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Emotion versus cognition: differential pathways to theory of mind for children with high versus low callous-unemotional traits

Running Head: CU traits and differential pathways to theory of mind

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Background: Theory of Mind (ToM) serves as a foundation for developing social cognition. Developmental theory suggests that early emotion understanding supports the development of ToM, but few studies have tested this question within longitudinal designs. Additionally, children with callous-unemotional (CU) traits directly challenge this theory as they develop intact ToM despite apparent deficits in emotion understanding. Inhibitory control is proposed as one possible compensatory mechanism for ToM development in children with high CU traits. **Methods:** We examined emotion understanding and inhibitory control at age 3 as predictors of ToM at age 6, and tested whether these pathways were different in children with high versus low levels of CU traits. Multimethod data included observations of child emotion understanding and inhibitory control and parent-reports of CU traits drawn from a prospective, longitudinal study (*N*=240, 48% female). **Results:** Consistent with our hypothesis, emotion understanding at age 3 significantly predicted ToM at age 6 only for children with low CU traits. Although there was a significant interaction between inhibitory control and CU traits in relation to later ToM, the simple slopes were not significant. **Conclusions:** We find prospective longitudinal evidence that emotion understanding is a developmental precursor of ToM. However, this pathway was not evident in children with high CU traits. Future research is needed to further explore potential mechanisms by which children with CU traits develop ToM with a potential focus on higher-order cognitive skills. **Keywords:** Theory of mind; callous-unemotional traits; emotion understanding; executive function.

Introduction

Theory of Mind (ToM), the understanding of mental states, is a vital social-cognitive skill (Wellman, 2002), deficits in which impair interactions and relationships with others (Baron-Cohen, Leslie, & Frith, 1985). ToM is traditionally operationalized by the false belief task (Wimmer & Perner, 1983), which requires children to predict a character's behavior based on

his/her beliefs about the location of an item despite those beliefs being different to the real location. Children pass this task at around age 4 (Wellman, Cross, & Watson, 2001). However, ToM is broadly conceptualized as knowledge of and reasoning about all mental entities, including emotions, desires, and beliefs, which develops over many years (Wellman, 1990). Indeed, the predominant theory of how ToM develops, "Theory-theory," posits that ToM represents multiple iterative theories about the mind (Gopnik & Wellman, 1994). Thus, even though ToM, as operationalized via the false-belief task, emerges around age 4, children begin to develop theories about emotions, desires, and preferences within the first two years of life (Walker-Andrews & Dickson, 1997; Wellman & Woolley, 1990). Externally observable features indicating emotion or desire are thought to serve as an entry point for children to learn about others' internal states (Wellman & Woolley, 1990). Once children gain a rudimentary, pre-representational knowledge that mental entities exist based on others' external cues, a skill that even toddlers may possess (Scott & Baillargeon, 2017), they transition to understanding and learning about more abstract mental entities (Wellman & Liu, 2004). The earliest manifestations of emotion understanding involve recognizing external emotional faces, with gradual progression towards the recognition of more internal emotions, including mixed or hidden emotions (Harris, De Rosnay, & Pons, 2016). Thus, emotion understanding has been theorized to be one skill that supports the development of ToM in early childhood.

In support of this association, several cross-sectional studies have found that ToM and emotion understanding are significantly correlated in 3-5 year olds (Harwood & Farrar, 2006), 3-8 year olds (Grazzani, Ornaghi, Conte, Pepe, & Caprin, 2018), and 4-6 year olds (Weimer, Sallquist, & Bolnick, 2012). However, the cross-sectional nature of these studies does not allow for an understanding of the temporal nature of these associations. A handful of longitudinal studies provide evidence that early emotion understanding contributes to ToM, although these have been limited by short follow-up periods (O'Brien et al., 2011), assessing children at the earliest time point who were older than 4 years old (i.e., already with ToM capabilities; Hughes & Dunn, 1998), or assessing children at the final time point who were only just 4 years old (i.e., ToM still developing; LaBounty, Wellman, Olson, Lagattuta, & Liu, 2008). Thus, there remains a significant gap in our knowledge of how emotion understanding specifically contributes to emerging ToM, particularly using longitudinal designs beginning at an age young enough to capture emotion understanding before the onset false belief and followed-up at an age when ToM

skills may be more crystallized. The first aim of the current study was to address this gap in the literature by examining how individual differences in observed emotion understanding at age 3 were related to individual differences in observed ToM at age 6, controlling for rudimentary ToM at age 3.

Callous-unemotional traits

Extant literature examining the link between emotion understanding and ToM has focused largely on typically developing children (Wellman, 2014). However, a subgroup of children with callous-unemotional (CU) traits present a conundrum to the hypothesized relationships between emotion understanding and ToM. CU traits are defined by a lack of empathy or guilt, uncaring about school work or other important activities, and reduced emotional responsivity to others (Frick, Ray, Thornton, & Kahn, 2014). CU traits can be reliably measured in children as young three years old (for recent reviews see Waller & Hyde, 2017, 2018). Importantly, the presence of CU traits robustly predicts risk for more severe forms of aggression and rule-breaking across childhood (Frick et al., 2014), making CU traits a critical target of investigation for reducing these harmful outcomes.

