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Emotion processing in preschoolers with autism spectrum disorders
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Chapter 1

General introduction



Humans spend a great deal of their lives on social interactions, normally within the same species, and usually beneficial to one or more of the individuals. It is believed that social behavior evolved because it is helpful to those who engage in it, which means that these individuals are more likely to survive and reproduce (Brothers, 2002). Social behavior serves many purposes and provides many benefits to those who practice it. Being able to participate in a social environment is a condition for maintaining a successful personal and professional life, such as having friends and a career. But social functioning also determines greater feelings of worthiness, purpose, and experiencing quality of life. In infancy, social behavior is already of vital importance to the development of children, from the first social smile to responding to your own name. These early social interactions thrive the developing brain and are crucial in our early years of life. During childhood, social behavior further evolves and is important for making friends, feeling confident, discovering your own identity but also to adapt in different contexts such as school, social activities, and at home.

The human brain is designed for social interactions to run smoothly. The neuropsychology of social behavior studies these neural networks and related cognitive and emotional systems that enable humans to understand, predict and share feelings, thoughts, desires, and intentions (Van Rijn, Van 't Wout, & Spik, 2012). An important question is to what extent cognitive and emotion processes can be discriminated and how they work together in facilitating social behavior. It is believed that cognition and emotion are two specific, functionally different systems for information processing, that are closely working together to successfully navigate through a complex, dynamic, social, and constantly changing world (Beauchamp & Anderson, 2010).

Cognitive functions can be defined as mental processes involved in social interactions and can be divided into three stages; perception (attending), interpretation, and reaction (Van Rijn et al., 2012). Examples of social cognitive functions are the ability to recognize faces and facial expressions, understanding the feelings and needs of others, and taking part in a conversation. Social cognitive functions can be differentiated from more general cognitive skills that also work in facilitating social behavior, such as attention, inhibitory control, and working memory.

Emotions are a prerequisite for social motivation because emotional incentives, like finding reward or pleasure or successfully avoiding pain or sadness play a major role in facilitating behaviors. Social interactions are full of emotions and vice versa social emotions become meaningful when interacting with others. In social situations, that are often unpredictable and contain incomplete information, emotions can enhance adaptive behavior and can be helpful in making decisions (Izard, 1971). Emotions have a motivational function, and make you pay attention in a fearful situation, but also have a strong communicative function which is necessary for the environment to be able to rapidly understand what is needed (Blair, 2003). Emotions however, can also be hindering when the timing is off, when the intensity does not match the social situation, or when directed towards irrelevant aspects (Lazarus,

1991; Parrott, 2001). Emotion related processes, in contrast to cognitive processes, are physical or bodily reactions that lead to adequate adaptive behavior to the specific situation. Given the complex nature of social functioning, involving not only social cognitive processes but also emotion related processes, social development is vulnerable to developmental disruptions and shows great individual variability. Ranging from children who easily tune in to others, to children who have substantial difficulties navigating their social environment. This vulnerability and the impact of developmental disruptions can be seen in Autism Spectrum Disorders (ASD; Box 1.), a spectrum of pervasive neurodevelopmental disorders which manifest before the age of four and are characterized by persistent deficits in social communication and social interaction, such as social-emotional reciprocity, nonverbal communicative behaviors, and deficits in developing, maintaining and understanding relationships (APA, 2013). The worldwide population prevalence of ASD is about 1% and affects more male than female individuals (Lai, Lombardo, & Baron-Cohen, 2014). Consequences of the social communication problems in ASD on later outcomes can be severe, expressed in a high risk for poor quality of (social) life, even compared to other childhood psychopathology (Barneveld, Swaab, Fagel, van Engeland, & de Sonnevile, 2014). The compromised overall quality of life in individuals with ASD stresses the importance of understanding the underlying mechanisms of impaired social behavior. The majority of studies in ASD that aimed at explaining the social behavior problems over the last decades, have had a focus on cognitive functions such as facial recognition and theory of mind. In addition, emotion has mainly been investigated in terms of empathy. Empathy has been defined as ‘the capacity to be affected by and share the emotional state of another, to assess the reasons for the other’s state, and to identify with the other, adopting his or her perspective’ (de Waal, 2008). A distinction is typically made between ‘cognitive empathy’, i.e. understanding emotions of others (also termed Theory of Mind), and affective empathy, i.e. resonating with others in terms of affective state. Much more research has been done on cognitive empathy (Theory of Mind) than affective empathy, and how affective empathy relates to other aspects of emotion processing remain poorly understood in ASD. There is a need for studies integrating all levels of emotion processing, including how children with ASD perceive, experience, regulate, and express emotions by investigating not only what can be seen on the ‘outside’ in terms of behavior, but also the processing of emotions on the ‘inside’ referring to underlying processes.

