Empathy and its association with aggression in early childhood

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TABLE OF CONTENTS

1 General Introduction

The first signs of aggressive behavior can be observed early in infancy, as soon as infants develop the motor ability to use force against others (Hay et al., 2010). Such early signs of aggression manifest as physical aggression, such as hitting and biting, which are part of the typical development of young children (Alink et al., 2006; Hay et al., 2010; Tremblay et al., 1999; Tremblay et al., 2004). Although virtually all young children show physical aggression at least occasionally, persistently high levels of physical aggression in toddlerhood have been shown to be an important risk factor for aggressive behavior later in childhood and adolescence (Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006). Intervening to reduce or prevent chronic aggressive behavior at school age is difficult and expensive, and intensive individualized training programs are required to reach significant effects (Hoogsteder et al., 2014; Smeets et al., 2015). It is important to study risk factors of aggression early on, as these may form important components of developmental prevention programs (Cote et al., 2006; Farrington, Gaffney, Lösel, & Ttofi, 2017; Tremblay, 2010; Tremblay et al., 2004). Impaired empathy has been considered an important risk factor for aggressive behavior, and negative associations between empathy and aggression have consistently been found in school-aged children and adolescents. However, there is a lack of research on the association between empathy and aggression in the preschool period, when children typically learn to inhibit aggressive behavior (Alink et al., 2006; Bons et al., 2013; Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2013; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). Therefore the aim of the studies described in this dissertation is to study early manifestations of empathy as a predictor of aggression during the first years of life.

Empathy originates from the Greek word empatheia, which translates to in (em) and feeling (pathos); empathy generally refers to the ability to share and understand the feelings of another person (Cuff, Brown, Taylor, & Howat, 2014; Decety & Moriguchi, 2007). Although empathy has been studied for hundreds of years, the definition of empathy is still under debate (Cuff et al., 2014). For example, there is discussion on how to discriminate empathy from related concepts such as sympathy and compassion, whether empathy is a cognitive or an affective concept, and whether the feelings of the observer should be congruent with those of the observed person. Along with several other emotions, including guilt and shame, empathy has been viewed as playing a fundamental role in morality (Eisenberg, 2000). In particular, empathy has been suggested to motivate prosocial and altruistic behavior, and to inhibit aggression (Blair, 1995; de Waal, 2008; Eisenberg, 2000).

Self-report is the most common method to study empathy, for example by asking how children feel in response to emotional stories, pictures or movies to measure situationally-induced empathy or by using questionnaires to measure dispositional

empathy (Eisenberg, 2000; Zhou, Valiente, & Eisenberg, 2003). In addition to self-reports, other-reports have been used to examine dispositional empathy in children. Parents, teachers or peers report on empathy to obtain information that is less biased by social desirability, to obtain information from multiple perspectives, or to examine empathy in children that are too young to provide self-reports. Situationally-induced empathy has also been examined by observation of behavioral responses to empathy-evoking situations, such as facial, vocal or gestural reactions (Eisenberg & Fabes, 1990; Zhou et al., 2003). Furthermore, physiological responses to empathy-evoking situations have been used to examine empathy. Physiological measures, such as heart rate responses, are more objective than observational measures and relatively free from conscious control and social desirability bias. However, interpreting physiological measures is difficult, as physiology is also influenced by multiple non-emotional factors, such as attention and physical activity (Eisenberg & Fabes, 1990; Zhou et al., 2003).

EARLY MANIFESTATIONS OF EMPATHY

The first signs of empathy in humans can already be observed a few hours after birth. For example, motor mimicry has been shown in newborns, which refers to the automatic mimicry of emotional expressions of others and has been considered a motor aspect of empathy (Blair, 2005; Bons et al., 2013; Meltzoff & Moore, 1977). In addition, infants become more distressed in response to crying of other infants, compared to recordings of their own cries, to silence, and to noise, which is referred to as contagious crying or emotional contagion (Dondi, Simion, & Caltran, 1999; Sagi & Hoffman, 1976; Simner, 1971). In infancy, empathy-eliciting situations are often emotionally challenging and result in high levels of psychophysiological arousal (Eisenberg, 2010; Geangu, Benga, Stahl, & Striano, 2010; Hoffman, 2000). Such high levels of arousal manifest as personal distress (e.g. crying) and seeking comfort (e.g. sucking on their thumb or seeking comfort from their parents) because vicarious emotional responses cannot be regulated yet and become aversive. In other words, empathy evokes self-oriented behavior in order to relieve the infants' own distress (Liew et al., 2011; McDonald & Messinger, 2011). This empathic distress is considered to be a basic expression of empathy, because of its strong relation with automatic and relatively primitive processes such as emotional contagion and emotional resonance (de Waal, 2008).

In addition to empathic distress, early forms of other-orientation can also be observed in infants. For example, when a peer shows distress, infants have been shown to pay more attention to the distress of the other, by looking at their peer or the mother of their peer, than to their own distress, as indicated by looking at their own mother (Hay, Nash, & Pedersen, 1981; Liddle, Bradley, & McGrath, 2015). During the second and third year of life, infants start to show empathic concern. They increasingly

focus on the other's distress instead of focusing solely on one's own distress, because they are improving in regulation of empathic distress, in understanding that vicarious feelings are caused by feelings of the other and not by the child's own feelings, and in cognitively taking the perspective of the other in order to understand the feelings and needs of the other. Such empathic concern includes concern for the wellbeing of others (sympathy) and trying to understand the cause of the feelings of the other, which motivates prosocial attempts to reduce the other person's distress (Eisenberg, Eggum, & Di Giunta, 2010; McDonald & Messinger, 2011). At the age of three, over 50% of children perform some act of prosocial behavior in response to their mother's distress (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; McDonald & Messinger, 2011).

Empathic distress and empathic concern can be considered separate aspects of empathy, as distinct neural systems have been shown to underlie empathic distress and empathic concern (Decety & Michalska, 2010; Han et al., 2017; Singer & Klimecki, 2014). In addition, they are qualitatively different because empathic distress is focused on relieving one's own distress, whereas empathic concern is focused on relieving the other's distress. Although empathic distress may not lead to altruistic helping as empathic concern does, it is considered an important aspect of empathy because it reflects the extent to which an individual is affected by the suffering of another person (Batson, Fultz, & Schoenrade, 1987; Eisenberg et al., 2010; Singer & Klimecki, 2014). During the first and second year of life, children typically respond to empathy-evoking events with empathic distress, which has been suggested to be a precursor of empathic concern (de Waal, 2008; Hoffman, 2000; McDonald & Messinger, 2011; Zahn-Waxler & Radke-Yarrow, 1990). In addition to this hierarchical relation, empathic distress and empathic concern are positively associated and can occur simultaneously throughout development (Gill & Calkins, 2003; Israelashvili & Karniol, 2018; Liew et al., 2011; Lin & Grisham, 2017; Nichols, Svetlova, & Brownell, 2015; Young, Fox, & Zahn-Waxler, 1999). In contrast to the important role of empathic distress for empathy development in infancy and toddlerhood, high levels of empathic distress are known to be less adaptive at a later age. In adulthood, excessive levels of sharing feelings of others is a risk factor for negative feelings, stress, and burn-out, for example in healthcare professionals such as nurses and therapists (Singer & Klimecki, 2014). In contrast, the ability to control empathic distress and to show empathic concern is related to better health outcomes.

Both empathic distress and empathic concern result from sharing feelings of others, also referred to as affective empathy, whereas the definition of empathy also comprises the understanding of the feelings of others, which is referred to as cognitive empathy (Cuff et al., 2014; Decety & Moriguchi, 2007). Affective empathy and cognitive empathy have been suggested to be separate, but complementary aspects of empathy that rely on different neural networks (Decety, 2010; Decety, Meidenbauer, & Cowell,

2017; Singer, 2006; Smith, 2006). Cognitive empathy adds to affective empathy by providing the ability to fully understand the situation of another person while taking into account factors such as the context of the situation, and the goals and beliefs of the other (Decety, 2010; Singer, 2006). Early signs of understanding the feelings of others have been observed in toddlers who helped persons that were hurt, even when this person did not show any emotions that could induce affective empathy (Vaish, Carpenter, & Tomasello, 2009). This indicates that these children used some form of perspective taking to understand the possible emotion of the other in absence of overt emotion cues. Cognitive empathy is closely related to Theory of Mind, emotion recognition, executive functioning, and perspective taking, which rapidly develop from the age of four years (Blair, 2005; Bons et al., 2013; Decety, 2010; Rodger, Vizioli, Ouyang, & Caldara, 2015; Tonks, Williams, Frampton, Yates, & Slater, 2007). In line with this development, cognitive empathy has been shown to increase from age four and to become fully developed during adolescence (Pons, Harris, & de Rosnay, 2004; van der Graaff et al., 2014). Furthermore, neuro-imaging studies also indicated that brain structures associated with affective empathy mature earlier than brain structures associated with cognitive empathy (Decety, 2010; Singer, 2006).

Empathy is an important aspect of social development. Research has shown that higher levels of empathy were associated with higher levels of social competence (Sallquist, Eisenberg, Spinrad, Eggum, & Gaertner, 2009; Zhou et al., 2002), less prejudice and racism (Pettigrew & Tropp, 2008; Stephan & Finlay, 1999), better conflict resolution in friendship relations (de Wied, Branje, & Meeus, 2007), and more prosocial and altruistic behavior (de Waal, 2008; Eisenberg et al., 2010). Also, differences in empathy development can be expected to be associated with individual differences in other domains, such as temperament and other aspects of social cognition (e.g., social attention) (Bons et al., 2013; Liew et al., 2011; Young et al., 1999).

Regarding temperament, neurodevelopmental theories indicate that children who are more emotionally reactive themselves, might also be more sensitive to the distress of others and therefore become more empathic (Decety, 2010; Preston & de Waal, 2002; Spinrad & Stifter, 2006). Temperament refers to stable personality traits that are a function of biological predispositions and are expressed behaviorally, and emotional reactivity is a core aspect of temperament. In childhood, most studies indicate that emotional responses to challenge are positively associated with empathy (Eisenberg, 2000, 2010). However, across different studies in infants and toddlers, both positive and negative associations between negative emotional responses to challenge and empathy have been found (Eisenberg, 2000, 2010; Hastings & Miller, 2014). Possibly, these mixed results are due to the fact that the autonomic nervous system, which plays an important role in the psychophysiology of emotional responses, matures rapidly

during this developmental period. In infancy, diverse physiological responses occur in response to emotions, which become more stable around age 5 years (Alkon, Boyce, Davis, & Eskenazi, 2011; Quigley & Moore, 2018). Therefore, emotional responses to challenge might be an important precursor of empathy, however, the association between emotional responses to challenge and empathic behavior is not clear in infancy and toddlerhood.

In addition to emotional reactivity, social attention might play an important role in empathy development, as children who naturally attend to social cues (i.e. emotional faces), might also be better able to share and understand feelings of others (Bons et al., 2013; Yan, Pei, & Su, 2017). Social attention is necessary in order to recognize emotions of others and therefore, has been considered a prerequisite of empathy (Bons et al., 2013). Despite the importance of social attention for sharing and understanding emotions of others, research on the role of social attention in relation to empathy in early childhood is scarce (Bons et al., 2013; Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017). One study indicated a positive association between social attention and empathy, as five-year-old children who were high in empathy fixated more quickly on the eyes and mouth of presented faces, they did so for longer duration and also more frequently in response to painful expressions (Yan et al., 2017).

Further research on empathy and its associated domains of development in early childhood can help to provide better insight on how to foster empathy development, recognize empathy impairments, and develop interventions focusing on the enhancement of empathy to stimulate social development (Feshbach & Feshbach, 2011). In particular, it may also provide insights into the effects of impaired empathy on antisocial development.

EMPATHY AND AGGRESSION

Development of aggression starts, like the development of empathy, during infancy. As early as six months of age, as soon as infants develop the motor ability to use force against others, the first signs of aggressive behavior can be observed (Hay et al., 2010). Early signs of aggression manifest as physical aggression, such as hitting and biting, and peak during the second and third year of life, when virtually all children show physical aggression at least occasionally (Alink et al., 2006; Hay et al., 2010; Tremblay et al., 1999; Tremblay et al., 2004). During the fourth year of life, physical aggression declines again, due to brain development that enables children to inhibit physical aggression. At this age other forms of aggression start to develop, such as verbal aggression or indirect forms of aggression. High levels of physical aggression in toddlerhood have been shown to be an important risk factor for later antisocial development, as approximately one out of six children show high and stable levels

of aggression from toddlerhood to pre-adolescence (Cote et al., 2006). Furthermore, early physical aggression has been shown to be a better predictor of physical and non-physical offending in adolescence than hyperactivity and oppositional behavior (Broidy et al., 2003). The longitudinal associations seemed to be stronger for boys than for girls, which is in line with other studies indicating that boys are more aggressive than girls from toddlerhood onwards (Alink et al., 2006; Archer, 2004; Card, Stucky, Sawalani, & Little, 2008; Hay et al., 2011). In order to reduce and prevent aggression as early as possible, it is important to study risk factors of aggression early on (Cote et al., 2006; Tremblay, 2010; Tremblay et al., 2004).

Impaired empathy is considered an important risk factor of aggressive behavior, since the observation of distress in others prompts the withdrawal of aggression by increasing autonomic arousal (Blair, 1995, 2006). This arousal is experienced as aversive and may be considered a physiological marker of affective empathy. Thus, when an individual experiences and learns to understand the causal link between aggression and aversive arousal during early development, this person becomes motivated to refrain from actions that harm others. Therefore, aggression has been associated with a lack of affective empathy and not with impaired cognitive empathy (Smith, 2006). Empirical studies support this theory, indicating that affective empathy rather than cognitive empathy is negatively associated with aggression (Blair, 2005; Bons et al., 2013; van Zonneveld, Platje, de Sonneville, van Goozen, & Swaab, 2017; Winter, Spengler, Bermpohl, Singer, & Kanske, 2017). More specifically, reduced physiological arousal responses to emotional stimuli (i.e. affective empathy) have been found in school-aged children with high levels of aggression, such as children at risk of criminal behavior (van Zonneveld et al., 2017) and boys with disruptive behavior disorders (Anastassiou-Hadjicharalambous & Warden, 2008; Bons et al., 2013; de Wied, Boxtel, Posthumus, Goudena, & Matthys, 2009; Herpertz et al., 2005; Marsh, Beauchaine, & Williams, 2008).

Toddlerhood is an important developmental stage to study the association between empathy and aggression. Since approximately one in six children show high and stable levels of aggression from toddlerhood to pre-adolescence, interventions targeting empathy at very young ages may help reduce the chances of developing such high and consistent levels of aggression (Cote et al., 2006; Tremblay, 2010; Tremblay et al., 2004). Although both aggressive and empathic behavior can be observed in toddlers, research on the association between empathy and aggression has mainly focused on childhood, adolescence, and adulthood (Hay et al., 2010; Lovett & Sheffield, 2007; McDonald & Messinger, 2011). From school age to adulthood, low to moderate negative associations of empathy and aggression have consistently been found in both community samples and criminal offenders (Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon et al., 2013; van Langen et al., 2014). However, there is a lack

of research into the association between empathy and aggression in the preschool period and the results of previous studies are mixed.

In children under the age of 6 years, negative associations between empathy and aggression have been found in studies using observational measures of aggression in peer-play group interactions and assessment of empathy using videotaped vignettes, parent reports and teacher reports (Strayer & Roberts, 2004), parental reports of aggression and observations of empathy during dyadic play (Hughes, White, Sharpen, & Dunn, 2000), or teacher reports of both empathic and hostile behavior (Belacchi & Farina, 2012). In contrast, positive associations between empathy and aggression were found in boys aged 4-5 years (Feshbach & Feshbach, 1969), with aggression obtained by teacher reports and empathy by verbal affective responses to slides showing affective situations. Another study, using maternal reports to measure aggressive behavior and behavioral responses of 2-year-olds to a recording of a crying infant and an experimenter pretending to hurt herself to measure empathy, also demonstrated positive associations between empathy and aggression (Gill & Calkins, 2003). Other studies in children under the age of 6 years did not demonstrate significant results in either direction, using similar measurement methods or paradigms as the studies described above (MacQuiddy, Maise, & Hamilton, 1987; Zahn-Waxler, Cole, Welsh, & Fox, 1995). One study, using both behavioral and physiological markers of empathy, did not demonstrate concurrent associations between empathy and aggression, but only longitudinal associations from age 4-5 to 6-7 years (Hastings et al., 2000). In contrast, another longitudinal study from age 14-36 months to 4-17 years did not reveal significant results (Rhee et al., 2013). In order to explain these mixed results, the authors suggested that positive associations between empathy and aggression can be explained by the influence of inhibition (Gill & Calkins, 2003). Various studies indicate that poor inhibition is associated with high levels of aggressive behavior during the preschool period (Hughes et al., 2000; Raaijmakers et al., 2008; Waller, Hyde, Baskin-Sommers, & Olson, 2017). Furthermore, inhibition has also been shown to be negatively related to empathy at this age (Liew et al., 2011; Young et al., 1999). Possibly, a lack of inhibition leads to impulsive behavior (e.g. approaching the other) in both empathy- and aggression-evoking events in toddlerhood (Gill & Calkins, 2003). Thus, a positive association between empathy and aggression may be expected under conditions of impaired (or not yet sufficiently developed) inhibition, whereas good inhibition may result in a negative association between empathy and aggression.

In addition, sex differences could play an important role in the association between empathy and aggression. Females have been shown to be more empathic from birth until adulthood and sex differences in empathy have been suggested to have a neurobiological origin (Christov-Moore et al., 2014; Schulte-Ruther, Markowitsch,

Shah, Fink, & Piefke, 2008). Furthermore, boys have been shown to be more aggressive than girls in toddlerhood (Alink et al., 2006; Baillargeon et al., 2007) and boys are more likely to follow high and stable trajectories of aggression from toddlerhood to adolescence (Cote et al., 2006; Tremblay, Hartup, & Archer, 2005; Tremblay et al., 2004). Therefore, it is important to take sex differences into account when examining empathy and aggression.

Besides the mixed results regarding the association between affective empathy and aggression at preschool age, the association between cognitive empathy and aggression during this developmental stage is also unclear. Two studies including preschool aged children examined affective and cognitive empathy in relation to constructs closely related to aggression. One study on 3-6 year-old children indicated that both affective and cognitive empathy, according to teacher reports, were negatively associated with hostile roles in bullying (i.e. being a bully, assistant, or reinforcer) (Belacchi & Farina, 2012). In addition, parents of 3-13 year-old children reported that impaired affective empathy was associated with psychopathic traits (which include aggression), but only in boys, and that impaired cognitive empathy was associated with psychopathic traits in both sexes, although this association disappeared for boys during early adolescence (Dadds et al., 2009). These results are surprising given the fact that from a theoretical point of view, only affective empathy is expected to be associated with aggression (Blair, 2005; Smith, 2006). Furthermore, congruent with theory, studies in older children, adolescents and adults did not find associations between cognitive empathy and aggression (Bons et al., 2013; van Zonneveld et al., 2017; Winter et al., 2017).

AIMS AND OUTLINE OF THIS DISSERTATION

There is a lack of research on precursors of empathy, and on the association between empathy and aggression in early childhood. The results of previous studies are mixed and it is likely that these contradictory results can be explained by taking into account other factors that are related to empathy and aggression. Therefore, our main aim was to study early manifestations of empathy as a predictor of aggression during the first years of life, while taking into account the role of precursors of empathy and possible moderators of the association between empathy and aggression. In particular, we aimed to investigate (1) emotional responses in infancy as a precursor of empathy in toddlerhood, (2) sex differences in the association between empathy and aggression in toddlerhood, (3) the association between inhibition, empathy, and aggression in toddlerhood, and (4) the association between indicators of social attention, affective empathy, cognitive empathy and aggression in the preschool period.

In the first study (chapter 2), we aimed to predict empathic behavior at age 20 months from emotional responses at 6 months of age. We expected that children who were more emotionally reactive to mildly arousing emotional challenges would be more sensitive to the distress of others and become more empathic later on. We used two mild emotional challenges to examine behavioral and physiological reactivity at age 6 months. During the still face paradigm, the mother was affectively unavailable for a short time and during the car seat task, the mother was physically unavailable for a short time. Both behavioral and physiological responses to the challenges were used to examine emotional responses. At age 20 months, behavioral responses of the children were videotaped when the experimenter pretended to hurt her toe to a piece of furniture. Both empathic distress and empathic concern were coded afterwards in order to assess whether these empathic responses could be predicted from behavioral and physiological responses to mild emotional challenges in infancy.

In the second study (chapter 3) it was examined whether empathy is associated with aggression at age 20 months and whether empathy is a predictor of the development of aggression from 20 to 30 months of age. Empathic distress and empathic concern in response to distress simulation by the experimenter at age 20 months were examined in relation to maternal reports of physical aggression at age 20 and 30 months. Furthermore, sex differences were taken into account as previous studies have suggested that girls are more empathic and less aggressive than boys from toddlerhood onwards, and that the association between empathy and aggression might differ for boys and girls (Archer, 2004; Christov-Moore et al., 2014; Feshbach & Feshbach, 1969).

In order to explain the contradictory results regarding the association between empathy and aggression in previous literature, the aim of the third study (chapter 4) was to test the hypothesis that inhibition moderates the association between empathy and aggression (Gill & Calkins, 2003; Lovett & Sheffield, 2007). Impaired inhibition in aggressive children may cause impulsive responses to both empathy and aggression-evoking situations. Therefore, empathy might be negatively associated with aggression in children with relatively good inhibition, but positively associated with aggression in children with relatively poor inhibition. Empathy and aggression were examined at age 30 months. Similar to the procedure at age 20 months in Chapters 2 and 3, both empathic distress and empathic concern were coded, and physiological responses to the distress simulation were measured. Inhibition was examined with a delay task, in which the child had to wait to receive a gift from the experimenter. Behavior of the child during the task was videotaped and coded afterwards. Maternal reports of physical aggression at age 30 months were used.

The fourth study (chapter 5) aimed to examine affective empathy and cognitive empathy in relation to aggression at age 45 months. Furthermore, social attention was taken into account because social attention is needed to recognize emotions of others and is therefore a possible prerequisite of empathy (Bons et al., 2013). Affective empathy, cognitive empathy and social attention were assessed with a single paradigm during which the children watched three video clips of peers showing emotions (fear, sadness and happiness). Affective empathy was measured by comparing physiological responses from non-social baseline clips to the emotional clips, cognitive empathy was measured by asking questions about the emotions in the clips, and eye tracking was used to measure social attention by calculating the time the children watched the face of the emotional children. Similar to the procedures at age 20 and 30 months, maternal reports were used as an indicator of aggressive behavior of the child. At this age, a broad measure of aggression was used, which took into account multiple types of aggression and not exclusively physical aggression, because during the fourth year of life levels of physical aggression are declining, whereas other forms of aggression (e.g. verbal aggression) are increasing (Alink et al., 2006; Hay et al., 2010; Tremblay et al., 1999).

In chapter 6, the results and conclusions of the studies above are summarized and discussed. Implications for prevention of aggression as well as directions for future research are suggested.

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2 Infant emotional responses to challenge predict empathic behavior in toddlerhood

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ABSTRACT

Although emotional responses are theorized to be important in the development of empathy, findings regarding the prediction of early empathic behavior by infant behavioral and physiological responses are mixed. This study examined whether behavioral and physiological responses to mild emotional challenge (still face paradigm and car seat task) in 118 infants at age 6 months predicted empathic distress and empathic concern in response to an empathy-evoking task (i.e, experimenter's distress simulation) at age 20 months. Correlation analyses, corrected for sex and baseline levels of physiological arousal, showed that stronger physiological and behavioral responses to emotional challenge at age 6 months were positively related to observed empathic distress, but not empathic concern, at age 20 months. Linear regression analyses indicated that physiological and behavioral responses to challenge at 6 months independently predicted empathic distress at 20 months, which suggests an important role for both physiological and behavioral emotional responses in empathy development. In addition, curvilinear regression analyses showed quadratic associations between behavioral responses at 6 months, and empathic distress and empathic concern at 20 months, which indicates that moderate levels of behavioral responsivity predict the highest levels of empathic distress and empathic concern.

Keywords: autonomic nervous system, empathy, infant, pre-ejection period, respiratory sinus arrhythmia.

INTRODUCTION

Empathy is a fundamental component of social competence that involves the ability to share and understand the feelings of others. Precursors of empathy may already be present at a very early age, as newborns and infants become distressed in response to other infants' crying, but not to recordings of their own crying (Dondi, Simion, & Caltran, 1999; Geangu, Benga, Stahl, & Striano, 2010). Research suggests that physiological and behavioral responses to emotional challenge predict empathic behavior in children and adults, which supports neurodevelopmental theories indicating that emotional responsivity is a predictor of empathy (Decety, 2010; Eisenberg, 2010; Preston & de Waal, 2002). Emotional responses are determined by emotional reactivity and emotion regulation. Emotional reactivity refers to the way in which input from the external or internal world is perceived, valued, and triggers action, and is generally associated with activity in subcortical emotional processing systems (Etkin, Buchel, & Gross, 2015; Gross, 2015; McRae et al., 2012). Emotion regulation refers to the implementation of conscious or non-conscious goals to start, stop, or otherwise modulate the trajectory of an emotion, and is associated with activity in prefrontal systems. Emotional reactivity is a core aspect of temperament and individuals who are reactive themselves, in particular to negative emotions, have been shown to be more sensitive to the distress of others and therefore become more empathic (Eisenberg, 2000; Rothbart & Bates, 2006; Spinrad & Stifter, 2006). In addition to (negative) emotional reactivity, subsequent emotion regulation has been shown to be important in order to prevent oneself from becoming overwhelmed by vicariously induced feelings of others (Eisenberg, 2000). In childhood, most studies indicate that emotional responses to challenge are positively associated with empathy (Eisenberg, 2000, 2010). However, in infants and toddlers, both positive and negative associations between negative emotional responses to challenge and empathy have been found (Eisenberg, 2000, 2010; Hastings & Miller, 2014). Possibly, this is due to the fact that the autonomic nervous system, which plays an important role in emotional responses, matures rapidly during this period and becomes stable around age 5 (Alkon, Boyce, Davis, & Eskenazi, 2011; Quigley & Moore, 2018). Therefore, the association between emotional responses to challenge and empathic behavior is not clear at this developmental stage.

EMPATHY IN INFANCY AND TODDLERHOOD

Sharing the feelings of others (empathy) can result in empathic concern for the other, which is an other-oriented response, and in empathic distress, which is a self-oriented response (Eisenberg, 2010). In infancy, empathy-eliciting situations are often emotionally challenging and result in over-arousal (Eisenberg, 2010; Hoffman, 2000). Over-arousal can manifest as personal distress and seeking comfort, because

vicarious emotional responses cannot be regulated and become aversive (Liew et al., 2011; McDonald & Messinger, 2011). Empathy does not always lead to empathic distress in infancy, because the infant's responses to empathy depend on the nature of the stressor and the capacity of the infant to regulate emotions (Davidov, Zahn-Waxler, Roth-Hanania, & Knafo, 2013; Roth-Hanania, Davidov, & Zahn-Waxler, 2011).

In addition to empathic distress, other-oriented empathic concern also occurs in infancy and toddlerhood, which includes concern for the wellbeing of others and trying to understand the cause of the feelings of the other, and motivates attempts to reduce the other person's distress (Davidov et al., 2013; Eisenberg, Eggum, & Di Giunta, 2010; McDonald & Messinger, 2011). As a result of development in emotion regulation, self-other differentiation and perspective taking during the second and third year of life, toddlers increasingly focus on the other's distress instead of focusing exclusively on their own distress, which results in higher levels of empathic concern. In turn, empathic concern can motivate prosocial behavior (Eisenberg et al., 2010; Eisenberg, Spinrad, & Knafo, 2015; Hoffman, 2000; Williams, O'Driscoll, & Moore, 2014). At the age of 3, over 50% of the children have been shown to perform some act of prosocial behavior in response to their mother's distress, although less than 20% of the children do so in response to a distressed stranger, which confirms the suggestion that empathic behavior increases with familiarity and similarity to the victim (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; McDonald & Messinger, 2011; Preston & de Waal, 2002). Prosocial behavior can be motivated by empathic distress instead of empathic concern, in particular in adults, when prosocial behavior is aimed at comforting oneself (Batson, Fultz, & Schoenrade, 1987; Cialdini, 1991; Cialdini et al., 1987). In children, however, positive associations between prosocial behavior and empathic concern have been found, whereas prosocial behavior and personal distress were unrelated or negatively related (Knafo et al., 2008; Liew et al., 2011; Lin & Grisham, 2017; Vaish, Carpenter, & Tomasello, 2009; Williams et al., 2014).

Although empathic distress may not lead to helping as empathic concern does, it may still be considered an important aspect of empathy, since it reflects the extent to which an individual is affected by the suffering of another person (Batson et al., 1987; Eisenberg et al., 2010; Singer & Klimecki, 2014). In addition, empathic distress has been suggested to be a precursor of empathic concern (Hoffman, 2000; McDonald & Messinger, 2011; de Waal, 2008; Zahn-Waxler & Radke-Yarrow, 1990). However, empathic distress and empathic concern both result from empathy and can occur simultaneously throughout development (Gill & Calkins, 2003; Israelashvili & Karniol, 2018; Liew et al., 2011; Lin & Grisham, 2017; Young, Fox, & Zahn- Waxler, 1999). In line with Hoffman's stages of empathy, which indicate that empathic concern starts to co-occur with empathic distress as soon as self-other distinction is present, neuroimaging

research in children indicates that brain regions associated with empathic distress develop earlier than brain regions associated with empathic concern, and behavioral research indicates that empathic distress is stable over time, whereas empathic concern increases during the first years of life (Decety, 2010; Decety & Michalska, 2010; Geangu et al., 2010; Hoffman, 2000; Roth-Hanania et al., 2011). It remains unclear whether the association of emotional responses with empathic behavior differs for distressed and concerned responses to empathic situations.

