Motor, Emotional and Cognitive Empathic Abilities in Children with Autism and Conduct Disorder

Danielle M.A. Bons[1,2]
d.bons@psy.umcn.nl
+31 (0)488 – 469 611

Floor E. Scheepers[1]
f.scheepers@karakter.com

Nanda N.J. Rommelse[1,2]
n.lambregts-rommelse@psy.umcn.nl
+31 (0)24 351 2222

Jan K. Buitelaar[1,2]
j.buitelaar@psy.umcn.nl

[1]Karakter child- and adolescent psychiatry
University Centre Nijmegen, Zetten-Tiel
P.O. Box 104, 6670AC Zetten, The Netherlands

[2]Department of Psychiatry UMC St. Radboud
P.O. Box 9101, 6500HB Nijmegen, The Netherlands

ABSTRACT
This paper gives an overview of the studies that investigated motor, emotional and cognitive empathy in juveniles with autism or conduct disorder. Studies that measured response to emotional faces with use of facial EMG, ECG, skin conductance, eye-tracking or emotion recognition are discussed. In autism facial mimicry and emotion recognition, as well as attention to the eyes, seem to be reduced. In conduct disorder facial mi micry seems to be impaired as well as recognition of fear and sad facial expressions, and possibly associated with lack of attention to the eyes. Further research is needed to investigate autonomic emotional empathic response to emotional faces in both patient groups. Major differences between ASD and CD are hypothesized.

Author Keywords
Empathy, Autism, Conduct Disorder, facial mimicry, EMG, heart rate, skin conductance, eye-tracking, emotion recognition

ACM Classification Keywords
J.3 Life and medical sciences: Health, Medical information systems, J.4 Social and behavioral sciences: Psychology

INTRODUCTION
Autism spectrum disorders (ASD; including autism and Asperger syndrome) are characterized by atypical communication, impaired social interaction and restricted repetitive patterns of behavior, interests and activities. Children with conduct disorder (CD) show a pattern of behavior violating the basic rights of others and age-appropriate norms and rules, which may develop in antisocial behavior in adulthood. At first sight these disorders appear to have little in common. However, lack of empathy is a core symptom in both ASD and CD.

Empathy is assumed to consist out of three components: motor, emotional and cognitive empathy [5]. Motor empathy refers to unconsciously mirroring the facial expressions of another, which is suggested to induce shared representations of perception and emotional contagion. Emotional empathy refers to the experience of emotions consistent with and in response to those of others. Cognitive empathy is the ability to rationally understand the emotional state of others. These three aspects of empathy have been frequently studied, mostly using facial expressions as stimuli, since facial expressions are essential in social communication and empathy. Our aim was to review the studies that investigated the three components of empathy in juveniles with ASD or CD and normal intelligence, in order to determine the overlap and specificity of empathic abilities in these disorders. Studies were included that used the 6 universal basic emotions; happy, angry, sad, fear, disgust and surprise [11]. In addition, eye-tracking studies are included, since attention to the eyes may play an essential role in facial emotion recognition as well as motor and emotional empathy, and possibly explaining impairments in these young patients.

MOTOR EMPATHY
Motor empathy is usually measured as facial mimicry using electromyography (EMG) electrodes to record muscle activity, on the cheek at the zygomator major muscle (smiling muscle) and corrugator supercilii muscle above at the inside of the eyes (frowning muscle). EMG amplitude in response to emotional faces is compared to a pre-stimulus

baseline level. Normal facial reaction patterns are increased zygomaticus activity during happy faces or positive pictures and increased corrugator activity during angry faces or negative images [10].

Motor Empathy in Autism

Recently, two studies measuring motor empathy in autism were conducted with children. Results were inconsistent, as were findings in adults. One study investigated spontaneous facial mimicry to emotional faces (happy, angry and fear) without using an emotion recognition task [3]. Children with ASD (n=11, age 7-13) did not show congruent rapid facial EMG responses to happy, angry or fearful faces. The second study [18], focused on timing of facial mimicry. No significant differences were found in emotion recognition or facial mimicry. However, facial mimicry appeared to be delayed in ASD (n=13, age 8-12) across all emotional expressions. This delay of facial mimicry in ASD might explain the inconsistent findings. When EMG response was measured within the first second after stimulus onset reduced facial mimicry in ASD was found [3]. Whereas measuring facial mimicry up to 2 seconds after stimulus onset showed no significant differences [18]. In addition, inconsistent results between studies may also be explained by using an emotion recognition task or measuring spontaneous responses. Indeed, it has to be noted that the study without a task and automatic facial EMG response within 1 second did find reduced facial mimicry in ASD [3]. In contrast, results of the other study using an emotion recognition task and EMG response measured up to 2 seconds after stimulus onset showed no significant difference between ASD and control subjects [18]. Therefore, voluntary imitation associated with active cognitive emotion processing may explain different results. Based on these results it seems to be that juveniles with ASD are impaired in motor empathy, at the level of spontaneous automatic facial mimicry (<1second). If they are cognitively processing and naming the emotion in an emotion recognition task they may use voluntary imitation in order to do so, which is delayed (1<second<2) as compared to automatic responses. The impairment in spontaneous automatic facial mimicry may be related to the lack of empathy in ASD, since empathy has been shown to be associated with facial mimicry in healthy individuals [20].

