., 2020), which reported no group differences in affective empathy. Possibly, the presence of an adult stranger, which is usually the case in observational studies, induces a lot of stress and thus disrupts the empathy process in autistic children (Corbett et al. 2014; O'Connor et al., 2019). Intact affective empathy of autistic children and adults is further supported by evidence from neurophysiological research, which reported that when their attention to the social stimuli was maintained, autistic individuals showed comparable or even higher levels of physiological arousals and brain activations related to empathy (Dijkhuis et al., 2019; Fan et al., 2014; Hadjikhani et al., 2017; Trimmer et al., 2017).

Whereas affective empathy may stay intact in autistic children, their deficient cognitive empathy and reduced social attention can hinder them from reacting properly and prosocially towards others, leading to the impression that they are unempathetic (Fletcher-Watson & Bird, 2020). Not surprisingly, most studies reported fewer prosocial actions in autistic children than non-autistic children (e.g., Hudry et al., 2009; Russell et al., 2013). Two studies did not find group differences, which evaluated children's prosocial reactions to the emotional display of parents (McDonald & Messinger, 2012) and of a virtual player in

computerized tasks (Deschamps et al., 2014). Possibly, compared to the social demand of reacting to an adult stranger, it is less stressful for autistic children to react to parents and a virtual player.

As discussed so far, empirical evidence gathered from cross-sectional studies shows that autistic children do not lack the ability to feel for others, and yet they have difficulties in understanding, attending and reacting appropriately towards others. The challenges are present already in early childhood. Some problems seem to persist into adulthood. Albeit very informative, the cross-sectional nature of these studies precludes an evaluation of the developmental course of empathy in autistic children. To date, only a few longitudinal studies checked the development of some empathy components in young autistic children. First, regarding affective empathy, a stable trend in a short term of six months (McDonald & Messinger, 2012; Zantinge et al., 2018) and an increasing trend in a long term of three years (Hutman et al., 2010) have been reported in autistic toddlers. Besides, attention to others and prosocial actions are observed to increase in autistic children (Hutman et al., 2010; Zantinge et al., 2018; McDonald & Messinger, 2012; Russell et al., 2013). To our best knowledge, no empathy research has examined the development of cognitive empathy in autistic children. Indirect evidence comes from research on emotion understanding and Theory of Mind, both reporting age-related improvements in autistic children (e.g., Rosen & Lerner, 2016; Steel et al., 2003). It is reasonable to assume that autistic children's cognitive empathy also improves with age. However, the fact that autistic children still lag behind in emotion understanding at older ages and this gap is widening from early childhood to adolescence and adulthood suggests that the magnitude of improvement in autistic children is less than in non-autistic children (Harms et al., 2010; Lozier et al., 2014).

Present study

This study aimed to investigate the presence and developments of four empathy components (affective empathy, attention to others, cognitive empathy and prosocial actions) in autistic children aged 1 to 6 years, as compared to non-autistic peers. Furthermore, given that the associations between empathy development and positive psychosocial outcomes are well established in typical development (for reviews, see Eisenberg et al. (2010) and Jolliffe & Farrington (2004)), we wanted to examine whether the same associations existed in autistic children.

Prior research showed that autistic children were viewed as more empathic by parents than experimenters in observational tasks. While parents' insight is based on long-term and close observations, the evaluation from observational tasks provides information about how

autistic children react in real daily situations and how their reactions are perceived by non-autistic people other than parents. Considering that any single measure provides only a partial assessment of the underlying construct and can limit the explanatory power of the results (Kienbaum, 2014), we assessed empathy using both parent questionnaires and observational tasks. We asked parents to evaluate the levels of all four empathy components in their children. In the observational tasks the experimenter acted out three emotional episodes, i.e., pretending to be happy, angry and in pain, and observed the reactions of the children. Since it was difficult to incorporate a test of cognitive empathy during the acting-outs, only affective empathy, attention to others and prosocial actions were measured in the observational tasks.

Based on the former discussed literature, the following hypotheses were tested in the current study. We expected autistic children to have lower levels of cognitive empathy, pay less attention to others, display fewer prosocial actions than non-autistic peers, and the group differences would be maintained over time. Regarding affective empathy, we expected that the experimenters would evaluate autistic children as showing less affective empathy in the observational tasks whereas parents would report equivalent levels of affective empathy of autistic and non-autistic children.

Regarding the developmental trajectories of empathy components, for non-autistic children, we expected their affective empathy to either show a small increase or remain stable, and that their attention to others, cognitive empathy and prosocial actions would increase with age. Due to the limited evidence from longitudinal data of autistic children, our hypotheses regarding their developmental trajectories were explorative in nature. We expected autistic children to show similar developmental trajectories of affective empathy, attention to others and prosocial actions as their non-autistic peers. As for cognitive empathy, we expected it to increase in autistic children but the increase would be of a smaller magnitude than in non-autistic children.

We also explored the extent to which empathy as a compound contributed to the development of autistic children's psychosocial functioning. We expected that, similar as in non-autistic children, a higher level and an improvement of empathy would contribute to the prediction of decreased externalizing problems and increased social competence in autistic children.

Methods

Participants and procedure

This study was part of a larger-scaled longitudinal research in the Netherlands on the social and emotional development of preschool children with limited access to the social world, including children with hearing loss, with developmental language disorder and with autism. The total sample of the larger-scaled research included 73 autistic children (65 boys) and 418 non-autistic children (226 boys). Autistic children met the following inclusion criteria: the child received an autism diagnosis according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., *DSM-IV-TR*, American Psychiatric Association, 2000), backed up by the *Autism Diagnostic Interview-Revised* (Lord et al., 1994) set by a qualified child psychologist or psychiatrist at Time 1; the parent confirmed three years later that the child retained the autism diagnosis; the child had IQ scores above 70 and no additional *DSM-IV-TR* diagnoses. Inclusion criteria for non-autistic children were IQ scores above 70 and no *DSM-IV-TR* diagnoses.

Autistic children were recruited via a specialized institution for diagnosis and treatment of autism (Center for Autism, Leiden, The Netherlands). Non-autistic children were recruited from day-care centers and mainstream schools in the same region. Since the IQ profiles of autistic children were either retrieved from school or collected by the institution, various intelligence tests were used, including the Snijders-Oomen Nonverbal Intelligence Tests (SON-R), Wechsler Intelligence Scale for Children, Wechsler Preschool and Primary Scale of Intelligence, and Wechsler Nonverbal Scale of Ability. Non-autistic children were tested with the SON-R.

The Ethics Committee of Leiden University and Center for Autism granted permission for the larger-scaled research project. All parents provided written informed consent. Children and their parents participated the research once a year for four consecutive years (mean duration between Time 1 and Time 2 = 13.15 months, *SD* = 3.31; between Time 2 and Time 3 = 12.13 months, *SD* = 1.58; between Time 4 and Time 3 = 12.37, *SD*=1.06). Children were visited either at school or at the specialized institution (for the autistic group only), where they finished a series of tasks under the guidance of a psychologist who had received training for administering the tasks and for coding children's behaviors. Parents filled out questionnaires to report on their children's development. The Social Responsive Scale (SRS; Constantino & Gruber, 2005) were filled out at Time 1, Time 3 and Time 4, where parents reported on the degree of their children's autistic symptomatology. It consists of 65 items with responses on a 4-point scale, where higher scores indicated greater severity

of autistic traits. First, raw total scores were calculated. Then the raw scores were converted to T-scores according to the Dutch SRS manual (Roeyers et al., 2011).

Due to time constraints, not all children were administered the full battery of tasks. Participants of the larger research project were included in this study if they had data of the examined variables on at least one time point (see Supplementary Table 1, 2 and 3 for available data at each time point). The final sample included 61 autistic children (7 girls; aged 21 to 72 months at Time 1) and 145 non-autistic children (11 girls; aged 21 to 71 months at Time 1).

Table 1 shows the descriptive characteristics of the two groups. The autistic and non-autistic group did not differ in gender distribution (χ^2 (1) = 0.81, p = .367) or age (1.21 < ts < 1.74, ps > .05). Autistic children on average had a lower IQ than non-autistic children (t(83.22) = 2.21, p = .03). Autistic children scored higher on the SRS scale than non-autistic children at Time 1(t(37.87) = 11.21, p < .001), Time 3 (t(63.63) = 9.09 , p < .001), and Time 4 (t(48.19) = 9.51, p < .001). Mothers of autistic children had lower education levels than mothers of non-autistic children (t(95.04) = 3.03, p = .003). The education levels of fathers did not differ between groups (t(89.95) = 1, p = .32). Families of autistic children had lower income than families of non-autistic children (t(130) = 3.64, p < .001).

Materials

Empathy. Two parent questionnaires were used to measure empathy. The Empathy Questionnaire (EmQue; Rieffe et al., 2010) asks parents to evaluate the extent to which their children showed affective empathy (6 items, e.g., “When another child cries, my child gets upset too”), attention to others (7 items, e.g., “When an adult gets angry with another child, my child watches attentively”), and prosocial actions (6 items, e.g., “When another child starts to cry, my child tries to comfort him/her”) over the past two months on a three-point scale: 0 = not at all applicable; 1 = a little or sometimes applicable; 2 = clearly or often applicable.

The Emotion Expression Questionnaire (EEQ; Li et al., 2020; Rieffe et al., 2010) asks parents to evaluate their children’s emotion expression and emotion acknowledgement. To measure cognitive empathy, we used the subscale “Emotion acknowledgment” (6 items), where parents reported the extent to which their children recognized and understood happiness, anger, fear, sadness and joy in their parents (e.g., “Does your child understand when you are happy?”) on a 5-point scale (ranging from “1 = (almost) never applicable” to “5 = (almost) always applicable”).

Table 1: Demographic characteristics of participants: means (standard deviations) of background variables

		Total participants at Time 1 N = 206			
		Autistic	N 61	**Non-autistic**	N 145
Age in months	Time 1	55.49 (12.64)	61	52.16 (12.50)	145
	Time 2	66.90 (13.19)	49	66.57 (13.48)	51
	Time 3	80.67 (11.80).	46	77.54 (13.29)	48
	Time 4	93.38 (11.83)	40	88.95 (13.37).	41
Male%		88.5%	54	92.4%	134
IQ*		99.08 (16.46)	50	105.14 (11.03)	59
SRS T score	Time 1**	75.13 (11.42)	40	46.92 (6.32)	13
	Time 3**	72.92 (20.40)	51	45.21 (7.33)	47
	Time 4**	78.23 (15.77)	31	47.06 (9.16)	31
Education mother[a*]		3.82 (1.13)	52	4.43 (0.87)	48
Education father[a]		3.79 (1.28)	53	4.03 (0.96)	39
Net annual income[b**]		2.96 (1.11)	43	3.74 (1.19)	89

[a] Parental education level: 1 = no/primary education; 2 = lower general secondary education; 3 = middle general secondary education; 4 = higher general secondary education; 5 = college/university.

[b] Net household income: 1 = less than €15,000; 2 = €15,000 – €30,000; 3 = €30,000 – €45,000; 4 = €45,000 – €60,000; 5 = more than €60,000.

* $p < .05$ ** $p < .001$

In addition to parent questionnaires, three Empathy Observational Tasks (EMT; Ketelaar et al., 2013; Rieffe et al., 2010) were administered to evaluate children's empathic responses to the emotional display of the experimenter. The EMT and their coding schemes were designed based on the classical empathy task developed by Zahn-Waxler and colleagues (1992) for measuring empathic responses in toddlers and preschoolers. At each time point, the experimenter acted out three emotional episodes, where he or she pretended to be happy (e.g., clicking a pen and meanwhile laughing aloud), angry (e.g., being mad at a pen which did not write), and in pain/distress (e.g., hurting a finger when closing a folder). Following

each acting-out performance, children's reactions were rated using a three-point scale (0 = not at all applicable; 1 = a little or sometimes applicable; 2 = clearly or often applicable). The coding schemes consist of three scales: (1) affective empathy (6 items; e.g., "The child shows similar emotions as the experimenter"), (2) attention to others (6 items; e.g., "The child stops playing and looks at the experimenter"), and (3) prosocial actions (4 items, not for the happy-emotion episodes; e.g., "The child tries to help").

To avoid that children remembered the tasks from the previous time, the content of the tasks varied at each time point, yet the nature of the tasks remained unchanged. Children's reactions were rated by the psychologist who administered the tasks. All the participating psychologists had received intensive training on administering and coding the behaviors. They had achieved a high inter-rater reliability during practice before they went to work independently. Besides, one author took a random selection of 10% participants (6 autistic children and 14 non-autistic children) and rated their behaviors from video recordings. The interrater agreements were good (Time 1: $.80 < k < 1.00$; Time 2: $.84 < k < 1.00$; Time 3: $.81 < k < 1.00$; Time 4: $.81 < k < 1.00$).

Psychosocial functioning. The Early Childhood Inventory-4 (ECI-4; Sprafkin et al., 2002) is a parent questionnaire designed for evaluating the psychopathological symptoms in children. The ECI-4 consists of 108 items, each item rated on a 4-point scale (from "0 = never" to "3 = very often"). The scores can be used for the screening purposes, or for indicating the symptom severity. We used the subscales "Peer conflict" (10 items), "Oppositional defiant disorder" (8 items), and "Conduct disorder" (10 items), and calculated their total mean score as the index of the severity of externalizing problems.

At the end of each testing session, experimenters completed a questionnaire that was designed for the larger-scaled research to evaluate children's performances and attitudes during the test session (Ketelaar et al., 2015). We used the subscale "Cooperation" (9 items), which evaluated the extent to which children were motivated to complete the tasks and how responsive they were to the experimenter's instructions (e.g., "The child did the task with enthusiasm and pleasure"; "The child waits for the experiment's signal to begin the task"). Items were rated on a three-point scale (0 = not, 1= sometimes, 2 = often).

Psychometric properties of the measurements. The means, standard deviations and reliabilities of the measurements were reported in Supplementary Table 1, 2 and 3. The reliabilities were examined by McDonald's ω_t. Compared to Cronbach's α, McDonald's ω-statistics are more tolerant for assumption violations and have been proven the best reliability tests for both unidimensional and multidimensional measures (Revelle & Zinbarg, 2009). The

questionnaires filled out by parents and experimenters showed satisfactory to good reliabilities across time (autistic group: $0.83<\omega_t<0.96$; non-autistic group:$0.73<\omega_t<0.95$).

The observational tasks also showed satisfactory to good reliabilities across time (autistic group: $0.71<\omega_t<0.93$; non-autistic group: $0.75<\omega_t<0.88$), except for the "Prosocial actions" scale at Time 3 (autistic: $\omega_t=0.66$; non-autistic: $\omega_t=0.55$) and at Time 4 (autistic: $\omega_t=0.64$; non-autistic: $\omega_t=0.64$). A data inspection showed that the low reliabilities were due to the little variation of the ratings of some items at Time 3 and Time 4. A decrease of reliabilities is often observed in longitudinal studies. Sample attrition can make the remaining sample more similar, and the narrowing differences of the sample can cause a decrease of the measurement reliability (Bernardi, 1998).

Statistical analyses

R (version 3.3.3; R Core Team 2019) was used to check measurement reliabilities (with the package "psych"; Revelle, 2020) and to make figures (with the package "ggplot2"; Wickham, 2009). IBM SPSS Statistics for Macintosh (version 26.0; Armonk, NY: IBM Corp.) were used to conduct Linear Mixed Model (LMM) analyses for examining the developmental trajectories of empathy and its longitudinal associations with psychosocial functioning. LMM can account for the dependency within the longitudinal data (Hox et al., 2010) and is robust in handing randomly missing data (Twisk et al., 2017). The current data had missing values at every time point. Little's MCAR tests indicated that the missing patterns could be completely at random (Time 1: $\chi^2 = 15244.44$, $df = 43995$, $p > .05$; Time 2: $\chi^2 = 4853.35$, $df = 11244$, $p > .05$; Time 3: $\chi^2 = 5184.55$, $df = 19163$, $p > .05$; Time 4: $\chi^2 = 4407.23$, $df = 15410$, $p > .05$).

We followed a formal model-fitting procedure, i.e., fitting increasingly more complex models to the data step by step. Simpler models with a better model fit were selected over the more complex model. To evaluate model fit, for nested models, the preferred model showed significant less deviance, i.e., lower values of -2 Log Likelihood (-2LL). For non-nested models, the preferred model showed lower Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values.

To examine the developmental trajectories of empathy, we started with an unconditional means model which included only a fixed and a random intercept. Then, age (centered around 21 months, the youngest age of all participants) was added to the model. We examined two models of change: linear and quadratic, respectively. Next, group (0 = non-autistic, 1 = autistic) was added to examine if the levels of empathy differed between the two groups across time. Fourth, we added the interactions between age and group to the model to examine whether the two groups differed in developmental trajectories.

To investigate the contributing role of empathy to the prediction of psychosocial development, we first calculated the mean scores (mean of Time 1, Time 2, Time 3, and Time 4) and change scores (Time 1 - Time 1, Time 2 – Time 1, Time 3 – Time 1, Time 4 – Time 1) of empathy. Then we started with the model that had only age and group as the control variables. Next, we added empathy (means and change scores) to the model. Fourth, we added interactions of empathy with group to the model, to explore whether the groups differed in the relations. Non-significant interactions were removed during the procedure.