Interestingly, studies have consistently shown that children with CU traits do not perform differently from their typically developing peers on ToM tasks, including higher-order cognitive perspective-taking tasks, at ages 7-11 years old (Anastassiou-Hadjicharalambous & Warden, 2008) or 9-16 years old (Jones, Happé, Gilbert, Burnett, & Viding, 2010). Further, functional magnetic resonance imaging studies have demonstrated that children aged 6-17 with CU traits show similar neural activation patterns to typically developing children during ToM tasks (O'Nions et al., 2014; Sebastian et al., 2012). These findings are surprising because children with CU traits as young as 3 years old show deficits in emotion recognition (Kimonis et al., 2016), affective perspective-taking (Lui, Barry, & Sacco, 2016), and empathy (Waller, Hyde, Grabell, Alves, & Olson, 2015). Thus, children with CU traits present a challenge to the proposed typical development model, leaving an important question of whether there exist other potential mechanisms through which ToM develops that can be identified in these children.

Inhibitory control and pathways to ToM

A preponderance of cognitive, rather than emotional, skills represents one possible alternative mechanism that children with CU traits could recruit to successfully develop ToM. Typically-developing children are motivated to develop their social-cognitive skills to foster positive peer relationships (Denham, 2007), which often occur within an emotional context (Halberstadt, Denham, & Dunsmore, 2001). An affective mechanism therefore makes sense. In contrast, children with CU traits may develop social cognitive skills in order to achieve goals like dominance and status (Pardini & Byrd, 2012). Thus, their metacognitive understanding of the social world could hinge on a different entry point, namely observation and cognitive understanding of others' behavior. Consistent with a social information processing framework (Crick & Dodge, 1994), which suggests that children encode social information by processing, representing, and interpreting situational cues, children with CU traits may attain ToM by adopting cognitive strategies that focus on the behavioral, as opposed to emotional, responses of peers. Indeed, prior research suggests that executive function skills, including inhibitory control, contribute to the development ToM, because children need to inhibit their own beliefs and knowledge in order to better understand the beliefs of others (Carlson, Moses, & Breton, 2002). Importantly, unlike children with high levels of externalizing problems and low CU traits, children with CU traits do not show deficits in cognitive skills, including IQ, executive functions, and social problem solving (Feilhauer & Cima, 2013; Salekin, Neumann, Leistico, & Zalot, 2004; Waschbusch, Walsh, Andrade, King, & Carrey, 2007). Thus, cognitive processing and inhibitory control skills may represent important compensatory mechanisms through which they are able to develop intact ToM. However, to our knowledge no prior investigators have tested this hypothesis.

Current study

Our overarching goal was to test the theory that emotion understanding supports the development of ToM. Importantly, we also sought to test whether this relationship is specific to children with low CU traits relative to children high on CU traits. Moreover, we examined inhibitory control as a potential mechanism through which children high on CU traits develop intact ToM. We focused on ages 3 and 6. Beginning at age 3 allowed us to capture emotion understanding and inhibitory control when they can be reliably tested (Denham, 1986; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996) but before onset of false belief

(Wellman et al., 2001), allowing for a clearer examination of their contributions to ToM, especially relative to other studies that have employed cross-sectional designs. We hypothesized that, for children with low CU traits, emotion understanding at age 3 would be related to ToM at age 6, but that for children with high CU traits, emotion understanding would be unrelated to ToM. We further hypothesized that inhibitory control at age 3 would be more strongly related to ToM at age 6 among children with high CU traits.

Methods

Participants

Participants were 240 children (118 girls) and their parents who were part of an ongoing longitudinal study of young children at risk for conduct problems (Olson & Sameroff, 1997). 95% of families were recruited from newspaper announcements and fliers sent to daycare centers and preschools; the rest were referred by preschool teachers and pediatricians (Choe, Lane, Grabell, & Olson, 2013). Screening questionnaires and telephone interviews were used to determine appropriateness for participation and to obtain consent. Recruited children represented the full range of externalizing symptom severity on the Child Behavior Checklist (Achenbach, 1992), with intentional oversampling of children in the upper range of the Externalizing Problems subscale (see Olson, Sameroff, Kerr, Lopez, & Wellman, 2005 for more detail). The majority of children were of European American heritage (86%), with others self-identifying as African American (5%) or biracial (8%). Most mothers were married (89%), 3% lived with a partner, 5% were single, and 3% were divorced. Median annual family income was $52,000 (range=$20,000-$100,000). The current study utilizes two time points; children were 3 years old at Time 1 (*M*=41.41, *SD*=2.09 months) and 6 years old at Time 2 (*M*=68.81, *SD*=3.84 months). Retention from Time 1 to 2 was high (88%) and families who dropped out did not differ on target or sociodemographic variables (Olson, Lopez-Duran, Lunkenheimer, Chang, & Sameroff, 2011).