EMOTIONAL RESPONSES

In infancy, emotional responses have been examined by behavioral observations and physiological measurement of changes in the autonomic nervous system. The autonomic nervous system consists of the sympathetic nervous system and parasympathetic nervous system, and both branches of the autonomic nervous system independently influence cardiac autonomic balance (Cacioppo, Uchino, & Berntson, 1994; Quigley & Moore, 2018). Reciprocal activation (i.e., the increase in the sympathetic and decrease in the parasympathetic nervous system) is considered optimal in response to arousing situations, but coactivation and coinhibition also occur and these responses have been related to relatively poor adaptation, including aggressive behavior and impaired emotion regulation (Berntson, Cacioppo, & Quigley, 1991; Stifter, Dollar, & Cipriano, 2011; Suurland, van der Heijden, Huijbregts, van Goozen, & Swaab, 2017a, 2017b). Therefore, it is important to measure indicators of both parasympathetic (RSA) and sympathetic (pre-ejection period) activation when examining autonomic nervous system responses (Hastings, Miller, Kahle, & Zahn-Waxler, 2014). Parasympathetic activity can be measured using RSA, which is the variability of heart rate during the respiratory cycle. More RSA suppression in response to challenge has been associated with better emotion regulation (Calkins & Dedmon, 2000; Calkins, Dedmon, Gill, Lomax, & Johnson, 2002). Sympathetic activity can be measured by pre-ejection period, which represents the time between the depolarization of the left ventricle (onset of the heartbeat) and the onset of the left ventricular ejection of blood into the aorta. Although measurement of sympathetic activity by skin conductance level is more common, pre-ejection period is considered a more direct indicator of cardiac sympathetic activity that can reliably be used in infancy (Alkon et al., 2006; Cacioppo et al., 1994; Suurland et al., 2016). Increased sympathetic activity in response to emotional challenge, which is reflected by shortening of the pre-ejection period, has been associated with fewer behavioral problems (Boyce et al., 2001; Stifter et al., 2011).

The importance of both the sympathetic and parasympathetic nervous system for emotional responses has been explained by the polyvagal theory, which indicates that suppression of the parasympathetic nervous system suffices to cope

with stress in mild emotional situations, whereas activation of the metabolically demanding sympathetic nervous system is adaptive in more stressful situations that cannot be regulated by the parasympathetic nervous system alone (Hastings & Miller, 2014; Porges, 2007; Porges & Furman, 2011). According to the polyvagal theory, both positive and negative associations between autonomic arousal and empathic behavior could be adaptive (Porges, 2007; Porges & Furman, 2011). On the one hand, a decrease in autonomic arousal (i.e., an increase in parasympathetic activity and/or decrease in sympathetic activity) might contribute to a calm bodily state and engagement in social behavior, which could comprise high levels of empathic concern and low levels of empathic distress (Hastings & Miller, 2014; Hastings et al., 2014). On the other hand, an increase in autonomic arousal contributes to mobilization of resources, which might not only be necessary for empathic distress, but also to act concerned and prosocial. The two opposing mechanisms, both in accordance with the polyvagal theory, might explain the contradictory results that have been found for the association between physiological responses and empathy (Hastings & Miller, 2014). Another explanation for these contradictory results could be that the association between physiological responses and empathy is quadratic rather than linear. Possibly, children need sufficient physiological response to become empathic, but excessive responses could reflect over-arousal. This indicates that under-arousal would predict low empathic concern and low empathic distress, whereas overarousal would predict low empathic concern and high empathic distress (Miller, Kahle, & Hastings, 2017; Tully, Donohue, & Garcia, 2015).

EMOTIONAL RESPONSES AND EMPATHY IN TODDLERHOOD

Several studies have investigated the association of physiological or behavioral emotional responses with different types of empathic behaviors in toddlers. A study in 30-month-old children examined suppression of RSA in response to hearing a recording of a crying infant (Gill & Calkins, 2003). More RSA suppression was associated with less empathic concern and less behaviorally observed arousal (i.e., distress). Similarly, more RSA suppression in response to recordings of a crying infant was also associated with less personal distress in 3-year-olds (Schuetze, Eiden, Molnar, & Colder, 2014). However, another study found that, at age 18 months, more RSA suppression in response to simulated distress was associated with more comfort seeking and personal distress (which are behavioral components of empathic distress), whereas the association was in the opposite direction at age 30 months (Liew et al., 2011).

Sympathetic responses, as indicated by pre-ejection period, have been investigated in relation to empathic behavior in one study, which showed that empathy, as indicated by sad facial expressions in response to a sad empathy-eliciting video in primary school aged children, was associated with reduced sympathetic (lengthened

cardiac pre-ejection period) and increased parasympathetic (RSA augmentation) activity during the video (Marsh, Beauchaine, & Williams, 2008). In addition, pre-ejection period has been investigated in relation to constructs that are closely related to empathy. One study in 5-year-olds indicated that more pre-ejection period shortening and more RSA suppression were associated with reduced teacher reported prosocial behavior, which is an indicator of empathic concern (Kalvin, Bierman, & Gatzke-Kopp, 2016), whereas another study indicated that only RSA suppression (and not pre-ejection period shortening) was associated with helping others during an altruism task at age 4 (Miller, Kahle, & Hastings, 2015). Furthermore, one study using skin conductance in response to emotional video clips as a measure of the sympathetic nervous system at age 5, did not show an association with empathic behavior in response to distress simulation (Zahn-Waxler, Cole, Welsh, & Fox, 1995).

Four studies used a longitudinal design to examine whether infant emotional responses predicted empathic behavior. In these studies, positive associations between emotional responses and empathy were observed. At age 4 months, more situational emotional responses, as indicated by self-soothing strategies in response to a distress-eliciting situation, predicted more personal distress in an empathy-eliciting situation at 12 months (Ungerer et al., 1990). Another study indicated that less situational emotional responsivity, as indicated by behavioral responses to arousing stimuli at 4 months of age, predicted less personal distress and less empathic concern and caring behavior during an empathy-eliciting task at age 2 years (Young et al., 1999). Furthermore, positive associations have also been reported between dispositional emotional responses, as indicated by parent reports of negative emotionality in response to fear at age 10 months, and both empathic concern and empathic distress in response to distress simulation at age 18 months (Spinrad & Stifter, 2006). Recently, it has been shown that greater RSA suppression at 18 months predicted more helping, an indicator of empathic concern, at 30 months of age (Liew et al., 2011).

In sum, emotional responses have been linked to empathy in children and adults, but the association remains unclear in infancy and toddlerhood. In infancy and toddlerhood, both positive and negative associations have been found between physiological responses as indicated by withdrawal of the parasympathetic nervous system (RSA suppression) and empathic behavior (Gill & Calkins, 2003; Kalvin et al., 2016; Liew et al., 2011; Miller et al., 2015; Schuetze et al., 2014). However, the associations were positive in the youngest children (age 18 months; Liew et al., 2003). Research on the association between physiological response as indicated by activation of the sympathetic nervous system (shortened PEP or increased skin conductance) and empathy is scarce and contradictory as well, and has only included children above age 4 (Kahle, Miller, Lopez, & Hastings, 2016; Marsh et al., 2008; Miller et al., 2015;

Zahn-Waxler et al., 1995). Finally, longitudinal studies showed that situational and dispositional measures of emotional responses were positively associated with empathic behavior at a later age (Spinrad & Stifter, 2006; Ungerer et al., 1990; Young et al., 1999).

THE PRESENT STUDY

Clearly, more research on infant emotional responses as a predictor of later empathy is necessary. This study investigated whether empathic distress, as indicated by self-distress and comfort seeking, and empathic concern, as indicated by concerned expressions, hypothesis testing and prosocial behavior, at age 20 months could be predicted from physiological and behavioral responses to mild emotional challenges in infants at age 6 months. In addition, we examined whether these associations were linear or quadratic.

Our aim was to predict empathy from emotional responses in early infancy. Although emotional responses are present from birth, they were examined at age 6 months because previous studies indicated that physiological measurements can only be considered reliable from age 6 months (Alkon et al., 2006; Cacioppo et al., 1994; Suurland et al., 2016). As discussed above, empathic distress (i.e., personal distress and comfort seeking) is clearly present early in development, but becomes relatively less important in early childhood. In contrast, empathic concern (i.e., concerned expressions, hypothesis testing, and prosocial behavior) starts to develop during the second and third year of life and becomes more important in childhood. In toddlerhood, around age 20 months, expressions of both empathic distress and empathic concern are expected to occur in response to empathy eliciting stimuli. We hypothesized, in line with the polyvagal theory and based on previous studies in children up to age 2 years, a positive association between emotional responses at age 6 months and empathic distress at age 20 months. As for empathic concern, we did not have specific hypotheses about the direction of the association with emotional responses, given the inconsistency in previous findings and the suggestion that, based on the polyvagal theory, both positive and negative associations could be adaptive.

In order to gain better insight into the associations between emotional responses and empathy, quadratic associations were examined in addition to linear associations. Possibly, both high and low emotional responses predict low empathic distress and concern, whereas moderate responses represent an optimum and predict high empathic distress and concern. This study adds to the previous literature by investigating empathic behavior in relation to physiological as well as behavioral responses to emotional challenge, using two different emotional challenge tasks: the still face paradigm and car seat task, which represent a mild social challenge and a mild frustration challenge, respectively. In addition, physiological responses were

examined using parasympathetic (RSA) as well as sympathetic (pre-ejection period) cardiac measures of the autonomic nervous system. Finally, both linear and quadratic models were tested.

METHODS

PARTICIPANTS

This study is part of the Mother-Infant Neurodevelopment Study in Leiden, The Netherlands (MINDS – Leiden). MINDS – Leiden is an ongoing longitudinal study into neurobiological and neurocognitive predictors of early behavior problems. The study was approved by the ethics committee of the Department of Education and Child Studies at the Faculty of Social and Behavioral Sciences, Leiden University (ECPW-2011/025), and by the Medical Research Ethics Committee at Leiden University Medical Centre (NL39303.058.12). All participating women provided written informed consent. Dutch speaking primiparous women between 17 and 25 years old (M = 23.28, SD = 2.21) with uncomplicated pregnancies were eligible to participate and 134 women were recruited during pregnancy via midwifery clinics, hospitals, prenatal classes, and pregnancy fairs. Women from high-risk backgrounds were oversampled in this study and screened for the following risk factors during pregnancy: positive screening on psychiatric disorder, substance use (alcohol, tobacco, drugs) during pregnancy, single status, unemployment, financial problems, no secondary education, limited social support network, and teenage pregnancy (see Smaling et al., 2015 for a detailed description of the procedures). The current sample consisted of 45.5% women that screened positively on one or more risk factors. Oversampling women from high risk backgrounds may increase variability in infant behavior and would compensate for a bias caused by possibly higher levels of dropout in the high-risk population. For this study, data from home visits at 6 months and 20 months post-partum were used. Dropout (N = 9 at 6 months and N = 16 at 20 months) was primarily due to unreachability of the mother, was not related to age or ethnicity, but was related to lower education level ($F(1, 132) = 7.56$, $p = .007$) and the presence of at least one risk factor ($F(1, 132) = 5.05$, $p = .026$).

PROCEDURES

Mothers were included in the study during pregnancy, when a first home visit took place in order to obtain background information and informed consent (N = 134). At age 6 months, a second home visit was scheduled at a time of day when the mother expected the infant to be most alert (N = 125). After some time to familiarize with the presence of the experimenters, the cardiac monitoring equipment was attached to the infant. Subsequently, the two mild emotional challenges were administered in a fixed

order. To limit carryover effects, there was a break of approximately 30 min after the first challenge, which included the execution of some non-emotional tasks, and the second challenge was administered when the infant was calm. At age 20 months, a third home visit was scheduled, again at a time of day when the mother expected the child to be most alert (*N* = 118, including one participant who did not participate in the 6 month home visit). Empathy was examined after approximately 15 min of mother-child interaction. All home visits were carried out by two trained female experimenters, of whom at least one was familiar with the mother (for the second and third home visits). At the end of each appointment, the child was rewarded with a gift and the mother received a reimbursement for her time.

INSTRUMENTS

Infant physiological and behavioral responses to emotional challenge

In order to measure behavioral and physiological responses to mildly stressful emotional challenges we used the still face procedure and the car seat task (Goldsmith & Rothbart, 1999; Tronick, Als, Adamson, Wise, & Brazelton, 1979). The still face paradigm is a validated mild social challenge during which mothers are instructed to play with their child for 2 min (play episode) (Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009; Tronick et al., 1979). Subsequently, the interaction is interrupted by 2 min during which the mother is instructed to keep a neutral face and refrain from interacting with the child (still face episode). Finally, play with the child is resumed (reunion episode). Autonomic arousal was assessed during the play episode (baseline) and the still-face episode (challenge). The car seat task was drawn from the pre-locomotor version of the Laboratory Temperament Assessment Battery (Lab-TAB) and was designed to elicit mild frustration in infants (Goldsmith & Rothbart, 1999). First, the infant watched a 2-min relaxing movie on their mother's lap in order to measure baseline state. Subsequently, the child was buckled in a car seat. For 1 min, the mother stood behind the child without interacting with the infant, but she was still visible if the child turned its head. Previous studies found behavioral and physiological distress in response to this task at 6 months of age (Kim & Kochanska, 2012; Kochanska, Aksan, & Carlson, 2005; Suurland, Heijden, Huijbregts, Goozen, & Swaab, 2017a, 2017b). Autonomic arousal was measured during the baseline and the frustration episode.

All episodes of the still face paradigm and car seat task were video recorded and behavioral displays of emotional responses to the emotional challenges were coded afterwards by trained experimenters, allocating global scores from 0 to 3 (higher scores indicate more behavior) for distress vocalizations (intensity of whining, fussing, or crying), struggle (squirming in the seat or arching his/her back), and self-soothing behavior (using a body part or object for self-stimulation; Goldsmith & Rothbart, 1999;

Miller, McDonough, Rosenblum, & Sameroff, 2002; Shapiro, Fagen, Prigot, Carroll, & Shalan, 1998). One average score was created from global ratings for the first and second half of the challenge episode. The coding training consisted of one instruction meeting, 10 clips that were coded independently and a second meeting to discuss these clips with the trainer. Subsequently, another set of ten clips was coded and compared to a standard that was created by experienced coders in order to establish sufficient reliability (ICC > 0.80) to move to the formal coding phase. Inter-rater reliability for 20% of the video clips that were double coded (intra-class correlation of absolute agreement, ICC) was 0.96 for distress vocalizations, 0.85 for struggle and 0.93 self-soothing behavior during the still face paradigm, and 0.94 for distress vocalizations, 0.75 for struggle and 0.90 for self-soothing behavior during the car seat task. This is comparable to previous studies (Kim & Kochanska, 2012; Kochanska et al., 2005; Miller et al., 2002). Behavioral data on the car seat task were missing for three children due to technical recording problems.

Autonomic nervous system parameters were assessed during the challenge tasks with the Vrije Universiteit Ambulatory Monitoring System (VU-AMS; de Geus & van Doornen, 1996; de Geus, Willemsen, Klaver, & van Doornen, 1995; Willemsen, DeGeus, Klaver, VanDoornen, & Carrofl, 1996). Seven disposable pre-gelled Ag/AgCl electrodes (ConMed Huggable 1620-001) were attached to the trunk of the infant after removing oil with alcohol wipes. Electrocardiogram and impedance cardiogram were continuously measured. The electrocardiogram electrodes were placed slightly below the right collar bone 4 cm to the left of the sternum, at the apex of the heart on the left lateral margin of the chest approximately at the level of the processus xiphodius and the ground electrode was placed on the right side, between the lower two ribs. Thoracic impedance was assessed against a constant current of 50 KHz, 350 microamperes. Two electrodes on the back were used for sending this high-frequency signal through the subject's body, with two measuring electrodes on the chest picking up the voltage drop over the thorax. These measuring electrodes were placed at the suprasternal notch above the top of the sternum and at the processus xiphodius at the bottom of the sternum. The sending electrodes were placed at the back on the spine, at least 3 cm above the electrode at the top of the sternum and 3 cm below the electrode at the bottom of the sternum. Impedance cardiogram measures consisted of thorax impedance (Z0), impedance change (d*Z*) and the first derivative of impedance change (d*Z*/d*t*). The electrocardiogram and d*Z*/d*t* signal were sampled at 1,000 Hz, and the Z0 signal was sampled at 10 Hz. The VU-AMS calculates Large Scale Ensemble Averages across the entire baseline and challenge periods for the impedance electrocardiogram instead of 1 min ensemble averaging (see Riese et al., 2003 for the rationale). Mean values of pre-ejection period and RSA across the entire baseline and challenge episodes

were automatically calculated using VU-DAMS software suite version 2.0, then visually checked by a trained experimenter and adjusted manually if necessary. The peak-trough method was used to compute RSA (de Geus et al., 1995; Grossman, Beek, & Wientjes, 1990), in which the respiration signal and the inter beat intervals are combined to compute the shortest inter beat interval during inspiration (when heart rate accelerates) and the longest inter beat interval during expiration (when heart rate decelerates). Pre-ejection period was obtained by calculating the difference between the Q-wave onset on the electrocardiogram (onset of the ventricular depolarization) and the B-point on the d*Z*/d*t* signal of the impedance cardiogram (onset of left ventricular ejection; Willemsen et al., 1996). Shorter pre-ejection periods reflect more sympathetic activation. Two trained raters independently performed the manual scoring of the data (ICC was 0.84 for the B-point and 0.86 for the Q-point) to make sure the location of the B-point and Q-point were correct and morphologically consistent across the entire recording. One consensus score for analysis was created in case of differences between the raters' scores. Two infants' autonomic nervous system data were excluded due to technical problems. Two mothers were unwilling to comply with the procedures due to resistance of the infant during the still face paradigm, and four mothers during the car seat task. In addition, movement artefacts caused missing data for RSA (6.9%) and pre-ejection period (18.2%) measurements. Missing values were unrelated to other relevant variables in the study (e.g. maternal age, ethnicity and educational level). Pre-ejection period shortening could be calculated for 101 infants in response to the still face paradigm and for 98 infants in response to the car seat task. RSA suppression could be calculated for 116 infants in response to the still face paradigm and 107 infants in response to the car seat task.

Behavioral responses to an empathy-eliciting event

Empathic distress and empathic concern were assessed at 20 months post-partum using a distress simulation procedure adapted from Zahn-Waxler, Radke-Yarrow, Wagner, and Chapman (1992). Before the start of the study, the experimenter asked the mother to fill out some questionnaires, not to respond to the upcoming event and to refrain from interacting with the child during the task. Subsequently, the experimenter pretended to bump her toe into a piece of furniture. She pretended to be in pain for 30 s and to slowly recover from the pain during another 30 s. During this simulation, the experimenter sat down on the floor to rub her foot, she expressed pain vocally (eg, saying: "ouch, that hurts!") and did not make eye contact with the child. Behavioral responses of the child were videotaped by a second experimenter and coded for two subscales of Empathic distress: *Comfort seeking* (0–4), (0); does not seek comfort with self or mother; (1) mild self-comforting behavior or seeking proximity to mother; (2)

moderate comfort seeking with self or mother, or combining mild comfort seeking with self and mother; (3) moderate comfort seeking by climbing onto mothers lap combined with self-comforting behavior or high levels of comfort seeking with the self or mother; (4) self-comforting behavior for nearly the whole task and high levels of proximity to mother by "flying" onto the mother's neck, and *Personal distress* (0–3), (0) no distress; (1) mild distress; (2) moderate distress, as indicated by eyes wide and mouth open; (3) severe distress by whimpering, whining, or crying (Liew et al., 2011; Lin & Grisham, 2017; Zahn-Waxler, Radke-Yarrow, et al., 1992). Furthermore, three subscales of empathic concern were coded: *Concerned expressions* (0–3), (0) no concern; (1) slight or some concern as indicated by brow furrowing for less than 3 s; (2) moderate concern expressed in face (brow furrowing 3–8 s) or voice such as saying "ouch"; (3) strong facial concern as indicated by brow furrowing for at least 8 s, *Hypothesis testing* (0–4), (0) no hypothesis testing; (1) simple nonverbal gestures such as looking back and forward to the victim's face and foot or simple verbal inquires such as "hurt?"; (2) a combination of gestures and verbal inquires; (3) at least two distinct combined attempts to understand; (4) four or more combined attempts to understand, and *Prosocial behavior* (0–3), (0) no prosocial behavior; (1) assisting for less than 3 s by comforting the experimenter or sharing toys; (2) assisting for 3–5 s; (3) assisting more than 5 s (Liew et al., 2011; Lin & Grisham, 2017; Young et al., 1999; Zahn-Waxler, Robinson, Robinson, & Emde, 1992). All videos were coded by two reliable coders that created one consensus score in case of differences between them (ICC of absolute agreement: hypothesis testing = 0.85; prosocial behavior = 0.81; concerned expressions = 0.69; self-distress = 0.87; comfort seeking = 0.78). This is comparable to previous studies (Gill & Calkins, 2003; Zahn-Waxler, Robinson, et al., 1992). Due to failure of the video equipment, the score for comfort seeking could not be determined for one participant and all empathy data were missing for another participant.

DATA ANALYSIS

All variables were checked for outliers and violations of assumptions. Due to a lack of variance on the subscales hypothesis testing and prosocial behavior (only 16.1% of the children showed prosocial behavior and only 14.4% of the children scored higher than 1 on hypothesis testing), dichotomous variables were created for these subscales before entering them in point-biserial correlation analyses (i.e., correlation between one continuous variable and one dichotomous variable). Values that were three standard deviations above or below the average were removed (one value for PEP during the still face procedure, one value for lnRSA during the still face procedure, and two values for lnRSA during the car seat baseline). The natural logarithm of RSA (lnRSA) was used because RSA was positively skewed at all time-points. In order to

test autonomic nervous system changes from baseline to challenge on the still face paradigm and car seat task, paired sample *t* tests were conducted. For autonomic nervous system variables on the still face paradigm and the car seat task, change scores were calculated for responses to challenge in a manner that positive difference scores indicated increased arousal resulting from activation of the sympathetic nervous system as indicated by shortened pre-ejection period and suppression of the parasympathetic nervous system as indicated by suppression of lnRSA. Missing data on emotional responses and empathy were imputed according to a multiple imputation approach resulting in 126 cases to be used in the analyses (Graham, 2009; Horton & Lipsitz, 2001). In addition to emotional responses and empathy variables, baseline autonomic arousal and control variables that were significant in preliminary analyses were included in the imputation model. A total of 10 imputed datasets were generated and relative efficiency estimates exceeded 95% for each parameter (Dong & Peng, 2013). The correlation and regression analyses were performed using the pooled estimates across imputed datasets. The quadratic terms R2 and X2 for the multiple regression analyses and the data points for Figure 1 were obtained from the complete case data because pooled estimates were not available for these terms.

Associations between behavioral and physiological responses to the challenge tasks and empathy scores were examined with bivariate correlations and partial correlations, controlled for baseline autonomic arousal and variables that appeared significant in preliminary analyses, in order to provide insight into the influence of control variables on the associations between emotional responses and empathy. Multiple regression analyses were performed in order to test the independent contribution of behavioral and physiological responses to empathic behavior. Logistic regressions were used for dichotomous variables. Curvilinear (logistic) regression analyses were conducted to determine non-linear associations between behavioral and physiological responses to the challenge tasks and empathic behavior. The predictors were centered on the mean before entering them in the curvilinear regression analyses. In each curvilinear regression a linear predictor (mean centered variable) and quadratic predictor (mean centered and squared variable) was entered. Negative quadratic betas indicate that the quadratic pattern can be described as an inverted U-curve and significant linear betas indicate that the top of the curve lies somewhat to the right of the average score for empathic behavior. Separate analyses were performed for the still face paradigm and car seat task in order to explore possible task effects. All analyses were done using the Statistical Package for Social Sciences (SPSS for windows, version 23, SPSS Inc.) and statistical significance was set at $p < .05$ a priori.

RESULTS

DESCRIPTIVES

Sample characteristics and descriptive statistics are displayed in Table 1. The sample included nine children with low birthweight (<2,500 g) and 12 children were born preterm (<37 weeks). These children did not differ from the other children in the sample on any of the relevant variables in the study. No differences were found between mothers from high- and low-risk background on any of the measures examined in this study. However, individual risk factors were associated with some of the variables used. If the mother had no secondary education (more risk), the child showed less concerned expressions ($r(118) = -0.19$, $p = .038$). In addition, mothers with substance use during pregnancy had children with less lnRSA suppression in response to the still face procedure ($r(116) = -0.19$, $p = .039$), more pre-ejection period shortening in response to the car seat task ($r(98) = 0.22$, $p = .034$), less vocal distress in response to the car seat task ($r(120) = -0.24$, $p = .010$), and less struggle during the still face procedure ($r(123) = -0.21$, $p = .023$) at age 6 months. Mothers with limited social support networks had children with less lnRSA suppression in response to the car seat task ($r(107) = -0.25$, $p = .009$). Correlational analyses including these subscales were controlled for the specific risk factors that were associated with each specific subscale. During the distress simulation at age 20 months, girls showed more concerned expressions ($t(116) = -2.19$, $p = .030$, $d = 0.41$) and personal distress ($t(116) = -2.25$, $p = .026$, $d = 0.42$) than boys. Therefore, correlational analyses including these subscales were controlled for sex. In addition, correlational analyses including physiological responses were controlled for baseline physiological state. Paired sample *t* tests showed shortened pre-ejection period (still face paradigm: $t(100) = 2.26$, $p = .026$, $d = 0.23$; car seat task: $t(97) = 3.46$, $p = .001$, $d = 0.35$); and lnRSA suppression (still face paradigm: $t(115) = 4.79$, $p < .001$, $d = 0.44$) from baseline to challenge, except for lnRSA during the car seat task. Related samples Wilcoxon Signed Rank tests, indicated no difference between levels of vocal distress and struggle during the still face procedure and car seat task at age 6 months, but infants showed more self-soothing during the still face procedure ($M = 0.90$, $SD = 1.00$, $Mdn = 0.5$) than during the car seat task ($M = 0.50$, $SD = 0.68$, $Mdn = 0.0$), ($Z(116) = 3.56$, $p < .001$).

Based on interrelations, the behavioral scores for personal distress and comfort seeking at age 20 months were transformed into standardized scores and averaged to form one composite scores for empathic distress (Liew et al., 2011; Lin & Grisham, 2017). Hypothesis testing, concerned expressions and prosocial behavior are indicators of empathic concern at age 20 months, but only hypothesis testing and prosocial behavior were positively associated. Results from a nonlinear principal component analysis

indicated that the data were best described by two factors. One factor (eigenvalue 1.220 which accounted for 40.66% of the variance) that included hypothesis testing (unrotated component loading 0.807) and prosocial behavior (unrotated component loading 0.731), and another factor including concerned expressions (eigenvalue 1.052; accounting for 35.06% of the variance; unrotated component loading 0.915). One composite variable was created for hypothesis testing/prosocial behavior which indicated whether no hypothesis testing/prosocial behavior was observed (value 0) or some hypothesis/testing prosocial behavior was observed (value 1). The concerned expressions variable was retained.

Table 1. Sample characteristics

Variable	N	M	SD	Range
Caucasian ethnicity	126	85.8%		
Highest education completed (mother)	126			
Primary education		3.0%		
Secondary education		21.6%		
Tertiary education		46.3%		
Bachelor degree or higher		29.1%		
Infant sex (male)	126	54.8%		
Infant gestational age at birth (weeks)	125	39.33	2.04	31.43-42.00
Infant birth weight (gram)	126	3345	541	1700-4530
Infant APGAR score (5-min)	76	9.49	0.96	4-10
Infant age at 6 month measurement	126	6.43	0.46	5.72-8.90
Infant age at 20 month measurement	118	20.43	0.70	18.73-24.05
Empathic concern (20 months)				
Prosocial behavior	118	0.30	0.77	0-3
Hypothesis testing	118	1.30	0.83	0-4
Hypothesis testing/Prosocial behavior	118	0.25	0.44	0-1
Concerned expressions	118	1.31	0.90	0-3
Empathic distress (20 months)	117	0.00	0.79	-1.40-2.82
Personal distress	118	0.95	0.81	0-3
Comfort seeking	117	1.70	0.98	0-4
Still face paradigm (6 months)				
Baseline PEP	106	62.53	6.55	44.13-76.89
Baseline lnRSA	117	3.39	0.38	2.39-4.36
Challenge PEP	110	61.39	7.40	37.90-76.89

Table 1. Continued

Variable	N	M	SD	Range
Challenge lnRSA	116	3.22	0.42	2.29-4.18
Distress vocalizations	123	1.04	1.06	0-3
Struggle	123	1.06	0.96	0-3
Self-soothing	123	0.90	1.00	0-3
Car seat task (6 months)				
Baseline PEP	113	63.23	6.28	45.06-76.89
Baseline lnRSA	113	3.30	0.40	2.28-4.56
Challenge PEP	101	61.52	6.84	45.00-76.00
Challenge lnRSA	111	3.30	0.55	1.92-4.86
Distress vocalizations	120	1.24	1.08	0-3
Struggle	119	1.05	0.44	0-2
Self-soothing	117	0.50	0.68	0-2.5

Note: Maternal background variables were obtained during pregnancy, infant birth characteristics were obtained 6 months post-partum; Pre-ejection period (PEP); natural log of respiratory sinus arrhythmia (lnRSA).