The central aim of this dissertation was to further explore emotion processing by combining new, sensitive, and direct measures of physiological, cognitive, and behavioral mechanisms that are involved in the development of emotion processing in preschool children with ASD during a critical period of development. Knowledge about the development of early emotion processing that are building blocks of social development is crucial for identifying windows of opportunity to stimulate development. This knowledge could benefit parents and professionals in understanding and supporting children with ASD, optimizing the

circumstances in which these children develop and benefitting from brain plasticity during the early preschool years in particular. Eventually this could lead to improvement of interventions that are adapted to the origins and underlying mechanisms of social dysfunction.

Box 1. DSM-5 diagnostic criteria for autism spectrum disorder 299.00 (F84.0)

- 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 non-verbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and non-verbal 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 non-verbal 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 of verbal or non-verbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat same 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 interests).

- 4) Hyper- or hyporeactivity to sensory input or unusual interest 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.

From the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (APA, 2013)

What are emotions?

Already 36 years ago, a list was composed of the 92 definitions of emotion (Kleinginna & Kleinginna, 1981). And still, there is debate as to what an emotion actually is considered to be. The first important characteristic of an emotion that is commonly mentioned is *when it occurs*. Generally, an emotion is felt when you direct your attention, which can either be conscious, complicated and enduring (writing a thesis), or less conscious, simple and transient (such as a startle response when the window washer suddenly appears). They may be widely shared in a group, containing complex social interactions (laughing in response to social interactions during coffee with colleagues) or individual (in response to reading an acceptance email from an editor). Emotions can be experienced in response to what others do, but can also be felt intrapersonal. It is the subjective meaning of the particular situation that gives rise to the emotion and these emotions change constantly due to changes in the situation itself or changes in the meaning the situation holds for the individual (Gross, 2013).

Another broadly accepted characteristic of emotions is that they are *multifaceted*. This is described in the definition by Hockenbury & Hockenbury (2010) stating that an emotion is a complex psychological state that involves three distinct components; *a subjective experience (feeling), observable behavior or expression, and physiological activity*. So

emotions not only make us feel, but they make us act (Gross, 2013). Examples of these actions are facial and bodily expressions, but also instrumental actions such as staring and cheering and the actions that are initiated by the fight or flight response. These changes that occur in the body and in behavior are closely related to underlying autonomic and neurobiological (physiological) responses, that enable us to achieve our goals that gave rise to the emotion in the first place (Levenson, 2014).

As our environment is largely social, we are able to adapt to changes in our social environment with the help of our emotions. A distinction can be made between perceiving the emotions of others and own experienced emotions. The perception of other people's emotions is necessary to continuously collect information in a social context, to give meaning to this information, and to adjust your behavior and responses accordingly. Besides the emotions of others, it is of equal importance to recognize your own emotions, which also has social consequences. For example, showing sadness results in getting support from others and smiling eases entering into relationships. A crucial prerequisite for recognizing emotions in others but also one's own emotions, is that you have attention for the social information in your environment.

Attention and emotion

Attending to (the emotions of) others is an important part of social information processing and is one of the most valuable sources of social information. It is believed that this capacity is part of an evolutionarily ancient process activating animals to preferentially attend to other animals (Simion, Regolin, & Bulf, 2008). Preferential attention towards biological motion (such as motor movements) and other meaningful social signals in humans is already present from a very early age, even in two-day-old infants (Haith, Bergman, & Moore, 1977; Klein, Shepherd, & Platt, 2009; Salva, Farroni, Regolin, Vallortigara, & Johnson, 2011; Simion et al., 2008) and is referred to as social attention. Social attention is considered an intrinsic capacity of the visual system, triggered by or resulting in an arousal response. Detecting emotions of others, as evident from facial expressions, tone of voice, body postures, and motor movements, is crucial for the development of adaptive social behaviors, such as learning to socialize and tune into the wishes, desires, and intentions of others. Thus, adequate attention to other people's emotions is supposed to be necessary to continuously gather information about the social interaction that is taking place and if necessary to adjust behavior accordingly.