Motor Empathy in Conduct Disorder

Up to date there are only two reports of facial mimicry in 22 boys (age 8 – 12) with disruptive behavior disorder (DBD, including CD and oppositional defiant disorder, ODD). In the first report [8], film clips were shown with 2600ms dynamic happy or angry expression. Boys with DBD showed significantly reduced mean EMG amplitude corrugator response during the dynamic phase of angry faces, as compared to the control group. In addition, they scored lower on an emotional empathy self-report. In the second report [9], again reduced corrugator EMG reactivity was found in the DBD boys in response to both sadness- and anger inducing film fragments from documentaries with a length of 58 to 158 seconds. No differences were found for happy facial expression or happiness inducing film clips. Motor empathy seems to be impaired in DBD for negative emotions, although only a few children with CD were included in these studies, therefore further research is needed in CD specifically.

EMOTIONAL EMPATHY

Emotional empathy is usually measured as heart rate (HR) or skin conductance response (SCR) to distressing or threatening pictures as compared to pleasant pictures. Though faces may be included, the stimuli are usually not emotional facial expressions only. Thus, these stimuli might provoke an emotional response and induce increased arousal, but not necessarily shared basic emotional experiences with others. A better indicator for emotional empathy would be the autonomic response to emotional facial expressions, which is discussed below.

Emotional Empathy in Autism

Autonomic response to facial emotional expressions specifically, has not been studied yet in ASD. No difference was found in SCR to distressing stimuli between juveniles with ASD and controls [4]. Further research is needed concerning emotional empathy in ASD, investigating autonomic response to emotional facial expressions of other people and sharing these emotions, rather than showing situations where just ***one's own*** emotion is triggered.

Emotional Empathy in Conduct Disorder

A reduced basal heart rate, increased heart rate reactivity and reduced basal SC was found associated with conduct problems and antisocial behavior [14,19]. Four studies investigated autonomic response in juveniles with CD or DBD to movie scenes. The presence of callous unemotional (CU) traits (e.g., lack of guilt and empathy, callous use of others) may be determining findings. CD children (n=33, age 7-11) with CU traits showed reduced basal HR and HR response to a scared boy, while no differences were found for CD children without CU traits (n=29) [1]. In two other studies HR response to film clips with sad people in DBD was investigated. Reduced HR response in DBD (n=22, age 8-12) was shown in one study [9], but no difference was found in the other study [16]. Using dynamic emotional faces, rather than movie scenes, no difference in HR response for the DBD (n=22, age 8-12) and control group was found [8]. Effects may be extinguished due to heterogeneity in the patient groups. DBD might include children with CU traits being autonomic ***hypo***responsive, hence showing reduced HR/SC response and lacking normal emotionality, as well as autonomic ***hyper***responsive children being highly emotional reactive.

COGNITIVE EMPATHY

Cognitive empathy can be measured with an emotion recognition task, using static or dynamic stimuli of emotional faces, or pictures of the eyes.

Cognitive Empathy in Autism

Emotion recognition abilities have been studied extensively in autism. Nevertheless, findings of studies on basic emotion recognition in juveniles with high functioning autism or Asperger are inconsistent. This may be the consequence of differences in methodology. Some of the studies analyzed recognition accuracy of all emotions separately [13], while other studies measured total accuracy of all basic emotions accumulated [7]. Although several databases for facial emotional expression were used, number of trials per emotion varied and accuracy analyses differ among studies; these factors did not explain the inconsistent findings. Interestingly, the majority of the reviewed studies did not find differences in basic emotion recognition between ASD and control groups, when verbal mental age and IQ were taken into account [21, 18]. In contrast, those studies with differences in verbal mental age or IQ, did report reduced emotion recognition in ASD [7, 13]. It seems that reduced recognition of the basic emotions in juveniles with ASD is probably explained by differences in verbal mental age or IQ, rather than diagnosis [23]. However, emotion recognition deficits may exist in ASD with normal IQ, for the more complex social emotions.