PREDICTING EMPATHIC DISTRESS AND CONCERN FROM BEHAVIORAL AND PHYSIOLOGICAL RESPONSES

Table 2 shows bivariate (below the diagonal) and partial correlations, controlled for baseline, maternal risk factors, and sex (above the diagonal), between physiological and behavioral responses to challenge at age 6 months and behavioral responses to the distress simulation task at age 20 months. The effect of controlling for baseline, maternal risk factors, and sex on the correlation coefficients and significance levels was marginal, except for a positive association between lnRSA suppression to the still face procedure and lnRSA suppression to the car seat task in the controlled correlations, which was not present in the uncontrolled correlations. The controlled correlations (above the diagonal) will be discussed further in the results and discussion sections. Correlations of baseline lnRSA and pre-ejection period with the main variables in the study are shown in Table 2. Regarding responses on the still face paradigm, preejection period shortening from baseline to challenge was associated with less comfort seeking and empathic distress (composite), and more struggle was associated with more empathic distress (composite) and more concerned expressions. The results on the car seat task indicated that shortened pre-ejection period and lnRSA suppression from baseline to challenge were related to more empathic distress (composite). Shortened pre-ejection period

was also associated with more personal distress and comfort seeking. In addition, more struggle was related to more empathic distress (composite) and comfort seeking.

Multiple linear regressions were performed to examine if behavioral and physiological responses to challenge at age 6 months contributed independently to empathic distress at age 20 months. Behavioral responses to challenge and physiological responses to challenge were included as predictors. Empathic distress (composite), concerned expressions, and hypothesis testing/prosocial behavior were used as dependent variables. Empathic distress was included as covariate in the prediction of concerned expression and hypothesis testing/prosocial behavior, and concerned expressions and hypothesis testing were included as covariates in the prediction of empathic distress. Logistic linear regressions were used for the dichotomous dependent variable hypothesis testing/ prosocial behavior. The results, reported in Tables 3 and 4, show that struggle and shortened pre-ejection period in response to the car seat task independently contributed to empathic distress. Linear regression analyses with behavioral and physiological responses to the still face procedure as predictors, or with concerned expressions or hypothesis testing/prosocial behavior as outcome measure yielded no significant results.

Curvilinear regression analyses on the association between emotional responses at age 6 months and empathy at age 20 months indicated that a quadratic association was present between self-soothing behavior during the car seat task and the empathic distress composite, and between distress vocalizations during the car seat task and concerned expressions (Table 5 and Figure 1). Curvilinear regression analyses with physiological responses or struggle to emotional challenge as predictors, or with hypothesis testing/prosocial behavior as outcome measure yielded no significant results.

Table 2. Correlation analyses of the main variables in the study.

	1	1a	1b	2a	2b	2bi	2bii	3	4	5	6	7	8	9	10	11	12
Empathic distress (20 months)																	
1. Empathic distress	-	.78**	.79**	.35**	-.09	-.06	-.08	-.20*	.11	.16	.19*	-.10	.25**	.19*	.10	.29**	.01
1a. Personal distress	.79**	-	.24*	.52**	-.00	-.04	-.07	-.05	.03	.10	.16	-.10	.19*	.13	.16	.16	-.03
1b. Comfort seeking	.79**	.24*	-	.03	-.15	-.16	-.07	-.26**	.14	.16	.17	-.05	.22*	.17	.00	.29**	.02
Empathic concern (20 months)																	
2a. Concerned expressions	.36**	.52**	0.4	-	-.00	.05	-.08	.05	.00	-.03	.20*	-.03	.00	-.10	.02	.09	.00
2b Hypothesis testing/ Prosocial behavior	-.09	.01	-.15	-.01	-	.69**	.77**	-.06	-.01	-.01	.05	-.09	-.08	.05	.07	-.01	-.02
2bi. Hypothesis testing	-.06	.06	-.16	.04	.69**	-	.24*	-.02	.07	.09	.02	-.08	-.11	.01	.08	.07	-.06
2bii. Prosocial behavior	-.08	-.06	-.07	-.09	.77**	.24*	-	-.08	-.06	-.10	.04	-.07	-.05	-.01	-.06	-.05	-.07
Still face procedure (6 months)																	
3. PEP shortening	-.21	-.06	-.28*	.04	-.08	-.03	-.09	-	.01	.16	.17	.03	.13	-.09	.05	-.11	-.17
4. lnRSA suppression	.18	.09	.19*	.02	-.02	.06	-.08	-.05	-	.33**	.13	-.01	-.06	.19*	.00	.04	-.10
5. Distress vocalizations	.16	.10	.16	-.03	-.01	.09	-.10	.14	.32**	-	.33**	-.22*	.20*	.04	.17	.01	.00
6. Struggle	.20*	.14	.18*	.17	.02	-.02	.01	.14	.18*	.34**	-	-.16*	.10	-.06	.01	.09	.02
7. Self-soothing	-.10	-.11	-.05	-.04	-.09	-.08	-.07	.03	-.00	-.22*	-.14	-	-.17	.08	-.12	-.05	-.16

Table 2. Continued

	1	1a	1b	2a	2b	2bi	2bii	3	4	5	6	7	8	9	10	11	12
Car seat task (6 months)																	
8. PEP shortening	.21*	.15	.19	.01	-.07	-.08	-.04	.07	-.09	.17	.04	-.18	-	.01	.07	.06	-.16
9. lnRSA suppression	.22*	.16	.18	-.05	.08	-.00	.04	-.08	.04	.03	-.10	.10	.04	-	.28**	.14	.01
10. Distress vocalizations	.12	.17	.02	.02	.03	.04	-.08	.06	.05	.18	.06	-.10	.02	.24*	-	-.04	-.05
11. Struggle	.29**	.17	.29**	.12	-.01	.07	-.06	-.12	.05	.01	.12	-.05	.03	.12	.00	-	-.23*
12. Self-soothing	.01	-.00	.02	.03	-.02	-.05	-.07	-.17	-.09	.00	.04	.22*	-.16	.02	-.02	-.23*	-

Note: *$p \leq .05$, **$p \leq .01$; pre-ejection period (PEP); natural log of respiratory sinus arrhythmia (lnRSA); PEP/lnRSA scores indicate difference scores between baseline and challenge; scores above the diagonal were controlled for maternal risk factors, sex and baseline effects whenever necessary and scores below the diagonal were not.

Table 3. Linear and logistic regression analyses of the effect of behavioral and physiological responses to the car seat task at age 6 months on empathic behavior at age 20 months.

Linear regression	**B**	**SE**	**R^2**	**p**
Model 1: Empathic distress			.43	**<.001**
Concerned expressions	.29	.23		**<.01**
Hypothesis testing/Prosocial behavior	-.16	.19		.41
Distress vocalizations	.05	.05		.82
Struggle	.44	15		**<.01**
Self-soothing	.10	.10		.32
PEP shortening	.03	.02		**.03**
lnRSA suppression	.26	.14		.06
Model 2: Concerned expressions			.21	**<.01**
Empathic distress	.46	.15		<.**01**
Distress vocalizations	.01	.08		.94
Struggle	.05	.20		.82
Self-soothing	.03	.14		.22
PEP shortening	-.01	.02		.54
lnRSA suppression	-.22	.16		.18
Logistic regression	B	SE	$\chi 2$	p
Model 3: Hypothesis testing/Prosocial behavior			16.20	**<.001**
Empathic distress	-.33	.43		.45
Distress vocalizations	.05	.21		.82
Struggle	.03	.55		.96
Self-soothing	-.09	.35		.81
PEP shortening	-.03	.05		.64
lnRSA suppression	.42	.45		.36

Note: pre-ejection period (PEP); natural log of respiratory sinus arrhythmia (lnRSA); scores were not standardized before entering them in the regression analyses.

Table 4. Linear and logistic regression analyses of the effect of behavioral and physiological responses to the still face procedure at age 6 months on empathic behavior at age 20 months.

Linear regression	**B**	**SE**	**R^2**	**p**
Model 1: Empathic distress			.28	**<.001**
Concerned expressions	.30	.09		**<.01**
Hypothesis testing/Prosocial behavior	-.21	.19		.28
Distress vocalizations	.10	.08		.22
Struggle	.10	.08		.19
Self-soothing	-.04	.07		.56
PEP shortening	-.05	.02		**<.01**
lnRSA suppression	.16	.20		.41
Model 2: Concerned expressions			.24	**<.001**
Empathic distress	.45	.13		**<.01**
Distress vocalizations	-.13	.09		.17
Struggle	.12	.09		.21
Self-soothing	-.02	.08		.84
PEP shortening	.03	.02		.25
lnRSA suppression	-.02	.24		.94
Logistic regression			$\chi 2$	p
Model 3: Hypothesis testing/Prosocial behavior			21.45	**<.001**
Empathic distress	-41	.37		.27
Distress vocalizations	-.03	.24		.91
Struggle	.14	.25		.57
Self-soothing	-.23	.23		.32
PEP shortening	-.06	.06		.36
lnRSA suppression	-.05	.63		.94

Note: pre-ejection period (PEP); natural log of respiratory sinus arrhythmia (lnRSA); scores were not standardized before entering them in the regression analyses.

Table 5. Curvilinear (logistic) regression analyses of the effect of behavioral and physiological responses to challenge at age 6 months on empathic behavior at age 20 months.

	Empathic distress		**Concerned expressions**		**Hypothesis testing/ Prosocial behavior**
Still face procedure	B (SE)	p	B (SE)	p	B (SE)
Linear:	-0.04 (0.08)	.05	0.00 (0.02)	.86	-0.04 (0.06)
PEP shortening Quadratic:	0.00 (0.00)	.35	0.00 (0.00)	.23	-0.01 (0.01)
PEP shortening Linear:	0.32 (0.19)	.09	0.06 (0.24)	.23	-0.13 (0.58)
lnRSA suppression Quadratic:	0.23 (0.32)	.46	0.08 (0.41)	.20	-0.15 (1.01)
lnRSA suppression Linear:	0.08 (0.09)	.34	-0.03 (0.10)	.79	-0.02 (0.25)
Distress vocalizations Quadratic:	0.05 (0.08)	.64	0.01 (0.10)	.96	-0.01 (0.23)
Distress vocalizations Linear:	0.14 (0.08)	.10	0.11 (0.10)	.24	0.03 (0.24)
Struggle Quadratic:	0.08 (0.09)	.35	0.13 (0.11)	.23	0.04 (0.26)
Struggle Linear:	0.01 (0.10)	.96	0.08 (0.12)	.67	-0.10 (0.30)
Self-soothing Quadratic:	-0.11 (0.09)	.24	-0.14 (0.10)	.18	-0.15 (0.28)
Self-soothing Car seat task Linear:	0.04 (0.02)	**.03**	0.01 (0.02)	.82	-0.03 (0.06)
PEP shortening Quadratic:	-0.00 (0.00)	.67	-0.00 (0.00)	.69	-0.01 (0.10)
PEP shortening Linear:	0.29 (0.15)	0.6	-0.08 (0.17)	.63	0.31 (0.43)
lnRSA suppression Quadratic:	0.08 (0.18)	.68	0.04 (0.20)	.20	0.01 (0.45)
lnRSA suppression Linear:	0.14 (0.08)	.06	0.12 (0.09)	.20	0.14 (0.23)
Distress vocalizations Quadratic:	-0.12 (0.08)	.14	-0.23 (0.11)	**.04**	-0.17 (0.26)
Distress vocalizations Linear:	0.53 (0.16)	**<.01**	0.22 (0.20)	.28	0.02 (0.51)
Struggle Quadratic:	-0.04 (0.31)	.89	0.26 (0.36)	.46	-1.08 (1.05)
Struggle Linear:	0.29 (0.17)	.09	0.13 (0.19)	.50	0.33 (0.49)
Self-soothing Quadratic:	-0.32 (0.14)	**.02**	-0.10 (0.17)	.54	-0.53 (0.49)
Self-soothing					

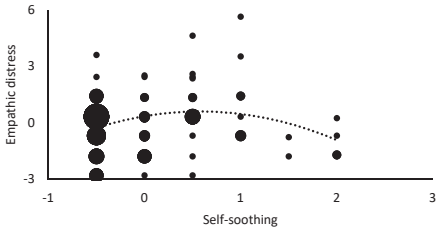

Figure 1a. The quadratic association between self-soothing during the car seat task (6 months) and empathic distress (20 months).

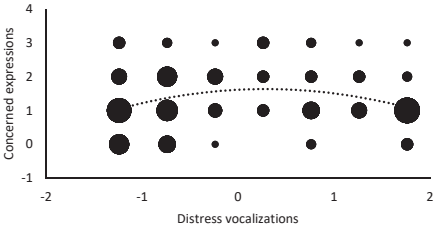

Figure 1b. The quadratic association between distress vocalizations during the car seat task (6 months) and concerned expressions (20 months).

Note: The size of the dots indicate the amount of participants at each data point based on complete case data.

DISCUSSION

The main goal of this study was to examine the predictive value of physiological and behavioral responses to mild emotional challenge at age 6 months to empathic distress and empathic concern in response to simulated distress by a stranger at age 20 months. We expected a positive association between emotional responses and empathic distress, but we did not have specific hypotheses about the direction of the association between emotional responses and empathic concern. In addition, we examined whether these associations were linear or quadratic.

Empathic distress

The results indicated that empathic distress was predicted by behavioral and physiological responses to challenge. Shortened pre-ejection period and lnRSA suppression in response to the car seat task were positively associated with the empathic distress composite. In addition, struggle during the car seat task and still face paradigm was positively associated with the empathic distress composite. These results indicate that infants who are more emotionally responsive themselves, are also more sensitive to the distress of others and confirm previous findings indicating that behavioral and physiological responses to challenge are positively related to empathic distress until age two (Liew et al., 2011; Ungerer et al., 1990; Young et al., 1999). In contrast, a negative association between pre-ejection period shortening to the still face paradigm and empathic distress (composite) was present, which will be discussed in more detail further on (see section Task effects 4.1). Behavioral (i.e., struggle) and physiological responses (i.e., shortened pre-ejection period) to the car seat task were, independently of each other, significant predictors of empathic distress. These

results stress the importance of both behavioral and physiological responses for the development of empathy.

In addition to the linear associations, quadratic associations were found between self-soothing behavior during the car seat task and empathic distress (composite). The findings suggest that low and high levels of self-soothing behavior result in low empathic distress, whereas moderate levels of self-soothing behavior are associated with more empathic distress. An explanation for the association between high levels of self-soothing behavior and low levels of empathic distress might be that high arousal levels as reflected by strong self-soothing behavior could be related to "over-arousal" and freezing behavior during the empathy task, which is reflected behaviorally as a low level of empathic distress (Gill & Calkins, 2003; Porges, 2007).

EMPATHIC CONCERN

As for empathic concern, the three indicators of empathic concern(i.e., concerned expressions, hypothesis testing, and prosocial behavior) could not be represented as a single factor, whereas these indicators were positively associated in previous studies at this age (Knafo et al., 2008; Liew et al., 2011). However, hypothesis testing and prosocial behavior could be combined into one factor. Possibly, concerned expressions was a separate factor because it refers to a feeling, which is difficult to inhibit, whereas hypothesis testing and prosocial behavior refer to actions, which increase with familiarity with the victim (Knafo et al., 2008; McDonald & Messinger, 2011; Preston & de Waal, 2002). Therefore, the concerned expressions variable may have represented the extent to which the children felt concern for the experimenter and the hypothesis testing/prosocial behavior composite represented whether children were able to act upon these feelings in an empathy-evoking situation with a stranger. With regard to the association between indices of empathic concern and emotional responses, a positive association was found between struggle during the still face paradigm and concerned expressions. This is in line with a longitudinal study suggesting that lower behavioral responses to challenge (under-arousal) predicted less empathic concern in toddlers (Young et al., 1999). In addition, a quadratic association was found between distress vocalizations during the car seat task and concerned expressions. This indicates that both high levels (over-arousal) and low levels (under-arousal) of behavioral responses to challenge (i.e., distress vocalizations) predicted low levels of empathic concern (i.e., concerned expressions), whereas moderate levels of behavioral responses to challenge represented optimal levels of arousal that predict the highest levels of empathic concern in response to empathy.

Remarkably, no quadratic associations of physiological responses with empathic concern or empathic distress were found. In addition, linear as well as

quadratic associations were found between behavioral responses and empathic behavior. The co-occurrence of linear and quadratic associations could indicate that only the increasing part of the curve was present in the data yielding linear associations (struggle, pre-ejection period, and lnRSA), whereas the whole curve was reflected by distress vocalizations and self-soothing behavior, which yielded quadratic associations. This study used mild emotional challenges that may not elicit high levels of physiological arousal and more severe stressors, such as longer challenges (e.g., an extended still face period) or physical challenges (eg, examining stress in responses to vaccination), might be necessary to be able to examine the whole curve (Bosquet Enlow et al., 2014; Jansen, Beijers, Riksen-Walraven, & de Weerth, 2010).

In addition to the co-occurrence of linear and quadratic associations, it stands out that there was a smaller number of significant findings regarding empathic concern (i.e., hypothesis testing, concerned expressions and prosocial behavior) compared to empathic distress (i.e., personal distress and comfort seeking). We propose several explanations for this difference. First, behavioral and physiological responses might have a stronger influence on empathic distress than on empathic concern because empathic concern develops under the influence of other factors such as socialization and perspective taking (Farrant, Devine, Maybery, & Fletcher, 2012; Vaish et al., 2009). Second, according to the polyvagal theory, positive associations are expected between physiological responses and empathic distress, whereas both activation and withdrawal of the parasympathetic nervous system could facilitate empathic concern (Hastings & Miller, 2014). In line with this suggestion, previous studies indicated stronger associations between physiological responses and empathic distress than between physiological responses and empathic concern (Hastings & Miller, 2014; Liew et al., 2011; Schuetze et al., 2014). Third, we chose for a distress simulation task performed by a trained experimenter instead of the child's mother in order to reduce the bias caused by differences in the credibility and intensity of the distress simulation. Distress as a result of stranger fear might have influenced the measure of empathic distress. Higher levels of empathic distress have been shown in relatively fearful toddlers (Liew et al., 2011). Although we used an introductory period of at least 15 min for the child to become familiar with and comfortable in the presence of the experimenter, we cannot exclude the possibility that stranger fear might have been present in a part of the sample. Fourth, while we used difference scores between baseline and challenge episodes for analyses regarding emotional responses, more advanced techniques, such as dynamic RSA trajectories, have previously been shown to yield associations between physiological responses and empathic concern in children from age 4 (Miller, Nuselovici, & Hastings, 2016). Fifth, 74.6% of the children did not show prosocial behavior or hypothesis testing and the large number of zero's may have led to false negative

findings. However, logistic regression analyses applied in this study are considered robust to zero-inflation and strategies to correct for class imbalance (i.e., zero inflation for dichotomous variables) are generally only recommended in case of extremely rare events, for example, 99.9% zero's (King & Zeng, 2001; Sun, Wong, & Kamel, 2009); see (Perumean-Chaney, Morgan, McDowall, & Aban, 2013; Wagh & Kamalja, 2017) for extensive discussion on advanced techniques to correct for possible bias).

TASK EFFECTS

There was a discrepancy in physiological responses between the still face paradigm and car seat task. For the car seat task, RSA suppression and shortened pre-ejection period positively predicted empathic distress (composite), whereas shortened pre-ejection period in response to the still face paradigm was a negative predictor of empathic distress (composite). This suggests that these paradigms might be qualitatively different, resulting in different physiological responses. Although we did not have hypotheses regarding task differences, the discrepancy between findings on the car seat task and still face paradigm is contradictory to a meta-analysis demonstrating that the link between RSA suppression and children's adaptive functioning outcomes did not vary as a function of type of challenge (i.e., frustration, cognitive, social, positive, or sensory oriented tasks; Graziano & Derefinko, 2013). In addition, our results are also contradictory to previous findings that behavioral responses to a social interaction task (still face paradigm) were more pronounced than responses to a non-social task in which a mobile, which had previously moved in response to the infants' kicking, could no longer be moved by the infant (Shapiro et al., 1998).

Several explanations are possible. First, children were possibly more tired during the car seat task because this task always was the last task of the home visit, while the still face paradigm was performed approximately 30 min earlier. Tiredness has been suggested to reduce RSA suppression to distress, which is in line with our finding that RSA did not significantly decrease in response to the car seat task (Keltikangas-Järvinen & Heponiemi, 2004). It is surprising that RSA suppression in response to the car seat task predicted empathic distress, whereas on average RSA did not change from baseline to the car seat phase. Previous studies indicated that RSA suppression in response to challenge is not stable yet at age 6 months, as some infants show RSA suppression and others show RSA augmentation, which results in no net RSA suppression for the entire sample (Alkon et al., 2011; Quigley & Moore, 2018). In line with those previous findings, in the current study both RSA suppression (45.8%) and RSA augmentation (54.2%) were found in response to the car seat task. The correlation analyses showed that more RSA suppression was associated with more empathic distress. Similarly, Liew et al. (2011) did

not find overall RSA suppression at 18 months, but RSA suppression at age 18 months did predict empathic behavior at age 30 months.

A second explanation for the task effects is the presence of a carryover effect. Although there was sufficient time to recover between tasks, infants could have remembered that being in the car seat was not pleasant the first time (still face paradigm). This may have caused them to become distressed faster when they were put in the car seat for the second time (car seat task). Previous studies on the still face paradigm indicate that a second still face phase was more distressing than the first one, although it should be noted that the recovery time between the challenges was much shorter in these studies (Bosquet Enlow et al., 2014; Haley & Stansbury, 2003). Therefore, the lack of counterbalancing of the challenge tasks is a limitation of this study and should be taken into account in further research. Third, the contrast in the direction of the results might be explained by the principals of the polyvagal theory, which suggests that activation of the metabolically demanding sympathetic nervous system is only adaptive in more stressful situations, whereas suppression of the parasympathetic nervous system suffices to regulate stress in less threatening situations (Porges, 2007). If the car seat task was somewhat more stressful for infants than the still face paradigm, sympathetic nervous system responses would be positively related to comfort seeking, because activation of the sympathetic nervous system is adaptive in this situation, whereas this relation would be reversed during a milder stressor (still face paradigm), because in such events activation of the sympathetic nervous system is not adaptive. Although this suggestion is in line with previous research showing that pre-ejection period responses depends on task characteristics (Maier, Waldstein, & Synowski, 2003; Quigley & Stifter, 2006), we did not find any indications that the car seat task was more stressful, as there was no significant difference in pre-ejection period shortening between the still face procedure and car seat task.

LIMITATIONS

In addition to the limitations that already have been discussed, there are some general limitations concerning the design of the study. This study investigated empathy at an important point in development, because empathy, in particular responses to empathy-evoking events that include empathic concern, rapidly develop during the second year of life and by age three the majority of children show prosocial behavior in response to empathy eliciting situations performed by both caregivers and strangers (Knafo et al., 2008; McDonald & Messinger, 2011; Zahn-Waxler, Radke-Yarrow, et al., 1992). Therefore, studies using the distress simulation task have particularly focused on the second year of life (Mark, Ijzendoorn, & Bakermans-Kranenburg, 2002; Spinrad & Stifter, 2006; Young et al., 1999). However, it would be valuable to keep track of the

prediction of empathic behavior by behavioral and physiological responses to challenge over a longer period of time, until empathy has fully developed. With such a design, it is possible to examine the effect of behavioral and physiological responses to challenge on the developmental course of empathic distress and empathic concern.

Furthermore, because internal arousal related to empathy is sometimes hard to observe from behavior, measurement of physiological responses to objectively examine empathy during the distress simulation task would have provided better insight into empathy at age 20 months. Physiological measurements during empathy eliciting tasks have been shown to result in reliable measures of empathy and have been found to be associated with behavioral measures of empathy in toddlerhood (Gill & Calkins, 2003; Liew et al., 2011; Schuetze et al., 2014). In addition, the physiological and the different behavioral outcome measures of empathy could be considered simultaneously using structural equation models.

Finally, RSA suppression and shortened pre-ejection period in response to challenge have been suggested to be indicators of emotion regulation (Calkins & Dedmon, 2000; Porges & Furman, 2011; Stifter et al., 2011; Suurland et al., 2016). Therefore, this study supports previous suggestions that emotion regulation is an important component of empathy (Eisenberg, 2010; Hoffman, 2000). Future studies could benefit from examining emotion regulation in depth by taking both physiological reactivity (from baseline to challenge) and physiological recovery (from the challenge to subsequent recovery phase) into account (Cole, Martin, & Dennis, 2004; Suurland et al., 2016).

CONCLUSION

We extended the current literature by examining the predictive value of behavioral and physiological responses to two emotional challenges to later empathic behavior. Furthermore, this study is the first to simultaneously examine behavioral responses and responses of both branches of the autonomic nervous system in order to predict observed empathic behavior. The results of the study revealed a clear linear association between early physiological and behavioral responses to mild emotional challenge and later empathic distress, but the correlations were relatively small, which limits the impact of our findings. Furthermore, the linear association between emotional responses and indicators of empathic concern was less clear. In addition, quadratic associations were found between behavioral responses to challenge and empathic distress and empathic concern, which indicates that moderate levels of behavioral responses represent optimal levels of arousal that predict the highest levels of empathic distress and empathic concern. Overall, our results indicate that stronger physiological and behavioral responses to emotional challenge at age 6 months predict

more empathic distress at age 20 months. In turn, empathic distress in response to others' distress during infancy is a precursor of later empathic concern (McDonald & Messinger, 2011; Zahn-Waxler & Radke-Yarrow, 1990). Behavioral and physiological responses to emotional challenge independently predicted empathic distress, which emphasizes the importance of research on the interplay between behavioral and physiological responses to challenge as predictors of empathy development. Identifying processes that shape emotional responses early in life may be key to understanding how impairments in empathy develop. Therefore, identification of these processes facilitates the identification of infants at risk for impairments in empathy, which could be included in preventive interventions that aim to improve empathy (Feshbach & Feshbach, 2009).

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Supplement 1. Correlation analyses of baseline lnRSA and PEP, and the main variables in the study.

	1.	**2.**	**3.**	**4.**
Baseline (6 months)				
1. PEP, still face procedure	-			
2. lnRSA, still face procedure	.04	-		
3. PEP, car seat task	.61**	.00	-	
4. lnRSA, car seat task	-.16	.68**	-.13	-
Still face procedure (6 months)				
5. PEP shortening	.13	-.10	-.02	.01
6. lnRSA suppression	-.15	.43**	-.23*	-.02
7. Distress vocalizations	-.12	.06	-.06	-.02
8. Struggle	-.17	.09	-.09	-.02
9. Self-soothing	.03	-.02	-.04	.03
Car seat task (6 months)				
10. PEP shortening	-.03	.05	.22*	-.03
11. lnRSA suppression	-.13	.11	.01	.39**
12. Distress vocalizations	.06	.04	.03	.06
13. Struggle	-.13	-.02	.02	-.04
14. Self-soothing	.00	-.04	.07	.01
Empathy-related behavior (20 months)				
15. Empathic distress	-.12	.16	-.04	.14
15a. Personal distress	-.02	.12	-.04	.09
15b. Comfort seeking	-.17	.13	-.02	.14
16. Empathic concern	.07	.12	.05	.08
16a. Concerned expressions				
16b. Hypothesis testing/Prosocial behavior	-.13	.03	-.09	.04
16bi. Hypothesis testing	-.02	.08	-.03	-.05
16bii.Prosocial behavior	-.16	-.03	-.09	.09

Note: *$p \leq .05$, **$p \leq .01$; pre-ejection period (PEP); natural log of respiratory sinus arrhythmia (lnRSA)

2

3

Empathic distress and concern predict aggression in toddlerhood: The moderating role of sex

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ABSTRACT

Impaired empathy is an important risk factor of aggression, but results are contradictory in toddlerhood. The association between empathy and aggression may differ for empathic distress and empathic concern in response to empathy-evoking situations, and for boys and girls. Therefore, the current study investigated whether empathic distress and empathic concern at age 20 months (N=133, 69 boys) predicted aggression at ages 20 and 30 months (N=119, 62 boys), while taking a potential moderating effect of sex into account. Empathic behavior was observed during a distress simulation task 20 months post-partum. Physical aggression was assessed through maternal report, using the Physical Aggression Scale for Early Childhood. Linear regression analyses revealed sex differences in the associations between empathic distress and concern on the one hand and physical aggression at age 20 months on the other. Furthermore, physical aggression at age 30 months was predicted by the interaction of sex with empathic distress at age 20 months, while controlling for aggression at age 20 months. More empathic distress and concern were associated with less physical aggression in girls, but not in boys. The findings indicate that the prediction of physical aggression by empathic distress was more robust over time than for empathic concern. This study sheds new light on the intricate relationship between empathy, aggression, and sex from a developmental perspective.

Keywords: Empathy, Aggression, Toddlerhood, Sex.

INTRODUCTION

Empathy refers to the sharing and understanding of feelings of others, and empathy deficits in adults have been associated with aggressive behavior (Blair, 1995, 2006; Decety, Norman, Berntson, & Cacioppo, 2012; Miller & Eisenberg, 1988). The observation of distress in others has been suggested to prompt the withdrawal of aggression by increasing autonomic arousal, which is experienced as aversive (Blair, 2006, 1995). Thus, understanding the causal link between aggressive behavior and the subsequent experience of aversive arousal due to the distress of the other, motivates people to refrain from actions that harm others. In line with this model, empathy, as measured by affective arousal in response to another individual's distress, has been shown to be impaired in children with conduct disorder (Bons et al., 2013). In addition, elementary and middle school children involved in interventions targeting improvement of empathy through practice of the recognition of emotions in themselves and others, perspective taking, and responding emotionally to others, have been found to become less aggressive, more prosocial, more assertive, and more empathic (Feshbach & Feshbach, 2011; Jagers et al., 2007; McMahon & Washburn, 2003; Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2011).