Results

Developmental trajectories of parent-reported empathy. The estimates of the best age models for parent-reported empathy were reported in Table 2 and Supplementary Table 4. The developmental trajectories of parent-reported affective empathy, attention to others, prosocial actions and cognitive empathy were depicted in Figure 1. For the development of parent-reported affective empathy, the best fitting model was with fixed effect of linear age ($t(323.04) = -0.001$, $p = .348$), indicating that affective empathy did not change over time. Adding group did not contribute to increasing the model fit, indicating that parents reported equivalent levels of affective empathy of the two groups. The best fitting model for parent-reported attention to others was with fixed effects of linear age ($t(346.26) = 0.91$, $p = .361$) and group ($t(173.30) = -7.13$, $p < .001$). This indicates that attention did not change over time, and autistic children paid less attention to others than non-autistic children. For parent-reported prosocial actions, the best fitting model was with fixed effects of linear age ($t(345.83) = 6.22$, $p < .001$) and group ($t(164.15) = -11.25$, $p < .001$), which indicates that prosocial actions increased with age in all children. Yet, autistic children displayed overall fewer prosocial actions than non-autistic children. For parent-reported cognitive empathy, the best fitting model was with fixed effects of linear age ($t(401) = 1.03$, $p = .303$), group ($t(401) = -1.56$, $p < .001$), and the interaction of age and group ($t(401) = 2.46$, $p = .014$). Overall, autistic children were evaluated as having lower levels of cognitive empathy. However, cognitive empathy increased with age in autistic children ($b = .013$, $t(167) = 3.07$, $p = .002$), whereas it did not change over time in non-autistic children ($b = .003$, $t(234) = 1.39$, $p = .167$).

Table 2. Fixed and random effects of the best age models for parent-reported empathy.

	Affective Empathy				**Attention to Others**			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.35	.04	[.27, .43]		1.35	.05	[1.25, 1.45]	
age	-.002	.001	[-.004, .0001]		.001	.001	[-.001, .003]	
group	-	-	-		-.42	.06	[-.54, -.30]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.05	.01	[.04, .06]	10.05	.06	.01	[.05, .07]	10.69
Intercept	.11	.02	[.08, .14]	6.81	.10	.01	[.08, .13]	7.10

	Prosocial Action				**Cognitive Empathy**			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.80	.05	[.71, .90]		3.88	.12	[3.65, 4.11]	
age	.006	.001	[.004, .008]		.003	.003	[-.002, .008]	
group	-.64	.06	[-.75, -.53]		-1.55	.21	[-1.95, -1.14]	
*age * group*	-	-	-		.01	.004	[.002, .018]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.06	.01	[.05, .07]	10.49	.51	.04	[.45, .59]	14.16
Intercept	.10	.01	[.07, .13]	6.79	-	-	-	-

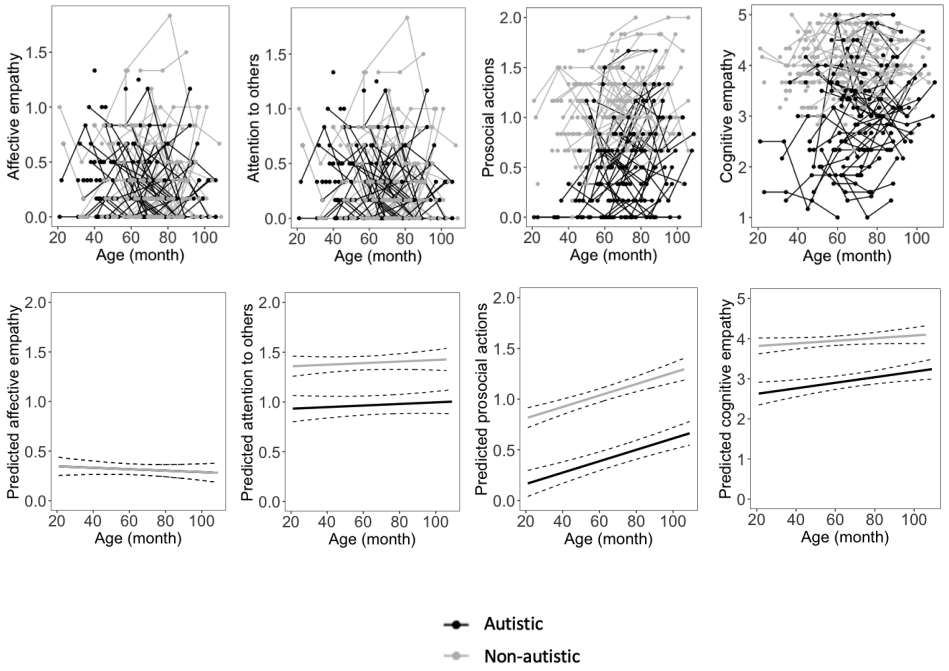

Fig 1. Developmental trajectories of parent-reported empathy. Upper from left to right: graphic representations of the levels of parent-reported affective empathy, attention to others, prosocial actions and cognitive empathy at four time points. The points were connected in lines, each line representing one participant. Participants who had data at one time point are presented by points. Lower from left to right: regression lines depicting predicted levels of parent-reported affective empathy, attention to others, prosocial actions and cognitive empathy with 95% CI's based on the best age models.

Developmental trajectories of empathy observed in tasks. The estimates of the best age models for observed empathy were reported in Table 3 and supplementary Table 4. The developmental trajectories of observed affective empathy, attention to others and prosocial actions were depicted in Figure 2. The best fitting model for observed affective empathy was with the fixed effects of linear age ($t(470.18) = 1.04$, $p = .301$) and group ($t(146.88) = -4.26$, $p < .001$), indicating that affective empathy did not change over time, and that the experimenters observed lower levels of affective empathy in autistic children than non-autistic children. The best fitting model for observed attention was with fixed effects of linear age ($t(479) = -4.14$, $p < .001$), group ($t(479) = -6.75$, $p < .001$), and the interaction of age and group ($t(479) = 3.82$, $p < .001$). Autistic children paid overall less attention than non-autistic

children to the emotional display of the experimenter. Besides, attention was decreased with age in non-autistic children (b = -.006, t(284) = -4.55, p < .001), whereas it did not change in autistic children (b = .003, t(195) = 1.39, p = .167). The best fitting model for observed prosocial actions was with fixed effects of linear age (t(430.41) = 2.54, p = .012), group (t(448.01) = -2.51, p =.013), and the interaction of age and group (t(461.29) = 2.59, p = .010). Although autistic children showed overall fewer prosocial actions than non-autistic children, prosocial actions increased in autistic children with a greater magnitude (b = .008, t(191.38) = 5.88, p < .001) than in non-autistic children (b = .003, t(252.12) = 2.43, p = .016).

Empathy and the development of psychosocial functioning. To examine the integrated effects of empathy on the development of children's psychosocial functioning, three compound scores of empathy were calculated. First, we calculated the total mean of the EmQue, which included affective empathy, attention to others, and prosocial actions. Second, to incorporate cognitive empathy, we combined the EmQue and the Emotion acknowledgement scale of the EEQ. Since the former used a 3-point scale whereas the latter used a 5-point scale, to keep the more distinguished scale, we converted the 3-point-scale scores to 5-point-scale scores: 0=1 ("never applicable"), 1=3 ("sometimes or often applicable"), 2=4 ("often applicable"), and calculated the total mean of the items of the two questionnaires combined. Third, we calculated the total mean of the empathy observation tasks, which included affective empathy, attention to others, and prosocial actions.

Three separate LMM analyses were run to fit the three empathy compound scores to the models respectively and the results were similar (see Table 4 and Supplementary Table 5 for the estimates of the best predicting models). The best predicting models for externalizing problems were with the fixed effects of age (-7.67 < ts < -6.99, ps < .001), group (5.29 < ts < 6.44, ps < .001), the mean levels of empathy (-0.14 < ts < .55, ps > .05), and the change levels of empathy (-3.35 < ts < -2.36, ps < .05). This indicates that externalizing problems decreased with age in both groups, autistic children showed overall more externalizing problems than non-autistic children, and for all children increased empathy was associated with decreased externalizing problems. As for social competence, the best predicting models were with fixed effects of age (5.03 < ts < 5.19, ps < .001) and group (-9.06 < ts < -3.79, ps < .001), indicating that social competence increased with age in all children, and autistic children had lower social competence than non-autistic children. While the change level of observed empathy contributed to increased social competence in non-autistic children (b = 0.29, t(282.86) = 3.55, p < .001), the mean levels of observed and parent-reported empathy

(0.34 < *b*s < 0.78, 3.58 < *t*s < 7.55, *p*s ≤ .001) contributed to increased social competence in autistic children.

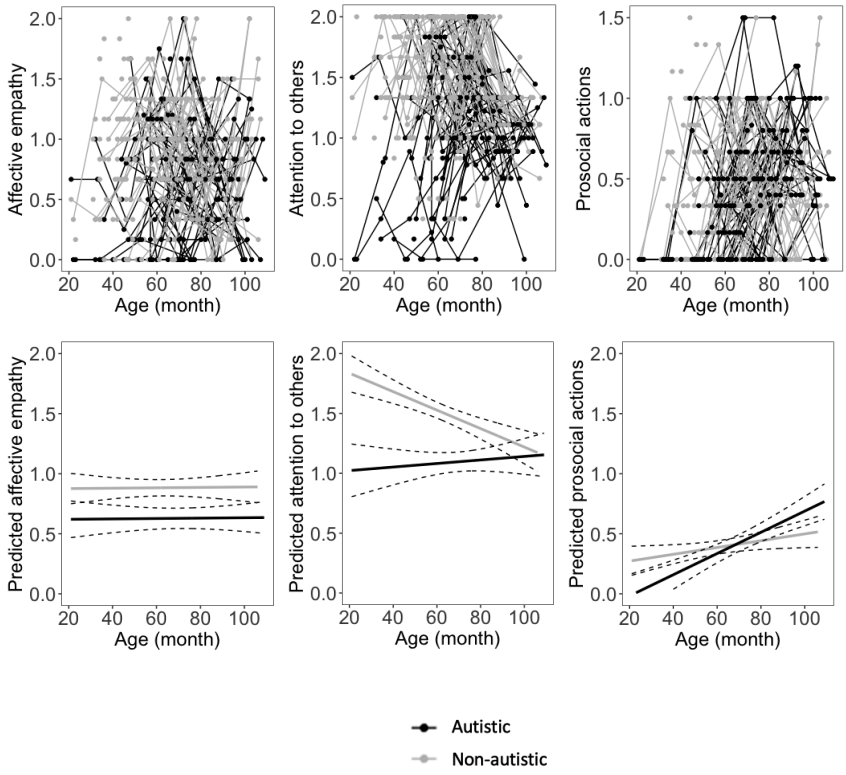

Fig 2. Developmental trajectories of empathy observed in tasks. Upper from left to right: graphic representations of the levels of observed affective empathy, attention to others and prosocial actions at four time points. The points were connected in lines, each line representing one participant. Participants who had data at one time point are presented by points. Lower from left to right: regression lines depicting predicted levels of observed affective empathy, attention to others, and prosocial actions with 95% CI's based on the best age models.

Table 3. Fixed and random effects of the best age models for observed empathy.

	Affective empathy				**Attention to others**				**Prosocial actions**			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.81	.06	[.69, .92]		1.73	.07	[1.60, 1.87]		.26	.06	[.16, .37]	
age	.001	.001	[-.001, .004]		-.006	.001	[-.009, -.003]		.003	.001	[.001, .005]	
group	-.23	.06	[-.34, -.13]		-.79	.11	[-1.02, -.56]		-.24	.09	[-.42, -.05]	
*age * group*	-	-	-		.009	.002	[.004, .013]		.005	.002	[.001, .008]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.17	.01	[.15, .20]	11.94	.21	.01	[.19, .24]	15.48	.11	.01	[.09, .13]	12.08
Intercept	.05	.01	[.03, .09]	3.57	-	-	-	-	.02	.01	[.01, .05]	3.00

Table 4. Fixed and random effects of the best empathy models for predicting psychosocial functioning.

Externalizing problems												
	Parent-reported empathy (without cognitive empathy)				**Parent-reported empathy (with cognitive empathy)**				**Observed empathy**			
Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	.61	.10	[.42, .80]		.68	.07	[.34, 1.02]		.69	.09	[.51, .88]	
age	-.007	.001	[-.008, -.005]		-.007	.001	[-.008, -.005]		-.007	.001	[-.009, -.005]	
group	.35	.06	[.23, .46]		.33	.06	[.21, .46]		.35	.05	[.24, .46]	
Memp	.05	.09	[-.13, .24]		-.008	.06	[-.12, .10]		-.03	.09	[-.20, .14]	
Cemp	-.22	.09	[-.41, -.04]		-.21		[-.33, -.09]		-.17	.06	[-.29, -.06]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald's Z**
Residual	.06	.01	[.05, .07]	9.70	.06	.01	[.05, .07]	9.79	.06	.01	[.05, .07]	9.83
Intercept	.07	.01	[.05, .09]	5.55	.07	.01	[.05, .09]	5.62	.07	.01	[.01, .05]	5.80
Social competence												
	Parent-reported empathy (without cognitive empathy)				**Parent-reported empathy (with cognitive empathy)**				**Observed empathy**			

Fixed effects	**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**		**Estimates**	**SE**	**CI [low, high]**	
Intercept	1.58	.12	[1.34, 1.82]		1.50	.24	[1.02, 1.98]		1.49	.09	[1.32, 1.66]	
age	.005	.001	[.003, .007]		.005	.001	[.003, 007]		.005	.001	[.003, .007]	
group	-.73	.14	[-1.02, -.44]		-1.10	.29	[-1.67, -.53]		-1.02	.11	[-1.24, -.80]	
Memp	.007	.12	[-.23, .25]		.03	.08	[-.13, .19]		.09	.08	[-.08, .25]	
*Memp*group*	.60	.17	[.26, .95]		.33	.11	[.12, .54]		.93	.13	[.67, .1.20]	
Cemp	-.09	.10	[-.29, .11]		-.02	.06	[-.13, .10]		.35	.09	[.18, .52]	
*Cemp*group*	-	-	-		-	-	-		-.32	.12	[-.55, -.09]	
Random effects	**Estimates**	**SE**	**CI [low, high]**	**Wald ’s Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald ’s Z**	**Estimates**	**SE**	**CI [low, high]**	**Wald ’s Z**
Residual	.08	.01	[.06, .09]	10.65	.08	.01	[.07, .09]	10.66	.08	.01	[.07, .10]	12.04
Intercept	.05	.01	[.03, .07]	4.83	.05	.01	[.03, .07]	4.68	.03	.01	[.02, .05]	3.98

NOTE. Memp=Mean levels of empathy; Cemp = Change levels of empathy.

Discussion

To our knowledge, this four-wave longitudinal study is the first simultaneously addressing the four key components of empathy and their developments in young autistic children, using parent reports and on-site observations. Consistent with the literature, autistic children were evaluated by their parents as having equivalent levels of affective empathy, whereas they were evaluated in the observational tasks as showing less affective empathy than non-autistic peers. Besides, parents reported lower levels of cognitive empathy in autistic children, and they were evaluated by both parents and experimenters as paying less attention to another's emotions and showing fewer prosocial actions than non-autistic peers. Our findings agreed with the few existing longitudinal studies that affective empathy remained stable whereas cognitive empathy and prosocial actions increased with age in autistic children. Regarding attention to others, instead of showing age-related increases as suggested by the literature, we did not find any age effect in autistic children. Furthermore, the developmental trajectories of cognitive empathy, attention to others and prosocial actions differed between autistic and non-autistic children. While cognitive empathy increased in autistic children, it remained stable in non-autistic children. Also, while autistic children maintained their attention to the experimenter in the observational tasks, non-autistic children's attention was observed to decrease with age. Remarkably, autistic children showed a greater increase of prosocial actions towards the experimenter than non-autistic children. In line with the literature, we found that higher levels and improvements of empathy were associated with better psychosocial outcomes in both groups.

First, consistent with previous findings and as we expected, parents evaluated autistic children as having more affective empathy than experimenters in the observational tasks. The social demand of interacting with an adult stranger in the observational tasks can be very taxing for autistic children and thus disrupt their empathy process (Corbett et al. 2014; O' Connor et al., 2019). On the other hand, parents' observations were based on their daily interactions with their child and the interactions of their child with other children. These situations were more relaxing and could invite more emotional responses from autistic children. It is also possible that autistic children were emotionally more involved with their parents and acquainted peers than adult strangers, and thus their emotions resonated more with these familiar agents (Pierce & Redcay, 2008; Shanok et al., 2019). It should be noted that the moderating effect of agent familiarity on empathic concerns was observed not just in autistic children but also in non-autistic children (Hudry & Slaughter, 2009). Our finding that non-autistic children still showed more affective empathy towards the experimenter indicates

that autistic children might be more vulnerable to unfamiliar situations. It should also be mentioned that in observational tasks autistic children's emotional experiences could be underestimated given their atypical emotional expressions (Brewer et al., 2016; Sheppard et al., 2016), whereas parents of autistic children might be more sensitive to detect the feelings of their children due to their long-term and close interactions with their children. It is beyond the scope of the current study to identify which factors explain the incongruence between the evaluations of parents and the observational tasks.