Emotional arousal

Another aspect of social information processing is an arousal response which triggers an emotion and enables the body to respond accordingly. Arousal is driven by the complex and interactive functioning of the autonomic nervous system. Together with other neurophysiological and neuroanatomical processes, reciprocally linked with the central

nervous system (the brain and the spinal cord) as part of the nervous system, and is considered a primary behavioral regulator (Porges, 2001). The autonomic nervous system has two branches, the sympathetic nervous system (involved in stress and activity, also referred to as the ‘gas pedal’) and the parasympathetic nervous system (promoting calm, vegetative activities, described as the ‘brake’). For example, the perception of a dangerous situation leads to rapid physiological changes, such as the production of adrenaline, increase in heart rate, and tension of muscles which prepares the body for action. The importance of the autonomic nervous system as regulator, activator, coordinator, and communicator is reflected in the constant monitoring and adjusting of our functioning, enabling the body to respond to internal and external demands (Levenson, 2014).

In daily life, an arousal response is necessary for being able to experience emotions but also has a regulatory function with regard to the response to emotions of others, expressed in behavior. An arousal response, or modulation in arousal is necessary for responding to situational demands, such as emotionally resonating with others but also for example to tone down a behavioral response when others seem to be hurt by your actions or words (Lydon et al., 2016). Vice versa, autonomic rigidity is related to a lessened capacity to generate or alter physiological and emotional responses in synchrony with changes in the environment (Appelhans & Luecken, 2006) and has been identified as risk factor for later development of behavioral and emotional problems (Lydon et al., 2016).

An increase in arousal is thought to improve performance, but only up to a certain level (which is different for every individual), also called the optimum level of arousal (Yerkes & Dodson, 1908). When tipping over the optimum level of arousal (e.g. hyper-arousal), performance begins to suffer and this high level of arousal can lead to stress, panic, anger or even violence. On the contrary, a blunted arousal response is associated with feelings of dullness, under-stimulation, and also interferes with social behavior (Lydon et al., 2016). So, regulation of these arousal responses is necessary for promoting calm behavior or action in order to emotionally resonate with others in the social environment.

Emotion regulation

The ability to regulate emotions is crucial for social interactions and important for achieving long-term goals. An arousal response triggers emotions but then, this emotional arousal response needs to be regulated into goal-directed behavior, in proportion to the situation. For example, imagine a girl taking the ball from a boy, unannounced. This might trigger an arousal response in the boy and an emotional reaction (maybe anger or surprise). Without regulating the emotional response, the boy might burst in to anger or even worse, use violence to get the ball back. Short-term consequences of this outburst could be an affected relationship with that girl, and parents needing to intervene in the situation. In the long-term, not being able to regulate such emotions in an age appropriate way by for example asking the girl to return the ball or even suggest to play together, might eventually lead to social dysfunction

Emotion regulation is defined as “those behaviors, skills, and strategies, whether conscious or unconscious, automatic or effortful, that serve to modulate, inhibit, and enhance emotional experiences and expressions” (Gross & Thompson, 2007, p. 229). Emotion regulation can be achieved through roughly two categories of strategies, antecedent focused and response-focused. Antecedent-focused strategies refer to tactics that are implemented before emotion response tendencies have become fully activated or while they are becoming activated. Examples are situation selection (going to the playground when chances of encountering other children are little), situation modification (bringing more than one toy in case someone takes the ball), attentional deployment (changing your mind and find something else to play with), and cognitive change (reappraisal; recognizing the fun of playing together and joining the girl). Response-focused strategies refer to strategies implemented once an emotion is already under way and the response tendencies have been generated, such as thinking afterwards and revalue that the situation was not that bad. All of these examples of regulatory behavior can be considered more or less adaptive, depending on the situation and the goals that were set.