Approximately one out of six children show high and stable levels of aggression from toddlerhood to pre-adolescence (Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006; Tremblay et al., 2004; Tremblay, 2010). Considering the association between empathy and aggression, interventions targeting empathy at very young ages may help reducing the chances of developing high and consistent levels of aggression. Therefore, toddlerhood is a particularly important developmental stage to study the association of empathy with aggression. Although both aggressive and empathic behavior can be observed in toddlers, research on the association between empathy and aggression has mainly focused on childhood, adolescence, and adulthood (Hay, Perra et al., 2010; Lovett & Sheffield, 2007; McDonald & Messinger, 2011). From school age to adulthood, low to moderate negative associations of empathy with aggression have consistently been shown in both community samples and forensic populations (Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2013; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). However, there is a lack of research on the association between empathy and aggression in the preschool period and the results are mixed.

In children under the age of 6, negative associations between empathy and aggression have been found in studies using observational measures of aggression in peer-play groups and measurements of empathy using videotaped vignettes, parent reports and teacher reports (Strayer & Roberts, 2004), parental reports of aggression and observations of empathy during dyadic play (Hughes, White, Sharpen, & Dunn,

2000), or teacher reports of both empathic and hostile behavior (Belacchi & Farina, 2012). In contrast, positive associations between empathy and aggression were found in boys aged 4–5 years (Feshbach & Feshbach, 1969), with aggression measured by teacher reports and empathy by verbal affective responses to slides showing affective situations, and in 2-year-olds, in a study using maternal reports to measure aggressive behavior and behavioral responses to a recording of a crying infant and an experimenter pretending to hurt herself to measure empathy (Gill & Calkins, 2003). There are also quite a few studies, using similar measurements or paradigms as the studies described above, and examining empathy-aggression associations in children under the age of 6, that did not find significant results in either direction (MacQuiddy, Maise, & Hamilton, 1987; Zahn-Waxler, Cole, Welsh, & Fox, 1995). One study, using both behavioral and physiological markers of empathy did not find concurrent associations between empathy and aggression, but only longitudinal associations (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000), although these results were not replicated in another longitudinal study (Rhee et al., 2013).

Clearly, more research is necessary on the association between empathy and aggression in young children. Although positive associations between empathy and aggression are counterintuitive, contrasting results may be explained by other factors, such as type of empathic behavior and sex differences.

With respect to type of empathic behavior, a negative association between empathy and aggressive behavior has been shown in particular for affective empathy, which refers to the sharing of the other's emotions and is related to increased autonomic arousal, and to a lesser extent for cognitive empathy, which is based on the understanding of the other person's emotions (Theory of Mind) and starts to develop around the age of 4 (Blair, 2005; Bons et al., 2013; Smith, 2006), although some precursors of cognitive empathy can already be observed during toddlerhood (Vaish, Carpenter, & Tomasello, 2009). Regarding the development of affective empathy, it should be noted that empathy-eliciting situations during infancy are often emotionally challenging and result in overarousal (Eisenberg, 2010; Hoffman, 2000). Over-arousal can manifest itself as personal distress and seeking comfort (Geangu, Benga, Stahl, & Striano, 2010; Liew et al., 2011; McDonald & Messinger, 2011). Empathic distress is considered a rudimentary expression of affective empathy, because it is strongly related to automatic and rudimentary processes such as emotional contagion and emotional resonance (de Waal, 2008).

During the second and third year of life, empathy-eliciting situations also increasingly result in empathic concern, which includes concern for the wellbeing of others and trying to understand the cause of the feelings of the other, and motivates attempts to reduce the other person's distress (Eisenberg, Eggum, & Di Giunta, 2010;

McDonald & Messinger, 2011; Roth-Hanania, Davidov, & Zahn- Waxler, 2011). As a result of development in emotion regulation, self-other differentiation, and perspective taking, toddlers increasingly focus on the other's distress instead of attending exclusively their own distress (Tousignant, Eugene, & Jackson, 2017). At the age of three, over 50% of the children are able to perform some act of prosocial behavior in response to their mother's distress (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; McDonald & Messinger, 2011).

Although empathic distress may not lead to comforting and helping as empathic concern does, it is considered an important aspect of empathy since it reflects the extent to which an individual is affected by the suffering of another person (Batson, Fultz, & Schoenrade, 1987; Eisenberg et al., 2010; Singer & Klimecki, 2014). Empathic distress has been suggested to inhibit aggression and to be a precursor of empathic concern, for example, by Blair's Violence Inhibition Mechanism model (Blair, 2006; de Waal, 2008; Hoffman, 2000; McDonald & Messinger, 2011; Zahn-Waxler & Radke-Yarrow, 1990). Furthermore, empathic distress and empathic concern can occur simultaneously and have been shown to be positively associated throughout development (Gill & Calkins, 2003; Israelashvili & Karniol, 2018; Liew et al., 2011; Lin & Grisham, 2017; Young, Fox, & Zahn-Waxler, 1999). Nonetheless, recent research has shown evidence in support of distinct neural systems underlying empathic distress and empathic concern (Decety & Michalska, 2010; Han et al., 2017; Singer & Klimecki, 2014). In line with Hoffman's stages of empathy, which indicate that empathic concern starts to co-occur with empathic distress as soon as the self-other distinction is present, neuroimaging research in children indicates that brain regions associated with empathic distress develop earlier than brain regions associated with empathic concern, and behavioral research indicates that empathic distress is stable over time, whereas empathic concern increases during the first years of life (Decety & Michalska, 2010; Decety, 2010; Geangu et al., 2010; Hoffman, 2000; Roth-Hanania et al., 2011).

Since empathic distress and empathic concern represent different, but related empathic responses, their associations with aggression may differ (Israelashvili & Karniol, 2018; Lin & Grisham, 2017). Empathic distress results solely from affective arousal, which has been suggested to prompt the inhibition of aggression, and can be hypothesized to be negatively associated with aggression in toddlerhood. Empathic concern is under the influence of arousal as well as other factors, such as socialization and perspective taking (Farrant, Devine, Maybery, & Fletcher, 2012; Vaish et al., 2009). Because arousal has less influence on empathic concern than on empathic distress, the association between empathic concern and aggression can be hypothesized to be weak or absent. In toddlerhood, however, studies that have included measures of both empathic distress and empathic concern did not indicate clear distinctions between

empathic distress and empathic concern in relation to aggression (Gill & Calkins, 2003; Hastings et al., 2000; Zahn-Waxler et al., 1995).Thus, other factors might also play a role in explaining the contradictory results regarding empathy-aggression associations in toddlerhood. For example, sex differences could play an important role.

Studies with toddlers have shown that girls generally express more empathic behavior than boys (Hastings et al., 2000; Knafo et al., 2008; Spinrad & Stifter, 2006; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992; Zahn-Waxler, Robinson, & Emde, 1992). Moreover, females have been shown to be more empathic from birth until adulthood and sex differences in empathy have been suggested to have a neurobiological origin (Christov-Moore et al., 2014; Schulte-Ruther, Markowitsch, Shah, Fink, & Piefke, 2008). Still, several studies on toddlers did not find sex differences regarding empathy (Gill & Calkins, 2003; Rhee et al., 2013; Roth-Hanania et al., 2011; Vaish et al., 2009). Regarding aggression, boys have been shown to be more aggressive than girls in toddlerhood (Alink et al., 2006; Baillargeon et al., 2007) and boys are more likely to follow high and stable trajectories of aggression from toddlerhood to adolescence (Cote et al., 2006; Tremblay et al., 2004; Tremblay, Hartup, & Archer, 2005). Consequently, the association between empathy and aggression might be different for boys and girls (Feshbach & Feshbach, 1969). Although empirical findings on sex differences in aggression and empathy are well documented, the potential moderation effects of the association between empathy and aggression by sex is still not explored enough. Some indications for a moderating effect of sex have been found. A study in 4–7 yearold children demonstrated a positive association between self-reported empathy in response to vignettes and aggression in boys, but not in girls (Feshbach & Feshbach, 1969). On the other hand, another study demonstrated a negative association between parentreported empathy and psychopathic traits (which include aggression) in 3–13 year-old boys, but not in girls (Dadds et al., 2009). Research in adults indicate stronger negative associations between self-reported empathy and aggression in women (Stanger, Kavussanu, & Ring, 2016). Based on these studies, it remains unclear if a moderating effect would be present for both empathic concern and empathic distress.

The association between empathy and aggression might be stronger for physical aggression than for other types of aggression in toddlerhood, because physical aggression has been shown to emerge during the first year of life, to peak during the second and third year of life and to decline during the fourth year of life, while other forms of aggression (e.g. verbal aggression) start to increase during the fourth year of life (Alink et al., 2006; Hay, Perra et al., 2010; Tremblay et al., 1999). Moreover, physical aggression has been shown to be a better predictor of continued problem behavior than other types of problem behavior (Broidy et al., 2003). Therefore, the current study will focus on maternal reports of physical aggression.

The present study aimed to investigate the association between empathy and physical aggression in toddlerhood, while taking into account its different expressions, empathic distress and empathic concern, and sex differences in empathy and physical aggression. A negative association between empathic distress and physical aggression was expected, whereas a weak negative or no association between empathic concern and physical aggression was expected. In addition, girls were expected to show more empathic distress and concern, and boys were expected to show more physical aggression. Furthermore, a possible moderating effect of sex on the association between empathy and physical aggression was explored.

METHODS

PARTICIPANTS

The present study is part of the Mother- Infant Neurodevelopment Study in Leiden, The Netherlands (MINDS – Leiden). MINDS–Leiden is a longitudinal study into neurobiological and neurocognitive predictors of early behavior problems. The study was approved by the ethics committee of the Institute of Education and Child Studies at the Faculty of Social and Behavioural Sciences, Leiden University (ECPW-2011/025), and by the Medical Research Ethics Committee at Leiden University Medical Centre (NL39303.058.12). All participating women provided written informed consent. 162 women were recruited during pregnancy via midwifery clinics, hospitals, prenatal classes and pregnancy fairs. Dutch speaking primiparous women between 17 and 25 years old (M = 23.35, SD=2.13) with uncomplicated pregnancies were eligible to participate. Women from high-risk backgrounds were oversampled in this study, which increases variance in infant's behavior (see Smaling et al., 2015 for detailed procedures). Data collection for the present study was part of a home visit 20 months post-partum and a lab visit 30 months post-partum. Dropout (N=29 at 20 months and N=43 at 30 months) was mainly due to unreachability and unwillingness to participate without explaining the reason. Dropout was not related to ethnicity, level of education and marital status. At the end of the appointments, the child was rewarded with a gift and the mother received a reimbursement for her time.

EMPATHY

Behavioral responses to an empathy-evoking situation were observed during a distress simulation task adapted from Zahn-Waxler, Radke-Yarrow et al. (1992) at age 20 months (N=133, 69 boys). The experimenter asked the mother to refrain from interacting with her child or to respond in a neutral way when the child would seek contact with her. Subsequently, the experimenter pretended to bump her toe into a

piece of furniture. She pretended to be in pain for 30 s and to slowly recover from the pain during another 30 s. During this simulation, the experimenter sat down on the floor to rub her foot, she expressed pain vocally (e.g. saying: "ouch, that hurts!") and did not make eye contact with the child. Behavioral responses of the child were videotaped by a second experimenter and coded for two dimensions of empathic distress (higher score indicates more observed behavior): comfort seeking (0–4; does not seek comfort with self or mother; mild self-comforting behavior or seeking proximity to mother; moderate comfort seeking with self or mother, or combining mild comfort seeking with self and mother; moderate comfort seeking by climbing onto mothers lab combined with self-comforting behavior or high levels of comfort seeking with the self or mother; self-comforting behavior for nearly the whole task and high levels of proximity to mother by 'flying' onto the mother's neck) and personal distress (0–3; no distress; mild distress; fear present; whimpers, whines, or cries) (Liew et al., 2011; Lin & Grisham, 2017; Zahn-Waxler, Radke-Yarrow et al., 1992). In addition, three dimensions of empathic concern were coded: concerned expressions (0–3; no concern; slight or some concern such as brow furrowing for less than 3 s; moderate concern expressed in face or voice; strong facial concern for at least 8 s), testing hypotheses (0–4; no hypothesis testing; simple nonverbal gestures such as looking back and forward to the victim's face and foot or simple verbal inquires such as 'hurt?'; a combination of gestures and verbal inquires; at least two distinct combined attempts to understand; four or more combined attempts to understand) and prosocial behavior (0–3; no prosocial behavior; assisting for less than 3 s by comforting the experimenter or sharing toys; assisting for 3 to 5 s; assisting more than 5 s) (Liew et al., 2011; Lin & Grisham, 2017; Zahn-Waxler, Radke-Yarrow et al., 1992). All measures were videotaped and coded afterwards by two reliable coders that created one consensus score in case of differences between them. The ICC's were .850 for testing hypothesis, .807 for prosocial behavior, .692 for concerned expressions, .868 for self-distress and .776 for comfort seeking. The scores on these scales were transformed into standardized scores. In accordance to previous studies, comfort seeking and personal distress were summed to a composite score for empathic distress, and prosocial behavior, hypothesis testing, and concerned expressions were summed to a composite score for empathic concern (Liew et al., 2011; Lin & Grisham, 2017).

PHYSICAL AGGRESSION

In order to measure physical aggression, all mothers completed the physical aggression scale for early childhood (PASEC) at 20 (*N*=133, 69 boys) and 30 (*N*=119, 62 boys) months of age (Alink et al., 2006). The PASEC has been shown to be a valid measure to examine physical aggression in infancy and consists of 11 items to be scored on a 3-point Likert scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true

or often true) (Alink et al., 2006). The PASEC combines six items from the Child Behavior Checklist (Achenbach & Rescorla, 2000) and five items constructed by Tremblay et al. (1999) to measure physical aggression (e.g. hits others, bites others and destroys his/her own things). Scores were added to create one physical aggression score at age 20 months and one physical aggression score at age 30 months (Cronbach's α = .75 in infancy and α = .71 in toddlerhood).

DATA ANALYSIS

All variables were checked for outliers and normality. For physical aggression, the natural log of the PASEC was used because this variable was positively skewed before transformation. No data was missing on the PASEC and empathy observations. First, Spearman correlations between the ordinal variables of the behavioral responses to the distress simulation task and the PASEC scores were performed for boys and girls separately. The main and interaction effects of empathic distress, empathic concern, and sex on physical aggression were examined by separate multivariate linear regression analyses for physical aggression at age 20 months and 30 months. Regarding physical aggression at age 20 months, the following variables were entered in the regression: empathic distress, empathic concern, sex, sex×empathic distress, and sex×empathic concern. For the regression analyses regarding physical aggression at age 30 months, physical aggression at 20 months was entered first and the variables described above were entered in the second step of the regression. The empathy variables were centered at the mean in advance and interaction effects were further examined by repeating the regression analyses at different levels (0 for boys and 1 for girls) of the moderator (Aiken, West, & Reno, 1991; Holmbeck, 2002). All analyses were done using the Statistical Package for Social Sciences (SPSS for windows, version 23, SPSS Inc., Chicago) and statistical significance was set at $p < .05$ a priori.

RESULTS

Characteristics of the sample are shown in Table 1. Descriptive statistics of the scales of the distress simulation task and physical aggression scores, and Spearman correlations between the scales are shown in Table 2. No sex differences were present on any of the composite measures or individual items of the empathy and aggression instruments. Paired samples T-Tests indicated no difference in physical aggression between age 20 and 30 months (Boys: $t(62)=.858$, $p= .394$, $d=0.10$; Girls: $t(57)=1.407$, $p= .165$, $d=0.22$).

Table 1. Sample characteristics

Variable	%	M(SD)
Caucasian ethnicity	86.3%	
Highest education completed		
Primary education	2.3%	
Secondary education	19.1%	
Tertiary education	48.1%	
Bachelor degree or higher	30.5%	
Infant age at 20 months measurement		20.46 (0.71)
Infant age at 30 months measurement		30.65 (1.11)

Note: Maternal background variables were obtained during pregnancy.

Table 2. Spearman correlations and descriptive statistics of behavioral responses to the distress simulation task at age 20 months and maternal reports of physical aggression at age 20 and 30 months.

Boys \ Girls	1.	1a.	1b.	1c.	2.	2a.	2b.	3.	4.	M girls	SD girls
1. Empathic concern		.556**	.556**	.633**	-.151	.220	-.428**	-.252*	.092	0.04	1.66
1a. Prosocial behavior	.440**		.313**	-.047	-.287*	-.189	-.228	-.100	.270*	0.25	0.64
1b. Hypothesis testing	.595**	.018		-.025	-.186	-.022	-.299*	-.186	.079	1.25	0.61
1c. Concerned expressions	.632**	-.186	.181		.098	.401**	-.234	-.203	-.077	1.34	0.91
2. Empathic distress	.267*	-.097	-.031	.535**		.703**	.738**	-.215	-.325**	0.15	1.39
2a. Personal distress	.333**	-.090	-.016	.637**	.832**		.096	-.241	-.396**	1.02	0.70
2b. Comfort seeking	.099	-.052	-.050	.207	.765**	.312**		-.076	-.141	1.75	1.01
3. Aggression 20 months	.196	.183	.148	.058	.203	.208	.122		.414**	2.50	2.15
4. Aggression 30 months	.129	.117	.231	-.038	.245	.215	.232	.447**		2.07	1.97
M boys	-0.13	0.32	1.16	1.23	-.19	0.86	1.62	3.10	2.71		
SD boys	-1.78	0.83	0.63	0.94	1.60	0.84	0.93	2.62	2.26		

Note: *p≤.05, **p≤.01; No sex differences were found for these variables.

MAIN ANALYSES

The results of the regression analyses that were performed to examine main and interaction effects of empathic distress and concern, and sex on physical aggression are shown in Table 3. At age 20 months, no main effects of empathic distress, empathic concern, or sex on physical aggression were found, but interactions of both empathic distress and empathic concern with sex were present. Regarding physical aggression at age 30 months, physical aggression at age 20 months was a significant predictor, but nomain effects of empathic distress, empathic concern, and sex were found. Furthermore, an interaction of sex with empathic distress, but not empathic concern, was found.

Table 3. Regression analyses of the effects of empathic distress, empathic concern and sex on physical aggression.

	β	**t**	**R^2 change**	**β**	**t**	**R^2 change**	**Sig.**
	20 months			**30 months**			
Model 0						.199	<.001
Aggression T1				.446	5.393		<.001
Model 1			.106			.082	.031
Aggression T1				.402	4.776		<.001
Empathic distress	.148	1.329		.172	1.591		.114
Empathic concern	.205	1.788		.048	.423		.673
Sex	-.114	-1.352		-.119	-1.455		.148
Empathic distress × sex	-.239	-2.159		-.308	-2.858		.005
Empathic concern × sex	-.328	-2.885		.060	.528		.598

Note: Aggression T1: physical aggression at age 20 months.

POST HOC ANALYSES

To be able to interpret the regression lines of empathic distress and empathic concern on physical aggression for boys and girls, post hoc hierarchical regression analyses were performed with sex at level 1, which represents girls (the default is 0, which represents boys and is displayed in Table 3), according to the method of Aiken, West, and Reno (Aiken et al., 1991; Holmbeck, 2002). The results indicated empathic distress did not predict physical aggression in boys (**β** =.148, *t*=1.329, *p* = .186), but a negative trend was found for girls (**β** = −.239, *t* = −1.795, *p*=.075) at age 20 months. In addition, empathic distress at age 20 months did not predict boys' physical aggression at age 30 months (**β** =.172, *t*=1.591, *p*=.114), but was a negative predictor of girls' physical

aggression at age 30 months (**β** = −.315, *t* = −2.436, *p*=.016), while controlling for physical aggression at age 20 months. Empathic concern was marginally positively associated with physical aggression in boys (**β** =.205, *t*=1.788, *p* = .076) and negatively associated with physical aggression in girls (**β** = −.317, *t* = −2.411, *p*=.017) at age 20 months.

DISCUSSION

The aim of the current study was to investigate whether empathic distress and empathic concern at age 20 months predict physical aggression at age 20 and 30 months, while taking into account possible sex differences. In contrast to our hypotheses, there were no main effects of empathic distress, empathic concern, or sex on physical aggression. The results showed that the effects of empathic distress and empathic concern on physical aggression were moderated by sex. Negative associations between empathic concern and physical aggression at age 20 months, as well as between empathic distress and physical aggression at age 30 months, were present for girls only. No associations between empathy and aggression were found for boys. Regarding prosocial behavior specifically, a positive association was found with physical aggression at age 30 months in girls.

In girls, higher levels of empathic distress at age 20 months predicted lower levels physical aggression at age 20 months (marginal effect) and age 30 months, while controlling for physical aggression at age 20 months. These results are in line with our hypotheses, and support both theory and empirical results indicating negative associations between empathy and aggression (Belacchi & Farina, 2012; Blair, 2005; Hughes et al., 2000; Lovett & Sheffield, 2007; Strayer & Roberts, 2004). However, a positive association between prosocial behavior at age 20 months and physical aggression at age 30 months was present in girls. Possibly, this was due to the fact that empathic distress at age 20 months was negatively associated with both prosocial behavior and physical aggression at age 30 months. These associations may have resulted in the positive association between prosocial behavior and physical aggression at age 30 months in girls. In line with this suggestion, the positive association disappeared when empathic distress was controlled for.

We expected weak negative or no associations between empathic concern and physical aggression, because affective arousal plays less of a role in empathic concern than in empathic distress, and because empathic concern depends on other factors such as socialization and perspective taking (Farrant et al., 2012; Vaish et al., 2009). However, higher levels of empathic concern in girls were associated with lower levels of physical aggression at age 20 months. A possible explanation for this association is that empathic concern may still be influenced by affective arousal, despite the additional influence of other factors. Therefore, the same mechanism may cause an

association between empathic distress and aggression, and between empathic concern and aggression. Furthermore, perspective taking has also been shown to motivate the withdrawal of aggression and empathic concern might be a mediator of this association (Richardson, Hammock, Smith, Gardner, & Signo, 1994). Therefore, further research is necessary on the affective and cognitive aspects of empathic concern in relation to aggression. However, where empathic distress was predictive of physical aggression both concurrently and longitudinally, empathic concern showed only concurrent effects at age 20 months. This indicates that the prediction of physical aggression by empathic distress is more robust over this early developmental course than for empathic concern.

Although higher levels of empathic distress and empathic concern, and lower levels of physical aggression were expected for girls, no main effects of sex on empathic behavior or aggression were found. Our results were in line with findings in previous studies (Gill & Calkins, 2003; Rhee et al., 2013; Roth-Hanania et al., 2011; Vaish et al., 2009). However, the majority of studies have shown higher levels of empathy in girls than in boys from birth onwards (Christov-Moore et al., 2014; Hastings et al., 2000; Knafo et al., 2008; Spinrad & Stifter, 2006; Zahn-Waxler, Radke-Yarrow et al., 1992; Zahn-Waxler, Robinson et al., 1992). Possibly, sex differences in empathy have been masked by differences in social inhibition between boys and girls in response to the distress simulation task. Specific impairments in inhibition have been shown in aggressive preschool children, in particular in boys (Raaijmakers et al., 2008). Therefore, boys might have responded more impulsively (e.g. approaching the victim) to the distress simulation task, which could have resulted in more behavioral responses, such as prosocial behavior, hypothesis testing and comfort seeking (Gill & Calkins, 2003). Inhibition impairments could also explain why no association between empathy and physical aggression was found for boys. Thus, boys with impaired inhibition will not only show more empathic behavior, but also more aggression. Inhibition impairments may therefore underlie a positive association between empathy and aggression, and this positive association may counteract the negative association between empathic distress and physical aggression that was initially hypothesized (Eisenberg et al., 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007).

Alternatively, the association between empathy and aggression may have been different for boys and girls because of differences between boys and girls in the associations between indicators of empathic behavior. For example, prosocial behavior and hypothesis testing are positively associated in girls only, whereas personal distress and comfort seeking are only positively associated in boys. In addition, the composite scores of empathic concern and empathic distress were positively associated in boys, but not in girls. Therefore, the correlation analyses only supported the empathic concern composite for girls and the empathic distress composite for boys, which is a limitation

of the study. However, it should be noted that both composites were supported by their constituents, as empathic concern was positively associated with concerned expressions, hypothesis testing, and prosocial behavior, and empathic distress was positively associated with personal distress and comfort seeking in both boys and girls.

In addition to the lack of sex differences on empathy, no differences between boys and girls on physical aggression were found. The interaction effects between empathic distress and empathic concern, and physical aggression indicated that lower levels of physical aggression were reported for girls than for boys, but only if their empathic behavior was high. Although higher levels of aggression have previously been found in boys at age 17 months (Baillargeon et al., 2007) and boys are more likely to follow high and stable trajectories of aggression from toddlerhood to adolescence (Cote et al., 2006; Tremblay et al., 2004, 2005), sex differences in aggression might not be clearly present yet in toddlerhood. No sex differences were found until the age of 24 months in a study using the PASEC (Alink et al., 2006). In addition, a longitudinal study showed more aggression for girls than boys before the age of 24 months, while the opposite was found after 24 months of age (Hay et al., 2011). Future research on the development of sex differences in aggression is needed.

The current study adds to the literature by focusing on both empathic distress and empathic concern in response to an empathy-eliciting event. As the results showed, at an early developmental stage, empathic distress is an import aspect of empathy and shows more robust associations with physical aggression compared to empathic concern. Furthermore, the use of a longitudinal design is a strength of this study, as it provides insight on how empathic behavior is associated with change in physical aggression over time. Although negative associations between empathy and physical aggression have been found before in toddlerhood, this is the first study to find both cross-sectional and longitudinal effects of empathy-related behavior on physical aggression at this age (Belacchi & Farina, 2012; Hastings et al., 2000; Hay, Hudson, & Liang, 2010; Hughes et al., 2000; Strayer & Roberts, 2004).

In addition, infants' empathic behavior was examined using videotaped observations of an empathy-evoking task that were double coded for empathy-related behavior. In order to increase the reliability of the empathy measure, the distress simulation was performed by the experimenter rather than the child's mother. This is a limitation of the study because it is likely that distress in unfamiliar people evokes less empathic concern and more empathic distress in infants than distress in familiar people (Preston & de Waal, 2002; Young et al., 1999). The fact that maternal reports have been used to measure physical aggression might be a limitation of the current study. Parent reports provide ecologically valid information about behavior in daily situations, but maternal reports of physical aggression might be biased by maternal factors such as

personality, memory capacity, and tendency of social desirability response (Kagan, Snidman, Arcus, & Reznick, 1994). Still, the PASEC has shown to be a reliable and valid measure of physical aggression in toddlerhood (Alink et al., 2006; Koot, Van Den Oord, Verhulst, & Boomsma, 1997). Furthermore, our results also indicated stability of physical aggression over time ($r(119)=.446$, $p < .001$). It should also be noted that structural equation modeling could have been a more optimal method to deal with latent variables (empathic concern and empathic distress) and the longitudinal nature of the data (De Stavola et al., 2006).

To conclude, this study revealed that the association between empathy and physical aggression is already present in toddlerhood. In particular, more empathic concern in response to an empathy-evoking situation at age 20 months predicted lower levels of physical aggression in girls, but not boys, at age 20 months. Furthermore, in girls, more empathic distress at age 20 months predicted lower levels of physical aggression at age 30 months, while controlling for physical aggression at age 20 months. The current study suggests that the basis for the association between empathy and physical aggression is established in toddlerhood. Future studies should investigate the effects of interventions aiming to increase empathy and reduce aggression. Furthermore, more research is needed to address the effect of other factors (e.g. inhibition) on empathy and aggression in toddlerhood. Finally, more research is needed into the development of the association between empathy and aggression in boys.

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4

Associations between empathy, inhibitory control, and physical aggression in toddlerhood

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ABSTRACT

Impaired empathy has been associated with aggression in children, adolescents and adults, but results have been contradictory for the preschool period. Impaired inhibitory control also increases the risk of aggression, and possibly moderates empathy-aggression associations. The current study investigated whether empathy and inhibitory control are associated with aggression in toddlerhood. Furthermore, we aimed to clarify the role of inhibitory control in empathy and aggression, specifically, whether inhibitory control moderates the association between empathy and aggression. During a laboratory visit at age 30 months (*N* = 103), maternal reports of physical aggression were obtained and child inhibitory control was examined using a gift delay task. Empathy was examined by obtaining behavioral observations and recording physiological responses (heart rate response and respiratory sinus arrhythmia response) to an empathy-eliciting event (i.e., simulated distress). Reduced inhibitory control was associated with more aggression. Behavioral and physiological indicators of empathy were not associated with aggression. Hierarchical regression analyses revealed an interaction effect of heart rate response to distress simulation with inhibitory control in the prediction of aggression. Post hoc analyses indicated a negative association between heart rate response and aggression when inhibitory control was high, but a positive association was found in toddlers who demonstrated low inhibitory control. These results suggest that children are less aggressive when they have both high levels of empathy and inhibitory control. Therefore, both empathy and inhibition are important targets for interventions aiming to reduce or prevent aggression at a young age.

Keywords: Empathy, inhibition, aggression, respiratory sinus arrhythmia, heart rate.

INTRODUCTION

Aggression emerges during the first year of life and manifests as physical aggression (e.g., hitting and biting). Physical aggression peaks during the second and third year of life, when virtually all children show physical aggression at least occasionally, and declines during the fourth year of life, when other forms of aggression start to increase (e.g., verbal aggression; Alink et al., 2006; Hay et al., 2010; Tremblay et al., 1999). Persistently high levels of physical aggression in toddlerhood have been shown to be an important risk factor for aggressive behavior later in development, as approximately one out of six children shows high and stable levels of aggression from toddlerhood to preadolescence (Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006). Physical aggression at age 5–7 years has been shown to be a better predictor of continued problem behavior in adolescence than other types of problem behavior (Broidy et al., 2003). It is important to study the risk factors of aggression early on, as these risk factors may be important targets for preventive interventions (Cote et al., 2006; Tremblay, 2010; Tremblay et al., 2004).