We confirmed the literature on the challenges in cognitive empathy and other-oriented attention in autistic children. Cognitive empathy constitutes a crucial part of empathy, as understanding how the other feels is the prerequisite for reacting empathetically and appropriately (Baron-Cohen & Wheelwright, 2004; Dziobek et al., 2008). For autistic children, not understanding the emotions of another while being exposed to that person's emotional display can be very stressful. To cope with the stress, autistic children may switch their attention away, i.e., "out of sight, out of mind" (Markram & Markram, 2010; Tanaka & Sung, 2016). Although not looking at the emotional stimuli might be relieving at the moment, in the long run it is detrimental to children's social and emotional development. A vicious circle can be formed, where impaired emotion understanding propels autistic children to avoid attending to others' emotions; this hinders them from learning about emotions, which in turn leads to future and further avoidance of the emotional stimuli.

Also, in line with the literature, autistic children displayed fewer prosocial actions in response to others' emotional display. In order to take prosocial actions, one needs to correctly interpret the emotional state of another and infer what the other person needs in such a situation. This can be very challenging for autistic children considering their struggles in perspective-taking and in cognitive empathy (Dunfield et al., 2019). The situation can be even worsened if they do not attend to the emotional stimuli. After all, if an autistic child does not pay attention to the situation and does not understand what is needed from them, how can we expect the child to react prosocially and appropriately?

Despite the difficulties and challenges, autistic children showed great improvements in cognitive empathy and prosocial actions, both increasing with age. What is unexpected, cognitive empathy did not increase in non-autistic children. Considering that we only asked parents to report on their children's understanding of basic emotions, the lack of age effect in non-autistic children could be due to the fact that they already had a good knowledge of basic emotions at such young ages (Widen & Russell, 2008), and hence there was little space for improvement. On the other hand, autistic children were still developing their understanding of

basic emotions. As for prosocial actions, like non-autistic children, autistic children showed age-related increase. Remarkably, their prosocial actions towards the experimenter in the observational tasks increased more sharply than non-autistic children. This again supports our assumption that autistic children did have the motivation to help others, otherwise we would not expect to observe any increase here.

As we expected, affective empathy remained stable in both groups. Whereas appropriate levels of affective empathy and emotional concern are crucial for motivating prosocial and compassionate actions towards others, excessive personal distress can disrupt the empathy process and make the person absorbed in self-concern. The finding that children's affective empathy did not increase with age may reflect their enhanced ability to distinguish between self-distress and the distress of others (Hoffman, 2000). It may also have to do with their improved ability to regulate emotional arousals (Tousignant et al., 2017). It is remarkable to find that, like non-autistic peers, autistic children were able to keep their emotional arousals in control, and meanwhile showing improved cognitive empathy and increased prosocial actions. Contrary to our expectation that children's attention to others would increase with age, we found no age effect on parent-reported attention to others, and non-autistic children's attention in the observational tasks actually dropped from Time 1 to Time 4. Possibly, with age children became more proficient in evaluating others' emotions, and thus there was no need to spend more time looking at the emotional display. Their attention may even decrease if the situation becomes increasingly easier for them to process, which might be the case for non-autistic children in the observational tasks. However, it probably still required many efforts from autistic children to process the emotional information, and thus their attention was maintained over time.

In our study, we also examined the integrated effects of empathy on the development of children's externalizing problems and social competence. In line with the literature (e.g., Li et al., 2020), we found that autistic children had more externalizing problems and lower social competence than non-autistic children. Yet, they showed age-related improvements as their externalizing problems decreased and social competence increased over time. Importantly, our findings added to the extent literature that not only for non-autistic children, but also for autistic children, empathy is a protective factor against the development of externalizing problems and facilitates the development of social competence.

This study has the advantages of examining an autistic sample at a young age and using a multicomponent and multimethod approach to investigate the early development of empathy. Nonetheless, there are also limitations. First, cognitive empathy was measured only

by a parent questionnaire, which evaluated the extent to which children understood their parents' experiences of basic emotions. In daily life, social interactions involve multiple and complex emotional exchanges with not only parents but also peers and other adults. To capture the full picture of children's development of cognitive empathy, future research should use multiple informants and examine not only basic emotion understanding but also the understanding of complex emotions and mental states. Another limitation is that affective empathy was measured only by the subjective evaluations of parents and experimenters. To increase the reliability, future research could add physiological measurements such as heart rates and skin conductance to the experimental paradigm. Third, the autistic sample included in this study did not have intellectual impairments, and these children and their parents participated in rehabilitation programs for autism. Caution is warranted when generalizing our findings to other autistic groups.

Despite the limitations, the current study advanced our knowledge of empathy development in young autistic children. Empathy is a multicomponent construct. To make this complex machine run, all the components must function well and work closely. Any problem in any link will affect children's ability to empathize. Our study identified autistic children's struggles in cognitive empathy, other-oriented attention and prosocial actions. These difficulties were present already at young ages and persisted over time. Nonetheless, autistic children did not lack the capacity to feel for others and they showed great potential for developing empathic abilities. We suggest that future supporting programs can focus more on helping autistic children increase their attention to emotional stimuli and help them improve emotion understanding. Meanwhile, it is vital to inform non-autistic people about the differences, enhance their awareness of autism and encourage them to interact with autistic children in a respectful and empathic way. This will not only benefit empathy development but will also contribute to more positive psychosocial outcomes in autistic children.

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5

CHAPTER 5.

Emotional functioning and the development of internalizing and externalizing problems in young boys with and without autism spectrum disorder

Li, B., Bos, M.G.N., Stockmann, L., & Rieffe, C. (2020). Emotional functioning and the development of internalizing and externalizing problems in young boys with autism spectrum disorder. *Autism, 24(1), 200-210*

ABSTRACT

Children with Autism Spectrum Disorder (ASD) are at risk for developing internalizing and externalizing problems. However, information on early development of behaviour problems and the contributing role of emotional functioning in preschool children with ASD is scarce. This study collected data of boys with and without ASD (N=156; age 2 to 6 years) over three consecutive years (3 waves), about their internalizing and externalizing symptoms and emotional functioning (i.e., emotion control, recognition, and vocabulary), using parent-report questionnaires. No age effect was found on internalizing or externalizing problems for boys with and without ASD. Boys with ASD displayed more behaviour problems than their TD peers, and showed lower levels of emotional functioning. Better emotion control and improved emotion recognition were associated with a decrease in problem behaviours for boys with and without ASD, whereas improved emotion vocabulary was uniquely related with a decrease in externalizing problems in boys with ASD. Our findings suggest that boys with and without ASD showed similar developmental courses of internalizing and externalizing problems. However, lower levels of emotional functioning were already more pronounced in boys with ASD at a young age. This contributes to higher levels of behaviour problems.

Introduction

Children diagnosed with an Autism Spectrum Disorder (ASD) are at high risk for comorbid conditions including internalizing problems such as anxiety and depression, and externalizing problems such as hyperactivity and aggression (Bauminger, Solomon, & Rogers, 2010; Salazar et al., 2015). The prevalence rates of having at least one psychiatric condition in addition to their core syndrome range from 70% to 90% (de Bruin, Ferdinand, Meester, de Nijs, & Verheij, 2007; Leyfer et al., 2006; Salazar et al., 2015; Simonoff et al., 2008), about three to ten times higher than in the general population (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Comorbid internalizing and externalizing problems start early in life. Recent research reported that in preschool and elementary school children with ASD, about 67% had generalized anxiety disorder, 15% had major depressive disorder, and 29% had oppositional opponent disorder (Salazar et al., 2015). Although internalizing and externalizing problems are well recognized in mental health profiles of children with ASD, information on their developmental trajectories, especially in early childhood, is scarce (Vaillancourt et al., 2017). Furthermore, little is known about the contribution of emotional functioning to the development of internalizing and externalizing problems in young children with ASD, although this relation has been established in typically developing (TD) children (see for a review, Trentacosta & Fine, 2010). Finding out the developing trends of behaviour problems and identifying the contributing factors are crucial for effective prevention and intervention (Simonoff et al., 2008). The present three-wave longitudinal study aimed to address this gap by examining (1) the developmental trajectories of internalizing and externalizing problems in 2- to 6-year old boys diagnosed with ASD, and (2) the developmental associations between emotional functioning and these internalizing and externalizing problems in boys with ASD, as compared to their TD peers.

Previous studies examining the development of internalizing problems such as anxiety and depression in TD samples reported an increase in early childhood (Bongers, Koot, Van der Ende, & Verhulst, 2003; Carter et al., 2010; Côté et al., 2009). The increasing trend may relate to cognitive maturation. With age children develop higher levels of emotional complexity, and become more capable to predict negative events. Without adequate coping skills, this cognitive maturity can make children more vulnerable to depressive or anxious affects (Pianta & Castaldi, 1989). For externalizing problems, previous studies showed mixed findings, reporting either a stable or decreasing pattern in the majority of TD children (Bayer et al., 2012; Fanti & Henrich, 2010; Miner & Clarke-Stewart, 2008; Olson, Choe, & Sameroff, 2017). The discrepancy may be due to the fact that different studies included

different externalizing symptoms. While all included aggressive behaviours, some also included other symptoms such as inattention, hyperactivity or emotion dysregulation.

As for the development of internalizing and externalizing problems in young children with ASD, only a few studies are available, and their findings are mixed. Cross-sectional studies comparing toddlers and preschoolers to school-aged children found an increasing trend of anxiety in children with ASD (Davis III et al., 2011; Vasa et al. 2013). This is congruent with the findings in TD children (e.g., Carter et al., 2003). To our knowledge, only one longitudinal study exists, using the Child Behaviour Check List (CBCL, Achenbach & Rescorla, 2000) for the broadband of internalizing and externalizing problems in 3- to 5-year-old children with ASD. The majority of children showed a low starting level and a declining trend for both domains (77% for internalizing and 87% for externalizing problems). Others showed however high starting levels, but the symptoms remained stable (Vaillancourt et al., 2017). While the developmental trajectory of externalizing problems reported by Vaillancourt e al. (2017) is congruent with the findings in TD children, the results of internalizing problems differ from others. This is probably because they have examined not only anxiety but also other internalizing symptoms. It should be noted that neither the cross-sectional studies nor the longitudinal study included a control group, so we cannot directly compare children with ASD to TD peers.

In TD children, the development of internalizing and externalizing problems are associated with deficits in emotional functioning (e.g., Hill, Degnan, Calkins, & Keane, 2006; Keenan, 2000). “Emotional functioning” is an umbrella term that covers various intertwined abilities of children’s overall capacity to deal with emotion-provoking situations. Three pivotal abilities that children need to learn from early on are: how to keep their emotional arousal at an optimal level for achieving social and personal goals (emotion control); how to read and interpret others’ emotions for maintaining good interpersonal relationships (emotion recognition); and how to monitor and communicate their own and others’ emotional experiences with the adequate emotion labels (emotion vocabulary).

Emotions are functional. They prepare us to deal efficiently with environmental demands (e.g., anger and fear prepare us to fight or flight in challenging situations), signal our emotional states to others and elicit responses (e.g., sadness elicits comfort and help) (Levenson, 1999; Scherer, 2000). However, emotions are functional only when the level of arousal and duration are under control or manageable. Being overwhelmed by emotions, as indicated by elevated levels of negative emotion expressions, puts children at risk for developing behaviour problems (Cole, Martin, & Dennis, 2004). For example, persistent

expression of sadness is a sign or early symptom of depression (Horwitz & Wakefield, 2007), and excessive and intensive expressions of anger are related to externalizing behaviours such as aggression (Zeman, Shipman & Suveg, 2002). Fäsche and Friedlmeier (2015) found that in TD children aged 5 to 6 years, more positive emotion expressions were related to fewer internalizing problems, and more negative emotion expressions were related to more internalizing and externalizing problems.

Early development of behaviour problems is also related to children's ability to recognize others' emotions (see for a review, Trentacosta & Fine, 2010). Correctly identifying others' emotions is prerequisite to establishing and maintaining positive interpersonal relations. Frequent experience of unpleasant and stressful social interactions can contribute to social exclusion and the development of internal feelings such as anxiety, loneliness and sadness (Fine, Izard, Mostow, Trentacosta, &Ackerman, 2003). Besides, children who tend to attribute anger to others in ambiguous situations, and who are less able to recognize sadness in others, exhibit elevated levels of externalizing problems such as aggression (Martin, Boekamp, McConville, & Wheeler, 2010; Schultz, Izard and Ackerman, 2000).

A third index of emotional functioning is children's knowledge of emotion and mental state words. When labeling either their own or other people's emotional state, children need to reflect upon and monitor the emotional episode. This attentional process helps them understand the underlying causes and differentiate emotions (Rieffe, Oosterveld, Miers, Meerum Terwogt, & Ly, 2008). In addition, knowing emotion and mental state words enable children to communicate about emotions. Lack of emotion vocabulary can compromise their ability to cope with emotion-provoking situations and create difficult interpersonal relations, which in turn put them at risk for developing behaviour problems. In TD children, the ability to label emotions is related to fewer behaviour problems both concurrently (Schultz, Izard, Ackerman, & Youngstrom, 2001) and longitudinally (Fine et al., 2003; Izard et al., 2001).

To date, the association between emotional functioning and behaviour problems is established mainly based on findings in TD children. Only a few studies reported the links in adolescents with ASD, focusing on the role of emotion control (Rieffe, Bruine, De Rooij, & Stockmann, 2014; Bos, Diamantopoulou, Stockmann, Begeer, Rieffe, 2018). It is unclear whether the same relations exist in young children with ASD. This study aimed to examine the development of internalizing and externalizing problems, and their associations with emotional functioning in preschool boys diagnosed with ASD. We expected that boys with ASD would exhibit more internalizing and externalizing behaviours overall than their TD peers (e.g., Stewart, Barnard, Pearson, Hasan, & O'Brien, 2006). We assumed that

internalizing symptoms would increase in TD boys (e.g., Côté et al., 2009). Due to mixed findings on the developmental course of externalizing problems in TD children, no directional hypothesis was made. We also did not make directional hypotheses regarding the developmental courses of internalizing and externalizing problems in boys with ASD, because there is only one longitudinal study (i.e., Vaillancourt et al., 2017), and its findings differ from the cross-sectional studies (Davis III et al., 2011; Vasa et al. 2013). Finally, we expected that, as in TD children (Eisenberg et al., 2000; Southam-Gerow & Kendall, 2002), poor emotional functioning (emotion control, emotion recognition, and emotion vocabulary) would contribute to the development of internalizing and externalizing problems in boys with ASD.

Methods

Participants and procedure

This study was a part of a larger-scale longitudinal investigation into the social-emotional development of toddlers and preschoolers with limited access to the social learning environment, including children with hearing loss, children with Developmental Language Disorder, and children with ASD (Ketelaar, Wiefferink, Frijns, Broekhof, & Rieffe, 2015; Rieffe & Wiefferink, 2017; Broekhof et al., 2015).

The total sample of the larger project included 73 children with ASD (65 boys) and 418 TD children (226 boys). Since there were too few girls with ASD, we used the data of 59 boys with ASD aged 22 to 71 months (*Mean* 54.73, *SD* 11.69) and 97 TD boys aged 22 to 78 months (*Mean* 51.04, *SD* 15.25) at Time 1. Participants of the larger project were included if parental reports were available for the included questionnaires on at least one time point (see Supplementary Table 1, for available data at each time point).

Boys with ASD were recruited via a specialized institution for diagnostics and treatment of children with ASD (the Center for Autism in Leiden, the Netherlands). TD boys were recruited from day-care centers and mainstream primary schools. Inclusion criteria for the ASD sample were: (1) the child received ASD diagnosis according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (American Psychological Association, 1994) based on the Autism Diagnostic Interview-Revised (Lord, Rutter, & Lecouteur, 1994) set by a qualified child psychologist or psychiatrist at Time 1, (2) the parents confirmed three years later that the child retained the ASD diagnosis, (3) IQ scores above 70, and (4) no additional DSM-IV-TR diagnosis. Inclusion criteria for the TD sample were (1) IQ scores above 70, and (2) no DSM-IV-TR diagnosis.

Information regarding IQ scores in the ASD sample were retrieved from school files, or through testing at the Centre for Autism. Hence, various intelligence tests were used, including the Snijders-Oomen Nonverbal Intelligence Tests (SON-R), Wechsler Intelligence Scale for Children (WISC III), Wechsler Preschool and Primary Scale of Intelligence (WPPSI), and the Dutch version of Wechsler Nonverbal Scale of Ability (WNV-NL). TD boys were tested by the SON-R. Parents also filled in Social Responsive Scale (Constantino & Gruber, 2005) at Time 3 to report on children's social abilities.

For three consecutive years (mean duration between Time 1 and Time 2 = 13.30 months, *SD* = 2.84; between Time 2 and Time 3 = 11.93 months, *SD* = 1.54), parents were asked to complete questionnaires concerning the social-emotional development of their child as well as a list of background information. Permission for this study was granted by the Ethical Committee of Leiden University and the Center for Autism (P08.140/SH/sh). All parents provided written informed consent.