Cognitive Empathy in Conduct Disorder

Recently, a meta-analysis was conducted [15] considering 20 emotion recognition studies in antisocial individuals, with and without CU traits, including children and adults. Most studies used Ekman's [11] static facial stimuli and a multiple-choice response format. Results showed significant deficits in recognizing fear and sadness. Results were not related to CU traits, age or gender. Only a few studies have focused on conduct disorder or disruptive behavior disorder specifically, rather than antisocial behavior in general. Two studies were published after 2006 and therefore not included in this meta-analysis. These studies [22, 12] are in line with the results of the meta-analysis in the way that juveniles with CD have deficits in recognition of sad and/or fearful facial expressions, while no consistent relation with CU traits was found.

ATTENTION TO THE EYES

Eye gaze can be followed with an infrared eye-tracker device. Usually relative fixation time or fixation frequency is calculated for the areas of interest; the eyes and the mouth of the emotional faces.

Attention to the Eyes in Autism

In juveniles with ASD reduced attention to the eyes was found consistently for static and dynamic emotional faces [2, 7, 17]. Actually, only one study did not find reduced attention to the eyes in ASD [21]. The inconsistent finding in this particular study [21] could be explained by the fixation points counted from 100ms, while most other studies counted 20ms to 50ms as being fixation points or even just accumulated all time spent looking at the eyes. (However, see also [17].) The other explanation could be the fact that in this study [21] both ASD and controls groups had maximum scores on emotion recognition, which is probably related to eye fixation [2]. In addition, reduced emotion recognition was reported in studies with reduced eye fixation in ASD [7]. In boys with ASD eye fixation seems also to be associated with amygdala activity [7], which might indicate increased emotional responsiveness to the eyes. Thus, emotional ***hyper***responsiveness might explain eye avoidance in individuals with ASD.

Attention to the Eyes in Conduct Disorder

No studies with CD juveniles and eye-tracking have been conducted. Only one eye-tracking study was done with juveniles concerning CU traits. It was reported that poor fear recognition in a community sample of 100 boys (age 8-15) was associated with higher CU traits, though not when explicitly instructed to look at the eyes [6]. Moreover, they found reduced time and frequency looking to the eyes in the group scoring high on CU traits. Further research is needed to investigate whether this applies to juveniles with conduct disorder as well, as they are particularly impaired in fear and sad expression recognition.

CONCLUSION

In juveniles with autism spectrum disorder (ASD) motor and cognitive empathy seem to be impaired: reduced mirroring of emotional faces was reported in ASD as well as impaired emotion recognition. The latter finding appears to be related to verbal developmental level. Emotional empathy, i.e. the autonomic response to emotional faces is not yet studied in ASD. Reduced attention to the eyes has consistently been found in ASD and could be related to emotional autonomic ***hyper***responsivity resulting in eye contact avoidance.

In juveniles with conduct disorder (CD) cognitive empathy was found to be impaired, specifically sad and fear recognition being reduced. Motor and emotional empathy have not been studied in CD specifically. Although studies in a broader category of behavior disorders suggest reduced mirroring of emotional faces (motor empathy), further research is needed to investigate whether this is the same in CD specifically. Reduced autonomic response to emotional eliciting stimuli (emotional empathy) has been reported in CD, which may be related to callous unemotional traits, and impaired emotion recognition in these juveniles. No eye-tracking studies have been conducted in CD yet, though reduced sad and fear recognition may be associated with lack of attention to the eyes.

In both ASD and CD emotional empathy needs to be further investigated and attention to the eyes may play an essential role. Importantly, major differences between the patient groups can be hypothesized. Whereas in autism eye contact might be avoided because of emotional ***hyper-***responsiveness, in CD a lack of attention to the eyes might be associated with emotional ***hypo***responsiveness. In both disorders the outcome would be impaired emotional and cognitive empathy.While in some studies

electrophysiological autonomic measurements and eye-tracking were combined, it has not been measured ***simultaneously*** in response to emotional faces in ASD or CD. This would be the best suited method for investigating the association between attention to the eyes and emotional response to facial expressions. In addition, wireless electrophysiological equipment gives the possibility of obtaining measurements in real life or virtual reality situations. This could be a great step forward, since people with autism might be functioning much better in a structured test-setting than in chaotic unpredictable real life. Juveniles with CD may show social appropriate behavior in a test-setting, in contrast to real life following their personal benefits despite the harm of others.

Finally, psychiatric patients are of particular interest in order to investigate the underlying neurophysiological processes of empathy, because they are differentially impaired in the various subcomponents of empathy, allowing us to disentangle the motor, emotional and cognitive aspects of empathy. Besides a better understanding of empathy and emotional processing, this might provide opportunities for developing diagnostic or socio-emotional training tools for patients.