With regard to emotion regulation, cognitive capacities play an important role, expressed in for example language skills. Language is important for social navigation, including the regulation of emotions that are part of the social interaction, so for example asking the ball back or suggesting to play together with the ball (Beauchamp & Anderson, 2010). Thus, language is a means for influencing the environment, it enables children to communicate about social interactions and to learn about appropriate ways to manage emotions (Eisenberg, Sadovsky, & Spinrad, 2005). (Non-) verbal language evolves in the early years from the first social smile to the emergence of intentional imitative behavior and dyadic interaction with aspects of communication such as joint attention and expressive and receptive communication. Being able to identify and express emotions is a prerequisite for regulating emotions (Eisenberg et al., 2005).

Besides language, executive functioning is also important for emotion regulation. Executive function is an umbrella term for a broad range of higher order cognitive processes that are critical for efficient functioning in everyday life such as attention, problem solving, cognitive flexibility, and inhibitory control. With regard to the example of the ball, this would mean paying attention to what just happened, thinking of different solutions, being able to switch between solutions when they don't work, and preventing yourself from starting to cry, yell or worse. Executive functions develop mostly stepwise through childhood and adolescence, together with the maturation of prefrontal regions of the brain (Anderson, 2008) and thus can be considered an indicator of very early frontal brain development. Together, executive functioning and language reflect the ability to express, control and steer emotions and are important to study as they are related to emotion processing in daily life.

The development of emotion regulation is strongly dependent on the maturation of neural networks in the brain that support these capacities. This refers not only to the development

of certain structures and related functions, but also the integration and specialization of these brain regions. Of interest with regard to the study of ASD and emotion regulation are the prefrontal cortex and the amygdala. The amygdala, an almond-shaped structure located deep in the frontal portion of the temporal lobe and is related to emotion and social cognition. Among other functions, it is important in the registration and taxation of for example fearful or threatening situations and connects to the brain functions that initiate physical responses (hypothalamus) expressed in heart rate increases. The amygdala is directly linked to the survival response of fight or flight, but is also active in the process of recognizing facial expressions. The amygdala not only sends information to the frontal cortex, but is also directed by the same frontal areas, which allows for regulation of emotions. The prefrontal cortex is the center for emotional regulation and regulatory functions in general (e.g. executive functioning) and when functioning of the prefrontal cortex is impaired or even damaged, this leads to in control over behavior and emotions.

Emotion expression

Closely related to the regulation of emotion as expressed in observable behavior, is the expression of emotions. Emotional (facial) expressions were a topic of research since Darwin's *The expression of the emotions in man and animals* (Darwin, 1872) and have been of specific interest with regard to the study of ASD. Emotions have an important motivational function which is especially important in a complex, ever changing environment. As our environment is largely social, we are able, through our emotions, to adjust to changes in our social environment and in ourselves. The expression of emotions has important social consequences. Seeing sadness or someone in pain results in being able to support others and eases entering into relationships. Therefore, the behavioral expression and translation into action of what is experienced emotionally on the inside needs to be in tune with each other. This coordination between (behavioral and facial) expression, regulation, and perception is referred to as emotional concordance (Hollenstein & Lanteigne, 2014) Concordance allows parents, caregivers, but also the social environment in general to be able to rely on the emotional expressions of children as a signal that may trigger the need for support, comfort, and help. An impediment in the concordance, or discordance, may disrupt caregiver responses which, over time, may amplify early vulnerability into a developmental trajectory of increasingly dysfunctional emotion regulation, social development, and early language skills (Kasari, Sigman, Mundy, & Yirmiya, 1990; Sullivan & Lewis, 2003; Wan et al., 2012).

Emotion processing in Autism spectrum disorders

Considering the complex picture of social functioning and its components, behavioral disorders such as ASD manifest themselves heterogeneously and clinically divers. The importance of understanding the underlying emotion processes of social behavior and their relationships can give more insight into the origins of the clinical symptoms of ASD.

Attention and emotion

Research in ASD has shown that children with ASD lack early social attention to the emotions of others and it is believed that problems in spontaneous visual orienting toward such social cues might be among the first manifestations of ASD (Ames & Fletcher-Watson, 2010; Falck-Ytter, Bolte, & Gredeback, 2013; Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Behaviors reported in children with ASD in the first year of life include less frequent orienting to their own name, diminished eye-contact, and social aloofness in response to others (Osterling, Dawson, & Munson, 2002). What we do not know however, is how this lack in early social attending to emotions of others is related to the emotional experience (e.g. emotional arousal). How does attending to emotions of others impact one's own emotional arousal system? In addition to this question, it is important to note that the majority of emotion research in ASD has had a focus on perceiving and cognitive appreciation of the emotions of others (empathy). Besides this important question of whether children with ASD have attention for the emotions of others, it is also important to study how children with ASD express and respond to *own* experienced emotions in terms of emotional arousal in response to such social triggers.