Materials

Internalizing and externalizing problems. The Early Childhood Inventory-4 (ECI-4) is a parent-report questionnaire that is validated and widely used to assess DSM-IV symptoms (Sprafkin, Volpe, Gadow, Nolan, & Kelly, 2002). The questionnaire consists of 108 items that can be scored in two ways: (1) screening cutoff (dichotomous), and (2) symptom severity (dimensional, ranging from "0 = never" to "3 = very often"). We used the severity scores of the subscales for Major Depressive Disorder (6 items) and Generalized Anxiety Disorder (12 items) as indices of internalizing problem severity, and the subscales for Peer Conflict (10 items), Oppositional Defiant Disorder (8 items), and Conduct Disorder (10 items) as indices of externalizing problem severity. The final scores for internalizing and externalizing problem severity were calculated by the sum of the scores of the corresponding ECI-4 subscales. A higher score indicated more severe symptomatology. We combined scales within each domain for two considerations. First, little is known about early development of internalizing and externalizing problems in young children with ASD. As a first step, it is informative to start with examining the general trends of the two large domains. Second, in young children, specific symptoms within the same domain often cannot be distinguished from each other and possibly represent the same underlying disorder (Wichstrøm & Berg-Nielsen, 2014). Internal consistency of internalizing problems ranged from acceptable to good across time (TD: $0.869<\alpha<0.874$; ASD: $0.639<\alpha<0.894$), and externalizing problems were good across time for

both groups (TD: 0.868<α<0.889; ASD: 0.895<α<0.962; see also Supplementary Table 2 for the internal consistency for all measures per time point per group).

Emotion control and emotion recognition. The Emotion Expression Questionnaire is a 35-item parent-report questionnaire that measures a child's emotion expressions (Rieffe, Ketelaar, & Wiefferink, 2010). In the current study we used three scales: (1) Negative Emotion Expression Scale (12 items) as a measure for emotion control, which indicates the frequency, intensity and duration of children's negative emotion expressions, including sadness, fear and anger (example item: "How often does your child experience fear?"), and the extent to which they can calm themselves or be calmed by their parents (example item: "Is your child easily calmed down when angry?"); (2) Positive emotion expression scale (6 items), which indicates the intensity and frequency of children's happiness and joy (example item: "How often does your child experience joy?"); and (3) Emotion Recognition Scale (6 items) which indicates the extent to which the child can recognize others' emotions (example item: "Does your child know when you are happy?"). Parents rated each item on a 5-point scale ranging from "1 = (almost) never" to "5 = (almost) always". For both groups, the internal consistency of the Negative Emotion Expression Scale was sufficient across time (TD: 0.679<α<0.802; ASD: 0.633<α<0.825). The internal consistency of the Emotion Recognition Scale ranged from sufficient to good (TD: 0.758<α<0.798; ASD: 0.878<α<0.908). The internal consistency of the Positive Emotion Expression Scale was sufficient for the ASD sample (0.673<α<0.780). However, the internal consistency was questionable for the TD sample at Time 1 (α=0.655) and Time 3 (α=0.600), and unacceptable at Time 2 (α=0.398). It is unclear what caused the poor internal consistency, and we excluded this measure from the subsequent analyses.

Emotion vocabulary. The Emotion Vocabulary Questionnaire is a parent report that measures children's knowledge of emotional words (Ketelaar, Wiefferink, Frijns, Broekhof, & Rieffe, 2015). Parents rated whether their child knew and used 20 emotion and mental state words (0 = no/ 1 = yes). We used two scales: Basic Emotion Vocabulary (4 items: happy, angry, fearful and sad) and Mental State Vocabulary (5 items: dream, think, know, forget, and want). A total score for each subscale was calculated. A higher score indicated better emotion vocabulary. For the ASD sample, the internal consistency of Basic Emotion Vocabulary (0.748<α<0.831) and Mental State Vocabulary (0.752<α<0.824) ranged from sufficient to good. For the TD sample, the internal consistency of both scales ranged from sufficient to good at Time 1 and Time 2 (Basic Emotion Vocabulary: 0.749<α<0.865; Mental State Vocabulary: 0.697<α<0.827). However, the internal consistency of both scales at Time 3 were poor for the

TD sample (Basic Emotion Vocabulary: α=-0.360; Mental State Vocabulary: α=0.134). This was because the TD sample showed a near-ceiling effect at Time 3 (Table 2), which resulted in little variance in the scoring of some items.

Statistical analyses

Statistical analyses were performed using the statistical software package for social sciences version 21.0 (SPSS Inc., Chicago). Graphs were made by R (R Core Team, 2014; GGplot2 package). To test for group differences in demographic features, emotional functioning and behaviour problems at the three time points, independent *t*-tests were used. Linear Mixed Models (LMM) were used to assess (1) the developmental trajectory of internalizing and externalizing problems, and (2) contributing factors for the change in internalizing and externalizing problem severity. The advantage of LMM is that it allows for data hierarchies, such as observed in longitudinal data. Within a longitudinal data set, time points are nested within participants and multilevel modeling can account for this type of data dependency. Furthermore, LMM can handle missing data.

We used a formal model-fitting procedure. We started with an unconditional means model that only includes a fixed and random intercept, to allow for individual differences at starting points. Second, the unconditional means model was compared to additional models that tested the grand mean trajectory of age. These models were created by adding two polynomial terms (linear and quadratic) for age (centered around 22 months [age of the youngest child]) to the unconditional means model. Moreover, we included a random-slope effect of age into the best-fitting age model, but this did not improve model fit. Third, group and the interaction between group and age were included, to examine whether the developmental trajectory of internalizing and externalizing problems differed between boys with and without ASD.

Next, we tested whether levels of emotional functioning were associated with development of internalizing and externalizing problems. To do so, we included baseline level and subsequent change (TP1 – TP1; TP2 – TP1; TP3 – TP1) of negative emotion expressions, emotion recognition, and emotion vocabulary (basic and mental states) to the best fitting age model. Last, we added interaction terms between variables of emotional functioning and group. In the results, we report the results of the best fitting model. Akaike Information Criterion values (AIC) and Bayesian Information Criterion (BIC) were used to compare the unconditional means model with other models to test which model best explained the data. Preferred models should have significantly lower AIC and BIC values. For the LMM

analyses, we corrected for multiple comparisons by considering an alpha of .025 as significant.

Results

Table 1 shows descriptive characteristics of the samples. The two samples did not differ in age at Time 1, $t(145.78) = 1.698$, $p = .092$. Boys with ASD had a lower IQ than TD boys at Time 1, $t(119) = 3.881$, $p < .001$. They scored higher than TD boys in Social Responsiveness Scale at Time 3, $t(114) = -8.46$, $p < .001$. Parents of boys with ASD reported lower socioeconomic status: $t(141) = 2.36$, $p = .020$, which has been found in many studies on children with ASD (e.g., Kogan et al., 2008).

Table 1: Demographic characteristics of participants.

	Total study population at Time 1 N = 156			
	ASD	N	TD	N
Age[a]		59		97
Mean – age in months (SD) at Time 1	54.73 (11.69)		51.04 (15.25)	
Range – age in months	22-71		22-78	
Socio-economic Status[b](SD)*	4.20 (1.41)	56	4.89 (1.85)	87
IQ (SD)***	100.50 (16.61)	50	111.68 (14.85)	71
SRS at Time 3 (SD)***	1.62 (0.67)	52	0.60 (0.62)	64

ASD: autism spectrum disorder; TD: typically developing; SD: standard deviation; SRS: Social Responsive Scale.

[a]Age did not differ between groups at Time 2 or Time 3.

[b]The highest level of education of each parent and their net household income were categorized on a scale ranging from zero to five. Socio-economic status was calculated by averaging these three scores.

*$p < .05$, *** $p < .001$

Table 2 depicts the total scores and standard deviations of predictor and outcome measures at three time points. Boys with ASD showed more internalizing and externalizing problems than their TD peers at all time points. They also showed lower emotional functioning than TD peers at all time points. Yet, the LMM analyses only confirmed a group

difference for externalizing problems (t(330.59)=8.97, p<.001), but not for internalizing problems (t(331.40)=2.36. p=.11).

Table 2. Total scores, standard deviations (SD) and statistics (group comparisons) of outcome and predictor measures for TD and ASD group at three time points.

	TD			ASD				
	Total	SD	N	Total	SD	N	*t*-value	*P*
Time 1								
Internalizing	2.57	4.08	91	5.05	3.79	57	3.573	<.001
Externalizing	7.95	5.84	91	15.92	13.25	57	4.287	<.001
Negative Emotion expression	27.23	5.43	92	33.14	6.88	57	5.508	<.001
Emotion recognition	23.98	3.32	92	17.39	5.49	57	8.184	<.001
Emotion vocabulary Basic	3.73	0.85	92	3.01	1.31	57	3.695	<.001
Mental state	3.88	1.35	92	2.81	1.66	57	4.107	<.001
Time 2								
Internalizing	3.51	4.83	63	7.61	8.16	47	3.071	.003
Externalizing	8.49	6.69	63	13.88	8.81	47	3.653	<.001
Negative Emotion expression	27.06	5.64	63	32.90	6.52	48	5.052	<.001
Emotion recognition	24.34	4.48	64	17.86	5.53	48	6.851	<.001
Emotion vocabulary Basic	3.84	0.58	63	3.27	1.27	48	2.876	.006
Mental state	4.51	1.13	63	3.42	1.75	48	3.763	<.001
Time 3								
Internalizing	3.29	4.38	49	5.98	6.85	43	2.271	.026
Externalizing	7.84	5.91	49	13.84	9.17	43	3.673	<.001
Negative Emotion expression	28.17	5.30	57	33.08	7.68	43	3.594	.001
Emotion recognition	24.67	3.36	57	18.18	5.66	43	6.673	<.001
Emotion vocabulary Basic	3.96	0.19	57	3.49	1.05	43	2.928	.005
Mental state	4.75	0.47	57	3.93	1.53	43	3.403	.001

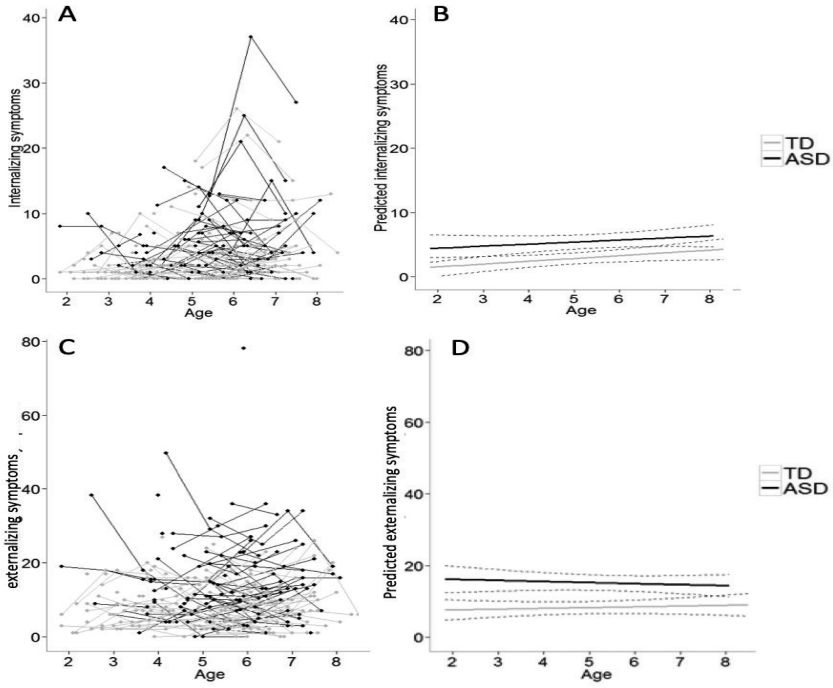

Figure 1. Longitudinal graphic representation of age at three time points and respectively internalizing and externalizing problems. **Figure 1A. 1C.** Participants are represented by individual lines. Participants measured only once are represented by points. **Figure 1B. 1D.** Predicted values for respectively internalizing, externalizing problems based on the optimal fitting model.

Table 3. Estimates (standard errors) of the LMM for the predictors at Time 1, and for the slopes (Change) of the predictors on internalizing and externalizing problems.

	Internalizing problems		**Externalizing problems**	
Fixed effects				
Intercept	-7.50 (2.68)		-3.84 (7.66)	
Age	0.04 (0.02)		-0.02 (0.03)	
Group	1.51 (0.92)		16.06 (10.23)	
	Time 1	**Change**	**Time 1**	**Change**
NEE	0.30 (0.06)***	0.24 (0.06)***	0.49 (0.15)**	0.10 (0.14)

ER		0.04 (0.09)	-0.29 (0.09)***	-0.21(0.25)	-0.01 (0.22)
EV	Basic	-0.30 (0.41)	-0.40 (0.36)	0.89 (1.22)	1.16 (0.81)
	Mental states	0.28 (0.31)	0.31 (0.26)	-0.07 (0.82)	-0.01 (0.59)
Interactions					
Group x NEE		-	-	-0.14 (0.22)	0.14 (0.18)
Group x ER		-	-	-0.52 (0.33)	-0.27 (0.28)
Group x EV basic		-	-	-1.63 (1.58)	-3.38 (1.15)**
Group x EV mental states		-	-	2.22 (1.11)	-0.37 (0.75)

LMM: linear mixed models; NEE: negative emotion expression; ER: emotion recognition; EV: emotion vocabulary.

** $p < .025$. ** $p < .005$. *** $p < .001$

Figure 1A-B depicts the developmental trajectories of internalizing problems. The LMM analyses showed that internalizing problems increased with age (Age: $t(331.57)=2.08$, $p=.04$), but after correcting for multiple comparisons the age effect became non-significant. The groups did not differ in the developmental patterns of internalizing problems (Group x Age: $t(304.70)=0.35$, $p=.73$). Figure 1C-D depicts the developmental trajectories of externalizing problems. LMM analyses showed no age effects (Age: $t(309.76)=0.44$, $p=.66$). There was no difference in the developmental patterns of externalizing problems between groups (Group x Age: $t(314.69)=0.35$, $p=.73$).

The LMM with only predictors (scores at Time 1 and change scores) fitted the data best for internalizing prob- lems (see Supplemental Table 3). As shown in Table 3, an increase in negative emotion expressions and more nega- tive emotion expressions at Time 1 was related to an increase in internalizing problems. Furthermore, an increase in emotion recognition was related to a decrease in internal- izing problems. For externalizing problems, the best fitting model was the model with predictors and interaction terms (see Supplemental Table 3). For boys both with and without ASD, more negative emotion expressions at Time 1 were associated with an increase in externalizing problems.

Interestingly,therewasaninteractioneffectofGroupand Basic Emotion Vocabulary (change scores): whereas improvement in basic emotion vocabulary was related to a decrease in externalizing behaviors in boys with ASD ($B = -2.17$, $t = -2.52$, $p = 0.01$), a non-significant relation was found in TD boys ($B = 1.14$, $t = 1.15$, $p = 0.14$).

Discussion

This longitudinal study was among the first to examine the development of internalizing and externalizing problems and contributing factors in boys aged 2 to 6 years, with and without ASD. Our main findings are: First, boys with ASD exhibited more severe internalizing and externalizing problems, and lower emotional functioning than TD boys at the three different time points. Second, we did not find an age effect on internalizing or externalizing problems for boys with and without ASD. Third, for boys with and without ASD, more negative emotion expressions (i.e., lower emotion control) at Time 1 and increased negative emotion expressions were associated with increased internalizing problems; improved emotion recognition was associated with decreased internalizing problems; and more negative emotion expressions at Time 1 were associated with increased externalizing problems. Fourth, improved emotion vocabulary was uniquely associated with decreased externalizing problems in boys with ASD.

The literature of TD children suggested that internalizing problems such as symptoms of anxiety and depression increased with age. Our multilevel analyses confirmed this age effect. However, after correcting for multiple comparisons the age effect was no longer significant. We suggest that this result should be interpreted with caution, as for exploratory studies correcting for multiple comparisons may be less desirable, and subsequent studies with pre-planned hypotheses are needed before ruling out the age effect (Althouse, 2016). For externalizing problems, we did not find any age effects. Although both stable and decreasing patterns for externalizing symptoms have been reported in the literature, our finding is consistent with those studies that examined symptoms related to Oppositional Defiant Disorder and Conduct Disorder, such as physical aggression, non-compliance, and irritability, all reporting no age effect in early childhood (Campbell et al., 2006; Carbonneau, Boivin, Brendgen, Nagin & Tremblay, 2016; Ezpeleta, Granero, de la Osa, Trepat & Domènech, 2015).

Remarkably, we found that boys with ASD did not differ from TD boys regarding the developmental courses. Yet, the problems seem to be more pronounced in them. This indicates that internalizing and externalizing problems start early in children with ASD (Bryce & Jahromi, 2013; Matson, Fodstad, Mahan, & Sevin, 2009; Georgiades et al., 2011), and are persistent or even increasing over time (Davis III et al., 2011; Mayes, Calhoun, Murray & Zahid, 2011).