REFERENCES

1. Anastassiou-Hadjicharalambous X, Warden D. Physiologically-Indexed and Self-Perceived Affective Empathy in Conduct-Disordered Children High and Low on Callous-Unemotional Traits. ***Child Psychiatry & Human Development*** 2008;39(4):503-17.
2. Bal E, Harden E, Lamb D, Van Hecke AV, Denver JW, Porges SW. Emotion recognition in children with autism spectrum disorders: relations to eye gaze and autonomic state. ***J Autism Dev Disord*** 2010 March;40(3):358-70.
3. Beall PM, Moody EJ, McIntosh DN, Hepburn SL, Reed CL. Rapid facial reactions to emotional facial expressions in typically developing children and children with autism spectrum disorder. ***J Exp Child Psychol*** 2008 November;101(3):206-23.
4. Ben SD, Mostofsky SH, Hazlett RL et al. Normal physiological emotions but differences in expression of conscious feelings in children with high-functioning autism. ***J Autism Dev Disord*** 2006 April;36(3):395-400.
5. Blair RJR. Responding to the emotions of others: dissociating forms of empathy through the study of typical and psychiatric populations. ***Conscious Cogn*** 2005 December;14(4):698-718.
6. Dadds MR, El MY, Wimalaweera S, Guastella AJ. Reduced eye gaze explains "fear blindness" in childhood psychopathic traits. ***J Am Acad Child Adolesc Psychiatry*** 2008 April;47(4):455-63.
7. Dalton KM, Nacewicz BM, Johnstone T et al. Gaze fixation and the neural circuitry of face processing in autism. ***Nat Neurosci*** 2005 April;8(4):519-26.
8. de Wied M., van BA, Zaalberg R, Goudena PP, Matthys W. Facial EMG responses to dynamic emotional facial expressions in boys with disruptive behavior disorders. ***J Psychiatr Res*** 2006 March;40(2):112-21.
9. de Wied M., Boxtel AV, Posthumus JA, Goudena PP, Matthys W. Facial EMG and heart rate responses to emotion-inducing film clips in boys with disruptive behavior disorders. ***Psychophysiology*** 2009 September;46(5):996-1004.
10. Dimberg U, Thunberg M, Elmehed K. Unconscious facial reactions to emotional facial expressions. ***Psychol. Sci.*** 2000 Jan;11(1):86-9.
11. Ekman P, Friesen WV. ***Pictures of facial effect.*** Palo Alto, CA: Consulting Psychologists Press; 1976.
12. Fairchild G, Van Goozen SH, Calder AJ, Stollery SJ, Goodyer IM. Deficits in facial expression recognition in male adolescents with early-onset or adolescence-onset conduct disorder. ***J Child Psychol Psychiatry*** 2009 May;50(5):627-36.
13. Kuusikko S, Haapsamo H, Jansson-Verkasalo E et al. Emotion recognition in children and adolescents with autism spectrum disorders. ***J Autism Dev Disord*** 2009 June;39(6):938-45.
14. Lorber MF. Psychophysiology of aggression, psychopathy, and conduct problems: a meta-analysis. ***Psychol Bull*** 2004 July;130(4):531-52.
15. Marsh AA, Blair RJ. Deficits in facial affect recognition among antisocial populations: a meta-analysis. ***Neurosci Biobehav Rev*** 2008;32(3):454-65.
16. Marsh P, Beauchaine TP, Williams B. Dissociation of sad facial expressions and autonomic nervous system responding in boys with disruptive behavior disorders. ***Psychophysiology*** 2008 January;45(1):100-10.
17. Norbury CF, Brock J, Cragg L, Einav S, Griffiths H, Nation K. Eye-movement patterns are associated with communicative competence in autistic spectrum disorders. ***J Child Psychol Psychiatry*** 2009 July;50(7):834-42.
18. Oberman LM, Winkielman P, Ramachandran VS. Slow echo: facial EMG evidence for the delay of spontaneous, but not voluntary, emotional mimicry in children with autism spectrum disorders. ***Dev Sci*** 2009 July;12(4):510-20.
19. Ortiz J, Raine A. Heart rate level and antisocial behavior in children and adolescents: a meta-analysis. ***J Am Acad Child Adolesc Psychiatry*** 2004 February;43(2):154-62.
20. Sonnby-Borgstrom M. Automatic mimicry reactions as related to differences in emotional empathy. ***Scand J Psychol*** 2002 December;43(5):433-43.
21. van der Geest JN, Kemner C, Verbaten MN, van EH. Gaze behavior of children with pervasive developmental disorder toward human faces: a fixation time study. ***J Child Psychol Psychiatry*** 2002 July;43(5):669-78.

22. Woodworth M, Waschbusch D. Emotional processing in children with conduct problems and callous/unemotional traits. ***Child Care Health Dev*** 2008 March;34(2):234-44.

23. Wright B, Clarke N, Jordan J et al. Emotion recognition in faces and the use of visual context in young people with high-functioning autism spectrum disorders. ***Autism*** 2008 November;12(6):607-26.