EMPATHY

Impaired empathy has been considered an important risk factor for aggressive behavior (Bons et al., 2013; Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2014; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). Empathy refers to the ability to share and understand feelings of others and is a fundamental component of social competence, which results from a complex interplay between involuntary neurocognitive, neuroendocrine, and autonomic processes (Decety, 2010; Eisenberg, Eggum, & Di Giunta, 2010). Precursors of empathy may already be present at a very early age, as newborns and infants become distressed in response to other infants' crying, but not to recordings of their own crying (Dondi, Simion, & Caltran, 1999; Geangu, Benga, Stahl, & Striano, 2010). In infants and toddlers, empathy-eliciting situations are often emotionally challenging and result in empathic distress, which is a self-oriented response (Eisenberg, 2010; Hoffman, 2000). Empathic distress can manifest as personal distress and seeking comfort, because vicarious emotional responses cannot be regulated and become aversive (Liew et al., 2011; McDonald & Messinger, 2011). In addition to empathic distress, other-oriented empathic concern also occurs in infancy and toddlerhood; it includes concern for the well-being of others and trying to understand the cause of the feelings of the other, and motivates attempts to reduce the other person's distress (Davidov, Zahn-Waxler, Roth-Hanania, & Knafo, 2013; Eisenberg et al., 2010; McDonald & Messinger, 2011). As a result of development in emotion regulation, self-other differentiation and perspective taking during the

second and third year of life, toddlers increasingly focus on the other's distress instead of focusing exclusively on their own distress, which results in more empathic concern.

Although behavioral observations are commonly used to examine empathy, they may be influenced by the effect of emotional expressiveness (Zhou, Valiente, & Eisenberg, 2003), and physiological measures can provide indices of empathy that are under less conscious control (Gill & Calkins, 2003; Liew et al., 2003; Miller, Nuselovici, & Hastings, 2016; Schuetze, Eiden, Molnar, & Colder, 2014). Empathic behavior results from a complex interplay between involuntary neurocognitive, neuroendocrine, and autonomic processes (Decety, 2010). Autonomic arousal in response to emotions of others, such as increased heart rate, is not synonymous with empathy, but is considered to represent a reliable and objective measure of empathy (Bons et al., 2013). Nevertheless, the association between heart rate responses and empathy is complex (Hastings & Miller, 2014; Hastings, Miller, Kahle, & Zahn-Waxler, 2014). Heart rate responses to empathy-evoking situations have been shown to indicate various types of empathic behavior. Heart rate deceleration has been associated with interest and an outward orientation of attention, such as empathic concern, whereas heart rate acceleration has been associated with a self-focus and empathic distress (Eisenberg, 2010; Zahn-Waxler, Cole, Welsh, & Fox, 1995). Empathic distress and empathic concern both result from empathy (sharing and understanding other's feelings) and can occur simultaneously, in particular in young children (Gill & Calkins, 2003; Israelashvili & Karniol, 2018; Liew et al., 2011; Lin & Grisham, 2017; Young, Fox, & Zahn-Waxler, 1999). At this developmental stage, experimental studies have shown increases of heart rate rather than decreases of heart rate in response to empathy-eliciting situations (Gill & Calkins, 2003; Schuetze et al., 2014).

In addition to heart rate, suppression of respiratory sinus arrhythmia (RSA), which is the variability of heart rate during the respiratory cycle that indicates parasympathetic cardiac control, has been shown to be an indicator of arousal regulation during empathy- evoking situations (Gill & Calkins, 2003; Liew et al., 2011; Miller et al., 2016; Schuetze et al., 2014). These studies found better regulation of arousal, as indicated by more RSA suppression, to be associated with less empathic distress and more empathic concern in the preschool period (Liew et al., 2011; Miller et al., 2016; Schuetze et al., 2014). Yet, another study indicated that more RSA suppression was associated with less empathic concern (Gill & Calkins, 2003). Despite the fact that physiological responses to others' emotional states have been used as indicators of empathy, the association between physiological responses and empathy remains complex and more research is necessary to better understand these associations (Hastings & Miller, 2014; Hastings et al., 2014).

EMPATHY AND AGGRESSION

Impaired empathy has been shown to be a risk factor of aggression in children, adolescents, and adults, but the results have been contradictory in the preschool period (Lovett & Sheffield, 2007). A negative association between empathy and aggression has been found in several studies examining empathy in relation to aggression and hostile behavior (Belacchi & Farina, 2012; Hughes, White, Sharpen, & Dunn, 2000; Strayer & Roberts, 2004). Conversely, positive associations have also been found in boys aged 4–5 years (Feshbach & Feshbach, 1969), and in 2-year-olds (Gill & Calkins, 2003). However, several studies did not find a significant association between empathy and aggression (Macquiddy, Maise, & Hamilton, 1987; Zahn-Waxler et al., 1995). One study did not reveal concurrent associations, but revealed only longitudinal associations between empathy and aggression from age 4–5 to 6–7 (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000). However, no significant results were found in another study from age 14–36 months to 4–17 years (Rhee et al., 2013). Therefore, it remains unclear whether empathy and aggression are already associated in the preschool period.

INHIBITORY CONTROL

Impaired inhibitory control is another factor that has been considered a risk factor for aggressive behavior. Inhibitory control refers to the conscious regulation of behavior, in particular the suppression of behavior to initiate less favorable behavior (Kochanska, Murray, & Coy, 1997; Kochanska, Murray, & Harlan, 2000). Inhibition develops rapidly in the preschool period. Simple inhibitory control, such as inhibiting motor responses, starts to develop from the first year of life and increases over time, whereas more complex inhibition skills, such as inhibition tasks that involve working memory, develop from age 3 years (Carlson, 2005; Garon, Bryson, & Smith, 2008; Kochanska et al., 2000). Various studies indicated that poor inhibitory control is associated with high levels of aggressive behavior during the preschool period (Hughes et al., 2000; Raaijmakers et al., 2008; Waller, Hyde, Baskin-Sommers, & Olson, 2017). Impairments in inhibitory control have been proposed to explain the contradictory effects and null-findings regarding the association between empathy and aggression in the preschool period (Eisenberg, 2010; Eisenberg et al., 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007). Possibly, a lack of inhibitory control leads to impulsive behavior (e.g., approaching the other) in both empathy- and aggressionevoking events in toddlerhood (Gill & Calkins, 2003). Under conditions of impaired (or not yet sufficiently developed) inhibitory control, both empathic and aggressive behavior may be expected to be high (i.e., a positive association between empathy and aggression), whereas high inhibitory control could result into more empathy and less aggression (i.e., a negative association between empathy and aggression).

THE CURRENT STUDY

The aim of the current study was to investigate whether empathy and inhibitory control are associated with aggression in toddlerhood. We hypothesized that higher levels of physical aggression would be associated with less empathy, as indicated by less empathic concern and empathic distress, and a reduced increase in heart rate and reduced RSA suppression in response to an empathy-eliciting event (Belacchi & Farina, 2012; Strayer & Roberts, 2004). In addition, higher levels of aggression were hypothesized to be associated with lower levels of inhibitory control (Hughes et al., 2000; Raaijmakers et al., 2008; Waller et al., 2017).

In addition to the association of empathy and inhibitory control with aggression, we aimed to investigate whether inhibitory control moderates the association between empathy and aggression. Negative associations between indicators of empathy (i.e., empathic distress, empathic concern, heart rate increase, and RSA suppression in response to an empathy-eliciting event) and aggression were hypothesized to be present for toddlers showing better inhibitory control. In contrast, lower levels of inhibitory control were hypothesized to be associated with positive associations between empathy and aggression.

METHODS

PARTICIPANTS

The present study is part of the Mother-Infant Neurodevelopment Study in Leiden, The Netherlands (MINDS-Leiden). MINDS-Leiden is an ongoing longitudinal study into neurobiological and neurocognitive predictors of early behavior problems. The study was approved by the ethics committee of the Department of Education and Child Studies at the Faculty of Social and Behavioural Sciences, Leiden University (ECPW-2011/025), and by the Medical Research Ethics Committee at Leiden University Medical Centre (NL39303.058.12). Women (N = 153) were recruited during pregnancy and signed informed consent. Primiparous women aged between 17 and 25 years (M = 23.62, SD = 2.03) were eligible to participate. Women with severe complications during pregnancy and women who could not speak or understand the Dutch language were excluded from participation. The MINDS-Leiden study oversampled on high-risk backgrounds, which increased variance in maternal and child's behavior (see Smaling et al., 2015 for detailed procedures). The data for the current study were collected during a laboratory visit 30 months post-partum, which was the fifth data wave of MINDS-Leiden. In this data wave, 103 mother–child dyads were included (M_{age} = 30.46 months, 5 3.4% males). In most cases, dropout (n = 50) was due to unwillingness to participate without further motivation, unreachability and health issues of the mother. Four mothers could

not visit the laboratory but did fill out the questionnaire regarding physically aggressive behavior at home and returned it by mail. Dropout was unrelated to maternal factors such as level of education, ethnicity, and marital status. All participants were given a reimbursement for their time and travel expenses and the children received a gift at the end of the appointment.

PROCEDURE

A laboratory visit was scheduled at a time of day that mother estimated the child would be most alert (*n* = 103). After some time to familiarize with the laboratory and the experimenters, the cardiac monitoring equipment was attached to the child. Subsequently, the children watched a video clip for 2 min in order to measure baseline heart rate and RSA. The baseline condition consisted of a 5-min age-appropriate movie clip. For each child, two consecutive minutes were selected during which the child was most relaxed and attended the movie clip, and few or no artifacts were present. The duration of the baseline was based on previous research indicating appropriate baseline periods between 2 and 5 min (Benevides & Lane, 2015; de Geus, Willemsen, Klaver, & van Doornen, 1995; Willemsen, DeGeus, Klaver, VanDoornen, & Carroll, 1996). Immediately after the baseline, an empathy-eliciting event occurred, which was followed by a break to allow the children to recover from the event. Inhibitory control was assessed at the end of the laboratory visit because this task includes a gift for the child to take home.

EMPATHY

Empathy was assessed by a distress simulation task adapted from Zahn-Waxler, Radke-Yarrow, Wagner, and Chapman (1992). The experimenter asked the mother to refrain from interacting with the child and the child was seated in a chair in order to reduce movement artifacts in the physiological data. Subsequently, the experimenter pretended to hurt her toe by bumping into a piece of furniture and performing a 1-min distress simulation. To maintain attention of the children for 1 min and to create an authentic distress simulation, the experimenter pretended to be in pain for 30 s and to slowly recover from the pain for another 30 s. The pain simulation consisted of the experimenter sitting down on the floor while rubbing her foot, and expressing pain vocally, but she did not make eye contact with the child.

Behavioral responses of the child were videotaped by a second experimenter and coded for the two dimensions of empathic distress: comfort seeking (0; does not seek comfort with self or mother - 4; self-comforting behavior for nearly the whole task and high levels of proximity to mother by “flying” onto the mother’s neck) and personal distress (0; no distress – 3; whimpers, whines, or cries; see Noten et al., 2019

for a detailed description of the coding procedure). In addition, three dimensions of empathic concern were coded: concerned expressions (0; no concern – 3; strong facial concern for at least 8 s), testing hypotheses (0; no hypothesis testing – 4; four or more combined gestures and verbal inquires to understand the situation), and prosocial behavior (0; no prosocial behavior – 3; assisting the experimenter by comforting or sharing toys for more than 5 s; Noten et al., 2019). Two trained coders coded all videos and created one consensus score when their scores differed (ICC of absolute agreement: testing hypothesis = 0.874; prosocial behavior = 0.953; concerned expressions = 0.742; self-distress = 0.839; comfort seeking = 0.782). Based on the results of a categorical principal component analysis of the five empathy scales, the scores on these scales were transformed into standardized scores and averaged into a composite score for empathic distress (comfort seeking and personal distress) and a composite score for empathic concern (prosocial behavior, hypothesis testing, and concerned expressions). Empathy data were missing for one child due to failure of the video equipment.

Physiological parameters were assessed during a 2-min baseline and the 1-min distress simulation task with the Vrije Universiteit Ambulatory Monitoring System (VU-AMS) (de Geus & van Doornen, 1996; de Geus et al., 1995; Willemsen et al., 1996). The VU-AMS is a portable device, which was attached to the back of the children with a small belt, allowing them to freely move around the room. Seven disposable pre-gelled Ag/AgCl electrodes (ConMed Huggable 1620–001) were attached to the trunk of the child. Electrocardiogram (ECG) and impedance cardiogram (ICG) were continuously measured. ICG measures consisted of thorax impedance (Z0), impedance change (dZ), and the first derivative of impedance change (dZ/dt). The ECG and dZ/dt signal were sampled at 1,000 Hz, and the Z0 signal was sampled at 10 Hz. Mean values of heart rate and RSA across baseline and distress simulation episodes were automatically calculated using VU-DAMS software suite version 3.9, then visually checked by a trained experimenter and adjusted manually if necessary. The peak-trough method was used to compute RSA (de Geus et al., 1995; Grossman, Beek, & Wientjes, 1990), in which the respiration signal, obtained from the filtered (0.1 – 0.4 Hz) dZ signal, and the inter beat intervals (IBI's) are combined to compute the difference between the shortest IBI during inspiration (when heart rate accelerates) and the longest IBI during expiration (when heart rate decelerates; de Geus et al., 1995). Physiological data were missing due to unwillingness to comply with the procedures (n = 7), movement a rtifacts (n = 1 for heart rate and n = 3 for RSA), loose electrodes (n = 2), and failure of the VU-AMS equipment (n = 1). For heart rate and lnRSA, change scores from baseline to the distress simulation were calculated in such a way that positive difference scores indicate responses in the expected direction (increased arousal as indicated by increase of heart rate and decrease of lnRSA).

INHIBITORY CONTROL

Inhibitory control was measured by a gift delay task, which has been shown to provide a valid measure of inhibitory control in a motivational setting (i.e., the child can earn a reward) at age 30 months (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013; Kochanska et al., 2000). At the end of the laboratory visit, the experimenter put a colorful gift box on a table in front of the child. Subsequently, the experimenter started a countdown to open the box, but halfway the experimenter suddenly remembered she forgot something and said that she would be right back. The experimenter left the room for 3 min and asked the child to not to open the gift until she was back. The mother of the child was seated in a corner of the room to fill out some questionnaires and she was asked not to respond or to respond neutrally to the child during the task. Upon return of the experimenter, the child was rewarded for waiting and invited to open the gift (if the gift had not been opened yet). Latency to touch the gift box was coded 0 (touches the box immediately), 1 (waits between 2 and 60 s) or 2 (waits longer than 60 s) and behavior during the task was coded 0 (the child opens the box and grabs the gift), 1 (the child peeks in the box), 2 (the child touches the box but does not open it), or 3 (the child does not touch the box). Given high correlations between latency and behavior measures ($r(99) = 0.535$, $p = <.001$), the two measures were transformed to *z*-scores and averaged into one inhibition score (Kim et al., 2013; Kochanska et al., 2000). Data were missing for one child because the child was too fussy to comply with the task and the latency score was missing for three children due to failure of the video equipment.

PHYSICAL AGGRESSION

All participating mothers completed the Dutch version of the Physical Aggression Scale for Early Childhood (PASEC) to measure physical aggression. The PASEC has been shown to be a valid measure of physical aggression in toddlerhood (Alink et al., 2006). The questionnaire consisted of 11 items that were scored on a 3-point Likert scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true), for example bites others, hits others, and destroys his own things. Scores were summed up to create one physical aggression score (Cronbach's $\alpha = 0.77$).

DATA ANALYSES

All variables were checked for outliers and violations of assumptions. Measurements that were three standard deviations above or below the average were replaced with the closest value within this range ($n = 1$ for heart rate and $n = 1$ for RSA). The natural logarithm of RSA and the PASEC was used because these variables were positively skewed before transformation. Baseline levels of heart rate and lnRSA were used as covariates in the analyses concerning physiological responses to control

for differences in baseline arousal levels. To check whether a physiological reaction was present from baseline to the simulated distress episode, paired sample *t*-tests were conducted. A categorical principal component analysis was performed on the five scales of the empathy observations to examine whether the empathic distress and empathic concern dimensions were indeed present in our data. Pearson correlations were performed to examine the associations between aggression, inhibitory control, heart rate response to simulated distress, RSA response to simulated distress, and the scales for empathic distress and empathic concern. Correlations with heart rate response and lnRSA response were controlled for baseline heart rate and baseline lnRSA respectively. Point-biserial correlation analyses were performed to assess the effect of sex. The main and interaction effects of empathy and inhibitory control on physical aggression were examined by four hierarchical linear regression analyses. One for each indicator of empathy: empathic distress, empathic concern, heart rate response, and lnRSA response to distress simulation. Control variables (sex, baseline heart rate, baseline lnRSA), the main effect of empathy indicators, and the main effect of inhibitory control on physical aggression were entered in the first step, and the interaction between empathy indicators and inhibitory control was added in the second step of the regression analysis. All variables were centered in advance and interaction effects were further examined by plotting the effect of the independent variable on the dependent variable at different levels (−1SD, mean, and +1SD) of the moderator (Aiken, West, & Reno, 1991; Holmbeck, 2002). All analyses were done using the Statistical Package for Social Sciences (SPSS for windows, version 23, SPSS Inc., Chicago) and statistical significance was set at $p < .05$ a priori.

RESULTS

PRELIMINARY ANALYSES

Characteristics of the sample are shown in Table 1. Maternal characteristics were not related to any of the child variables, except for a significant negative association between maternal educational level and aggression ($r_{spearman}(103) = -0.258$, $p = .009$). A categorical principal component analysis was conducted on the five behavioral observations during the distress simulation task with orthogonal varimax rotation. Two components had eigenvalues over Kaiser's criterion of 1 and explained 70.79% of the variance in total. Factor loadings confirmed that concerned expressions, hypothesis testing, and prosocial behavior loaded high on a component representing empathic concern, and that comfort seeking and personal distress loaded high on the other component representing empathic distress. All factor loadings and correlations between the behavioral observation scales are presented in supplement 1 and 2.

Table 1. Sample characteristics.

Variable	%	M(SD)
Mother		
Caucasian ethnicity	89.3%	
Highest education completed		
Secondary education	7.8%	
Tertiary education	55.3%	
Bachelor degree or higher	36.9%	
Child		
Sex (male)	53.4%	
Age (months)		30.46 (0.78)
Heart rate, baseline		110.91 (10.97)
Heart rate, distress simulation		113.17 (12.36)
lnRSA, baseline		3.92 (0.55)
lnRSA, distress simulation		3.85 (0.64)
Empathic behavior		
Prosocial behavior (0-3)		0.56 (1.13)
Hypothesis testing (0-4)		1.72 (1.07)
Concerned expressions (0-3)		1.39 (1.18)
Personal distress (0-3)		0.85 (0.76)
Comfort seeking (0-4)		1.12 (0.99)
IInhibitory control		
Latency to touch (0-2)		0.96 (0.73)
Behavior (0-3)		1.46 (0.95)
Physical aggression		2.59 (2.42)

Note: natural log of respiratory sinus arrhythmia (lnRSA).

Paired sample *t*-tests indicated that heart rate increased ($t(91) = 3.172$, $p = .002$, $d = 0.19$) and lnRSA decreased ($t(89) = 2.197$, $p = .031$, $d = 0.12$) from baseline to the distress simulation episode. Correlations between behavioral and physiological responses to the distress simulation, inhibitory control, and aggression are shown in Table 2. Point-biserial correlation analyses indicated that aggression was higher and inhibitory control was lower in boys compared to girls. In addition, Pearson correlation analyses demonstrated that higher levels of aggression were associated with lower baseline heart rate and higher baseline lnRSA. A larger increase in heart rate in response to the distress simulation task was associated with a larger decrease in lnRSA, more empathic concern, and more empathic distress.

Table 2. Correlations between behavioral and physiological responses to the distress simulation, inhibitory control and physical aggression.

	2	3	4	5	6	7	8	9
1. Sex	-.216*	.180	.233*	-.073	-.053	-.028	.071	.026
2. lnPASEC	-	-.218*	-.231*	-.026	.276**	.014	.027	.152
3. Inhibitory control		-	-.056	.122	.043	.162	.155	-.168
4. Heart rate baseline			-	-.096	-.736**	.090	-.167	.082
5. Heart rate response				-	-.134	.614**	.322**	.284**
6. lnRSA baseline					-	.029	.177	-.079
7. lnRSA response						-	.128	-.018
8. Empathic distress							-	.101
9. Empathic concern								-

Note: *p≤.05, **p≤.01; natural log of respiratory sinus arrhythmia (lnRSA). Higher scores indicate more, aggression, inhibitory control and empathy. Positive heart rate and lnRSA responses represent responses in the expected direction (increase of heart rate and decreases of lnRSA). Pearson correlations with heart rate response and lnRSA response are controlled for baseline levels of heart rate and lnRSA respectively.

EMPATHY AND INHIBITORY CONTROL IN RELATION TO AGGRESSION

Pearson correlations indicated that higher levels of aggression were associated with lower levels of inhibitory control. However, no significant associations were found between aggression and any behavioral or physiological responses to the distress simulation task. The results of the regression analyses on the effects of indicators of empathy and inhibitory control on aggression are shown in Table 3 and Table 4. A main effect was present for baseline heart rate and baseline lnRSA, but not for responses to empathic situations or inhibitory control on aggression. In addition, an interaction effect of heart rate response to the distress simulation task with inhibitory control was present in the prediction of aggression. In order to be able to interpret the interaction effects, the regression lines of low (–1 *SD*), moderate (0 *SD*), and high (+1 *SD*) empathy and inhibitory control are plotted in Figure 1.

Regarding heart rate response during the distress simulation, a significant positive effect was shown at low levels of inhibitory control (β = 0.362, t = 2.514, p = .014), no effect was shown at mean levels of inhibitory control (β = −0.021, t = −0.201, p = .834), and a significant negative effect was found at high levels of inhibitory control (β = −0.273, t = −1.993, p = .050).

Table 3. Regression analyses of main and interaction effects of behavioral responses to distress simulation and inhibitory control on physical aggression.

	β	t	R^2 change	Sig.	β	t	R^2 change	Sig.
	Empathic distress				Empathic concern			
Step 1			.085	.037			.096	.022
Sex	-.185	-1.856		.067	-.190	-1.910		.059
Empathic response	.071	0.712		.478	.129	1.305		.195
Inhibitory control	-.196	-1.945		.055	-.163	-1.615		.110
Step 2			.007	.410			.003	.561
Sex	-.183	-1.827		.071	-.189	-1.895		.061
Empathy	.088	.862		.391	.123	1.229		.222
Inhibitory control	-.198	-1.958		.053	-.150	-1.452		.150
Empathy ×	-0.83	-0.838		.410	-.059	-0.583		.561

Inhibitory control

Table 4. Regression analyses of main and interaction effects of physiological responses to distress simulation and inhibitory control on physical aggression.

	β	t	R^2 change	Sig.	β	t	R^2 change	Sig.
	Heart rate				lnRSA			
Step 1			.122	.024			.157	.006
Sex	-.130	-1.211		.229	-.162	-1.580		.118
Baseline	-.213	-2.026		.046	.275	2.725		.008
Empathic response	-.010	-0.092		.927	.042	0.412		.681
Inhibitory control	-.206	-1.962		.053	-.208	-1.998		.049
Step 2			.093	.002			.031	.079
Sex	-.208	-1.986		.050	-.207	-1.983		.051
Baseline	-.201	-2.007		.048	.276	2.762		.007
Empathy	.021	0.201		.834	.072	0.700		.486
Inhibitory control	-.140	-1.378		.172	-.187	-1.803		.075
Empathy × Inhibitory control	-.320	-3.146		.002	-.186	-1.778		.079

Note: natural log of respiratory sinus arrhythmia (lnRSA); positive heart rate and lnRSA responses represent responses in the expected direction (increase of heart rate and decreases of lnRSA).

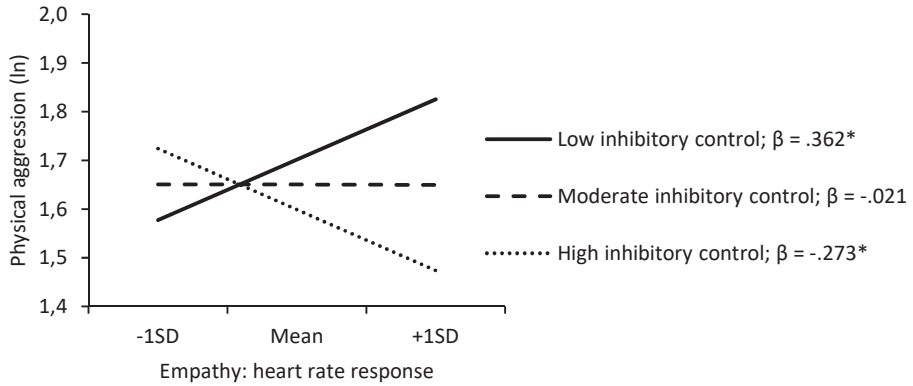

Figure 1. Interaction effect of heart rate response and inhibitory control on physical aggression. *Note:* *p≤.05; Positive heart rate responses represent increase of heart rate.

DISCUSSION

This study aimed to investigate whether empathy and inhibitory control are associated with aggression in toddlerhood. We expected higher levels of physical aggression to be associated with less inhibitory control and less empathy, as indicated by less empathic concern, less empathic distress, smaller increase of heart rate, and less RSA suppression in response to an empathy-eliciting event. In addition, we aimed to investigate whether inhibitory control moderates the association between empathy and aggression. Negative associations between indicators of empathy (i.e., empathic distress, empathic concern, heart rate increase, and RSA suppression in response to an empathy-eliciting event) and aggression were hypothesized to be present for toddlers showing higher levels of inhibitory control. In contrast, lower levels of inhibitory control were hypothesized to be associated with positive associations between empathy and aggression.

The results were partly consistent with the hypotheses. In contrast to our hypotheses, no association was present between any of the indicators of empathy and aggression. A negative association was found between inhibitory control and physical aggression, which is in line with our hypotheses. Previous studies also found negative associations between inhibitory control and aggression in the preschool period (Hughes et al., 2000; Raaijmakers et al., 2008; Waller et al., 2017). Therefore, deficits in inhibitory control may contribute to the development of aggression over time, and improving inhibition may be an important target for interventions aiming to prevent or reduce aggressive behavior in early childhood (Raaijmakers et al., 2008).

In line with our hypotheses, inhibitory control moderated the effect of heart rate responses to an empathy-evoking event on aggression. A negative association between heart rate response to distress simulation and aggression was present in

children who showed good inhibitory control, whereas a positive association was present at lower levels of inhibitory control. The lowest aggression scores were found in children with good inhibitory control and high levels of empathy. This in line with the underlying mechanism of the association between empathy and aggression as theorized in the violence inhibition model (Blair, 1995). This model proposes that children connect their own experience of negative emotions (e.g., when the child experiences pain) to the experience of others in similar situations and label these experiences as undesired. Subsequently, the child acts to prevent or reduce these experiences in others by responding empathically and inhibiting aggressive behavior. Adequate inhibition skills are a prerequisite for this mechanism to function optimally. Therefore, better inhibition skills could be expected to result in a negative association between empathy and aggression. The positive association between empathy and aggression in children with lower inhibitory control corresponds to the proposition that a lack of inhibition leads to impulsive responses to both empathy- and aggression-evoking events (Gill & Calkins, 2003). Therefore, differences between previous findings on the association of empathy and aggression in toddlerhood may be explained by heterogeneity within samples of children regarding inhibition (Eisenberg et al., 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007). Future research on empathy and aggression in toddlerhood could benefit from taking inhibition into account.

Furthermore, more research is necessary to further examine the differences between indices of empathy, as no association between empathy and aggression was found for lnRSA response, empathic concern, and empathic distress. The lack of significant results for the behavioral measures of empathy is in line with recent findings that 8- to 12-year-old children at risk of criminal behavior (children with delinquent siblings or parents) were found to have reduced heart rate responses to empathy-evoking video clips compared to typically developing controls, whereas no effects were found for social attention or self-reported empathy (van Zonneveld, Platje, de Sonneville, van Goozen, & Swaab, 2017). These results support the suggestion that objective physiological measures of empathy are more likely to result into positive findings than behavioral observations (Bons et al., 2013; Zhou et al., 2003). A possible explanation for the lack of results regarding RSA suppression might be that RSA suppression was not only affected by the empathy-eliciting situation, but also by inhibition. Previous studies indicate that RSA can be considered a biomarker for self-regulation, which includes inhibition (Holzman & Bridgett, 2017; Obradović, 2016; Skowron, Cipriano-Essel, Gatzke-Kopp, Teti, & Ammerman, 2014). Therefore, the influence of inhibition on RSA suppression may have confounded the association between RSA suppression in response to distress simulation and aggression. Heart rate is considered a general

measure of arousal and therefore may have been a better indicator of empathy in the current study.

Of note, our results indicate that a stronger increase in heart rate during the empathy-eliciting situation was related to more empathicdistress and higher empathic concern. Previous studies in older children indicate that a stronger increase in heart rate was related to more empathic distress but less empathic concern (Eisenberg, 2010; Zahn-Waxler et al., 1995). The inconsistency between our findings regarding empathic concern and previous findings might be caused by the fact that physiological responses were measured during a distress simulation task in the current study, whereas previous studies used a milder emotion induction (i.e., emotional video clips). During more intense emotion inductions, empathic distress and empathic concern may occur simultaneously. In those instances, heart rate responses may be indicative of both empathic distress and empathic concern. Possibly, simultaneous occurrence of empathic distress and empathic concern resulted in the similar direction of effects of heart rate responses on empathic distress and empathic concern in the current study (Zhou et al., 2003).

