Indicators of affective empathy, cognitive empathy and social attention during emotional clips in relation to aggression in three-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. Sixty-one 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 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.

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; P. A. 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, motivates children to refrain from actions that harm others. In children, adolescents and adults, negative associations between empathy and aggressive behavior have therefore particularly been shown 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 (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, 2017; 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; the ability to understand or make inferences about another person's affective and cognitive mental states (Shamay-Tsoory, 2011;

Shamay-Tsoory & Aharon-Peretz, 2007; Shamay-Tsoory et al., 2009). These top down circuits involve mainly prefrontal areas of the brain. Indicators of affective empathy can be observed from infancy onwards, as newborns already show distress in response to the distress of others, which develops into showing empathic concern and helping behaviors in toddlerhood (Hoffman, 2000; McDonald & Messinger, 2011). Cognitive empathy develops from preschool onwards, when perspective taking and emotion recognition abilities develop rapidly (Decety, 2010; Decety et al., 2017).

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 (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 others' 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 (A. A. 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 others, have been associated with higher levels of aggression (J. G. 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 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 3-6 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 two studies examining both affective and cognitive empathy in young children have used questionnaires to examine empathy. Although self-reports and parent reports of empathy are commonly used methods to asses empathy in older children, self-reports cannot be used in younger children as 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 others' 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 both or either the sympathetic or parasympathetic branch of the autonomic nervous system (Berntson et al., 1994). Although heart rate responses to others' emotional states have been used as 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, 2007; Porges & Furman, 2011). 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 others), but empathic concern has been suggested to be more adaptive than personal distress (Eisenberg, 2010; Singer & Klimecki, 2014). Personal distress is most common in 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; Anastassiou-Hadjicharalambous & Warden, 2008), as well as decreases in heart rate in response to empathy-evoking clips (De Wied, Boxtel, Posthumus, Goudena, & Matthys, 2009; van Zonneveld et al., 2017; Zahn-Waxler et al., 1995). Behavioral measures of empathic concern in children have also been associated with both decreased (Holmgren, Eisenberg, & Fabes, 1998; Zahn-Waxler et al., 1995) and increased heart rate in response to empathy-evoking clips (Anastassiou-Hadjicharalambous & Warden, 2007; Holmgren et al., 1998). 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 others 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 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, El Masry, Wimalaweera, & Guastella, 2008; Dadds et al., 2006). 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 in early childhood is scarce (Bons et al., 2013; Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017). One study indicated that five-year-old children who were high in empathy, fixated more quickly on the eyes and mouth, they 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, as 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 of 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 between social attention, empathy, and aggression.

In sum, the associations between affective and cognitive empathy, and aggression in 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, in early childhood, positive associations (Feshbach & Feshbach, 1969; Gill & Calkins, 2003), negative associations (Hughes et al., 2000; J. G. 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) in 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 firstly whether affective and cognitive empathy are associated with aggression. Based on previous studies in early childhood, we expected both affective and cognitive empathy to be negatively associated with aggression (Belacchi & Farina, 2012; Dadds et al., 2009). Secondly, 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 negatively with aggression (Bons et al., 2013; Dadds et al., 2008; Yan et al., 2017). In addition, the potential moderating role of social attention on the association between empathy and aggression was explored, as we had no hypothesis about the direction of this effect. It is important to examine the association between empathy, social attention, and aggression in the preschool period, because the preschool period 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 year of life the majority of children show aggressive behavior and in general they 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 of aggression in 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 to affective empathy and cognitive empathy in relation to aggression in preschool children. Furthermore, objective measures of social attention (eye-tracking), affective empathy (heart rate reactivity) were obtained.

Methods

Participants

The present study is a follow-up of 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 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. 120 Dutch speaking women between 17 and 25 years old (*M* = 23.28, *SD* = 2.18) who had taken part in MINDS – Leiden between the third trimester of pregnancy and 30 months post-partum were approached (see Smaling et al., 2015 for detailed procedures). Approximately one year after the final data wave of MINDS-Leiden the mother were invited to take part in a follow-up study. Thirty-two mothers declined, 27 agreed to fill out only questionnaires, and 61 participants agreed to participate in the full follow-up data wave at age 45 months (*M* = 45.59, *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 eye-tracking 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 non-emotional 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 seconds each and the duration of the baseline clips was approximately 60 seconds each. 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 non-emotional 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, DeGeus, Klaver, VanDoornen, & Carrofl, 1996). Disposable pre-gelled Ag/AgCl electrodes (ConMed Huggable 1620-001, New York) 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 VU-DAMS software suite version 3.9, then visually checked by a trained experimenter, and adjusted manually if necessary. The VU-AMS 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 children whether the child in the clip felt happy, sad, or scared (multiple choice).We subsequently asked them to support their choice by asking them to indicate how intense the named emotion was by showing them emoticons showing no, low intensity, or high intensity 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, i.e. a little sad, and 2 when the emotion was recognized at high intensity, i.e. 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; providing multiple factual reasons and possible consequences of the situation, such as 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 2-12 out of 21. Twenty percent 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 to 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 as 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, Sweden). By corneal reflection techniques the X and Y position of the eye on the screen was recorded at 120Hz. 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 AOI's 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 seconds for the happy clip, 13 seconds for the sad clip and 14 seconds for the fear clip). The relative total visit duration of the screen was calculated in order to control for the time the children were 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. In order 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, and is easily frustrated) was used to calculate the score for the subscale aggressive behavior (Cronbach's $\alpha = .874$). Data were missing for one 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 clip to the clips for the neutral, fear, sad, and happy conditions. Heart rate response was calculated as the difference in heart rate between the baselines and the emotional clips (emotion minus baseline), such that higher scores indicated larger increases in heart rate from baseline to emotional clips. Subsequently, standardized residualized 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, 2017). 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 residualized 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 value of relative total visit duration to the screen was ≥3SD 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-ANOVA's 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 between heart rate response, emotion understanding, attention to emotional faces, and aggression. Multivariate linear regressions were used to examine moderating effect 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 (-1SD, mean, and +1SD for social attention; 0 for boys and 1 for girls) (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