Furthermore, we found that as in TD children, lower levels of emotional functioning in boys with ASD contributed to higher levels of internalizing and externalizing problems. First,

poor emotion control, as indicated by elevated levels of negative emotion expressions, was associated with increased internalizing and externalizing problems in boys with and without ASD. For internalizing symptoms, this association involved both the levels of emotion control at the first time children were tested, as well as the change scores, whereas only levels of emotion control at Time 1 were related to more externalizing symptoms. These outcomes stress the importance to address problems in the domain of emotion control at the earliest age, and they seem to indicate that boys this young can already be at risk for internalizing problems which go often unnoted when they grow older. Similar relations have been found in TD children (e.g., Eisenberg et al., 2000) and in adolescents with ASD (e.g., Rieffe et al., 2011; Bos et al., 2018). Our study indicates that the relation also exists in the younger age group with ASD, and even more importantly, persists over time.

Second, improvement in emotion recognition decreases the risk of developing internalizing problems in boys with and without ASD. Social interactions are full of emotional exchanges, and when a child cannot decipher how others feel, the social world may appear unpredictable and confusing. This could lead to fear and frustration in children, especially in children with ASD (Bellini, 2004). We did not find a longitudinal relation between emotion recognition and externalizing behaviours. Note that in our study, parents reported on children's recognition of multiple emotions. Possibly, deficits in recognizing certain emotions such as anger and sadness are particularly relevant to externalizing problems (Fine, Trentacosta, Izard, Mostow, & Campbell, 2004). As mentioned before, TD children who tended to attribute anger to ambiguous situation and who had decreased accuracy in recognizing sadness in others showed more externalizing symptoms (Martin et al., 2010; Schultz et al., 2000). Future research could examine whether this would also apply to children with ASD.

Third, improved emotion vocabulary was uniquely related to a decrease of externalizing problems in boys with ASD. However, we did not find a main effect of emotion vocabulary on developing internalizing or externalizing problems. This was unexpected, because previous studies showed that the ability to label and communicate about emotions was related to better social competence and fewer behaviour problems in TD children (e.g., Fine et al., 2003; Izard et al., 2001) and in children with other communication problems (e.g., Ketelaar et al., 2015). Possibly, our measure did not fully reflect children's capacity when they grew older, as TD boys showed a near-ceiling effect at Time 3. To study the relation, future research could use instruments that measure more complex emotion vocabulary.

Nonetheless, our findings highlight the need to help children with ASD to improve their emotion vocabulary. At this young age, engaging in emotion talk with parents and caregivers is an important pathway for children to acquire knowledge of emotion words (Grazzani, Ornaghi, Agliati, & Brazzelli, 2016; Rieffe & Wiefferink, 2017). Children do not learn emotion words in isolation, but in the context of a wealth of information about emotional situations. The social impairments related to ASD leave children with ASD less opportunity for social learning, which is crucial for developing not only emotion vocabulary, but also other aspects of emotional functioning such as emotion control and emotion recognition (Saarni, 1999).

This study has its strengths, in using a three-wave longitudinal design and measuring a clinical sample at an early stage of the diagnosis of ASD. However, there are also limitations. First, our study examined the broadband inter- nalizing and externalizing symptoms. Considering the high comorbidity rates of symptoms within each category and the very young age of our sample, studying broadband symptoms is a good start point for us to understand their development. Nonetheless, grouping symptoms together may mask the unique development of more discrete differentiated symptoms, and future studies should further look into this. Second, our sample included only high-functioning children and only boys. Thus, caution is warranted when generalizing our findings to other populations with ASD. For example, our findings differ from Vaillancourt et al. (2017), which reported a declining trend for both internalizing and externalizing problems in young children with ASD. Their sample is more heterogeneous which included girls and low-functioning children with ASD. Also, it bears mentioning that we did not have IQ data of 15% and 25% of our sample with ASD and TD, respec- tively. Third, all variables were measured with parent ques- tionnaires, which increased the risk of common-method variance bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Adding observational tasks in future studies could strengthen the outcomes of our study. Besides, the Emotion Vocabulary Questionnaire had poor internal consistency for the TD children at Time 3. Using an observational task to record children's use of emotion words in daily emotional conversations could be a more valid and reliable measure for checking children's emotion vocabulary. We also had to remove the measure of positive emotions from our analyses due to the low internal reliability in TD children. A good emotion control is indicated not only by appropriate expres- sions of negative emotions but also by appropriate expres- sions of positive emotions. Children with ASD are known to display less positive expressions than TD peers (Hirschler-Guttenberg, Golan, Ostfeld-Etzion, & Feldman,

2015). Future studies should examine to what extent posi- tive emotion expressions contribute to the development of behavior problems in children with and without ASD.

Despite the limitations, this study made significant contributions to the existing knowledge. We found that the developmental courses of internalizing and externalizing problems in early childhood did not differ between boys with and without ASD. However, these problems were more pronounced in boys with ASD. This highlights the importance of addressing the underlying problems with emotional functioning at the earliest age possible. At this young age, the parent–child relationship is of crucial importance for the development of emotional functioning. Especially, children with ASD might need extra parental support and scaffolding to improve their emotion control and recognition. As a recent study showed in TD children, parents need to be able to adapt their levels of support depending on the child's needs (Spruijt, Dekker, Ziermans, & Swaab, 2018). Furthermore, emotional functioning requires not only early and sensitive interactions between caregivers and their children but also opportunities for incidental learning, that is, unintentional learning by overhearing and observing others. Future studies should also address how a rich social environment could benefit children with ASD, without becoming overwhelming or bringing social withdrawal.

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6

CHAPTER 6.

General discussion

It is never easy for an autistic person to live in a world which is predominantly non-autistic and full of social and emotional exchanges. Social communication and social interaction constitute one of the most challenging areas for many people with autism[1] (American Psychiatry Association, 2013). Emotion plays an essential role in guiding and facilitating social interactions (Lopes et al., 2011). From the functionalistic perspective (see Box 2 in Chapter 1), emotions are inherently informative and communicative. Experiencing an emotion signals us that something important to us is at stake (Frijda, 1986), and through expressing that emotion towards others, we communicate with others what we want to achieve (Horstmann, 2003). Although the ability to experience and express emotions are largely innate, which emotion is experienced and when and how this emotion should be expressed is constantly regulated by social and cultural norms (Kappas, 2013). To navigate smoothly in the social world, every child needs to learn from a young age the "rules" of social interactions, and how to manage emotions in a socially and culturally accepted way, so that emotions facilitate rather than hinder one's personal and social goals. For young children, the learning process often takes place through observing how parents respond in social interactions, having discussions over emotions with parents, and through interacting with peers and learning from trial and error (Mathieson & Banerjee, 2011; Westrupp et al., 2020). When compared to non-autistic children, autistic children more often miss out on these spontaneous learning opportunities and have more difficulties recognizing the "rules" of social interaction. This may not be a problem for some autistic children, who do not have a strong interest in connecting with others and prefer to spend time alone with their own imaginations and thoughts. Their preferences and choices should be accepted and respected. However, many other autistic children do have the desire to interact with others and make friends, and yet they often struggle with how to initiate and maintain social interaction, or may be put off by unpleasant experiences in the past, where the interaction "went awry" but they did not know why.

The predicament is partly because many autistic children interpret, express and respond to emotions in a different way from children without autism. Decades of research on autism have reported repeatedly that autistic people often experience difficulties in recognizing and responding to emotions of others as well as in regulating and expressing their own emotions (Lozier et al., 2014; Mazefsky et al. 2012). These studies contributed to our understanding of the wide variety of challenges that autistic people can face in social

[1] In this chapter, both person-first language such as "people with autism" and identity-first language such as "autistic people" are used. See Box 3 in Chapter 1 for justifications of using both types of language.

interactions, and enhanced our awareness about how complicated daily life experience can be for autistic individuals. This thesis hoped to build upon the existing research and knowledge and move one step forward. The unique contributions of this thesis include (1) focusing on a young sample, i.e., 1- to 6-year-old children with autism and their non-autistic peers, to obtain knowledge of the early condition and early development of autistic children in the emotional domain; (2) examining essential and diverse emotional abilities to establish an extensive profile of emotional functioning in preschool autistic children; (3) using a longitudinal approach to identify the changes of emotional functioning over time in autistic children and providing insights into cause-and-effect relationships regarding the contributing factors and the psychosocial outcomes related to emotional functioning.

The central aim of this thesis was to contribute to a more comprehensive understanding of the early development of emotional functioning in preschool children with autism and their differences in the emotional domain as compared to non-autistic peers. Understanding the challenges that autistic children face, truly accepting their differences, and acknowledging their potential is important for creating a supportive and respectful social environment around them, where autistic children can develop at ease and to their full potential. To achieve the goal, a multidimensional and multimethod approach was applied. Using a combination of tasks, on-site observations and parent questionnaires, four longitudinal studies were conducted to examine a group of key emotional abilities in preschool autistic children from both (1) the horizontal dimension: investigating the *interpersonal* differences and detecting the unique challenges that autistic children faced in the emotional domain; and (2) the vertical dimension: investigating the *intrapersonal* variations and following children's development over a period of two to three years. See also Figure 1 in Chapter 1 for a graphic presentation of the variables and chapter arrangement.

It is important to note that the outcomes of this thesis referred to the average performances of the autistic participants. The Linear Mixed Model (LMM) analyses adopted in this thesis have the advantage of taking into consideration individual differences when detecting the general trend of the group (Snijders & Bosker, 2011). As found in STUDY 1, 2 and 3, significant individual differences were observed in almost every aspect of emotional functioning. Notwithstanding, the quantitative approach adopted in this thesis did not allow us to gain detailed information on the capacity and the qualitative change within each child. As accurately pointed out by Doctor Stephen Shore, a professor of special education who focuses on matching best practices to the needs of people with autism, "If you've met one person with autism, you've met one person with autism" (Shore, 2018). The autistic population is as

heterogenous and diverse as the non-autistic population. What was found in this thesis should not be used to label autistic children. Instead, the findings of this thesis can be used as a starting point for eliciting more understanding of the challenges that autistic children may face at a young age. Each individual child with autism has his or her own characteristics, strengths, and special needs, and should be treated as a unique human being.

In this final chapter, first, the main outcomes are integrated and summarized to paint an overall picture of the early development of emotional functioning in autistic children. Next, the findings in each emotional domain are discussed in detail and in association with previous research. Third, considerations and directions for future research are discussed. This chapter concludes with associating the findings of this research and exploring their implications for societal practices.

Main outcomes

The horizontal dimension investigated the extent to which autistic children differed from non-autistic children in their emotional functioning. Differences were found in almost every aspect in the emotional domain. First, compared to non-autistic children, autistic children on average experienced more difficulties in recognizing and understanding the emotion of others (Chapter 2 & 4). It was also more challenging for many of them to regulate their own emotions. Emotion expression in autistic children was on average either more intensive or insufficient when compared to that of non-autistic children (Chapter 3 & 5). Besides, attending to the emotional display of other people was often not as automatic and effortless for autistic children as for their non-autistic peers (Chapter 4). Not surprisingly, many autistic children did not respond to others' emotional display in the socially expected ways to the same extent as their non-autistic peers (Chapter 4). These outcomes showed that participating in social interactions could be a very different experience for autistic children, which present many challenges and might bring a lot of stress. Indeed, on average, autistic children were viewed as less socially competent compared to their non-autistic peers and experienced more internalizing and externalizing problems (Chapter 4 & 5).

Despite the differences and challenges, remarkably, when looking at the vertical dimension, autistic children showed age-related improvement in almost every aspect of emotional functioning. Their ability to recognize emotions in prototypical situations as measured by behavioral tasks (Chapter 2) and in daily life as reported by parents (Chapter 4) all improved with age at the same rate as non-autistic children. Some emotional abilities, e.g., identifying happy and angry facial expressions (Chapter 2), prosocial actions observed in

behavioral tasks (Chapter 4), increased with even a greater magnitude in autistic children than in non-autistic children. These increasing trends convey a positive message, that is, like non-autistic children, many autistic children have the potential to learn and to improve in the emotional domain.

Worth noting, comparable levels and development were also found in autistic children for some emotional abilities. Regarding the development of attributing the emotion "fear" to fear-provoking situations (Chapter 2), the expression of pride in pride-provoking situations (Chapter 3) and parent-reported affective empathy (Chapter 4), the average levels and the developmental trajectories of autistic children did not differ from non-autistic children. The diverse patterns found in the development of different emotional abilities in autistic children suggest that it is important to investigate their emotional development at the molecular level instead of at the molar level. Not all emotional abilities were developed in a coordinated manner and some emotional abilities could be more affected by autism than others.

Decoding emotions in others: emotion recognition in autistic children

Social interactions start with perceiving and interpreting the emotions of another person. Correctly decoding emotional expressions of others is crucial for initiating adaptive and appropriate responding (Williams & Gray, 2013). Reversely, impaired emotion recognition disrupts social interactions and hinders one from establishing and maintaining positive relationships with others (Dede et al., 2021). Decades of research have examined emotion recognition in autistic individuals. Although the findings are not always consistent due to the heterogeneity of participant characteristics and task demands, overall, emotion recognition is found to be challenging for autistic individuals across a range of contexts and age groups (for a review, see Harms et al., 2010). These studies contributed greatly to our knowledge of the intergroup differences. However, relatively fewer studies examined emotion recognition in toddlers and preschoolers with autism. Besides, due to their cross-sectional designs, little is known about how emotion recognition develops within autistic individuals at different life stages (Rosen & Lerner, 2016).

To address the gap of knowledge and to start from an early life stage, three studies in this thesis examined the extent to which 1- to 6-year-old autistic children could recognize basic emotions and how their emotion recognition abilities developed over time. STUDY 1 (Chapter 2) zoomed in to examine three emotion recognition abilities (i.e., emotion differentiation, emotion identification, and emotion attribution) regarding four basic emotions (i.e., happiness, sadness, anger and fear). Behavioral tasks were used to examine whether

children could differentiate facial emotion expressions (emotion differentiation), to associate these facial emotion expressions to verbal labels (emotion identification), and to attribute emotions to emotion-provoking situations (emotion attribution). STUDY 3 (Chapter 4) and STUDY 4 (Chapter 5) examined emotion recognition in a more holistic manner. A questionnaire was used to ask parents how well their children could recognize basic emotions in others. Zooming in or zooming out, in line with the literature, all three studies confirmed that, on average, children with autism had more difficulties in recognizing basic emotions than children without autism, and these challenges were present already at a young age. Furthermore, STUDY 1 and STUDY 3 followed the development of emotion recognition abilities in children across four time points over a period of three years. Both studies found that emotion recognition abilities improved with age in both groups, and yet developmental gaps between autistic and non-autistic maintained over time.

Note that when looking at individual emotions and individual emotion-recognition abilities, the development gap was not always present. STUDY 1 found that autistic children did not differ from non-autistic children in attributing sadness and fear to emotion-provoking situations. Attributing emotions is a more complex ability and usually developed at an older age than differentiating and identifying emotions. It was unexpected to find that, while autistic children on average experienced more difficulties in differentiating and identifying emotions than non-autistic peers, they did not differ from non-autistic children in attributing negative emotions such as fear and sadness. As discussed in STUDY 1, the seemingly equivalent performances of the two groups in attributing negative emotions might be due to the still underdeveloped abilities of non-autistic children considering their young age. Future research following the development of emotion attribution over a longer period of time can inform us whether a gap between autistic and non-autistic children in attributing negative emotions starts to appear at older ages.

To summarize, this thesis confirmed that the challenges that many autistic children faced in emotion recognition were already present from a young age. Their challenges were global instead of emotion-specific. Compared to their non-autistic peers, autistic children on average experienced more difficulties in recognizing both positive and negative emotions in prototypical situations as examined by the behavioral tasks as well as in daily life as reported by parents. Remarkably, the emotion recognition abilities of autistic children all improved with age, and their ability to identify and attribute happiness and anger developed with even a larger magnitude than non-autistic children. The outcomes showed that, despite the

difficulties and challenges, autistic children had the capacity for improvement and the potential for catching up with non-autistic children in recognizing basic emotions.

Managing emotions in the self: emotion expression in autistic children

Emotions are often elicited during the interaction with other people (Van Kleef et al., 2016). People do not just passively experience emotions. Emotions are functional. They prepare us to deal efficiently with environmental demands (e.g., anger and fear prepare us to fight or flight in challenging situations), signal our emotional states to others and elicit responses (e.g., expressing shame and guilt to elicit forgiveness) (Scherer, 2000). However, emotions are functional only when the level of arousal and duration are under control and manageable. On the one hand, being overwhelmed by emotions, as indicated by elevated levels of negative emotion expressions, puts children at risk of developing behavior problems (Cole, Martin, & Dennis, 2004). On the other hand, nonchalance and lack of emotion expression when the situation demands it can jeopardize social relationships (Van Kleef & De Dreu, 2010). For example, when a social relationship is threatened by a transgression, expressing shame and guilt is necessary, which can help remedy the damage and elicit forgiveness (Leach, 2017).