The results of this study emphasize the importance of specifically considering inhibitory control as a moderating factor when examining empathy-aggression associations in toddlerhood. No association was present between inhibitory control and empathy and it remains unclear whether such an association is already present in toddlerhood. Some behavioral studies on toddlers have shown a negative association between inhibited temperament (fearfulness) and empathy (Liew et al., 2011; Mark, Ijzendoorn, & Bakermans-Kranenburg, 2002; Young et al., 1999), whereas studies in older children suggest positive associations between inhibitory control and empathic concern (Eisenberg, 2010; Eisenberg et al., 2007). Further research is necessary to elucidate this association.

STRENGTHS AND LIMITATIONS

The current study adds to the literature by examining empathy both behaviorally and physiologically, which provides valuable information on toddler's responses to empathy-eliciting events. Furthermore, both empathic distress and empathic concern were coded and the factors were confirmed by principal component analysis. A limitation is that maternal reports were used to examine aggression in toddlerhood. Parent reports provide ecologically valid information about behavior in daily situations that toddlers cannot report themselves and are difficult to capture during observations (Lorber, Del Vecchio, & Slep, 2018). In addition, the PASEC has shown to be a reliable and valid measure of physical aggression in toddlerhood and previous studies showed that physical aggression was a better predictor of continued

problem behavior than other domains of problem behavior, such as nonaggressive conduct problems and oppositional behaviors (Alink et al., 2006; Broidy et al., 2003). Nevertheless, it should be noted that maternal reports of aggression might be biased by maternal factors such as personality, memory capacity, and tendency of social desirability response (Kagan, Snidman, Arcus, & Reznick, 1994).

A second limitation is that the distress simulation was performed by the experimenter rather than by the child's mother in order to reduce bias caused by differences in the credibility and intensity of the distress simulation. Although this strengthens the reliability of the empathy measure, a limitation is that distress in unfamiliar people evokes less empathic concern in toddlers compared to when distress is expressed by their mothers (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; Preston & de Waal, 2002; Young et al., 1999). Therefore, our setup may have limited the children's empathic concern, resulting in low variance on prosocial behavior. In addition, the brief duration of the distress simulation to maintain children's attention may have affected the reliable and valid collection of physiological indices of empathy.

The impact of the inhibition task may have been limited by the presence of the mother in the room. Parental involvement has been shown to be associated with children's performance on the gift delay task at age 2–3 years (Russell, Londhe, & Britner, 2012). Further research could benefit from including observations of parental behavior as covariate or by asking parents to leave the room. A final limitation is the cross-sectional design of the study. Future research should examine whether empathy and inhibition are predictors of aggression over time and to what extend these associations change over the course of development. When using longitudinal designs, further research should also take Theory of Mind into account, which refers to the ability to attribute mental states to others and understand that others' mental states, desires, and beliefs might differ from one's own. Theory of Mind develops rapidly from the age of four and is closely related to the development of cognitive aspects of empathy (i.e., understanding other's emotions) and executive function, including inhibition, at this age (Carlson, Mandell, & Williams, 2004; Decety, 2010). Furthermore, taking the perspective of the other in empathy-evoking situations, which is a cognitive aspect of empathy and requires Theory of Mind, is an important factor for future research; it also inhibits aggression by reducing the impulse to respond aggressively and enhancing reflective thinking about the situation (Richardson, Hammock, Smith, Gardner, & Signo, 1994).

CONCLUSION

This study showed that inhibitory control, but not empathy, is negatively associated with aggression in toddlerhood. In addition, inhibitory control moderated the effect of heart rate response to an empathy-eliciting situation on aggression. Higher

levels of empathic responses were associated with lower levels of aggression, but only if inhibitory control was good, which indicates that high empathy combined with high inhibitory control is associated with lower levels of aggression. When inhibitory control was relatively poor, higher levels of empathic responses were associated to higher levels of aggression, reflecting impulsive responses to both empathy- and aggression-evoking situations. Since empathy and inhibition develop rapidly during toddlerhood, it is important for future studies that investigate their relations with aggression to adopt longitudinal designs. Furthermore, toddlerhood would be a particularly interesting period for further research on the effects of interventions aiming to reduce or prevent aggression by targeting empathy and inhibition.

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Supplement 1. Varimax rotated solution of the categorical principal component analysis on the behavioral observations during the distress simulation task.

	Empathic concern	Empathic distress
Testing hypotheses	**.923**	.089
Prosocial behavior	**.846**	-.236
Concerned expressions	**.743**	.456
Personal distress	.063	**.832**
Comfort seeking	-.014	**.672**
Eigenvalues	2.213	1.327
% of variance explained	44.258	26.530

Supplement 2. Spearman correlations between the behavioral observations during the distress simulation task.

	Testing hypotheses	Prosocial behavior	Concerned expressions	Personal distress	Comfort seeking
Testing Hypotheses	-	.60*	.38*	-.05	-.10
Prosocial behavior		-	.64*	.02	.14
Concerned expressions			-	.10	.39*
Personal distress				-	.14
Comfort seeking					-

Note: *p≤.01

4

5

Indicators of affective empathy, cognitive empathy, and social attention during emotional clips in relation to aggression in 3-year-olds

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ABSTRACT

Research indicates that impaired empathy is a risk factor of aggression and that social attention is important for empathy. The role of social attention in associations between empathy and aggression has not yet been fully elucidated. Therefore, indicators of affective empathy, cognitive empathy, social attention, and aggression were simultaneously assessed in children aged 45 months. A total of 61 mother–child dyads participated in a lab visit, during which maternal reports of aggression were obtained. Children watched three clips showing a sad, scared, and happy child, respectively, and a neutral social clip while heart rate was recorded. Heart rate change from nonsocial baseline clips to emotional clips was calculated as an index of affective empathy. Questions about the emotions of the children in the clips were asked to assess cognitive empathy. Social attention was defined as time spent looking at faces during the clips. Correlation analyses revealed negative associations between affective empathy and aggression and between social attention and aggression. Furthermore, multivariate linear regression analyses indicated that the association between affective empathy and aggression was moderated by social attention; the negative association between affective empathy and aggression was stronger in children with relatively reduced social attention. No association was found between cognitive empathy and aggression. Therefore, both affective empathy and social attention are important targets for early interventions that aim to prevent or reduce aggression.

Keywords: Empathy, Social attention, Aggression, Preschool, Heart rate, Eye-tracking.

INTRODUCTION

Empathy, the sharing and understanding of feelings of others, is a fundamental aspect of social competence, and a lack of empathy has been associated with aggressive behavior (Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2013; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). The observation of distress in others may prompt the withdrawal of aggression by increasing autonomic arousal (e.g., increase in heart rate), which is experienced as aversive (Blair, 1995, 2006). Learning the causal link between aggressive behavior and the subsequent experience of aversive arousal due to the distress of the other person motivates children to refrain from actions that harm others. In children, adolescents, and adults, negative associations between empathy and aggressive behavior have, therefore, been shown particularly for affective empathy, which refers to the sharing of the other's emotions and is related to increased autonomic arousal, and to a lesser extent for cognitive empathy, which is based on the understanding of the other's emotions (Blair, 2005; Smith, 2006; van Zonneveld, Platje, de Sonneville, van Goozen, & Swaab, 2017; Winter, Spengler, Bermpohl, Singer, & Kanske, 2017). Affective empathy and cognitive empathy have been suggested to be separate but complementary aspects of empathy that rely on different neural networks (Decety, 2010; Decety, Meidenbauer, & Cowell, 2018; Singer, 2006; Smith, 2006). Affective empathy involves bottom-up processes such as emotional contagion and emotion recognition, which rely on the mirror neuron system (i.e., the inferior frontal gyrus and inferior parietal lobule) and regions related to pain experience (i.e., the anterior cingulate cortex and insula) (Shamay-Tsoory, 2011; Shamay-Tsoory, Aharon-Peretz, & Perry, 2009). Cognitive empathy involves top-down processes including mentalizing, that is, the ability to understand or make inferences about another person's affective and cognitive mental states (Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory et al., 2009; Shamay-Tsoory, 2011). These top-down circuits involve mainly prefrontal areas of the brain. Indicators of affective empathy can be observed from infancy onward given that newborns already show distress in response to the distress of others, which develops into showing empathic concern and helping behaviors during toddlerhood (Hoffman, 2000; McDonald & Messinger, 2011). Cognitive empathy develops from preschool onward, when perspective taking and emotion recognition abilities develop rapidly (Decety et al., 2018; Decety, 2010).

The association between empathy and aggression differs for affective and cognitive aspects of empathy. Studies in aggressive children (e.g., children with psychopathic traits, risk of aggressive behavior, and conduct disorder) have shown reduced autonomic responses to stimuli associated with the distress of another person (Anastassiou-Hadjicharalambous & Warden, 2008; Schwenck et al., 2012; van Zonneveld et al., 2017) and less self-reported affective empathy to emotional clips (Anastassiou-

Hadjicharalambous &Warden, 2008; van Goozen et al., 2016; Winter et al., 2017). However, no association between impairments in cognitive empathy and aggression have been found in these studies (Schwenck et al., 2012; van Goozen et al., 2016; van Zonneveld et al., 2017). Furthermore, neuroimaging studies indicate that reduced volume of the insula, which is involved in affective empathy, is associated with antisocial behavior (Sterzer, Stadler, Poustka, & Kleinschmidt, 2007), that aggressive adolescents exhibit atypical neural affective empathic responses to other people's distress (Decety, Michalska, Akitsuki, & Lahey, 2009), and that youths with psychopathic traits show less responsiveness in the anterior cingulate cortex, which is involved in the affective response to another's pain (Marsh et al., 2013). However, no atypical neural processing regarding cognitive empathy has been found in adolescents with conduct disorder (O'Nions et al., 2014). In addition, elementary and middle school children involved in interventions targeting improvement of empathy have been found to become less aggressive, more prosocial, more assertive, and more empathic, which indicates that empathy is important in shaping social skills (Feshbach & Feshbach, 2011; Jagers et al., 2007; McMahon & Washburn, 2003; Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2011).

EMPATHY AND AGGRESSION IN PRESCHOOL CHILDREN

Findings on the association between affective empathy and aggression are less clear for preschool children. Some studies indicated that reduced affective empathy as measured with dyadic peer play observations, videotaped vignettes, parent reports, teacher reports (Hughes, White, Sharpen, & Dunn, 2000; Strayer & Roberts, 2004), or reduced physiological reactivity to emotions of other people has been associated with higher levels of aggression (Miller et al., 2013; Zahn-Waxler, Cole, Welsh, & Fox, 1995). However, other studies that examined affective empathy with behavioral responses to simulated distress, parent reports (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000; MacQuiddy, Maise, & Hamilton, 1987; Rhee et al., 2013; Zahn-Waxler et al., 1995), or physiological arousal in response to emotions of others (Gill & Calkins, 2003; Hastings et al., 2000) did not show an association between empathy and aggression. Finally, positive associations between affective empathy and aggression have been found in studies using verbal affective responses to slides showing affective situations, behavioral responses to a recording of a crying infant, or behavioral responses to simulated distress by the experimenter to examine empathy (Feshbach & Feshbach, 1969; Gill & Calkins, 2003).

There is a lack of research examining affective empathy and cognitive empathy simultaneously in relation to aggression at the preschool age. Two studies have addressed this issue in relation to constructs closely related to aggression. One

study of 3- to 6-year-olds indicated that both affective empathy and cognitive empathy, according to teacher reports, were negatively associated with hostile roles in bullying (i.e., being a bully, assistant, or reinforcer) (Belacchi & Farina, 2012). In addition, parents of 3-to 13-year-olds reported that impaired affective empathy was associated with psychopathic traits (which include aggression), but only in boys, and that impaired cognitive empathy was associated with psychopathic traits in both sexes, although this association disappeared for boys during early adolescence (Dadds et al., 2009).

These two studies examining both affective empathy and cognitive empathy in young children used questionnaires to examine empathy. Although self-reports and parent reports of empathy are commonly used methods to assess empathy in older children, self-reports cannot be used in younger children because they are not yet capable of self-reflection and to report accurately on their feelings; moreover, parent reports may be biased (Zhou, Valiente, & Eisenberg, 2003). Measuring empathy from behavioral observation is commonly used and less biased, but may be influenced by the effect of emotional expressiveness (Zhou et al., 2003). More objective indices of affective empathy are provided by changes in physiological measures, such as heart rate, in response to other people's emotional states (Bons et al., 2013; van Zonneveld et al., 2017; Zhou et al., 2003). Heart rate is considered a global measure of affective arousal, which is under the influence of the sympathetic branch and/or parasympathetic branch of the autonomic nervous system (Berntson et al., 1994). Although heart rate responses to others' emotional states have been used as an index of empathy, the association between heart rate responses and empathy is complex (Hastings & Miller, 2014; Hastings, Miller, Kahle, & Zahn-Waxler, 2014).

According to the polyvagal theory, both increases and decreases of arousal may facilitate empathy; a decrease in autonomic arousal (i.e., an increase in parasympathetic and/or decrease in sympathetic activity) in response to empathy might contribute to a calm bodily state and engagement in social behavior, which could comprise high levels of empathic concern (Porges & Furman, 2011; Porges, 2007). However, an increase in autonomic arousal contributes to the mobilization of resources, which might be needed to act in a concerned and prosocial way. In addition, heart rate deceleration has been associated with interest and an outward orientation of attention, such as empathic concern, whereas heart rate acceleration has been associated with a self-focus and personal distress in response to empathy in children and adults (Hastings et al., 2014; Zhou et al., 2003). Both empathic concern and personal distress result from affective empathy (i.e., sharing the feelings of other people), but empathic concern has been suggested to be more adaptive than personal distress (Eisenberg, 2010; Singer & Klimecki, 2014). Personal distress is most common during infancy, and empathic

concern becomes more important during toddlerhood as a result of the development of emotion regulation (Decety, 2010; McDonald & Messinger, 2011).

Experimental studies in children indicate increases in heart rate (Anastassiou-Hadjicharalambous & Warden, 2007, 2008) as well as decreases in heart rate (de Wied, Boxtel, Posthumus, Goudena, & Matthys, 2009; van Zonneveld et al., 2017; Zahn-Waxler et al., 1995) in response to empathy-evoking clips. Behavioral measures of empathic concern in children have also been associated with both decreased heart rate (Holmgren, Eisenberg, & Fabes, 1998; Zahn-Waxler et al., 1995) and increased heart rate (Anastassiou-Hadjicharalambous & Warden, 2007; Holmgren et al., 1998) in response to empathy-evoking clips. Overall, there seems to be an association between heart rate responses and empathy, but this association can be either positive or negative.

SOCIAL ATTENTION

Social attention, which has generally been operationalized as attention to faces or more specifically to the eye and mouth regions, is necessary in order to recognize emotions of other people and can be considered a prerequisite of empathy (Bons et al., 2013). Therefore, social attention might be necessary for a negative association between empathy and aggression to occur. Conversely, high levels of social attention might dampen the effect of difficulties in empathy on aggression. Attending to faces of others may support children with difficulties in empathy to recognize emotional expressions of others and, therefore, to inhibit aggressive responses (Bons et al., 2013). For example, fear recognition increases when children showing aggressive behavior and callous–unemotional traits are instructed to attend to the eyes (Dadds et al., 2006; Dadds, El Masry, Wimalaweera, & Guastella, 2008). However, this effect is not found in children with aggressive behavior without callous–unemotional traits. Despite the importance of social attention for sharing and understanding emotions of others, research on the role of social attention in relation to empathy and aggression during early childhood is scarce (Bons et al., 2013; Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017). One study indicated that 5- year-olds who were high in empathy fixated more quickly on the eyes and mouth and did so for longer times, and also more frequently, in response to painful expressions (Yan, Pei, & Su, 2017). In addition, impaired social attention may also be a risk factor for aggression given that attention to the eyes has been shown to be reduced in children (8–15 years) with aggressive behavior and callous–unemotional traits (Dadds et al., 2008). However, this effect was not found in children with aggressive behavior without callous–unemotional traits. In addition, no impairment in attention to the eyes was found in children (8–12 years) at risk for criminal behavior despite the use of an eye-tracking paradigm with dynamic social stimuli rather than static images (van Zonneveld et al., 2017). Dynamic social stimuli have been shown to provide higher

ecological validity and a more sensitive measure of social attention than static stimuli (Chevallier et al., 2015). Cleary, investigating social attention simultaneously with empathy and aggression is important in order to clarify the associations among social attention, empathy, and aggression.

In sum, the associations between affective and cognitive empathy and aggression during early childhood remain unclear. Theoretical models (Blair, 2006; Smith, 2006) and literature on adolescents and adults (van Zonneveld et al., 2017; Winter et al., 2017) indicate negative associations between affective empathy and aggression but no association between cognitive empathy and aggression. However, during early childhood, positive associations (Feshbach & Feshbach, 1969; Gill & Calkins, 2003), negative associations (Hughes et al., 2000; Miller et al., 2013; Strayer & Roberts, 2004; Zahn- Waxler et al., 1995) and null results (Hastings et al., 2000; MacQuiddy et al., 1987; Rhee et al., 2013) were found regarding the association between affective empathy and aggression, whereas negative associations were found between cognitive empathy and aggression (Belacchi & Farina, 2012; Dadds et al., 2009). Furthermore, social attention might be negatively associated with empathy (Yan et al., 2017) and aggression (Dadds et al., 2008) during childhood, but the evidence is scarce and it remains unknown whether social attention may play a moderating role in the effects of affective and cognitive empathy on aggression.

THE CURRENT STUDY

The current study aimed to examine, first, whether affective empathy and cognitive empathy are associated with aggression. Based on previous studies during early childhood, we expected both affective empathy and cognitive empathy to be negatively associated with aggression (Belacchi & Farina, 2012; Dadds et al., 2009). Second, we aimed to clarify the role of social attention in empathy and aggression, specifically, whether social attention moderates the association between empathy and aggression. Social attention was expected to be positively associated with affective and cognitive empathy and to be negatively affected with aggression (Bons et al., 2013; Dadds et al., 2008; Yan et al., 2017). In addition, the potential moderating role of social attention for the association between empathy and aggression was explored because we had no hypothesis about the direction of this effect. It is important to examine the association among empathy, social attention, and aggression during the preschool period because that is a critical time for the development of emotion regulation and inhibition of aggression (Eisenberg, Eggum, & Di Giunta, 2010; Lovett & Sheffield, 2007; Tremblay et al., 2004). During the second and third years of life, the majority of children show aggressive behavior and then generally learn to inhibit this behavior during the preschool years (Alink et al., 2006; Tremblay et al., 2004). Children who fail to learn

to inhibit aggression are at risk for aggression during adolescence and adulthood, and empathy and social attention are important targets for interventions that aim to prevent or reduce aggression (Broidy et al., 2003; Feshbach & Feshbach, 2011). The current study adds to the literature by examining social attention simultaneously with affective empathy and cognitive empathy in relation to aggression in preschool children. Furthermore, objective measures of social attention (eye tracking) and affective empathy (heart rate response) were obtained.

METHOD

PARTICIPANTS

The current study is a follow-up to the Mother- Infant Neurodevelopment Study in Leiden, The Netherlands (MINDS-Leiden), which is an ongoing longitudinal study into neurobiological and neurocognitive predictors of early behavior problems. MINDS-Leiden and the follow-up were approved by the ethics committee of the Department of Education and ChildStudies at the Faculty of Social and Behavioral Sciences, Leiden University (ECPW-2011/025) and by the medical research ethics committee at Leiden University Medical Centre (NL39303.058.12). All participating women provided written informed consent. A total of 120 Dutch-speaking women between 17 and 25 years of age (M = 23.28 years, SD = 2.18) who had taken part in MINDS-Leiden between the third trimester of pregnancy and 30 months postpartum were approached (see Smaling et al., 2015 for detailed procedures). Approximately 1 year after the final data wave of MINDS-Leiden, the mothers were invited to take part in a follow-up study. In total, 32 mothers declined, 27 agreed only to fill out questionnaires, and 61 agreed to participate in the full follow-up data wave with children aged 45 months (M = 45.59 months, SD = 1.25; 33 boys). Willingness to participate was not related to educational level or ethnicity, but mothers who declined were younger than mothers who were willing to participate, $F(2, 117) = 4.79$, $p = .010$.

PROCEDURE

Mothers who agreed to participate were invited for a lab visit. After informed consent and a familiarization period to adapt to the presence of the experimenters, cardiac monitoring equipment was attached to the child. Subsequently, the child watched a nonsocial baseline video on the eyetracking monitor, which was immediately followed by a video clip with social content. After the social clip, the experimenter asked the child some questions about the content of this clip (Chevallier et al., 2015; van Zonneveld et al., 2017). This procedure was performed four times in four different social conditions: one nonemotional social condition (two children reading a book),

one happy condition (a happy child opening a gift), one fearful condition (a child being scared with a toy spider), and one sad condition (a sad child flushing a dead goldfish). The nonsocial baseline clips displayed calm music and abstract animations without social or emotional content (van Zonneveld et al., 2017; Zantinge, van Rijn, Stockmann, & Swaab, 2017). The duration of the social clips was approximately 50 s each, and the duration of the baseline clips was approximately 60 s each. (van Zonneveld et al., 2017; Zantinge et al., 2017). The social clips were selected based on characteristics that are important for studying social attention; dynamic rather than static stimuli were used, they contained authentic and real-life emotions (i.e., they were not acted), and the target emotion was clearly displayed in a social context that is common at preschool age (Chevallier et al., 2015; Chita-Tegmark, 2016; Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012; Speer, Cook, McMahon, & Clark, 2007; Zantinge et al., 2017). The nonemotional social clip was always shown first, and the order of the emotional clips was counterbalanced to avoid order effects. The mother was in the room during the whole procedure; she was asked to fill out questionnaires and not to engage with the child while the child participated in the study. At the end of the procedure, the child was rewarded with a gift and the mother received a reimbursement.

INSTRUMENTS

Heart rate response

The difference in heart rate from baseline to the emotional video clips was used as an index of affective empathy (Gill & Calkins, 2003; van Zonneveld et al., 2017; Zantinge et al., 2017). Heart rate was continuously monitored with the Vrije Universiteit Ambulatory Monitoring System (VU-AMS) (de Geus & van Doornen, 1996; de Geus, Willemsen, Klaver, & van Doornen, 1995; Willemsen, de Geus, Klaver, van Doornen, & Carroll, 1996). Disposable pre-gelled Ag/AgCl electrodes (Huggables, ConMed, New York, NY, USA) were attached slightly below the right collarbone, 4 cm to the left of the sternum, and at the apex of the heart on the left lateral margin of the chest, approximately at the level of the processus xiphoideus. The ground electrode was placed on the right side, between the lower two ribs. Mean values of heart rate across each of the baseline and emotional video clips were calculated automatically using the VU-DAMS software suite (Version 3.9) and then visually checked by a trained experimenter and adjusted manually if necessary. The VU-AMS software was synchronized with the Tobii software by manually creating a marker in the physiological data at the start of each video clip. Physiological data were missing due to unwillingness to comply with the procedure to attach the electrodes (n = 4) and loose electrodes (n = 3).

Emotion understanding

After each emotional video clip, the child was asked what type of emotions the main character in the video felt, how intense these emotions were (a little intense or very intense), and why these emotions were expressed. The answers were scored with a coding system adapted from van Goozen et al. (2016) and van Zonneveld et al. (2017). Coding of answers involved recognition of emotions in the clips and the quality of the explanations for the causes of the emotions. Emotion recognition was assessed by asking the child whether the child in the clip felt happy, sad, or scared (multiple choice). We subsequently asked the child to support this choice by asking him or her to indicate how intense the named emotion was by showing the child emoticons showing no-intensity, low-intensity, or highintensity emotions (Chronaki, Hadwin, Garner, Maurage, & Sonuga-Barke, 2015; Pollak, Cicchetti, Hornung, & Reed, 2000). The use of visual material and multiple-choice questions increases the likelihood of correctly recognizing emotions, including fear (Pollak et al., 2000). Answers were coded as 0 when the emotion was not recognized, 1 when the emotion was recognized at low intensity (e.g., a little sad), and 2 when the emotion was recognized at high intensity (e.g., very sad). The coding of the quality of the explanations for the causes of the emotions ranged from 0 (incorrect and irrelevant explanations of emotions) to 5 (multiple factual reasons and possible consequences of the situation, e.g., the child is sad because his fish died and he will never see it again). One total score was calculated by summing the scores for the three clips, and the scores ranged from 2 to 12 of 21. One fifth (20%) of the video clips were double coded, and inter-rater reliability (intra-class correlation of absolute agreement, ICC) for the total scores was .80. Data were missing for children who were unable or refused to answer the questions of the experimenter (n = 3).

Attention to emotional faces

Eye tracking was used to assess attention to emotional faces because it is a sensitive and objective technique to assess visual attention in young children (Zantinge et al., 2017). A Tobii T120 eye tracker was used in order to collect gaze data within a specific area of interest (AOI) (Tobii Technology, Danderyd, Sweden). By corneal reflection techniques, the x and y position of the eye on the screen was recorded at 120 Hz. The clips were shown on a screen that was positioned approximately 65 cm from the child's eyes. Before the start of the experiment, a five-point calibration procedure was performed. Tobii Studio (Version 3.4.8) and an I-VT fixation filter were used to process the data. Dynamic AOIs for the face and the total screen were drawn manually. One AOI for the whole face was drawn with a margin of 1 cm around the face (Hessels, Kemner, van den Boomen, & Hooge, 2016; van Zonneveld et al., 2017; Zantinge et al., 2017). The relative total fixation duration to the face was used as an index of social attention, which

represents the time that the child was looking at the face as a percentage of the total time that the face was visible on the screen and clearly showing emotion (29 s for the happy clip, 13 s for the sad clip, and 14 s for the fear clip). The relative total visit duration of the screen was calculated in order to control for the time the child was looking at the screen during the display of emotions. The fear clip displayed two children, but only the relative total fixation duration for the scared child was examined because this child showed the emotion that was expected to elicit empathy. Missing data were caused by children refusing to watch the clip or by excessive movement, which disturbed the measurement (n = 1 for the sad clip, n = 3 for the happy clip, and n = 3 for the fear clip).

Maternal reports of aggression

To assess aggression, mothers completed the Dutch version of the Child Behavior Checklist (CBCL, 1–5 years; Achenbach & Rescorla, 2000). The CBCL consists of 100 behavioral descriptions of problem behavior that mothers rated on a 3-point Likert scale (0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true) (Achenbach & Rescorla, 2000). The sum of 19 items regarding a broad range of aggressive behaviors (e.g., hits others, hurts animals or people without meaning to, is easily frustrated) was used to calculate the score for the aggressive behavior subscale (Cronbach's a = .874). Data were missing for 1 child because the mother was not willing to fill out the questionnaire.

STATISTICAL ANALYSES

Preliminary analyses

Outliers and violations of assumptions were analyzed. Paired-samples t tests were performed in order to examine change in heart rate from the baseline immediately before the clips to the clips for the neutral, fear, sad, and happy conditions. Heart rate response was calculated as the difference in heart rate between the baseline and the emotional clips (emotion minus baseline), such that higher scores indicated larger increases in heart rate from baseline to emotional clips. Subsequently, standardized residual change scores were calculated by regressing the difference scores on the baseline levels of heart rate to make sure that the heart rate response scores controlled for baseline levels of heart rate (El-Sheikh et al., 2009; Suurland, van der Heijden, Huijbregts, van Goozen, & Swaab, 2018). Differences between heart rate reactivity to the neutral and emotional clips were examined in order to determine whether the heart rate reactivity was the result of the emotional content of the clips specifically (affective empathy) rather than social content in general. Differences between clips were analyzed with repeated-measures analyses of variance (RM-ANOVAs). Based on interrelations between the standardized residual change scores for the emotional clips,

they were averaged into one index of heart rate response. Values of relative total fixation duration were excluded from analyses when the values of relative total visit duration to the screen were ≥ 3 standard deviations below average (happy clip: n = 3; sad clip: n = 2; fear clip: n = 3). Differences between emotional clips
regarding attention to emotional faces were analyzed with RM-ANOVAs, and based on interrelations between the relative total fixation durations to the emotional faces, these scores were averaged into one index of attention to emotional faces.

Main analyses

Pearson correlations were performed to analyze associations among heart rate response, emotion understanding, attention to emotional faces, and aggression. Multivariate linear regressions were used to examine moderating effects of attention to emotional faces on the associations between aggression and heart rate response and emotion understanding. Numeric variables were centered in advance, and interaction effects were examined further by plotting the effect of the independent variable on the dependent variable at different levels of the moderator (-1 standard deviation, mean, and +1 standard
deviation) (Aiken, West, & Reno, 1991; Holmbeck, 2002). All analyses were done using the Statistical Package for Social Sciences (SPSS for Windows, Version 23; IBM, Armonk, NY, USA), and statistical significance was set at $p < .05$ a priori.

RESULTS

PRELIMINARY ANALYSES

Demographic data and descriptive statistics for heart rate response, emotion understanding, attention to emotional faces, and aggression are shown in Table 1. No sex differences were present for these variables. Regarding the emotional clips, 64% of the children recognized the happy and sad emotions and 62% of the children recognized the fearful emotion, which indicates that the clips were perceived as happy, sad, and fearful by children aged 45 months.

Table 1. Sample characteristics

Variable	M(SD)
Mother	
Caucasian ethnicity	85.2%
Highest education completed	
Secondary education	11.7%
Tertiary education	50.0%
Bachelor degree or higher	38.3%
Child	
Heart rate response	
Baseline HR	
Neutral	104.74(10.86)
Happy	107.62(11.08)
Sad	105.49(10.48)
Fear	106.25(11.17)
Mean HR during social clip	
Neutral	103.64(10.08)
Happy	105.35(10.87)
Sad	101.49(11.31)
Fear	103.22(11.47)
Emotion understanding	6.29(2.09)
Attention to emotional faces	
Relative total visit duration to the screen	
Happy	95.33(9.12)%
Sad	98.08(4.35)%
Fear	96.57(6.69)%
Relative total fixation duration to the face	
Happy	24.39(8.65)%
Sad	54.87(14.28)%
Fear	15.65(9.66)%
Aggression (CBCL)	9.87(5.77)

Note: heart rate (HR) in beats per minute; HR reactivity: standardized residualized change scores; CBCL: Child behavior checklist.