Emotional arousal

Measuring the internal states of emotion as expressed in physiological arousal is important because this might help explain the observed behavioral dysregulation in children with ASD. Taking together the research on physiological arousal in ASD during rest, there is evidence for normal resting state heart rate levels (Benevides & Lane, 2015), but lower heart rate variability. Higher heart rate variability enables an individual to select from a larger repertoire of actions to react to environmental demands if needed and vice versa, lower heart rate variability is associated with impaired behavioral repertoires (Guy, Souders, Bradstreet, DeLussey, & Herrington, 2014; Neuhaus, Bernier, & Beauchaine, 2014; Van Hecke et al., 2009). Furthermore, studies indicate overall similar heart rate responses but different arousal patterns in response to a variety of stimuli (for a review see; Benevides & Lane, 2015). These results however, do not explicitly address the role of arousal responses triggered by the emotions of self or others in social situations. Studying emotional arousal in response to emotional expressions of others in ASD may help gain insight in specific and different dysfunctions that may underlie behavioral problems. For example, less engagement in social interactions may arise from high emotional arousal and related social anxiety, or from low emotional arousal related to low social motivation. Thus, it is important to study emotional arousal that accompanies own emotions, for example during frustration or anxiety, as well as arousal triggered by emotions of others.

Emotion regulation

Emotional behavior problems in ASD expressed in tantrums, irritability, aggression, self-injury, and impulsivity are among the most frequently reported behavioral difficulties by parents and professionals (Geller, 2005; Lecavalier, Leone, & Wiltz, 2006). Even though these behavior problems are neither a part of the clinical diagnosis for ASD (Box 1) nor are they exclusive to ASD, recent research stresses the importance to consider emotion dysregulation as potential underlying mechanism of the reported behavior problems in ASD (Mazefsky, Pelphrey, & Dahl, 2012). The consequences of not being able to adequately regulate your emotions is highlighted by related increases in social and behavioral difficulties across time (Berkovits, Eisenhower, & Blacher, 2017). More specifically, emotion dysregulation predicts negative outcomes in school success (Graziano, Reavis, Keane, & Calkins, 2007; Gumora & Arsenio, 2002; Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003), problem behavior, and mental health problems (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Graziano et al., 2007; Silk, Steinberg, & Morris, 2003). The effects of dysregulation are already present at 12 months of age, as is reported by parents of children with ASD (Gomez & Baird, 2005). Studying emotion regulation could potentially contribute to understanding the observed emotional behavior problems in ASD (Mazefsky et al., 2013; Mazefsky et al., 2012). Research has shown that children with ASD less often use adaptive social strategies, use more maladaptive strategies such as venting or avoiding the situation, and resign more quickly from a social situation (Jahromi, Meek, & Ober-Reynolds, 2012; Konstantareas & Stewart, 2006). The question to be answered is whether the observable problems in regulation of behavior correspond to the experienced emotional arousal response. In other words, is the perceived dysregulation of behavior in ASD a consequence of less arousal modulation or caused by over-arousal preventing children from adapting their behavior effectively to the situation.

Emotion expression

Studying emotion expressions may especially be relevant in early childhood when children in general, and children with ASD even more, are dependent on caregivers for their physical and emotional needs and when interaction patterns between the child and caregivers shape the developing brain. The nature and specificity of emotion expression difficulties however, do not seem universal for all individuals with ASD (Nuske, Vivanti, & Dissanayake, 2013) with studies reporting equal levels of emotional expressiveness (Jahromi et al., 2012) and studies reporting less expressivity (Stagg, Slavny, Hand, Cardoso, & Smith, 2013). Studies investigating the correspondence between expressivity and underlying arousal are scarce and have yielded evidence for both discordance (however measured with self-report), and concordance (Stein et al., 2014). A disconnection between expression and experience could serve as explanatory factor for reported behavior problems in ASD. However, more research into the relationship between arousal and expressed behavior, using sensitive and direct measures at a young age during critical periods of development to identify and target the developmental trajectory of ASD, is warranted.