In this thesis, two studies looked at emotion expression in children with autism. STUDY 4 (Chapter 5) used a parent questionnaire to examine the extent to which children expressed negative emotions such as anger, fear and sadness in daily life. STUDY 2 (Chapter 3) used behavioral tasks to observe children's expression of moral emotions including shame, guilt and pride in a lab setting. From the horizontal dimension, many children with autism were reported by parents as expressing more anger, fear and sadness whereas many were observed by the experimenters as expressing less shame and guilt than non-autistic peers. The heightened level of anger, fear and sadness expression is in line with previous findings that many autistic people have difficulties in regulating their emotional arousals. Living in a predominantly non-autistic world can often times be frustrating and overwhelming for autistic people (Jones et al., 2001). Not knowing how to deal with their intensive emotional arousals can make them vulnerable to experiencing emotional meltdowns and outbursts (Joshi et al., 2018).

In contrast to the heightened level of anger, sadness and fear expressions, children with autism showed an age-related decrease in their expression of shame and guilt, whereas the expression of shame and guilt remained stable in non-autistic peers. For non-autistic children, the fact that their expression of shame and guilt did not increase with age might result from their improved ability to regulate emotions and their growing understanding that

neither too much nor too little expression of emotions was functional. Nonetheless, the decreased shame and guilt expression in autistic children is puzzling. As discussed in STUDY 2, young children first experience moral emotions in an autonomous form (Stipek, 1995). Failing a task gives them the immediate feelings of frustration. With age the experience of shame and guilt becomes less autonomous and children attend more to other people's reactions. They realize that their failure or accomplishment can affect others and induce social disapproval or approval from others (Hart & Matsuba, 2007). Possibly, while the immediate frustration and distress induced by the failure of tasks fades over time in non-autistic children, they get a growing concern about how the other person would think of them. However, many children with autism might not be fully aware of the invisible social connections with other people, which in turn could compromise their experience and expression of shame and guilt.

Note, however, children with autism did not differ from children without autism in their expression of pride. This is probably because compared to shame and guilt, which demands children to understand another person's implicit attitude, pride relies less on an acute awareness and understanding of others' opinions and thus the situation is easier to process and less stressful for children with autism (Hobson et al., 2006).

Feeling, understanding and reacting to others' emotions: empathy in autistic children

Correctly interpreting the emotion of another person and meanwhile keeping one's own emotional arousal at control are prerequisites for initiating proper reactions in social interactions (Leppänen et al., 2001; Lopes et al., 2005). This is especially the case when considering the process of empathy. Empathy is a unique emotional process, where one's emotion is provoked by witnessing the emotional display of another ("affective empathy") (Decety & Meyer, 2008; Rieffe et al., 2020). Importantly, while resonating with another's emotion, one needs to be aware that the emotional dismals are not about oneself. The attentional switch from the self to the affected other ("attention to others") marks a crucial step in the empathy process (Bird & Viding, 2014; Rieffe et al., 2010). Only when the attention is switched to interpret the information relating to another, can the individual evaluate accurately how another person feels and why in that way ("cognitive empathy") (Baron-Cohen & Wheelwright, 2004; Dziobek et al., 2008). This in turn motivates and facilitates the person to react prosocially (Eisenberg et al., 2010), for example, to share another's pleasure or to ease another's distress ("prosocial actions").

STUDY 3 (Chapter 4) considered empathy as a multicomponent construct and examined the development of four key empathy components, i.e., affective empathy, attention

to others, cognitive empathy, and prosocial actions, in autistic children, using both parent questionnaires and observational tasks. When looking from the horizontal dimension, on average, autistic children were evaluated by both parents and experimenters as paying less attention to another's emotions and showing fewer prosocial actions than non-autistic peers. Besides, they were evaluated by parents as showing less understanding of others' emotions. These outcomes are consistent with the findings of previous studies. Reduced attention to social stimuli such as people, faces and body movements is repeatedly reported in autistic individuals of all ages (Chita-Tegmark, 2016). If an autistic child does not pay sufficient attention to the emotional stimuli, this could preclude the child from interpreting the emotional information correctly and in turn hinder him or her from reacting prosocially (Bal et al., 2009; Black et al., 2017).

Worth noting, while experimenters in our studies evaluated autistic children as on average showing less affective empathy than non-autistic children, parents reported equivalent levels of affective empathy. This disagreement echoes the discrepancy found in previous research between studies using observational tasks (e.g., Campbell et al., 2015; Dawson et al., 2004) and those using parent- and self-reports (e.g., Hudry et al., 2009; Pouw et al., 2013). Observational studies usually reported autistic people to display a lower level of affective empathy. However, according to parents and autistic individuals themselves, many autistic people do feel for others' emotions just as much as everyone else. In fact, although there is a stereotypical view that autistic people are "unempathetic" and indifferent to others, many parents reported that their autistic child was instead highly sensitive and resonated strongly with the emotions of the parent (Buruma & Blijd-Hoogewys, 2021). Sometimes the emotion resonation could be so fierce that the autistic child becomes overwhelmed (Smith, 2009).

What does this discrepancy tell us? Foremost, the finding on parent-reported affective empathy added to the existing evidence that autistic children did not lack the ability to feel for others' emotions. However, many factors can disrupt their empathy process. Among others, their troubled emotion recognition and proneness to overarousal might impede them from attending to the situation and reacting properly (Begeer et al., 2006; Gross, 2004). Not fully understanding what is going on while being exposed to the emotional display of another person can be overwhelming. Indeed, autistic people tend to avert their attention and use this as a regulating strategy to avoid becoming swamped by the intense social input, i.e., "out of sight, out of mind" (Markram & Markram, 2010; Tanaka & Sung, 2016). In observational tasks, the social demand of interacting with an adult stranger could be very taxing (Corbett et al. 2014; O'Connor et al., 2019). The average lower level of affective empathy observed in

autistic children might be the outcome of applying the avoidant coping. On the other hand, parents based their observations on their daily interactions with their child and the interactions of their child with other children. Presumably, these situations were more relaxing and thus could invite more emotional responses from autistic children. Furthermore, as noted by the "double-empathy problem", non-autistic people do not always understand the thoughts and feelings of autistic people (Milton, 2012). It is possible that the experimenters in the observational tasks had underestimated the extent to which autistic children felt for another, whereas parents might be more sensitive to detect the feelings of their children due to their long-term and close observations.

As discussed so far, many factors could disrupt the empathy process in autistic children, and yet their ability to feel for others was not absent. Moreover, they showed a great potential to learn and to improve. When looking at empathy from the vertical dimension, both cognitive empathy and prosocial actions showed age-related improvement in autistic children. Remarkably, their prosocial actions towards the experimenters in the observational tasks increased with a larger magnitude than non-autistic children. This again supports that autistic children were not indifferent to other people's agonies; otherwise no such great improvement would have been seen.

Psychosocial outcomes: longitudinal associations with emotional functioning in autistic children

Having seen the challenges that autistic children could face in the emotional domain, a question arose: would this in turn influence the development of their psychosocial functioning? The association between emotional competence and positive psychosocial outcomes has long been established in typical development (Trentacosta & Fine, 2010). In this thesis, two studies sought to find out whether the same association existed in autistic children. STUDY 3 (Chapter 4) examined the longitudinal associations between empathy development and the development of social competence and externalizing problems in autistic children, in comparison to non-autistic peers. STUDY 4 (Chapter 5) investigated the extent to which three important emotional abilities (emotion expression, emotion recognition and emotion vocabulary) influenced the development of internalizing and externalizing problems in children with and without autism.

In line with the literature (e.g., Bauminger et al., 2010; Salazar et al., 2015; Vickerstaff et al., 2007), on average, autistic children were viewed as less socially competent and they experienced more internalizing and externalizing problems than non-autistic peers.

Nonetheless, social competence improved with age in autistic children (STUDY 3); their externalizing problems were found to either remain stable (STUDY 4) or decreased (STUDY 3). Importantly, the development of emotional functioning was related to these positive changes. It was found that in autistic children, improved empathy, emotion recognition, emotion vocabulary and well-controlled emotion expression contributed to the advancement of social competence and preventing the development of internalizing and externalizing problems (STUDY 3 & 4). The contributing role of emotional functioning in promoting positive psychosocial outcomes highlights the importance of supporting the emotional development in autistic children from a young age.

The contributing factors to emotional development in autistic children

The most important contributing factor checked in this thesis was age. As discussed before, although many autistic children faced various challenges in the emotional domain, most of their emotional abilities kept growing throughout the years of measurement.

The contributing role of two other factors were examined in STUDY 1 (Chapter 2) and STUDY 2 (Chapter 3). STUDY 1 examined whether the autism symptom severity contributed to the development of emotion recognition in autistic children. Although some correlational studies found that more severe autistic traits were associated with lower emotion recognition ability (e.g., Brosnan et al., 2015; Evers et al., 2015; Xavier et al., 2015), when looking at the relation longitudinally, STUDY 1 did not find such a relation. STUDY 2 examined whether children's Theory of Mind (ToM) skills contributed to the development of moral emotions. Although ToM has been theorized as a prerequisite for experiencing moral emotions (Leary, 2004; Lewis, 2000), when looking at the association longitudinally, only one association was found in autistic children between better ToM and increased expression of pride.

The lack of strong association between symptom severity and the development of emotion recognition might be partly due to the measurement chosen in the study. The Social Responsive Scale (SRS; Constantino & Gruber, 2005) was used in STUDY 1 to measure the autism symptom severity in autistic children. The SRS is most appropriate for use with children from four to 18 years of age. Yet, many participants of this study were younger than four years. Therefore, the SRS might not be sensitive to detect autism symptom severity in such a young sample. In a similar vein, in STUDY 4, ToM was measured only by false-believe tasks and by parent reports on their children's understanding of basic emotions. These measures might not fully capture children's ability to understand the implicit attitude of other people.

Given the important role of emotional functioning in facilitating positive social interaction and promoting mental health, it is crucial to identify the protective and risk factors that influence the development of emotional functioning in autistic children. This thesis examined a few factors at the individual level, including age and autism symptom severity. Other individual factors such as cognitive ability and gender could also affect children's emotional development. Besides, beyond the individual level, factors at the family level and at the societal level can influence children's emotional development. These issues are discussed in the following sections.

Considerations and directions for future research

This thesis raises issues that future research can take into consideration. First, the focus of this thesis was on the development of emotional functioning in autistic children. Relatively little attention was paid to the contributing factors. However, knowing what promotes and hinders emotional development in young autistic children can provide vital information for parents, educators and clinical professionals, so they can support and facilitate the development of autistic children and help them reach their full potential.

At the individual level, in addition to age and diagnosis, children's intellectual and language abilities could influence their emotional development. A few studies which matched autistic and non-autistic children on verbal, non-verbal and full-scale IQ found that the group differences in emotional functioning disappeared (e.g., Castelli, 2005; Lacroix et al., 2014) However, when matching children on IQ, it often ends up with an older autistic group and a younger non-autistic group. As pointed out by Harms and colleagues (2010), an uneven IQ profile is phenotypically linked with autism. Removing the effect of IQ would remove some essential attributes linked with autism. Due to this consideration, this thesis did not match participants on IQ nor controlled for IQ when conducting the analyses. It should be noted that the autistic participants of this thesis all had normal intellectual abilities. However, if future research would include autistic children with intellectual disabilities, IQ could be an important factor for explaining the development of emotional functioning.

For the same reason, this thesis did not examine the effect of language. This was also because all the behavioral tasks used in this thesis were designed with caution to set minimal demands on language communication. However, language plays an important role in emotional socialization, the process during which children learn from their parents and environment how to understand emotions in a social context and how to express emotions in a socially accepted way (Kitzmann, 2012). Children listen to and observe how adults interact in

daily life. Besides, they use language to communicate about emotions and learn how to manage emotions through carrying out emotional conversations with parents and adults. Limited language can limit children's access to these learning opportunities. As found in STUDY 4 (Chapter 5), autistic children had on average a smaller emotion vocabulary than non-autistic children, and yet improved emotion vocabulary was a unique protective factor against the development of externalizing problems in autistic children. Future research could examine how language abilities, in particular the pragmatic aspects of language and emotion communication, contribute to the emotional development of autistic children.

Due to the very small number of autistic girls (about 10% of the total sample), this thesis did not examine whether there were gender differences in emotional functioning and emotional development. Girls with autism tend to receive their autism diagnosis later than boys with autism. Some of them may not receive this diagnosis at all (Gould & Ashton-Smith, 2011). This is partly due to girls' better social and emotional skills and higher tendency and ability to camouflage (Hull et al., 2019). Nonetheless, this does not mean that their struggles in daily life are of a lesser extent. In fact, due to their stronger motivation to interact with others and better awareness of the social rules and expectations, girls with autism may suffer more from loneliness, low self-esteem and they are at higher risk of developing depression and anxiety in teen years as compared to boys with autism and girls without autism (Holtmann et al., 2007; Rynkiewic & Łucka, 2018). The number of studies focusing on girls with autism has increased in recent years, reporting that the phenotypical profiles of girls with autism can be different from boys with autism (Duvekot et al., 2017; Werling & Geschwind, 2013). Future research should explore whether the gender differences are also present in early childhood regarding children's emotional development. Knowledge in this regard can benefit enhancing awareness of the unique characteristics of females with autism, providing them gender-tailored support and reduce their stresses on social occasions.

This thesis paid attention mainly to basic emotions, focusing on their expression and recognition. On the one hand, focusing on basic emotions matches the developmental stage of the young sample studied in this thesis. On the other hand, considering that moral emotions start to emerge and develop substantially in early childhood, capturing the developmental profile of moral emotions at this stage can deepen our understanding of emotional development in autistic children. This is especially the case after having discovered that while all the other emotional abilities increased with age in autistic children, the expression of shame and guilt showed a progressive decline. Future research on moral emotions in young autistic children could consider the following directions: (1) examining the underlying

mechanisms that contribute to the development of moral emotions in autistic children, such as the sense of self, self-other distinction and higher-order ToM (Immordino-Yang, 2011; Malti et al., 2014); (2) examining children's proneness to discrete moral emotions (e.g., examining shame and guilt separately) instead of investigating them at the global level, because different moral emotions are associated with different behavioral and psychological outcomes (Tangney & Dearing, 2003); (3) involving multiple informants and using multiple measures to investigate how other aspects such as the recognition and experience of moral emotions unfold at young ages in autistic children.

Societal implications

Navigating in a world full of emotional and social exchanges can be testing for any child. However, it is particularly challenging for those with autism. As shown by the outcomes of this thesis, autistic children were not in a favorable position when the situation required them to perceive, interpret and communicate emotions. Traditionally, the focus is on how to help autistic children change and to become "less autistic". This point of view neither accepts nor respects the fact that children with autism live a "different but not less" life. Furthermore, successful interaction requires efforts from both interacting parties. Instead of putting all the responsibilities on autistic children, finding a suitable way to interact with them, preventing social exclusion and reducing the negative impacts on their mental health is an ineluctable responsibility of everyone living in the society.

While this thesis focuses on emotions, the challenges that autistic children face are not confined to the emotional domain and permeate into every aspect of their life. To them, the world can be a mass of people, relations and events that do not always make sense. Above this, the misunderstanding and rejection from non-autistic people often make the situation even more challenging and stressful. Although the majority of the general population is non-autistic, this does not give them the privilege to demand and await autistic people to change and fit to the non-autistic world. Imagine the world was predominantly autistic, would non-autistic people perform better? Probably not. In the Theory of Double Empathy, Doctor Damian Milton pointed out that the lack of ToM and empathy is mutual (Milton, 2012, 2020). While autistic people may struggle to process and understand the intentions and emotions of non-autistic people in social interactions, non-autistic people are equally incapable of understanding the thoughts and emotions of autistic people. It is time that the non-autistic people make changes and adjustments. The attitude could be more understanding, respectful,

and open-minded. The behaviors could be more friendly and more caring. The environment could be more adapting and welcoming.

Importantly, when people's attitude becomes more respectful and understanding, and when the social environment becomes more inclusive and welcoming, it opens the gate to the optimal and most natural learning environment for autistic children to develop their emotional skills. An important finding of this thesis is that most emotional abilities of autistic children developed at a similar rate as non-autistic children. Some of their emotional abilities developed with even a greater magnitude than their non-autistic peers. This shows that autistic children did have the potential to learn and to improve. It should be mentioned that all the autistic participants and their parents were involved in a supporting program conducted by the Center for Autism, Leiden, the Netherlands, which was a rehabilitation center specialized in diagnosing and supporting autism. An important approach adopted at the center was to teach parents how to understand and react to the behaviors of their autistic child. The positive outcomes observed in our autistic participants could partly result from the caring and learning home environment created by parents.

Such caring and learning environment should not be confined just to home and with parents. Autistic children have the same right to every learning opportunity as non-autistic children. In addition to introducing autistic children to training programs and putting considerable pressure and responsibility on parents, it is vital to educate peers and everyone around about the uniqueness and value of autism (Tipton & Blacher, 2014), to promote true acceptance and understanding (Jones et al., 2021), and to encourage schools and societies to create an inclusive physical and mental environment (Rieffe et al., 2018), where autistic children can enjoy, feel supported and welcomed, not only survive but also thrive in the future.