Heart rate response

Paired-samples t tests indicated that heart rate significantly decreased in response to the neutral clip, $t(53) = 2.356$, $p < .022$, $d = 0.12$, the happy clip, $t(51) = 4.701$, $p < .001$, $d = 0.21$, the sad clip, $t(50) = 7.261$, $p < .001$, $d = 0.36$, and the fear clip, $t(51) = 5.064$, $p < .001$, $d = 0.27$. RM-ANOVA revealed within-participants effects of clip, $F(3, 41) = 3.176$, $p = .034$, $\eta^2 = .189$, on heart rate reactivity while controlling for heart rate at baseline. Simple contrasts indicated that heart rate decreased more in response to the sad clip, $F(1, 43) = 6.435$, $p = .015$, $\eta^2 = .130$, and the fear clip, $F(1, 43) = 6.954$, $p = .005$, $\eta^2 = .172$) than the neutral clip. Pearson correlations indicated that the standardized residual change score for the happy clip was positively associated with those for the sad clip, $r(50) = .297$, $p = .036$, and the fear clip, $r(51) = .321$, $p = .022$. The standardized residual change score for the sad clip was not associated with the standardized residual change score for the fear clip, and the standardized residual change score for the neutral clip was not associated with the standardized residual change scores for the emotional clips. This indicates that heart rate reactivity to the emotional clips was qualitatively different from heart rate reactivity to the neutral clip. Based on the interrelations, one mean reactivity score for the emotional clips was calculated ($M = -0.009$, $SD = 0.72$).

Attention to emotional faces

Two RM-ANOVAs were performed to examine differences between clips in terms of the relative total visit duration to the screen and the relative total fixation duration to the face. No differences among the three clips were found for the relative total visit duration to the screen. However, a main effect of clip was found for relative total fixation duration to the face, $F(2, 44) = 125.259$, $p < .001$,$\eta^2 = .851$. Post hoc Bonferroni comparisons indicated that children attended less to the face in the happy clip than in the sad clip and that children attended less to the face in the fear clip than in the sad and happy clips ($p < .001$ for all differences). Pearson correlations indicated that the relative total fixation duration to the happy clip was positively associated with the relative total fixation duration to the sad clip, $r(53) = .300$, $p = .029$, and the fear clip, $r(47) = .332$, $p = .022$. The relative total fixation duration to the sad clip was not associated with the relative total fixation duration to the fear clip. The relative total fixation durations were standardized to control for differences between clips and averaged to one score ($M = -0.259$, $SD = 0.73$).

MAIN ANALYSES

Zero-order correlations among heart rate response, emotion understanding, attention to emotional faces, and aggression are shown in Table 2. Negative associations

were present between heart rate response and aggression, $r(53) = -.312$, $p = .023$, and between attention to emotional faces and aggression, $r(59) = -.264$, $p = .044$. The results of the multiple regression analyses examining the interaction effects between heart rate response/emotion understanding and attention to emotional faces on aggression are shown in Table 3. The model indicated a negative main effect of attention to emotional faces and heart rate response on aggression and indicated a positive interaction effect of heart rate response by attention to emotional faces on aggression.

Table 2. Correlations between heart rate response, emotion understanding, attention to emotional faces, and aggression.

	Heart rate response	Emotion understanding	Attention to emotional faces	Aggression
Heart rate response	-	-.181	-.074	-.312*
Emotion understanding		-	.024	.036
Attention to emotional faces			-	-.264*
Aggression				-

Note: *p≤.05; Heart rate response is indicated by the average standardized residualized change score in response to the emotional clips, in which higher scores indicate increases in hear rate; Attention to emotional faces is indicated by the average standardized relative total fixation duration at the faces during the emotional clips.

Table 3. Regression analyses of the main and interaction effects of heart rate response/emotion understanding and attention to emotional faces on maternal reports of aggression.

	β	T	R^2	Sig.
Model			.282	.011
Heart rate response	-.279	-2.126		.039
Emotion understanding	-.005	-0.033		.974
Attention to emotional faces	-.398	-2.965		.005
Heart rate response × Attention to emotional faces	.317	2.337		.024
Emotion understanding × Attention to emotional faces	.132	0.962		.341

Note: The dependent variable is aggression as measured with the child behavior checklist (CBCL); Heart rate response is indicated by the average standardized residualized change score in response to the emotional clips, in which higher scores indicate increases in hear rate; Attention to emotional faces is indicated by the average standardized relative total fixation duration at the faces during the emotional clips.

To further examine the significant interaction effect, post hoc regression analyses were run at different levels of attention to emotional faces (-1 standard deviation, mean, and +1 standard deviation). The results indicated that the negative association between heart rate response and aggression was stronger in children with low levels of attention to emotional faces (β = -.621, t = -3.130, p = .003) than in children with moderate levels of attention (β = -.279, t = -2.126, p = .039) or high levels of attention (β = .062, t = 0.319, p = .751) to emotional faces. The lowest levels of aggression were found in children with high levels of attention to emotional faces regardless of their level of heart rate response, and the highest levels of aggression were found when low heart rate response was combined with low social attention (Fig. 1).

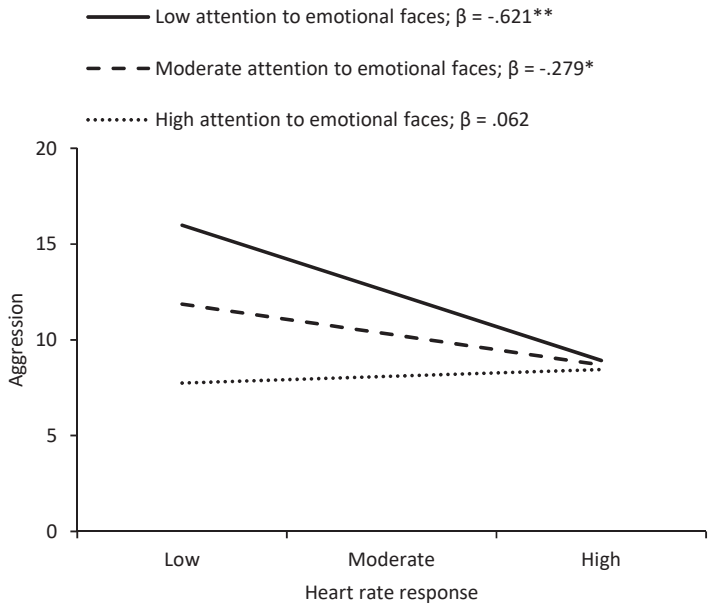

Figure 1. The effect of heart rate response on aggression at low, moderate, and high levels of attention to emotional faces.

DISCUSSION

The current study aimed to examine associations between indicators of affective and cognitive empathy, social attention, and aggression in 3-year-old children. We expected affective and cognitive empathy to be negatively associated with aggression. Social attention was expected to be positively associated with affective and cognitive empathy and to be negatively associated with aggression. In addition, the moderating role of social attention for the association between empathy and aggression was explored.

AFFECTIVE EMPATHY

Heart rate response in response to emotional clips was used as an indicator of affective empathy (Hastings et al., 2014; Zhou et al., 2003). Consistent with our hypothesis and previous literature, affective empathy was negatively associated with maternal ratings of aggression (Blair, 2005; Miller et al., 2013; Smith, 2006; van Zonneveld et al., 2017; Zahn-Waxler et al., 1995). More specifically, children with higher levels of aggression showed smaller reductions in heart rate in response to emotional clips. Although these results are similar to previous studies (van Zonneveld et al., 2017; Zahn- Waxler et al., 1995), it should be noted that a decrease in heart rate from baseline to the emotional clips seems counterintuitive because affective arousal is generally associated with an increase in heart rate. It is commonly found that heart rate decreases in response to visual stimuli, such as video clips, as a result of information processing and focused attention (Kreibig, 2010; Van Hulle et al., 2013; Zantinge et al., 2017). Furthermore, outward focus of attention as indicated by heart rate decrease has been associated with empathic concern and prosocial behavior (Hastings et al., 2014; Zahn-Waxler et al., 1995; Zhou et al., 2003). In the current study, heart rate decreased as a result of attention toward the neutral clip with social content, but a larger decrease was observed in response to the clips containing sad and fearful emotional content. Therefore, larger decreases in heart rate can be considered indicative of more affective empathy, which was associated with less aggression.

COGNITIVE EMPATHY

Emotional understanding in response to empathy-evoking clips was used as in index of cognitive empathy (Bons et al., 2013; van Zonneveld et al., 2017). No association was found between cognitive empathy and aggression, which is in line with previous studies in older children (Blair, 2005; Dadds et al., 2009; van Zonneveld et al., 2017; Winter et al., 2017) but is contradictory to studies indicating negative associations between cognitive empathy and aggression in preschoolers (Belacchi & Farina, 2012; Dadds et al., 2009). This contradiction possibly can be explained by the different measures of cognitive empathy that were used. Previous studies used parent and teacher reports of cognitive empathy, which might be biased by factors such as personality, memory, and the tendency to give socially desirable responses (Kagan, Snidman, Arcus, & Reznick, 1994), whereas children's own verbal responses to questions about the clips were coded in the current study. More research on the association between cognitive empathy and aggression during early childhood is needed in order to further elucidate this association. Overall, our results are in line with theories indicating that it is particularly affective empathy that is negatively associated with aggression (Blair, 2005; Smith, 2006).

SOCIAL ATTENTION

In line with previous studies, social attention was measured using eye tracking in the form of attention to emotional faces (van Goozen et al., 2016; van Rijn, Barendse, van Goozen, & Swaab, 2014; van Zonneveld et al., 2017). Attention to emotional faces can be considered indicative of social attention because, from infancy onward, humans have a preference toward faces, in particular a preference for the eyes and mouth (Chita-Tegmark, 2016; Klein, Shepherd, & Platt, 2009). Faces provide essential information for recognizing and understanding emotions, and attention to faces during infancy is a predictor of later social behavior (Emery, 2000; Peltola, Yrttiaho, & Leppanen, 2018). In the current study, reduced attention to emotional faces was associated with higher levels of mother-reported aggression, which extends the findings by Dadds et al. (2008) from children aged 8 to 15 years to preschool-aged children. Furthermore, social attention moderated the association between affective empathy and aggression, which indicated that the negative association between affective arousal and aggression was reduced in children with relatively high social attention and was increased in children with relatively low social attention. In general, children who showed both low levels of affective empathy and low levels of social attention were rated as significantly more aggressive than children who showed either low affective empathy or low social attention. Therefore, social attention serves as a protective factor for the negative effect of low affective empathy on aggression. These results indicate that the current measure of social attention, eye tracking during video clips of dynamic social situations, is a sensitive way to examine the role of social attention in empathy and aggression. However, in contrast to our hypothesis and previous research in 5-year-olds (Yan et al., 2017), no association was found between cognitive or emotional empathy and social attention. More research is necessary to reveal whether this association can be found before 5 years of age and whether the association between social attention and empathy is present for both cognitive empathy and affective empathy (Bons et al., 2013).

No sex differences in empathy or aggression were found, which is surprising given the consistent differences observed in previous research pointing toward more aggression and less empathy in boys (Card, Stucky, Sawalani, & Little, 2008; Christov-Moore et al., 2014). One possibility is that sex differences in empathy and aggression vary as a function of the methodology used to assess them; for example, no sex differences have been found in children when physiological measures of empathy were used, whereas clear sex differences are found when using parent reports, which might be under the influence of gender stereotypes (Eisenberg, Spinrad, & Knafo, 2015). In the current study, heart rate and verbal responses to emotional clips were used as indicators of affective and cognitive empathy but no parent reports, and this

may explain why no sex differences were found. Parent reports were used to examine aggression, but existence of sex differences in aggression may depend on the type of aggression measured, with higher levels of physical aggression being found in boys but higher levels of indirect aggression being found in girls (Archer, 2004). The CBCL includes the measurement of different types of aggressive behaviors, which may have resulted in similar aggression rates for boys and girls.

STRENGTHS, LIMITATIONS, AND FUTURE RESEARCH

The current study adds to the literature by examining affective empathy, cognitive empathy, and social attention within one experimental setup, in contrast to many studies on empathy that focused on specific aspects of empathy isolated from their context (Zaki & Ochsner, 2012). In addition, this is the first study that combined indicators of affective empathy, cognitive empathy, and social attention in relation to aggression at the preschool age, which is a critical time to learn to regulate aggression (Tremblay et al., 2004). We used maternal reports to measure aggression, which is a limitation. Although parent reports provide ecologically valid information about behavior in daily situations that young children cannot report on, maternal reports of aggression might be biased (Kagan et al., 1994). Still, the CBCL has shown to be a reliable and valid measure of aggression during early childhood (Koot, Van den Oord, Verhulst, & Boomsma, 1997). Another methodological limitation is the use of heart rate as an indicator of affective empathy. Although heart rate as a global index of physiological arousal may be an objective measure of affective empathy, physiological arousal is not synonymous with affective empathy (Bons et al., 2013). For example, a decrease in heart rate in response to emotional clips could be the result of attention or interest (Kreibig, 2010; Van Hulle et al., 2013). However, in the current study, it is likely that the changes in heart rate were related to the emotional content of the clips because the heart rate responses were larger in response to the sad and fearful clips than to the control clip (nonemotional social clip). Furthermore, whereas the heart rate responses to the happy clip was positively associated with the heart rate responses to the sad and fearful clips, the heart rate responses to the emotional clips were unrelated to those in the control condition (nonemotional social clip).

Another limitation is the cross-sectional nature of the study. Given that all constructs were measured at the same time point, no conclusions can be drawn regarding the direction of effects. Although we expect that difficulties in social attention and affective empathy underlie increased levels of aggressive behavior, we cannot rule out that aggressive behavior may have had effects on social attention and empathy. Nevertheless, previous studies using longitudinal designs indicate that empathy is a predictor of aggression over time and that children involved in interventions aimed at

improving empathy have been shown to become less aggressive (Hastings et al., 2000; Jagers et al., 2007; McMahon & Washburn, 2003; Schonert-Reichl et al., 2011).

Further research on the association between empathy and aggression could benefit from taking into account the valence of emotions because particularly empathy for negative emotions has been suggested to be associated with aggression in older children (Bons et al., 2013). However, in the current study, no differences between empathy for positive emotions and empathy for negative emotions were present. In addition, specific measures of the sympathetic (e.g., skin conductance or pre-ejection period) and parasympathetic (e.g., respiratory sinus arrhythmia) autonomic nervous system could be used to examine the importance of collaboration between both branches of the autonomic nervous system in response to empathy for the prediction of aggression (El-Sheikh et al., 2009; Marsh, Beauchaine, & Williams, 2008; Suurland et al., 2018). Furthermore, it would be valuable to study motor empathy, which refers to the automatic response to emotions of others by mimicking others' facial expressions (Blair, 2005; Bons et al., 2013). Motor empathy is the third important aspect of empathy, besides affective and cognitive empathy, that may be associated with aggression during childhood (Bons et al., 2013; Deschamps, Munsters, Kenemans, Schutter, & Matthys, 2014; van der Graaff et al., 2016).

CONCLUSION

This study indicates that higher levels of affective empathy and social attention are associated with a reduction in reported aggression during early childhood; no association was found between cognitive empathy and aggression. In particular, social attention was shown to have a protective effect on the negative association between affective empathy and aggression; the negative association between affective empathy and aggression was stronger in children with relatively reduced social attention. Therefore, both empathy and social attention are important aspects of behavior that need to be considered when it comes to designing early interventions that aim to prevent or reduce aggression (Dadds et al., 2006; Feshbach & Feshbach, 2011; Jagers et al., 2007; McMahon & Washburn, 2003; Schonert-Reichl et al., 2011). Interventions that focus on social attention, such as specific instructions to attend to faces and attention bias modification training, may facilitate young people to attend to social information, which is necessary to share and understand feelings of others (Bar-Haim, 2010; Dadds et al., 2006; Hubble, Bowen, Moore, & van Goozen, 2015). In turn, interventions aimed at affective empathy may facilitate children to learn to inhibit aggressive behavior (Feshbach & Feshbach, 2011). Because aggression has been shown to be relatively stable from early childhood to adolescence, interventions at a young age may reduce the chances of developing high and persistent levels of aggression (Tremblay, 2010).

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5

6 Summary and General Discussion

The studies described in this dissertation aimed to provide insight into early manifestations of empathy as a predictor of aggression during the first years of life, while taking into account the role of precursors of empathy and possible moderators of the association between empathy and aggression. Impaired empathy has been considered an important risk factor for aggressive behavior, and negative associations between empathy and aggression have consistently been found in school-age children and adolescents. However, there is a lack of research on the association between empathy and aggression in the preschool period, when children typically learn to inhibit aggressive behavior (Alink et al., 2006; Bons et al., 2013; Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2014; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). Furthermore, the results of previous studies are mixed and it is likely that these contradictory results can be explained by taking into account other factors that are related to empathy and aggression. We investigated emotional responses in infancy as a precursor of empathy in toddlerhood (Chapter 2), sex differences in the association between empathy and aggression in toddlerhood (Chapter 3), the association between inhibition, empathy, and aggression in toddlerhood (Chapter 4), and the association between indicators of social attention, affective empathy, cognitive empathy, and aggression in the preschool period (Chapter 5). The main findings of the studies described in chapters 2, 3, 4, and 5 are discussed below, followed by a discussion of the strengths and limitations of the research, recommendations for further research and concluding remarks.

In Chapter 2, the association between infant physiological and behavioral reactivity to emotional challenge at age 6 months and behavioral responses to an empathy-eliciting event at age 20 months was examined. Although emotional reactivity is theorized to be important in the development of empathy, findings regarding the prediction of early empathic behavior by infant behavioral and physiological reactivity are mixed (Decety, 2010; Hastings & Miller, 2014; Preston & de Waal, 2002). This study examined whether behavioral and physiological reactivity to mild emotional challenge in 118 infants at age 6 months predicted empathic distress and empathic concern during an empathy-evoking task at age 20 months. The still face paradigm and the car seat task were used as mild emotional challenges (Goldsmith & Rothbart, 1999; Tronick, Als, Adamson, Wise, & Brazelton, 1979). Physiological measures of reactivity consisted of the difference in autonomic arousal (indicated by pre-ejection period and respiratory sinus arrhythmia [RSA]) between baseline and the mild emotional challenges. Behavioral measures of reactivity consisted of observations of struggle, self-soothing behavior and distress vocalizations during the emotional challenges (Goldsmith & Rothbart, 1999; Miller, McDonough, Rosenblum, & Sameroff, 2002; Shapiro, Fagen, Prigot, Carroll, & Shalan, 1998). Distress simulation by the experimenter was used to elicit empathy in

toddlers. Personal distress and comfort seeking were coded as indicators of empathic distress, and concerned expressions, hypothesis testing and prosocial behavior were coded as indicators of empathic concern (Liew et al., 2011; Lin & Grisham, 2017). In general, stronger reactivity to emotional challenge at age 6 months was positively related to empathic distress at 20 months. Specifically, shortened pre-ejection period and RSA suppression from baseline to the car seat task, but not the still face paradigm, were positively associated with empathic distress. In addition, struggle during the car seat task and still face paradigm was positively associated with empathic distress. These results confirm previous findings indicating that behavioral and physiological responses to challenge are positively related to empathic distress until age two (Liew et al., 2011; Ungerer et al., 1990; Young, Fox, & Zahn-Waxler, 1999). Furthermore, the results showed that behavioral and physiological reactivity to the car seat task independently predicted empathic distress, which stresses the importance of both behavioral and physiological reactivity for the development of empathy. Furthermore, quadratic associations between behavioral responses at 6 months, and empathic distress and empathic concern at 20 months were present, which indicates that moderate levels of behavioral responsivity predict the highest levels of empathic distress and empathic concern.

In Chapter 3, aggression at age 20 and 30 months was predicted from empathic behavior at age 20 months. Impaired empathy is considered to be an important risk factor of aggression, but results are contradictory in toddlerhood (Lovett & Sheffield, 2007). Empathy can be expressed, especially during infancy and toddlerhood, as empathic distress and in empathic concern (de Waal, 2008; McDonald & Messinger, 2011). The association between empathy and aggression may differ for empathic distress and empathic concern because empathic distress derives solely from affective arousal, which motivates the inhibition of aggression, whereas empathic concern is also under the influence of factors such as socialization and perspective taking (Farrant, Devine, Maybery, & Fletcher, 2012; Vaish, Carpenter, & Tomasello, 2009). In addition, the association between empathy and aggression may also differ for boys and girls, as girls typically are more empathic and less aggressive than boys (Archer, 2004; Christov-Moore et al., 2014; Feshbach & Feshbach, 1969). Therefore, empathic distress and empathic concern at age 20 months were examined in relation to aggression at age 20 and 30 months, while taking a potential moderating effect of sex into account. Empathic behavior was observed during a distress simulation task 20 months post-partum (Spinrad & Stifter, 2006; Zahn-Waxler, Robinson, & Emde, 1992). Since physical aggression has been shown to be a better predictor of continued problem behavior than other types of problem behavior during toddlerhood, maternal reports of physical aggression were used to measure aggression (Broidy et al., 2003). Physical aggression was assessed with

the Physical Aggression Scale for Early Childhood 20 and 30 months post-partum ($N_{20\ months}$ = 133, 69 boys; $N_{30\ months}$ = 119, 62 boys), (Alink et al., 2006). Hierarchical linear regression analyses revealed sex differences in the associations between empathic concern and empathic distress, and physical aggression at age 20 months. Furthermore, physical aggression at age 30 months was predicted by the interaction of sex with empathic concern at age 20 months, while controlling for aggression at age 20 months. The results indicated that more empathic behavior was associated with less physical aggression in girls, but not in boys. In addition, empathic distress was a more robust predictor of physical aggression over time than empathic concern.

Possibly, the sex differences in the association between empathy and aggression can be attributed to differences in inhibition between boys and girls. Specific impairments in inhibition have been shown in aggressive preschool children, in particular in boys (Raaijmakers et al., 2008). Therefore, boys might have responded more impulsively (e.g. approaching the victim) to the distress simulation task, which could have resulted in more behavioral responses, such as prosocial behavior, hypothesis testing, and comfort seeking (Gill & Calkins, 2003). Such inhibition impairments could explain why no association between empathy and physical aggression was found for boys (Eisenberg et al., 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007).

In Chapter 4, it was examined whether inhibition fulfils such a moderating role in the association between empathy and aggression in 103 30-month-old children. During a lab visit at 30 months post-partum, maternal reports of physical aggression in their child were obtained (Alink et al., 2006), inhibition was examined using a gift delay task (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013; Kochanska, Murray, & Harlan, 2000), and behavioral observations (empathic distress and empathic concern) as well as physiological measures (heart rate and RSA responses) of empathy were obtained during a simulated distress paradigm (Spinrad & Stifter, 2006; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992). Reduced inhibitory control, low baseline heart rate and high baseline RSA were associated with higher levels of aggression. In addition, hierarchical regression analyses revealed a significant interaction effect of inhibition and heart rate response to an empathy-eliciting event, in the prediction of aggression: a negative association between empathy and aggression was present at higher levels of inhibition, but a positive association was found in toddlers who demonstrated lower levels of inhibition. These results suggest that children are less aggressive when they have both higher levels of empathy and inhibitory control. Therefore, inconsistencies between previous findings on the association between empathy and aggression in toddlerhood may be explained by heterogeneity within samples of children regarding inhibition (Eisenberg, Eggum, & Di Giunta, 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007).

In Chapter 5, the association between empathy and aggression was investigated at age three. At this age, cognitive empathy develops rapidly and cognitive empathy was examined in addition to affective empathy. In addition, the association of social attention and sex differences with empathy and aggression, and the association between empathy and aggression were taken into account. Theory and previous research suggest that impaired affective empathy, and not cognitive empathy, is a risk factor for aggression in children, adolescents and adults (Bons et al., 2013; Smith, 2006; van Zonneveld, Platje, de Sonneville, van Goozen, & Swaab, 2017). However, studies including children during the pre-school period found both affective and cognitive empathy to be associated with aggression (Belacchi & Farina, 2012; Dadds et al., 2009). This study extended previous research by combining physiological measures of affective empathy and standardized task scores of cognitive empathy instead of questionnaire data (Bons et al., 2013; van Zonneveld et al., 2017). In addition, sex differences and eye-tracking measures of social attention were taken into account as possible moderators of this association. Previously, less social attention has been suggested to be associated with less empathy and more aggression (Bons et al., 2013; Dadds, El Masry, Wimalaweera, & Guastella, 2008; Yan, Pei, & Su, 2017). Furthermore, sex differences were taken into account because girls have been shown to be more empathic and less aggressive than boys (Archer, 2004; Christov-Moore et al., 2014; Feshbach & Feshbach, 1969). Sixty-one mother-child dyads participated in a lab visit at age 45 months, during which maternal reports of aggression in their children were obtained by the Child Behavior Checklist (Achenbach & Rescorla, 2000). Children watched three video clips of peers in emotion-inducing situations (happy, sad, and fear), while heart rate responses were recorded to examine affective empathy, questions about the clips were asked to examine cognitive empathy and attention to emotional faces was observed by eye tracking to examine social attention. Consistent with our hypothesis, theory and previous literature, a negative association between affective empathy and aggression was present (Blair, 2005; Miller et al., 2013; Smith, 2006; van Zonneveld et al., 2017; Zahn-Waxler, Cole, Welsh, & Fox, 1995). Social attention was also negatively related to aggression and moderated the effect of affective empathy on aggression. The highest levels of aggression were found when low affective empathy was combined with low social attention, and high social attention served as a protective factor for the negative effect of low affective empathy on aggression. No association was found between cognitive empathy and aggression, and no sex differences were found for any of the measures. These results indicate that affective empathy and social attention are already negatively related to aggression at age three.

EMPATHY IN EARLY CHILDHOOD

The studies described in this dissertation add to the literature by examining early manifestations of empathy using different measures and by examining different elements of empathy. In Chapters 2, 3, and 4, empathic distress and empathic concern were examined as manifestations of empathy. At age 20 months, the results regarding empathic distress and empathic concern differed (Chapter 2). Infant emotional responses were both linearly and quadraticly associated with empathic distress in toddlerhood, while only quadratic associations were found for empathic concern. In addition, empathic distress at age 20 months was negatively associated with physical aggression at age 20 and 30 months in girls (Chapter 3), while empathic concern was only associated with aggression in girls at age 20 months. However, in Chapter 4 no association was found between physical aggression and either empathic distress or concern. Based on these results, we conclude that empathic distress and empathic concern are both important aspects of empathy development, in particular at a very young age. During the first years of life, empathy-evoking situations are challenging and overwhelming, and children typically respond to these situations with empathic distress, which is a precursor of empathic concern (de Waal, 2008; Eisenberg, 2010; Hoffman, 2000; McDonald & Messinger, 2011). Empathic distress is stable over time, but becomes relatively less important over the course of childhood because empathic concern starts to develop during the second and third year of life and increases over time. In our studies, this development of empathic concern is evident by the fact that different indicators of empathic concern could be represented as a single factor at age 30 months (Chapter 4), while they were independent of each other at age 20 months (Chapter 2). In addition, observations of indicators of empathic concern were still relatively scarce at age 20 months.

In addition to behavioral observations of empathic distress and empathic concern in response to simulated distress by an experimenter, empathy was also examined by physiological responses to simulated distress or empathy-inducing video clips. Behavioral observations of both empathic distress and empathic concern were positively associated with concurrent heart rate responses (Chapter 4). However, physiological responses to video clips were not associated with concurrent behavioral measures of cognitive empathy (Chapter 5). Together these results corroborate previous suggestions that physiological responses to emotions of others are an important indicator of affective empathy, but not cognitive empathy in early childhood (Hastings & Miller, 2014; Hastings, Miller, Kahle, & Zahn-Waxler, 2014; Zhou, Valiente, & Eisenberg, 2003). Therefore, it is important to take physiological measures into account, in addition to behavioral measures, when examining affective empathy.

Both physiological and observational measures of empathy had clear advantages for the measurement and understanding of empathy. One advantage of observation of empathy is that co-occurring manifestations of empathy, such as empathic distress and empathic concern can be examined, while physiological measures cannot discriminate between co-occurring manifestations (Hastings & Miller, 2014; Hastings et al., 2014; Zhou et al., 2003). Due to the fact that we included empathy observations in our methodology, we were able to reveal differences in predictability between empathic distress and empathic concern. Empathic distress at age 20 months, was better predicted by emotional responses at age 6 months than empathic concern (Chapter 2) and empathic distress was a better predictor of aggression at age 30 months than empathic concern (Chapter 3). Physiological measures of empathy (e.g., heart rate and RSA), however, are more objective than observational measures and relatively free from conscious control and social desirability bias (Zhou et al., 2003). Examining both observational and physiological measures of empathy in infancy and toddlerhood provides unique opportunities to further investigate early empathy and its stability over time. In Chapter 2, infant observational and physiological measures of emotional responses were examined to predict empathy in toddlerhood. Based on our studies it seems to be a valid conclusion that empathy in toddlerhood can be predicted from infant indicators of empathy in addition to infants' own emotional responses. Therefore, future research could focus on examining infant indicators of empathy, such as physiological measures of infants' arousal and behavioral measures of contagious crying in response to another infant's distress (Dondi, Simion, & Caltran, 1999; Geangu, Benga, Stahl, & Striano, 2010; Sagi & Hoffman, 1976; Simner, 1971).