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 ($t(53) = 2.356$, $p < .022$, $d = 0.12$), happy ($t(51) = 4.701$, $p < .001$, $d = 0.21$), sad ($t(50) = 7.261$, $p < .001$, $d = 0.36$), and fear ($t(51) = 5.064$, $p < .001$, $d = 0.27$) clips. RM-ANOVA revealed within subjects 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 ($F(1,43) = 6.435$, $p = .015$, $\eta^2 = .130$) and fear ($F(1,43) = 6.954$, $p = .005$, $\eta^2 = .172$) clips than the neutral clip. Pearson correlations indicated that the standardized residualized change score for the happy clip was positively associated with those for the sad ($r(50) = .297$, $p = .036$) and fear clips ($r(51) = .321$, $p = .022$). The standardized residualized change score for the sad clip was not associated with the standardized residualized change score for the fear clip and the standardized residualized change score for the neural clip was not associated with the standardized residualized 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-ANOVA's 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 between 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 ($r(53) = .300$, $p = .029$) and fear ($r(47) = .332$, $p = .022$) clips. The relative total fixation duration to sad clip was not associated with the relative total fixation duration to 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 between 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 a positive interaction effect of heart rate response × 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 (-1SD, mean, and +1SD). 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 (β = -.279, t = -2.126, p = .039) or high levels of attention to emotional faces (β = .062, t = 0.319, p = .751). 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 (Figure 1).

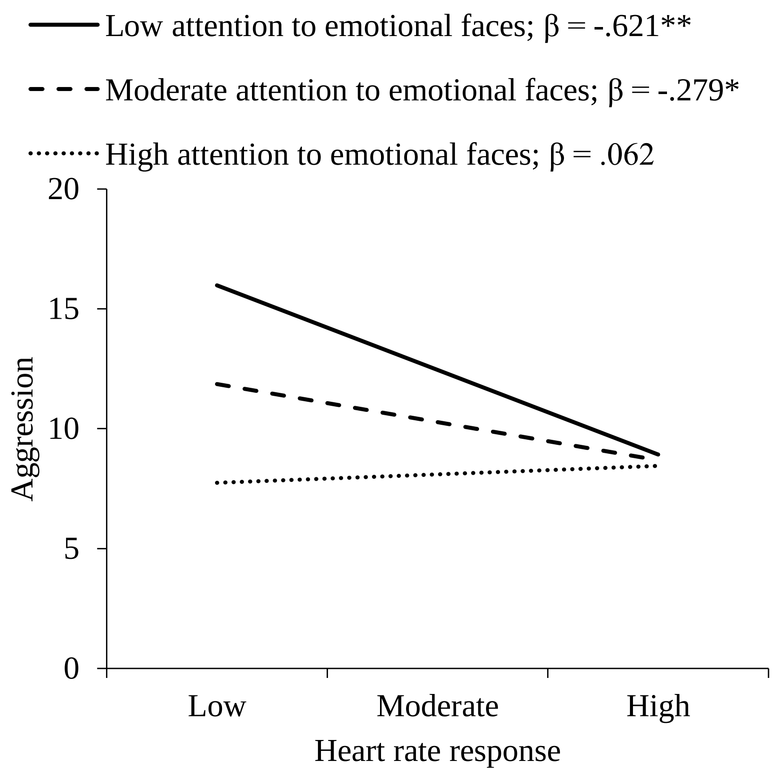

Figure 1. The effect of heart rate response on aggression at low, moderate, and high levels of attention to emotional faces.

Discussion

The current study aimed to examine associations between indicators of affective and cognitive empathy, social attention, and aggression in three-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 negatively with aggression. In addition, the moderating role of social attention on 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; J. G. 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 towards 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). Possibly, this contradiction 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 in 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 on, humans have a preference towards 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 in 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 extend the findings by Dadds et al. (2008) from children aged 8-15 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 increased in children with relatively low social attention. In general, children who showed 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 to examine the role of social attention in empathy and aggression. However, in contrast to our hypothesis and previous research in five-year-old children (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 age five and whether the association between social attention and empathy is present for both cognitive 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 towards 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 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 parental 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 and limitations, and future research

The current study adds to the literature by examining affective empathy, cognitive empathy and social attention within one experimental set-up, 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 combines 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 in early childhood (Koot, Van Den Oord, Verhulst, & Boomsma, 1997). Another methodological limitation is the use of heart rate as 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 (non-emotional social clip). Furthermore, whilst the heart rate response to the happy clip was positively associated with the heart rate response to the sad and fearful clips, the heart rate responses to the emotional clips were unrelated to those in the control condition (non-emotional 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, Smith, Zaidman-Zait, & Hertzman, 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 and 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; P. Marsh, Beauchaine, & Williams, 2008; Suurland et al., 2017). 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 in 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 in 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 may, such as specific instructions to attend to faces or 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). Since 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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