Conclusion

This thesis aimed to strengthen our understanding of the early development of emotional functioning in preschool children with autism. On the one hand, this thesis confirmed the challenges and difficulties that many autistic children faced in the emotional domain. These challenges were present already from a young age and persisted over time. Despite the difficulties and challenges, remarkably, most emotional abilities of autistic children increased with age and developed in a similar way as found in non-autistic children, showing that autistic children had the potential to learn and to improve. Receiving the diagnosis at the youngest possible age and receiving the needed support in the right way and promptly is vital

for stimulating their emotional development. Meanwhile, it is equally important to enhance autism awareness among non-autistic people, and create a learning, motivating, respectful and inclusive social environment, where autistic children can develop at ease and to their full potential.

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7

CHAPTER 7.

Nederlandse samenvatting

Vlot navigeren in de sociale wereld kan voor elk kind een test zijn. Maar voor kinderen met autisme is het een enorm zware uitdaging. Autisme, ook bekend als autismespectrumstoornis (ASS), is een levenslange aandoening die naast rigiditeitsproblemen wordt gekenmerkt door moeite met sociale communicatie en sociale interactie (American Psychiatric Association, 2013). Emoties spelen een sleutelrol bij het sturen en faciliteren van sociale interacties. De hachelijke situatie van autistische mensen is deels omdat velen van hen emoties op een andere manier interpreteren, uiten en erop reageren dan mensen zonder autisme (Hudepohl et al., 2015). Traditioneel worden autistische mensen verantwoordelijk gehouden voor de moeilijkheden die ze tegenkomen in sociale situaties. Succesvolle interactie vereist echter inzet van beide partijen in het communiceren. Het vinden van een geschikte manier om met autistische mensen om te gaan, het voorkomen van sociale uitsluiting en het verminderen van de negatieve effecten op hun geestelijke gezondheid is een onontkoombare verantwoordelijkheid van iedereen die in de samenleving leeft. Om dit te bereiken is een belangrijk traject het vergroten van het bewustzijn van autisme. Dit proefschrift hoopt hieraan bij te dragen en onderzocht het emotioneel functioneren en de ontwikkeling ervan bij autistische kinderen in de voorschoolse leeftijd.

Emotioneel functioneren onderzocht in dit proefschrift

Vanuit functionalistisch perspectief is emotie inherent informatief en communicatief. Naar het zelf toe geeft het ervaren van een emotie het signaal dat er iets belangrijks op het spel staat (Frijda, 1986). Het maakt ons gefocust, gemotiveerd en bereid om actie te ondernemen (Scherer, 2000). Naar anderen toe geeft het uiten van een emotie aan wat we willen bereiken (Horstmann, 2003). Door de krachtige boodschap die een emotie kan overbrengen, moeten kinderen al op jonge leeftijd leren hoe ze hun emotionele opwinding op een optimaal niveau kunnen houden en hun emoties op een sociaal geaccepteerde manier kunnen uiten. Ze moeten ook leren hoe ze de emotionele signalen van anderen moeten interpreteren. Immers, alleen wanneer een kind de emoties van anderen herkent en begrijpt, kan het kind gepast op anderen reageren (Elfenbein et al., 2007).

Gezien de essentiële rol van emoties bij het faciliteren van sociale communicatie en interactie, is het niet verwonderlijk dat het vermogen om emoties te uiten en te herkennen zich vanaf de onmondigheid begint te ontwikkelen bij het kind. De uitingen van basisemoties zoals blijdschap, boosheid, angst en verdriet zijn vanaf het eerste levensjaar aanwezig; het vermogen om basisemoties te herkennen (Hoofdstuk 2) groeit ook snel tijdens de kindertijd. Hoewel de uitdrukking en herkenning van basisemoties vanaf het begin van het leven dus

aanwezig zijn, is het pas aan het einde van het tweede levensjaar dat morele emoties zoals schaamte, schuld en trots naar boven komen. Morele emoties (Hoofdstuk 3) zijn complexere emoties dan basisemoties; ze worden immers pas uitgelokt wanneer kinderen zichzelf evalueren (Tracy & Robins, 2004). Dit unieke kenmerk van morele emoties definieert ook hun unieke rol bij het reguleren en vormgeven van gedrag in overeenstemming met de morele normen. Kinderen die geneigd zijn zich schuldig te voelen, vertonen minder agressief gedrag (e.g., Colasante et al., 2016); terwijl kinderen die zich weinig schamen wanneer ze zich misdragen juist een grotere neiging hebben om zich op asociale manieren te gedragen (bijv. Keltner et al., 1995).

Een ander complex en geavanceerd emotioneel vermogen dat in de vroege kinderjaren naar voren komt en een aanzienlijke ontwikkeling doormaakt, is empathie (Hoofdstuk 4). Om empathie te ervaren, moeten kinderen diverse emotionele vermogens mobiliseren en coördineren, waaronder het mede-ervaren van de emoties van anderen ('affective empathy'), het onderscheiden van het leed van anderen van dat van zichzelf en aandacht voor anderen ('other-oriented attention'), het begrijpen van hoe en waarom anderen zich voelen ('cognitive empathy'), en het gemotiveerd zijn om anderen te troosten en te helpen ('prosocial actions') (Rieffe et al., 2010). Empathie is een zeer belangrijk menselijk vermogen. Voor het zelf motiveert het prosociale acties en duwt het ons om anderen in nood te helpen (Morelli et al., 2014). Naar anderen toe, zorgt het ervoor dat de ander zich veilig, gehoord en begrepen voelt. Dit voedt en versterkt ook de sociale relaties met andere mensen (Anderson, 2018).

Het centrale doel van dit proefschrift

Dit proefschrift tracht ons begrip van de vroege ontwikkeling van het emotioneel functioneren bij peuters en kleuters met autisme te vergroten. Middels gedragstaken, observaties en oudervragenlijsten werden vier longitudinale onderzoeken uitgevoerd naar diverse belangrijke emotionele vaardigheden bij kinderen met autisme van 1,5 tot 7 jaar. Dit gebeurde vanuit zowel (1) de horizontale dimensie: het detecteren van de unieke uitdagingen waarmee kinderen met autisme in het emotionele domein worden geconfronteerd, door de verschillen tussen personen te onderzoeken in vergelijking met leeftijdsgenoten zonder autisme; en (2) de verticale dimensie: het onderzoeken van de variaties binnen de persoon en het volgen van de emotionele ontwikkeling van kinderen met en zonder autisme over een periode van twee tot drie jaar.

De horizontale dimensie:

Uitdagingen voor kinderen met autisme in het emotionele domein

Binnen de horizontale dimensie werd onderzocht in hoeverre kinderen met autisme verschilden van kinderen zonder autisme wat betreft hun emotioneel functioneren. In het emotionele domein werden op bijna alle aspecten verschillen gevonden. Ten eerste hadden kinderen met autisme, vergeleken met kinderen zonder autisme, gemiddeld meer moeite met het herkennen en begrijpen van emoties van anderen (Hoofdstuk 2 & 4). Het was voor velen van hen ook een grotere uitdaging om hun eigen emoties te reguleren. De emotie-expressies bij kinderen met autisme waren gemiddeld ofwel intensiever of minder intensief in vergelijking met kinderen zonder autisme (Hoofdstuk 3 & 5). Bovendien was het letten op de emotionele uitingen van anderen vaak niet zo automatisch en moeiteloos voor kinderen met autisme als voor hun leeftijdsgenoten zonder autisme (Hoofdstuk 4). Het is dus niet verrassend dat veel kinderen met autisme niet in dezelfde mate reageerden op de emotionele uitingen van anderen op sociaal verwachte manieren zoals hun leeftijdsgenoten zonder autisme (Hoofdstuk 4). Deze onderzoeksresultaten tonen aan dat deelname aan sociale interacties een heel andere ervaring kan zijn voor kinderen met autisme, die veel uitdagingen met zich meebrengt en stress kan veroorzaken. Inderdaad, kinderen met autisme werden gemiddeld gezien als minder sociaal competent vergeleken met hun niet-autistische leeftijdsgenoten en hadden zowel meer internaliserende als externaliserende gedragsproblemen (Hoofdstuk 4 & 5).

De verticale dimensie:

Ontwikkeling van emotioneel functioneren bij kinderen met autisme

Ondanks de verschillen en uitdagingen vertoonden kinderen met autisme, als we naar de verticale dimensie keken, in de loop van de tijd verbetering in bijna elk aspect van hun emotioneel functioneren. Hun vermogen om emoties te herkennen in prototypische situaties - zoals gemeten door gedragstaken (Hoofdstuk 2) - en in het dagelijks leven - zoals gerapporteerd door ouders (Hoofdstuk 4) - verbeterden allemaal in hetzelfde tempo als bij kinderen zonder autisme. Sommige emotionele vaardigheden, zoals het herkennen van blije en boze gezichtsuitdrukkingen (Hoofdstuk 2), en het aangaan van prosociale acties tijdens de empathietaken (hoofdstuk 4), namen zelfs nog sterker toe bij kinderen met autisme, dan bij kinderen zonder autisme. Dit biedt een positieve boodschap: veel kinderen met autisme, net als kinderen zonder autisme, hebben het potentieel om te leren en te verbeteren op het (sociaal)emotioneel gebied.

Waar kinderen met autisme niet verschilden van leeftijdsgenoten zonder autisme

Het is vermeldenswaard dat er voor sommige emotionele vermogens vergelijkbare niveaus en een vergelijkbare ontwikkeling werden gevonden bij kinderen met autisme als bij hun niet autistische leeftijdsgenoten. Met betrekking tot de ontwikkeling van het toeschrijven van negatieve emoties aan emotie-opwekkende situaties (Hoofdstuk 2), het uiten van trots in trots-opwekkende situaties (Hoofdstuk 3) en de door ouders gerapporteerde affectieve empathie (Hoofdstuk 4), verschilden de gemiddelde niveaus en de ontwikkelingstrajecten van kinderen met autisme niet van die van kinderen zonder autisme. De verschillende patronen die gevonden werden in de ontwikkeling van diverse emotionele vermogens bij kinderen met autisme suggereren dat het belangrijk is om hun emotionele ontwikkeling op microniveau te onderzoeken in plaats van op macroniveau. Niet alle emotionele vermogens zijn op een gecoördineerde manier ontwikkeld en sommige emotionele vermogens lijken meer door autisme te worden beïnvloed dan andere.

Conclusie en maatschappelijke implicaties

Dit proefschrift had tot doel ons begrip van de vroege ontwikkeling van het (sociaal)emotioneel functioneren bij peuters en kleuters met autisme te versterken. Enerzijds bevestigde dit proefschrift de uitdagingen en moeilijkheden waarmee veel kinderen met autisme in het emotionele domein worden geconfronteerd. Deze uitdagingen bleken al op een jonge leeftijd aanwezig en bleven in de loop van de tijd bestaan. Ondanks de moeilijkheden en uitdagingen, verbeterden de meeste emotionele vermogens van kinderen met autisme wel naarmate ze ouder werden en ontwikkelden ze zich op dezelfde manier als bij kinderen zonder autisme. Dit toont aan dat autistische kinderen wel het potentieel hebben om emoties te leren en te verbeteren. Het op een zo jong mogelijke leeftijd krijgen van de autismediagnose en het op de juiste manier en tijdig krijgen van benodigde ondersteuning lijkt essentieel voor het stimuleren van hun emotionele ontwikkeling. Ondertussen is het net zo belangrijk om het autismebewustzijn bij niet-autistische mensen te vergroten en een lerende, motiverende, respectvolle en inclusieve sociale omgeving te creëren, waar autistische kinderen gelijke kansen krijgen voor sociaal emotioneel leren en zich naar hun volle potentieel kunnen ontwikkelen.

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Appendices.

Supplementary materials

Acknowledgements

Curriculum Vitae

Supplementary Materials Chapter 2

Table S2.1. Means and standard deviations (SD) of emotion discrimination at four waves.

	Autistic			*Non-autistic*		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Positive vs. Negative (0-3)						
Time 1	1.91	1.08	61	2.19	.84	121
Time 2	2.30	.96	45	2.63	.74	51
Time 3	2.49	.83	43	2.86	.41	49
Time 4	2.59	.81	41	2.89	.31	47
Sad vs. Angry (0-3)						
Time 1	1.57	1.06	61	1.87	.91	121
Time 2	1.97	.95	45	2.17	.94	52
Time 3	2.17	.94	43	2.56	.75	49
Time 4	2.33	.90	40	2.73	.52	47

Table S2.2. Means and standard deviations (SD) of emotion identification at four waves.

	Autistic			*Non-autistic*		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Happy (0-2)						
Time 1	1.39	.88	62	1.75	.60	121
Time 2	1.67	.74	45	1.98	.14	52
Time 3	1.88	.45	43	1.94	.24	49
Time 4	1.93	.35	41	2.00	.00	47
Angry (0-2)						
Time 1	1.29	.91	62	1.77	.60	121
Time 2	1.60	.75	45	2.00	.00	52
Time 3	1.84	.53	43	2.00	.00	49
Time 4	1.83	.54	41	2.00	.00	47
Sad (0-2)						
Time 1	1.03	.94	62	1.37	.83	121
Time 2	1.38	.81	45	1.77	.47	52
Time 3	1.70	.64	43	1.92	.28	49
Time 4	1.83	.50	41	1.96	.20	47
Fear (0-2)						
Time 1	1.10	.95	62	1.36	.84	121
Time 2	1.42	.87	45	1.79	.50	52
Time 3	1.74	.62	43	1.94	.24	49
Time 4	1.88	.46	41	1.94	.32	47

Table S2.3. Means and standard deviations (SD) of emotion attribution at four waves.

	Autistic						*Non-autistic*					
	Verbal			***Visual***			***Verbal***			***Visual***		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**
Positive emotions (0-2)												
Wave 1	1.10	.89	62	1.11	.89	62	1.58	.69	121	1.59	.68	121
Wave 2	1.58	.78	45	1.58	.78	45	1.88	.32	52	1.88	.32	52
Wave 3	1.53	.74	47	1.60	.69	43	1.79	.45	53	1.78	.47	49
Wave 4	1.61	.61	47	1.63	.58	41	1.87	.34	53	1.86	.35	43
Negative emotions (0-2)												
Wave 1	1.18	.66	62	.94	.73	62	1.11	.52	121	1.13	.49	121
Wave 2	1.30	.61	45	1.34	.62	45	1.29	.31	52	1.33	.30	52
Wave 3	1.45	.55	43	1.47	.57	43	1.28	.38	49	1.27	.39	49
Wave 4	1.33	.55	41	1.34	.53	41	1.30	.45	47	1.34	.45	45

Table S2.4. Eight vignettes depicting emotion-provoking situations in the emotion attribution task.

Vignette content
1. The boy is building a tower; someone knocks it down.
2. The boy receives an ice cream.
3. Someone is pulling at the boy's shirt.
4. The boy falls off from the bicycle.
5. The boy receives a present.
6. The Boya sees a frightening dog.
7. The spade of the boy is broken.
8. The boy sees a crocodile.

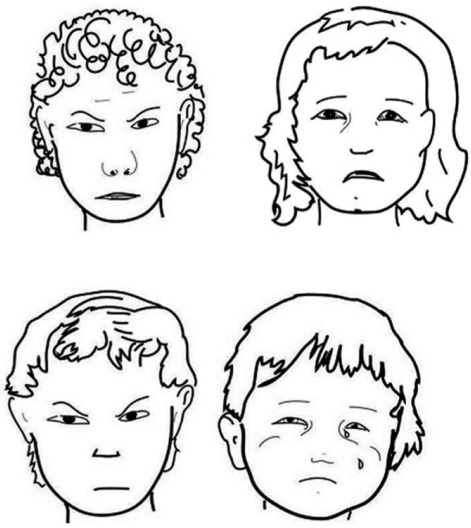

Figure S2.1. Examples of facial emotion expressions used in this study. From left to right: angry facial expressions and sad facial expressions.

Table S2.5. Model fit indices of the best age models for emotion recognition.

	Emotion discrimination			
	Positive vs. negative			
	AIC	BIC	-2LL	X^2 statistics
Null model	1143.21	1155.59	1137.21	-
Best age model**:** age (linear; fixed), group	1033.77	1054.28	1023.77	X^2 (2)=113.44, p<.001
	Sad vs. Anger			
	AIC	BIC	-2LL	X^2 statistics
Null model	1241.63	1254.01	1235.63	-
Best age model: age (linear; fixed), group	1118.13	1138.65	1108.13	X^2 (2)=127.50, p<.001

				Emotion identification
	Happy			
	AIC	BIC	-2LL	X^2 statistics
Null model	712.53	724.93	706.53	
Best age model: age (linear; fixed & random), group, age x group	552.65	585.50	536.65	X^2 (5)=169.88, p<.001
	Angry			
	AIC	BIC	-2LL	X^2 statistics
Null model	743.92	756.32	737.92	
Best age model: age (linear; fixed & random), group, age x group	561.89	594.73	545.89	X^2 (5)=192.04, p<.001
	Sad			
	AIC	BIC	-2LL	X^2 statistics
Null model	1003.97	1016.37	997.97	
Best age model: age (linear; fixed & random), group	857.09	885.84	843.09	X^2 (4)=154.89, p<.001
	Fear			
	AIC	BIC	-2LL	X^2 statistics
Null model	1017.72	1030.11	1011.72	
Best age model: age (linear; fixed & random), group	850.26	879.01	836.26	X^2 (4)=161.71, p<.001
				Emotion attribution
	Positive emotions (Verbal)			
	AIC	BIC	-2LL	X^2 statistics
Null model	963.13	975.52	957.13	
Best age model: age (linear; fixed & random), group	832.06	860.80	818.06	X^2 (4) = 139.07, p < .001

	Positive emotions (Visual)			
	AIC	BIC	-2LL	X^2 statistics
Null model	892.08	904.45	886.08	
Best age model: age (linear; fixed & random), group, age x group	782.54	815.32	766.54	X^2 (5) = 119.54, $p < .001$
	Negative emotions (Verbal)			
	AIC	BIC	-2LL	X^2 statistics
Null model	541.32	553.71	535.32	
Best age model: age (linear; fixed)	524.59	541.02	516.59	X^2 (1) = 18.73, $p < .001$
	Negative emotions (Visual)			
	AIC	BIC	-2LL	X^2 statistics
Null model	692.32	794.71	686.32	
Best age model: age (linear; fixed & random)	622.05	646.67	610.05	X^2 (3) = 76.27, $p < .001$

NOTE. Models removed during the formal model-fitting procedures were not presented here. The χ^2 statistics present the comparisons of the -2LL values between the best fitting models and the null models.