EMPATHY AND AGGRESSION IN EARLY CHILDHOOD

In the current dissertation, negative associations between empathy and aggression were found at the ages of 20 months, 30 months and 45 months (Chapters 3, 4, 5), meaning that low levels of empathy are already related to high levels of aggression at a very young age (Blair, 2005; Hughes, White, Sharpen, & Dunn, 2000; Lovett & Sheffield, 2007; Miller et al., 2013; Strayer & Roberts, 2004). Nevertheless, it is still largely unclear which factors influence the strength and direction of the association between empathy and aggression at a very young age. For example, more research is needed on the role of sex differences in empathy and aggression. Girls showed more concerned expressions and personal distress than boys in one study at age 20 months (Chapter 2). However, these differences became smaller and were not significant anymore when additional participants were included in a second study (Chapter 3). In addition, the association between empathy and aggression was only present for girls at age 20 months (Chapter 3), while no sex differences in the association between empathy

and aggression were found at age 30 and 45 months (Chapter 4, 5), which might suggest that sex influences a specific window of development. Previous literature is mixed as well. Studies with toddlers have shown that girls generally express more empathic behavior than boys (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000; Spinrad & Stifter, 2006; Zahn-Waxler, Radke-Yarrow, et al., 1992; Zahn-Waxler, Robinson, et al., 1992). However, several studies on toddlers did not find sex differences regarding empathy (Gill & Calkins, 2003; Roth-Hanania, Davidoy, & Zahn-Waxler, 2011; Vaish et al., 2009). Furthermore, two studies indicated that the association between empathy and aggression differs for boys and girls, but the results were contradictory. A study in 4–7 year-old children demonstrated a positive association between empathy and aggression in boys, but not in girls (Feshbach & Feshbach, 1969), while another study demonstrated a negative association between empathy and psychopathic traits (which include aggression) in 3–13 year-old boys, but not in girls (Dadds et al., 2009). Based on our findings and the suggestion that sex differences are present in the development of the relation between empathy and aggression it is important to take sex differences into account in further research examining empathy and aggression in order to gain further insight in development of sex differences in empathy over time and in the underlying mechanisms that cause these sex differences. Possibly, more cultural or environmental influences, like bias in measures of empathy, caused by expectations based on stereotypic gender roles, can explain some of the inconsistencies (Eisenberg, Spinrad, & Knafo, 2015).

In addition to sex, our studies indicated that inhibition moderates the association between empathy and aggression. A negative association between physiological response to empathic situations and aggression was present in children with high levels of inhibition, whereas a positive association was present in children with low levels of inhibition. Overall, boys have lower cognitive inhibition ability than girls (Cross, Copping, & Campbell, 2011; Raaijmakers et al., 2008). Therefore, positive associations between empathy and aggression may occur more often in boys than girls and relatively poor inhibition in boys could explain why no association between empathy and aggression was found for boys at age 20 months (Chapter 3). Furthermore, differences in previous findings on the association of empathy and aggression in toddlerhood may be (partially) explained by heterogeneity within samples of children regarding inhibition (Eisenberg et al., 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007). Future research on empathy and aggression in toddlerhood could benefit from taking inhibition into account.

Another factor that moderates the association between empathy and aggression is social attention. Social attention is necessary in order to recognize emotions of others and can be considered a prerequisite of empathy (Bons et al.,

2013). In Chapter 5, reduced attention to emotional faces was associated with higher levels of mother-reported aggression and social attention moderated the association between affective empathy and aggression. The negative association between affective arousal and aggression was reduced in children with relatively high social attention and increased in children with relatively low social attention. Therefore, we conclude that higher levels of social attention serve as a protective factor for the negative effect of low affective empathy on aggression. However, in contrast to previous research (Yan et al., 2017), no association was found between cognitive or affective empathy and social attention. At this age, the association between social attention and empathy might be still under development and more research is necessary to examine which factors influence this association (Bons et al., 2013).

Finally, it is important to examine the influence of emotional responsivity on the association between empathy and aggression in further research. Our results indicated a positive association between emotional responsivity and empathy (Chapter 2) and studies using the same paradigms indicated that emotional responsivity is also associated with aggression in infancy and toddlerhood (Calkins & Dedmon, 2000; Hay et al., 2010; Moore, Cohn, & Campbell, 2001). Therefore, examining the associations between emotional responsivity, empathy and aggression simultaneously may provide insight into the possible mediating or moderating role of emotional responsivity in the association between empathy and aggression.

STRENGTHS AND LIMITATIONS

This dissertation consists of four studies on subsamples of a longitudinal study (MINDS-Leiden), which enabled us to investigate predictors of empathy and aggression. Multiple innovative methods were used to examine emotional responses and empathy. We consider it a strength that the current study combined sympathetic and parasympathetic measures of the autonomic nervous system in order to predict empathy from early emotional reactivity. In addition, physiological and behavioral measures of empathy were combined, and affective empathy, cognitive empathy, and social attention have been examined within one paradigm. Also, women were included in the study during pregnancy and followed until their child reached the age of 4, which provided the opportunity to investigate different aspects of empathy, such as empathic distress, empathic concern and cognitive empathy, early in their development.

One might consider it a limitation of our studies that there is a lack of variation in the measurement of aggression. Maternal reports of aggression were used at each time point, which makes it at least possible to examine stability and development of aggression over time. Although maternal reports provide ecologically valid information about behavior in daily situations that toddlers cannot report yet on themselves,

they might be biased by maternal factors such as personality, memory capacity, and tendency of social desirability response (Kagan, Snidman, Arcus, & Reznick, 1994). Future research would benefit from using multiple informants of aggression, such as fathers and teachers (Kerr, Lunkenheimer, & Olson, 2007). Furthermore, observational measures of aggression could be used to prevent bias due to adult reports (Hay, Castle, & Davies, 2000; Hay et al., 2011).

Another limitation is the fact that a part of the children from MINDS-Leiden were at risk for high levels of aggression due to maternal risk factors, but there was no specific group of children included that showed clinical levels of aggression. Furthermore, the use of the experimenter to simulate distress during the distress simulation task limits the implications of the results. We decided that the distress simulation would be performed by a trained experimenter instead of the child's mother in order to reduce bias caused by differences in the credibility and intensity of the distress simulation. Although this strengthens the reliability of the empathy measure, a limitation is that distress in unfamiliar people evokes less empathic concern and more empathic distress in toddlers compared to when distress is expressed by their mothers (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; Young et al., 1999; Zahn-Waxler, Robinson, et al., 1992). Therefore, our setting might have prevented toddlers from showing empathic concern, resulting in low variance on empathic concern and stronger results for empathic distress. In future research it would be valuable to add a second distress simulation by the mother in order to compare the results of both conditions.

IMPLICATIONS

Due to the study of early manifestations of empathy, knowledge was gained on the typical development of empathy and risk factors of atypical development. Chapter two indicated that children who were more emotionally reactive in situations that were distressing to themselves were also more sensitive to the distress of others later on. Therefore, children who display a lack of emotional reactivity in infancy might show difficulties in sharing the feelings of others when they become older. This is in line with findings in other studies showing that that underarousal is a risk factor for impaired empathic responding later on (Liew et al., 2011; Ungerer et al., 1990; Young et al., 1999). Furthermore, underarousal is also widely known as a risk factor of aggression (Baker, Shelton, Baibazarova, Hay, & van Goozen, 2013; Raine, 2002) and the current dissertation indicates that empathy and aggression are negatively associated during early childhood. Possibly, empathy plays a role in the association between underarousal and aggression (Raine, 2002). For example, underarousal may result in a lack of empathy, which in turn could lead to aggression.

The current dissertation might have implications for early interventions that aim to reduce or prevent aggression. Early childhood is a particularly important developmental stage for the study of interventions because on one hand aggression is stable over time and approximately one out of six children show high and stable levels of aggression from toddlerhood to pre-adolescence (Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006; Tremblay, 2010; Tremblay et al., 2004). On the other hand, empathy training has been shown to be more effective if administered at younger age (Malti, Chaparro, Zuffiano, & Colasante, 2016). Based on the results from the current dissertation that empathy and aggression are already negatively associated in early childhood, interventions targeting empathy at very young ages may help reducing the chances of developing high and consistent levels of aggression. In addition to targeting empathy at early age, the results from the current dissertation also suggest that intervention programs could be more effective when possible moderators of the association between empathy and aggression, such as inhibition and social attention, are targeted simultaneously with empathy itself.

Although some efforts have been made to implement interventions in kindergarten and preschool, most studies have included older children and more attention is necessary for the development, implementation, and evaluation of preventive interventions (McMahon, Washburn, Felix, Yakin, & Childrey, 2000). “Second step” is a widely used program that aims to decrease aggression by increasing empathy, which has been applied from kindergarten until middle school (Frey, Hirschstein, & Guzzo, 2000; Frey, Nolen, Van Schoiack Edstrom, & Hirschstein, 2005; McMahon et al., 2000; McMahon & Washburn, 2003). Effect studies indicate that Second step increases empathy and decreases aggression (McMahon et al., 2000; McMahon & Washburn, 2003). In line with the results of Chapter 4, Second step does not only focus on improvement of empathy, but also on increasing inhibition, in order to reduce aggression (McMahon et al., 2000; McMahon & Washburn, 2003).

Another preventive intervention program called “Roots of empathy” aims to improve both affective and cognitive aspects of empathy by empathy education in children (Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2011). The program has been found effective in decreasing aggression and increasing prosocial behavior in children aged 8-12 years (Schonert-Reichl et al., 2011). Based on the results of Chapter 5 that aggression is associated with affective, but not cognitive empathy, we expect that the underlying effects of the program are mainly linked to components of the program that are focused on affective empathy.

CONCLUSION

Empathy is an important aspect of social development that develops from birth onwards. The studies in the current dissertation indicate that early manifestations of empathy can be predicted from emotional responses in infancy, as infants who are more emotionally reactive themselves are also more sensitive to emotions of others during toddlerhood. In addition, our studies indicate that impaired empathy already is a risk factor of aggression from the age of 20 months. Therefore, it is valuable to invest in recognizing impairments in empathy development, fostering empathy development, and targeting empathy in interventions that aim to prevent and reduce aggressive behavior, in particular in early childhood. The studies from the current dissertation also indicate that high levels of aggression are associated with low levels of affective empathy, but not cognitive empathy. Furthermore, the negative association between empathy and aggression was stronger for girls, children with high levels of inhibition, and children with low levels of social attention. It is important to take these factors into account in further research and intervention programs that target empathy and its association with aggression in early childhood.

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Nederlandse samenvatting (Summary in Dutch)

EMPATHIE EN DE RELATIE TUSSEN EMPATHIE EN AGRESSIE IN DE VROEGE KINDERJAREN

Baby's vertonen hun eerste uitingen van agressief gedrag, zoals slaan en bijten, zodra hun motorische ontwikkeling dit toelaat (Alink et al., 2006; Hay et al., 2010; Tremblay et al., 1999; Tremblay et al., 2004). Dit gedrag hoort bij hun ontwikkeling en komt voor bij nagenoeg alle kinderen, maar een hoge mate van agressie tijdens de vroege kindertijd is een risicofactor voor het voorkomen van bovenmatige agressie op latere leeftijd (Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006). Het is belangrijk om onderzoek te doen naar vroege risicofactoren van agressie op latere leeftijd, omdat zij een belangrijk aanknopingspunt kunnen zijn om interventies die zich richten op het voorkomen en verminderen van agressie bij kinderen vorm te geven (Cote et al., 2006; Farrington, Gaffney, Lösel, & Ttofi, 2017; Tremblay, 2010; Tremblay et al., 2004). Naast een hoge mate van agressie tijdens de vroege kindertijd, wordt ook gebrekkige empathie gezien als een belangrijke risicofactor voor agressie. Eerder onderzoek heeft een negatieve relatie aangetoond tussen empathie en agressie bij zowel kinderen in de basisschoolleeftijd als adolescenten. Er is echter zeer weinig onderzoek gedaan naar de relatie tussen empathie en agressie bij kinderen in de voorschoolse leeftijd, terwijl juist in deze periode empathie en de regulatie van agressie nog sterk in ontwikkeling zijn en daarmee mogelijk vatbaar zijn voor interventie (Alink et al., 2006; Bons et al., 2013; Jolliffe & Farrington, 2004; Miller & Eisenberg, 1988; Vachon, Lynam, & Johnson, 2014; van Langen, Wissink, van Vugt, Van der Stouwe, & Stams, 2014). Bovendien zijn de resultaten van eerdere onderzoeken tijdens de voorschoolse leeftijd tegenstrijdig. Deze tegenstrijdige resultaten kunnen hoogstwaarschijnlijk verklaard worden door de invloed van andere factoren die gerelateerd zijn aan empathie en agressie. De studies die worden beschreven in dit proefschrift hebben als doel om inzicht te verkrijgen in vroege uitingsvormen van empathie als voorspeller van agressie in de eerste levensjaren. Daarbij is ook gekeken naar de rol van voorlopers van empathie en mogelijke moderatoren die van invloed zijn op de relatie tussen empathie en agressie.

VROEGE UITINGSVORMEN VAN EMPATHIE

Personen die snel emotioneel geraakt worden zijn ook gevoelig voor de emoties van anderen en zijn daardoor meestal meer empathisch (Eisenberg, 2000; Rothbart & Bates, 2006; Spinrad & Stifter, 2006). Onderzoek heeft aangetoond dat ook in de kindertijd emotionele reactiviteit gerelateerd is aan empathie (Eisenberg,

2000, 2010). De bevindingen bij baby's en peuters zijn echter tegenstrijdig, bij sterk emotioneel reactieve kinderen wordt soms meer en soms minder empathisch gedrag waargenomen dan bij kinderen die minder reactief zijn (Decety, 2010; Hastings & Miller, 2014; Preston & de Waal, 2002). Dit kan mogelijk verklaard worden doordat het autonome zenuwstelsel, dat een belangrijke rol speelt in emotionele reactiviteit, zich nog sterk ontwikkelt tot de leeftijd van vijf jaar (Alkon, Boyce, Davis, & Eskenazi, 2011; Quigley & Moore, 2018). Bovendien omvatten vroege uitingsvormen van empathie zowel reacties die gericht zijn op de ander en geïnterpreteerd kunnen worden als uitingen van bezorgdheid (empathische bezorgdheid), als reacties die gezicht zijn op zichzelf en wijzen op een ongemakkelijke of oncomfortabele gemoedstoestand (empathisch ongemak) (de Waal, 2008; McDonald & Messinger, 2011). De relatie tussen emotionele reactiviteit en empathische bezorgdheid kan verschillen van de relatie tussen emotionele reactiviteit en empathisch ongemak. Daarom is in hoofdstuk twee onderzoek beschreven naar de relatie tussen emotionele reactiviteit en vroege uitingsvormen empathie.

Emotionele reactiviteit werd bij 118 baby's van 6 maanden gemeten aan de hand van fysiologische en gedragsmatige reactiviteit tijdens emotionele uitdaging. Het '*still face'* paradigma en een 'autostoel' taak werden gebruikt als milde emotionele uitdagingen (Goldsmith & Rothbart, 1999; Tronick, Als, Adamson, Wise, & Brazelton, 1979). De fysiologische maat voor reactiviteit bestond uit het verschil in activiteit van het autonome zenuwstelsel tussen een rustmeting en tijdens de emotionele uitdagingen. Activiteit van het autonome zenuwstelsel werd gemeten aan de hand van de pre-ejectie periode (PEP; een maat voor de samenknijpkracht van het hart) en respiratoire sinusaritmie (RSA; een maat voor ademhalingsafhankelijke hartslagvariabiliteit). Gedragsmatige reactiviteit werd in kaart gebracht aan de hand van observaties van het 'wurmen' in de stoel, het zichzelf troosten en het verbaal uiten van ongemak tijdens de emotionele uitdagingen (Goldsmith & Rothbart, 1999; Miller, McDonough, Rosenblum, & Sameroff, 2002; Shapiro, Fagen, Prigot, Carroll, & Shalan, 1998).

Om empathie op te wekken bij peuters van 20 maanden werd door de onderzoekers een pijnsimulatie uitgevoerd. Empathisch ongemak werd gecodeerd aan de hand van observatie van het vertonen van ongemak of stress en het zoeken van troost door bijvoorbeeld op de duim te zuigen of naar moeder toe te lopen. Empathische bezorgdheid werd gecodeerd aan de hand van observatie van bezorgde gezichtsuitdrukkingen, pogingen om te onderzoeken wat de mogelijke oorzaak van de pijn is en het proberen de pijn van de onderzoeker te verzachten (Liew et al., 2011; Lin & Grisham, 2017).

Meer fysiologische en gedragsmatige reactiviteit op een emotionele uitdaging op de leeftijd van 6 maanden was gerelateerd aan meer empathisch ongemak op 20 maanden. Meer reactiviteit van PEP en RSA tussen de rustmeting en autostoel-taak,

maar niet tussen de rustmeting en het still face paradigma, was positief gerelateerd aan empathisch ongemak. Bovendien was 'wurmen' in de stoel tijdens zowel de autostoel taak als het *still face* paradigma positief gerelateerd aan empathisch ongemak. Deze resultaten bevestigen eerdere bevindingen dat gedragsmatige en fysiologische reacties op emotionele uitdagingen positief gerelateerd zijn aan empathisch ongemak tot de leeftijd van 2 jaar (Liew et al., 2011; Ungerer et al., 1990; Young, Fox, & Zahn-Waxler, 1999). Bovendien laten deze resultaten zien dat gedragsmatige en fysiologische reactiviteit op emotionele uitdaging onafhankelijk van elkaar voorspellend zijn voor empathisch ongemak. Dit benadrukt het belang van zowel gedragsmatige als fysiologische reactiviteit voor de ontwikkeling van empathie. Naast bovenstaande lineaire relaties zijn er kwadratische relaties gevonden tussen enerzijds gedragsmatige responsen en anderzijds empathisch ongemak en empathische bezorgdheid. Dit duidt erop dat matige gedragsreactiviteit de hoogste mate van empathisch ongemak en empathische bezorgdheid voorspellen. Emotionele reactiviteit is dus een voorspeller van empathie op later leeftijd. Deze kennis van de vroege ontwikkeling van empathie draagt bij aan het identificeren van kinderen met risico op afwijkende ontwikkeling van empathie en het ontwikkelen van interventies gericht op het verbeteren van empathie.

DE RELATIE TUSSEN EMPATHIE EN AGRESSIE

Verminderde empathie is een belangrijke risicofactor voor agressie, maar resultaten van studies bij peuters zijn tegenstrijdig (Lovett & Sheffield, 2007). Empathie uit zich, vooral bij baby's en peuters, als empathisch ongemak en empathische bezorgdheid (de Waal, 2008; McDonald & Messinger, 2011). De relatie tussen empathie en agressie kan verschillend zijn voor empathisch ongemak en empathische bezorgdheid. Empathisch ongemak komt namelijk voort uit emotionele opwinding, hetgeen de inhibitie van agressie stimuleert, terwijl empathische bezorgdheid ook beïnvloed wordt door factoren zoals opvoeding en het vermogen om het perspectief van de ander in te nemen (Farrant, Devine, Maybery, & Fletcher, 2012; Vaish, Carpenter, & Tomasello, 2009). Bovendien kan de relatie tussen empathie en agressie ook verschillend zijn voor jongens en meisjes, omdat meisjes vaak meer empathisch en minder agressief zijn dan jongens (Archer, 2004; Christov-Moore et al., 2014; Feshbach & Feshbach, 1969). Daarom is in hoofdstuk 3 beschreven hoe agressie op de leeftijd van 20 en 30 maanden wordt voorspeld vanuit empathisch gedrag op de leeftijd van 20 maanden. Daarbij zijn empathisch ongemak en empathische bezorgdheid onderzocht en is er rekening gehouden met een mogelijk modererend effect van geslacht.

Empathisch gedrag werd geobserveerd tijdens een pijnsimulatietaak op de leeftijd van 20 maanden (Spinrad & Stifter, 2006; Zahn-Waxler, Robinson, & Emde, 1992). Moeders rapporteerden over fysieke agressie door middel van de Physical

Aggression Scale for Early Childhood (fysieke agressieschaal voor vroege kindertijd) op de leeftijd van 20 en 30 maanden ($N_{20\ maanden}$ = 133, 69 jongens; $N_{30\ maanden}$ = 119, 62 jongens), (Alink et al., 2006). Eerdere studies hebben aangetoond dat fysieke agressie een beter voorspeller is van probleemgedrag op de lange termijn dan andere vormen van agressief probleemgedrag (Broidy et al., 2003).

Er waren geslachtsverschillen tussen enerzijds empathisch ongemak en empathische bezorgdheid en anderzijds fysieke agressie op de leeftijd van 20 maanden. Meer empathisch gedrag was gerelateerd aan minder fysieke agressie bij meisjes, maar niet bij jongens. Bovendien werd agressie op de leeftijd van 30 maanden bij meisjes voorspeld door empathisch ongemak op de leeftijd van 20 maanden, terwijl er gecontroleerd werd voor agressie op de leeftijd van 20 maanden. Empathisch ongemak was dus een robuustere voorspeller van fysieke agressie over tijd dan empathische bezorgdheid.

DE ROL VAN INHIBITIE IN DE RELATIE TUSSEN EMPATHIE EN AGRESSIE

De geslachtsverschillen in de relatie tussen empathie en agressie die gevonden werden in onderzoek dat beschreven is in hoofdstuk 3, kunnen mogelijk verklaard worden door verschillen in inhibitie tussen jongens en meisjes. Bij agressieve kinderen in de voorschoolse leeftijd, in het bijzonder bij jongens, is een verminderd vermogen tot inhibitie aangetoond (Raaijmakers et al., 2008). Daarom is het mogelijk dat verminderde inhibitie leidt tot zowel de neiging tot agressief gedrag als tot empathisch gedrag (bijvoorbeeld door het slachtoffer te benaderen). Mogelijk vonden wij in het onderzoek dat beschreven is in hoofdstuk 3 geen relatie tussen empathie en agressie bij jongens omdat er bij jongens zowel een positieve als negatieve relatie tussen empathie en agressie mogelijk is, afhankelijk van de aanwezigheid van beperkingen in inhibitie (Eisenberg, Eggum, & Di Giunta, 2010; Gill & Calkins, 2003; Lovett & Sheffield, 2007). Daarom is in onderzoek dat werd beschreven in hoofdstuk 4 bij 103 kinderen van 30 maanden onderzocht of inhibitie een dergelijke modererende rol vervult in de relatie tussen empathie en agressie.

Op de leeftijd van 30 maanden vulden moeders een vragenlijst in over fysieke agressie bij hun kind (Alink et al., 2006). Inhibitie werd onderzocht aan de hand van een uitsteltaak met een cadeau (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013; Kochanska, Murray, & Harlan, 2000). Empathie werd onderzocht aan de hand van zowel gedragsobservaties (empathisch ongemak en empathische bezorgdheid) als fysiologische metingen (hartslag en RSA) tijdens een pijnsimulatietaak (Spinrad & Stifter, 2006; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992).

Verminderde inhibitie, lage hartslag tijdens een rustmeting en hoge RSA tijdens de rustmeting bleken gerelateerd aan meer fysieke agressie. Daarnaast was er een interactie-effect tussen inhibitie en de hartslag respons op de pijnsimulatie in de voorspelling van agressie: bij peuters met relatief goede inhibitie werd een negatieve relatie tussen empathie en agressie gevonden, terwijl er bij peuters met relatief lage inhibitie een positieve relatie gevonden werd. Deze resultaten laten zien dat kinderen minder agressief zijn wanneer er sprake is van een relatief hoge mate van inhibitie en empathie.

AFFECTIEVE EMPATHIE, COGNITIEVE EMPATHIE EN SOCIALE AANDACHT IN RELATIE TOT AGRESSIE

Naast affectieve empathie, het voelen van de emoties van de ander, ontwikkelt vanaf de leeftijd van drie jaar ook cognitieve empathie, het begrijpen van de emoties van de ander (Decety et al., 2018; Decety, 2010). Op basis van wetenschappelijke theorie en eerdere onderzoeksbevindingen kan verwacht worden dat beperkingen in affectieve empathie, maar niet in cognitieve empathie, een risicofactor vormen voor agressie bij kinderen, adolescenten en volwassenen (Bons et al., 2013; Smith, 2006; van Zonneveld, Platje, de Sonneville, van Goozen, & Swaab, 2017). Eerder onderzoek bij kinderen tijdens de voorschoolse periode toonde echter aan dat zowel cognitieve als affectieve empathie gerelateerd zijn aan agressie (Belacchi & Farina, 2012; Dadds et al., 2009). Sociale aandacht is noodzakelijk om emoties van anderen te herkennen en wordt daarom gezien als een voorwaarde voor cognitieve en affectieve empathie (Bons et al., 2013). Onderzoek naar sociale aandacht in relatie tot empathie en agressie is schaars, maar enkele studies vonden dat minder sociale aandacht gerelateerd is aan minder empathie en meer agressie (Bons et al., 2013; Dadds, El Masry, Wimalaweera, & Guastella, 2008; Yan, Pei, & Su, 2017)

In hoofdstuk 5 is onderzoek beschreven naar de relatie tussen empathie en agressie bij 61 3-jarige kinderen. Daarbij is rekening gehouden met de mogelijke invloed van sociale aandacht op empathie en agressie, en op de relatie tussen empathie en agressie. De kinderen keken naar drie videofilmpjes van leeftijdsgenoten in emotieopwekkende situaties (blijdschap, verdriet en angst). Tijdens de filmpjes werden hartslagresponsen gemeten om affectieve empathie te meten. Er werden vragen over de filmpjes gesteld om cognitieve empathie te meten. Sociale aandacht werd gemeten door met een *eye-tracker* te meten hoe lang de kinderen naar emotionele gezichten in de filmpjes keken. De moeders van de kinderen rapporteerde over agressie bij haar kind met de Child Behavior Checklist (Achenbach & Rescorla, 2000).

In lijn met onze verwachtingen werd er een negatieve relatie gevonden tussen affectieve empathie en agressie. Ook sociale aandacht was negatief gerelateerd aan

agressie en modereerde bovendien het effect van affectieve empathie op agressie. De meeste agressie werd gerapporteerd bij kinderen met lage affectieve empathie gecombineerd met weinig sociale aandacht. Veel sociale aandacht functioneerde als een beschermende factor tegen het negatieve effect van affectieve empathie op agressie. Er werd geen relatie gevonden tussen cognitieve empathie en agressie. Deze resultaten tonen aan dat affectieve empathie en sociale aandacht al negatief gerelateerd zijn aan agressie op de leeftijd van 3 jaar. Zowel affectieve empathie als sociale aandacht zijn dus belangrijke aanknopingspunten voor het vormgeven van interventies die zich richten op het voorkomen en verminderen van agressie.

CONCLUSIE

Empathie ontwikkelt al vanaf de geboorte en is een belangrijk onderdeel van de sociale ontwikkeling. Dit proefschrift laat zien dat vroege uitingsvormen van empathie voorspeld kunnen worden vanuit emotionele responsen in de babytijd. Baby's die meer reageren op emotionele uitdagingen zijn ook gevoeliger voor de emoties van anderen tijdens de peutertijd. Daarnaast laten onze onderzoeken zien dat beperkingen in empathie vanaf de leeftijd van 20 maanden een risicofactor vormen voor agressie op latere leeftijd. Daarom is het belangrijk meer aandacht uit te laten gaan naar het vroegtijdig herkennen van beperkingen in de ontwikkeling van empathie en het stimuleren van de ontwikkeling van empathie. Bovendien lijkt het op basis van dit onderzoek zinvol om interventies die als doel hebben om agressie te verminderen of te voorkomen te richten op empathie, in het bijzonder tijdens de vroege kindertijd. De onderzoeken uit dit proefschrift laten ook zien dat een hoge mate van agressie gerelateerd is aan lage affectieve empathie, maar niet aan cognitieve empathie. Daarbij is de negatieve relatie tussen empathie en agressie sterker voor meisjes, voor kinderen met een goede inhibitie en voor kinderen met weinig sociale aandacht. Het is van belang om rekening te houden met deze factoren bij vervolgonderzoek en interventies gericht op empathie en de relatie tussen empathie en agressie in de vroege kindertijd.

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6

About the author

Curriculum Vitae

Malou Noten werd geboren op 3 april 1990 te Budel. Na het behalen van haar gymnasiumdiploma aan het Bisschoppelijk College te Weert in 2008, startte zij aan de bacheloropleiding pedagogische wetenschappen aan de Radboud Universiteit Nijmegen. In 2009 stroomde zij in aan de Radboud Honours Academy van pedagogische wetenschappen en in het kader van dit programma schreef Malou haar bachelor scriptie aan Columbia University in New York. Aansluitend aan de bacheloropleiding rondde Malou in 2014 ook de research master Behavioural Science en een klinisch traject tot basis orthopedagoog met basisaantekening psychodiagnostiek af, waarbij zij onder andere stage liep op de klinische kinderafdeling van de St. Maartenskliniek te Nijmegen. Daarnaast rondde zij ook de mastervariant van de Radboud Honours Academy af tijdens een onderzoeksstage aan Australian Catholic University te Melbourne en was zij werkzaam als studentonderzoeker aan de Radboud Universiteit. In mei 2014 is Malou gestart als promovenda bij het onderzoeksproject Een Goed Begin aan het instituut pedagogische wetenschappen van de Universiteit Leiden, waar zij onderzoek deed naar de relatie tussen empathie en agressie op zeer jonge leeftijd. De resultaten van het onderzoek staan beschreven in dit proefschrift. Naast haar werkzaaamheden als onderzoeker verzorgde Malou bachelor en masteronderwijs en behaalde zij haar BKO (basiskwalificatie onderwijs) en BKE (basiskwalificatie taalvaardigheid Engels). Aansluitend op het promotietraject is Malou nog een jaar werkzaam geweest als onderzoeker aan het instituut pedagogische wetenschappen. Daarnaast is zij sinds 2018 werkzaam als gedragskundige in de gehandicaptenzorg bij stichting Cello.

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ABSTRACTS

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