Considering the current knowledge about emotion processing in ASD as just described, studying emotion processing in ASD should have a multi-faceted approach including the attention, arousal, regulation, and expression of emotional functioning. The combination of these components of emotion processes in scientific research is scarce, especially in developmental disorders and even more in early childhood.

The importance of studying early development

Research interest for ASD has shown dramatic increases from 6054 studies between 1940-1999, to 16741 between 2000 and 2012 (Lai et al., 2014). Even though the vast majority of this surge in ASD research has examined individuals from mid-childhood onwards, only over the past two decades there has been a shift to early childhood and even infancy in the study of ASD (Bradshaw, Steiner, Gengoux, & Koegel, 2015; Brian, Bryson, & Zwaigenbaum, 2015; Daniels, Halladay, Shih, Elder, & Dawson, 2014; Zwaigenbaum et al., 2015). And while there is increased consensus for reliable identification of ASD before 24 months, knowledge about the early markers, underlying mechanisms of social dysfunction, and windows of opportunity for positively influencing the developmental trajectory remains challenged. Early identification of ASD is still mainly based on behavioral characteristics, parent concerns, and early markers observed in clinical practice.

Early knowledge about the underlying mechanisms of social development is crucial for identifying windows of opportunity and recognizing the early signs of vulnerability for developmental disruptions. This knowledge could benefit parents and professionals in understanding and supporting children with ASD, optimizing the social circumstances in which these children develop and benefitting from brain plasticity during the early years in particular (Bölte et al., 2016). In addition, new technologies, such as non-invasive eyetracking and heart rate measures, could potentially lead to more objectively measurable, quantifiably, and generalizable phenotypes, especially in young children for whom these measures are non-invasive and provide rich information about underlying mechanisms.

Aims and outline of this dissertation

The central aim of the current thesis is to study emotions in young children with ASD, by focusing on the attention, arousal, regulation, and expression of emotion. The studies presented in this thesis are part of a larger longitudinal study, designed to gain insight into the underlying mechanisms of emotion processes in children with ASD.

Participants in the studies are typically developing children and children with ASD, aged between 3.5 and 6.5 years old. These children and their parents were recruited through two large regional institutions specialized in the diagnosis and treatment of ASD and through daycare centers and elementary schools in the western part of the Netherlands.

The first study (**chapter 2**) addresses the question of whether attention to the emotions of others is different in ASD, compared to typically developing children using eyetracking.

Children watch a social-emotional video clip of peers in an argument displaying negative emotions. The eyetracker records the exact location of visual focus, providing information about where children look when confronted with emotions of others. While they watch this clip, electrodes measure the heart rate of children as index of emotionally resonating with their peers. This study aims to gain insight into the experience of emotions while watching other's distress. The results are related to social behavioral problems as expressed in autism symptomatology. **Chapter 3** focuses on the emotions that young children with and without ASD experience. This is done by using a frustration task, which means that they choose a very desirable toy that was placed in a transparent locked box. The task always ends well, by providing the children the right key and letting them play with the toy for a while, which also enables us to measure recovery after frustration. The role of cognitive skills, especially executive functioning and language skills are discussed. In **chapter 4** we evaluate the experienced emotional arousal, but now in response to a frightening situation. The children are confronted with a remote-controlled robot that walks towards them and emits noise. In addition to measuring emotional arousal in response to the robot, facial and bodily expressions of fear were coded in order to assess the level of emotional concordance; how does the 'outside' expression relate to the 'inside' experience. In **chapter 5** results of a longitudinal study are presented to gain insight into the development of social attention towards others and corresponding emotional arousal. The assessment described in chapter 2 was repeated after six months, with a parallel version of the social-emotional video clip. In addition, the role of executive functioning in the development of social attention and arousal is investigated, in the typically developing children only. By studying this we aim to take the first preliminary steps in investigating which mechanisms are of influence on the development of these early processes of social behavior. This knowledge is important with regard to identifying windows of opportunity for children with ASD and possible sensitive periods for the development of social behavior which could lead to specific treatment targets. In **chapter 6** the conclusions and implications of these studies are summarized and directions for future research are provided.

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