Table S2.6. Model fit indices of the predicting models with the means score of SRS as the predictor on emotion recognition abilities in autistic children.

				Emotion discrimination
	AIC	BIC	-2LL	X^2 statistics
Age-only model	425.04	437.92	417.04	-
Model with SRS mean	338.55	353.71	328.55	X^2 (1) = 88.49, p < .001
				Emotion identification
	AIC	BIC	-2LL	X^2 statistics
Age-only model	283.88	296.76	275.88	-
Model with SRS mean	230.16	245.31	220.16	X^2 (1) = 55.72, p < .001
				Emotion attribution verbal condition
	AIC	BIC	-2LL	X^2 statistics
Age-only model	301.82	314.71	293.82	-
Model with SRS mean	243.82	258.98	233.82	X^2 (1) = 60, p < .001
				Emotion attribution visual condition
	AIC	BIC	-2LL	X^2 statistics
Age-only model	310.73	323.59	302.73	-
Model with SRS mean	251.71	266.83	241.71	X^2 (1) = 61.02, p < .001

NOTE. The χ^2 statistics present the comparisons of the -2LL values of the age-only models and the models with SRS mean and change scores as predictors.

Supplementary Materials Chapter 3

Table S3.1. Sample size justification.

Analysis	Explanation
Power analysis for the larger project	An a priori power analysis was conducted for the larger research project that embedded this study. It showed that to observe a medium-sized effect (effect size = .35, power = .80, alpha = .05), a total sample size of 216 children would be needed for analyses with four repeated measures and two groups. Note that this analysis was done for the larger project and based on a repeated measure ANOVA design. We opted for mixed models for the current study because it better accounts for the dependency within the data and can handle missing or unbalanced data.
Power analysis for the present study	We did not conduct an a priori power analysis specifically for this study because the study was based on the data already collected. Yet, to understand the sample size needed for detecting the effect of diagnosis group in multilevel models, a simulation analysis was conducted via the Optimal Design program (Version 3.01; Raudenbush et al., 2011). It showed that in the case where each participant has two waves of data, an effect of group can be detected with a power ≥ .80 when the total number of participants is ≥ 150; in the case where each participant has three waves of data, a total sample size of ≥ 100 is needed (alpha = .05; effect size = .35). Given that 80% of our participants had three waves of data, we assumed that the power for conducting the analyses is adequate.

Table S3.2. Internal consistency of measures at three times points.

	Cronbach's α		
	Autistic	**Non-autistic**	**Total**
Time 1			
Shame/guilt	0.97	0.79	0.96
Pride	0.88	0.78	0.83
EU	0.91	0.74	0.91
Time 2			
Shame/guilt	0.71	0.82	0.81
Pride	0.83	0.78	0.80
EU	0.92	0.76	0.92
Time 3			
Shame/guilt	0.81	0.83	0.86
Pride	0.79	0.81	0.82
EU	0.88	0.79	0.89

NOTE. EU: emotion understanding.

Table S3.3. Correlation matrix of the predicting variables and moral emotions at three time points.

		Pride			Age			FB[a]			EU[b]		
		T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Shame	**T1**	.29**			.06			.45**/.16			-.25/.15		
	T2		.09			-.21*			.03			.10	
	T3			.42**			.12			.30**			.36**
Pride	**T1**				.36*/.05			.40**/-.07			-.03		
	T2					.15			.45**/-.002			.15	
	T3						-.10			.39*/-.01			.13
Age	**T1**							.45**/.66**			.02		
	T2								.39**			-.01	
	T3									.23*			.22
FB[a]	**T1**										.16		
	T2											.45**/.13	
	T3												.34**

Note. [a.] false belief; [b.] emotion understanding. *$p < .05$; **$p < .001$.

First, the correlation analyses were conducted for children with and without ASD separately. Next, Fisher *r*-to-*z* transformations were used to compare the correlations of the two groups. Correlations that did not differ between groups were recalculated by collapsing groups. Correlations that differed between groups were both reported in the table, with the correlation of the ASD group on the left and the correlation of the non-ASD group on the right separated by slash.

Supplementary Materials Chapter 4

Table S4.1. Mean scores, standard deviations (SD) and reliabilities of parent-reported empathy of autistic and non-autistic group at four time points.

	Autistic				*Non-autistic*			
	Mean	**SD**	**ω_t**	**N**	**Mean**	**SD**	**ω_t**	**N**
Affective (0-2)								
Time 1	0.32	0.34	0.85	54	0.30	0.32	0.89	118
Time 2	0.34	0.38	0.86	50	0.30	0.31	0.88	49
Time 3	0.38	0.42	0.91	45	0.26	0.29	0.80	41
Time 4	0.38	0.36	0.83	31	0.22	0.30	0.91	33
Attention (0-2)								
Time 1	0.93	0.49	0.88	54	1.38	0.35	0.82	118
Time 2	0.97	0.49	0.89	50	1.40	0.36	0.81	49
Time 3	0.96	0.47	0.87	45	1.41	0.31	0.73	41
Time 4	1.02	0.48	0.87	31	1.36	0.42	0.88	33
Prosocial (0-2)								
Time 1	0.39	0.38	0.86	54	0.98	0.39	0.89	118
Time 2	0.41	0.42	0.91	50	1.12	0.36	0.89	49
Time 3	0.47	0.45	0.88	45	1.19	0.33	0.86	41
Time 4	0.58	0.40	0.90	31	1.26	0.42	0.94	33
Cognitive (0-5)								
Time 1	2.90	0.92	0.93	55	3.87	0.54	0.84	121
Time 2	2.94	0.91	0.94	50	4.13	0.81	0.89	49
Time 3	2.97	0.96	0.95	45	4.15	0.53	0.90	41
Time 4	3.14	0.98	0.94	31	4.04	0.55	0.90	33

Table S4.2. Mean scores, standard deviations (SD) and reliabilities of observed empathy of autistic and non-autistic group at four time points.

	Autistic				*Non-autistic*			
	Mean	**SD**	**ω_t**	**N**	**Mean**	**SD**	**ω_t**	**N**
Affective (0-2)								
Time 1	0.64	0.48	0.90	61	0.83	0.47	0.84	145
Time 2	0,63	0.53	0.83	50	0.89	0.53	0.80	51
Time 3	0.68	0.39	0.78	47	0.73	0.44	0.70	48
Time 4	0.59	0.46	0.83	43	1.13	0.43	0.74	44
Attention (0-2)								
Time 1	0.99	0.62	0.93	61	1.50	0.48	0.88	145
Time 2	1.36	0.57	0.89	50	1.83	0.28	0.75	51
Time 3	1.02	0.29	0.78	47	1.25	0.25	0.72	48
Time 4	0.95	0.38	0.85	43	1.21	0.24	0.80	44
Prosocial (0-2)								
Time 1	0.22	0.28	0.87	60	0.31	0.35	0.82	144
Time 2	0.40	0.40	0.71	50	0.54	0.41	0.84	51
Time 3	0.64	0.36	0.66	47	0.41	0.33	0.55	48
Time 4	0.49	0.29	0.64	42	0.57	0.40	0.64	43

Table S4.3. Mean scores, standard deviations (SD) and reliabilities of psychosocial functioning of autistic and non-autistic group at four time points.

	Autistic				*Non-autistic*			
	Mean	**SD**	**ω_t**	**N**	**Mean**	**SD**	**ω_t**	**N**
Externalizing (0-3)								
Time 1	0.94	0.49	0.95	55	0.43	0.25	0.89	112
Time 2	0.50	0.34	0.94	49	0.32	0.26	0.93	45
Time 3	0.50	0.33	0.94	45	0.30	0.24	0.94	34
Time 4	0.43	0.38	0.94	30	0.22	0.22	0.93	28
Cooperation (0-2)								
Time 1	1.33	0.62	0.96	60	1.74	0.35	0.92	145
Time 2	1.44	0.46	0.95	50	1.85	0.23	0.91	52
Time 3	1.56	0.40	0.94	47	1.77	0.34	0.93	47
Time 4	1.53	0.52	0.96	44	1.85	0.16	0.82	44

Table S4.4. Model fit indices of the best age models for empathy.

Parent reports				
	Affective			
	AIC	BIC	-2LL	X^2 statistics
Null model	165.69	177.81	159.69	-
***Best age model*:** age (linear)	155.43	171.37	147.43	X^2 (1)=9.26, p<.001
	Attention			
	AIC	BIC	-2LL	X^2 statistics
Null model	331.38	343.51	325.38	-
Best age model: age (linear), group	292.52	312.44	282.52	X^2 (2)=51.21, p<.001
	Prosocial			
	AIC	BIC	-2LL	X^2 statistics
Null model	386.91	399.03	380.91	
Best age model: age (linear), group	264.66	284.58	254.66	X^2 (2)=126.25, p<.001
	Cognitive			
	AIC	BIC	-2LL	X^2 statistics
Null model	1116.12	1124.23	1112.12	
Best age model: age (linear), group, age*group	881.75	901.72	871.75	X^2 (2)=240.37, p<.001
Observation				
	Affective			
	AIC	BIC	-2LL	X^2 statistics
Null model	662.43	675	656.43	
Best age model: age (linear), group	636.06	656.91	626.06	X^2 (2)=30.37, p<.001
	Attention			
	AIC	BIC	-2LL	X^2 statistics
Null model	705.34	717.92	699.34	

Best age model: age (linear), group, age*group	625.30	646.16	615.30	X^2 (3)=41.43, p<.001
	Prosocial			
	AIC	BIC	-2LL	X^2 statistics
Null model	423.79	436.34	417.79	
Best age model: age(linear), group, age*group	379.49	404.47	367.49	X^2 (3)=50.30, p<.001

Table S4.5. Model fit indices of the best fitting models for psychosocial functioning with empathy as the predictor.

	Externalizing problems			
	AIC	BIC	-2LL	X^2 statistics
Null model	210.06	229.75	200.06	-
Best predicting model with parent-reported empathy without cognitive empathy: age, group, mean, change	201.77	229.10	187.77	X^2 (2) = 12.29, p = .002
Best predicting model with parent-reported empathy including cognitive empathy: age, group, mean, change	201.46	228.87	187.46	X^2 (2) = 12.54, p = .002
Best predicting model with observed empathy: age, group, mean, change	206.74	232.26	190.74	X^2 (2) = 9.32, p = .009
	Social competence			
	AIC	BIC	-2LL	X^2 statistics
Null model	384.92	405.78	374.92	-
Best predicting model with parent-reported empathy without cognitive	261.03	292.62	245.03	X^2 (3) = 129.89, p < .001

empathy: age, group, mean, change, mean*group				
Best predicting model with parent-reported empathy including cognitive empathy: age, group, mean, change, mean*group	300.09	268.34	252.34	X^2 (3) = 122.58, $p < .001$
Best predicting model with observed empathy: age, group, mean, change, mean*group, change*group	299.23	336.74	281.23	X^2 (4) = 92.69, $p < .001$

Notes Supplementary Table 4 and 5. Models removed during the formal model-fitting procedures were not presented here. The χ^2 statistics present the comparisons of the -2LL values between the best fitting models and the null models.

Supplementary Materials Chapter 5

Table S5.1. Available data per group per time-point (TP).

		TD	ASD	TOTAL
Internalizing		n	n	N
	1 TP	33	11	44
	2 TP	22	8	30
	3 TP	42	40	82
Externalizing				
	1 TP	33	11	44
	2 TP	23	8	31
	3 TP	41	40	81
Negative Emotion expression				
	1 TP	29	11	40
	2 TP	21	7	28
	3 TP	47	41	88
Emotion recognition				
	1 TP	29	11	40
	2 TP	20	7	27
	3 TP	48	41	59
Emotion vocabulary basic				
	1 TP	29	11	40
	2 TP	21	7	28
	3 TP	47	41	89
Emotion vocabulary mental states				
	1 TP	29	11	40
	2 TP	21	7	28
	3 TP	47	41	89

Table S5.2. Internal consistency of measures per time point per group.

		Cronbach's α	
		TD	ASD
Time 1			
Internalizing		0.874	0.639
Externalizing		0.868	0.962
Negative emotion expression		0.787	0.633
Positive emotion expression		0.655	0.673
Emotion recognition		0.758	0.878
Emotion vocabulary			
	Basic	0.865	0.748
	Mental states	0.697	0.752
Time 2			
Internalizing		0.874	0.882
Externalizing		0.889	0.895
Negative emotion expression		0.802	0.817
Positive emotion expression		0.398	0.705
Emotion recognition		0.764	0.908
Emotion vocabulary			
	Basic	0.749	0.831
	Mental states	0.827	0.824
Time 3			
Internalizing		0.869	0.894
Externalizing		0.887	0.919
Negative emoiton expression		0.679	0.825
Positive emotion expression		0.600	0.780
Emotion recognition		0.798	0.908
Emotion vocabulary			
	Basic	-0.360	0.792
	Mental states	0.134	0.811

Table S5.3. Model fit indices per model.

	Internalizing			Externalizing		
Best fitting age-model	AIC	BIC	X^2 statistic	AIC	BIC	X^2 statistic
Null Model	2055	2062	-	2391	2399	-
Linear Age-model	1976	1983	$X^2(1) = -79$, $p < .001$	2315	2323	$X^2(1) = -67$, $p < .001$
Quadratic Age-model	1985	1993	$X^2(1) = 10$, $p > .20$	2324	2332	$X^2(1) = 9$, $p > .20$
Cubic Age-model	1995	2003	$X^2(1) = 10$, $p > .20$	2333	2340	$X^2(1) = 8$, $p > .20$
Linear Age x Group	**1966**	**1974**	$X^2(2) = 29$, $p < .001$	**2291**	**2299**	$X^2(2) = -41$, $p < .001$
Best fitting model including all predictors						
Full model	**1878**	**1885**	$X^2(5) = 89$, $p < .001$	2203	2211	$X^2(5) = -88$, $p < .001$
Full model including interactions with Group	1868	1875	$X^2(5) = 10$, $p > .10$	**2179**	**2186**	$X^2(5) = -25$, $p < .001$

With χ^2 analyses we tested whether adding extra variables to the model improved model fit. We used the difference between the BIC values of the most parsimonious model with the next model, so null model – linear age-model (i.e., BIC (linear age-model) 1983 - BIC (null model) 2062 = 79). For the full model including all variables of emotion functioning (i.e., emotion expression, emotion recognition, and emotion vocabulary), we compared with the best age-model. We report the χ^2 statistic of model comparison of the BIC values, given that BIC values take the number of added variables into account. Note that BIC and AIC indices resulted in the same selection of best fitting models.

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CURRICULUM VITAE

Boya Li was born on 27 April 1978, in Yichang, China. From 1996 to 2000, she did her Bachelor study at Beijing Language and Culture University, majoring in teaching Chinese as a foreign language. In 2000, she started her Master program at Peking University, specializing in Chinese linguistics. After one year, she moved to the Netherlands to do her doctoral research on Chinese sentence final particles, under the supervision of prof. dr. Rint Sybesma and prof. dr. Lisa Cheng at Leiden University Center for Linguistics. She obtained her PhD degree in linguistics in 2006. After finishing her PhD project, Boya moved to Warsaw, Poland, to live with her husband. During her stay in Warsaw, she grew a strong interest in psychology. From 2010 to 2013, she did her Bachelor study in psychology at the Faculty of Psychology, the University of Warsaw. She moved back to the Netherlands in 2013 and was admitted to the Research Master program in developmental psychology at Leiden University. After obtaining her Research Master degree in 2015, Boya received the opportunity to work as a researcher and teacher in the unit of Developmental and Educational Psychology at Leiden University. She started her second PhD project in December 2019, under the supervision of prof. Carolien Rieffe, dr. Kirstin Greaves-Lord, and dr. Els Blijd-Hoogewys, to investigate the development of emotional functioning in young children with autism. From January 2021, she joined a new research project as a postdoc researcher, working together with prof. Carolien Rieffe and dr. Els Blijd-Hoogewys, to investigate how to create a more inclusive social environment for pupils with autism.