Measures

Child emotion understanding (observed). At age 3, emotion understanding was assessed via three tasks, one of which had two components (i.e., 4 tasks total), and each enacted with a puppet (Denham, 1986). Children had to identify one of four emotions, predict the emotion that the

puppet would express, and demonstrate an understanding that the puppet could express an emotion different to the child's own experienced emotion. See Appendix S1 in the Supporting Information for more details. Children received two points for correctly identifying emotions, one point for recognizing emotional valence, and zero points for incorrect responses or no response. Following Denham (1986), a composite emotion understanding score was created by summing scores across the four tasks (α=.70). Based on a random 15 protocols, reliability of scoring was 100% (Waller et al., 2015).

Child inhibitory control (observed). At age 3, children completed six tasks from Kochanska et al.'s (1996) toddler-aged battery (turtle/rabbit, whisper, tongue, tower, lab gift, and delay; see Appendix S1). Fifteen tests were randomly selected to be independently scored, with excellent reliability (*mean kappa*=.95, range = .92-.98; see Kochanska et al., 1996; Olson et al., 2005). As recommended by Kochanska et al. (1996), total inhibitory control scores were computed by summing individual subtest scores (α=.70; Olson et al., 2005).

Child observed ToM (observed). At ages 3 and 6, ToM was assessed using the "False Belief Prediction and Explanation Tasks-Revised" (Bartsch & Wellman, 1989). Two tasks examined children's prediction and explanation of the choices of hypothetical protagonists who received erroneous information about the location of objects after locations were switched. To ensure this task captured meaningful variability at age 6, children had to not only *predict* where the protagonist would look for the object but also *explain* why the protagonist searched incorrectly. ToM total scores were computed by summing correct predictions and explanations. Scoring reliability (based on a random 15 children) was 97%. Disagreements were settled through consultation with a team leader, an expert in ToM assessment (Henry Wellman). Reliability for ToM scores was good at both age 3 (α = .71; Song, Waller, Hyde, & Olson, 2016) and age 6 (α = .68; Lane, Wellman, Olson, LaBounty, & Kerr, 2010).

CU traits. Mothers completed the Child Behavior Checklist (Achenbach, 1992) at age 3. The CBCL is a 99-item measure of behavioral and emotional problems. Items describe behavior of the children over the previous two months using a three-point scale (0=not true, 1=somewhat or sometimes true, 2=very true or often true of the child). Consistent with previous studies

(Willoughby, Waschbusch, Moore, & Propper, 2011), the CU traits scale was computed as the sum of five items, an approach that was previously validated in the current sample and shown to factor separately from other externalizing dimensions (i.e., ADHD and opposition/defiance, Waller et al., 2015). The reliability of the mother-reported CU traits scale was low (α=.59), but consistent with previous studies using the same five CU behavior items (α=.55 Willoughby, Mills-Koonce, Gottfredson, & Wagner, 2014; α=.65 Willoughby et al., 2011). To gain a fuller picture of the moderating effects of CU traits in this non-clinical sample, we analyzed the presence and/or level of CU traits via two methods. First, we computed a binary CU traits score coding the presence or absence of CU traits consistent with other clinical and diagnostic frameworks (e.g., DSM-5; American Psychiatric Association, 2013). Specifically, children who scored 0 (i.e., no symptoms) or 1 (i.e., only 1 of the five symptoms present somewhat/sometimes) were coded as the "low CU traits" group (55.9%), whereas children who scored 2 or more, were coded as "high CU traits" (44.1%). Second, we examined CU traits as a continuous moderator. We present findings from both approaches.

Covariates

Parents answered questions relating to child gender, age, and family income. Children's language functioning was assessed using the Vocabulary subtest of Wechsler's Preschool and Primary Scale of Intelligence-Revised (Wechsler, 1989). To isolate differential pathways based on CU traits, we also included scores on the six-item ADHD scale and the six-item ODD scale of the parent- and teacher-reported CBCL 2-3 (Achenbach, 1992) as covariates. Lastly, because our target outcome variable was ToM at age 6, observed ToM at age 3 was included as a covariate to ensure any relationships were due to the unique effects of emotion understanding or inhibitory control over and above stability in any early rudimentary ToM skills.

Analytic strategy

We used hierarchical multiple regression to examine whether emotion understanding and inhibitory control at age 3 predicted ToM at age 6, and whether these effects were contingent on the level of child CU traits. To examine the different pathways, we included the main effects of emotion understanding, inhibitory control, and CU traits and two-way interaction terms for "CU traits x emotion understanding" and "CU traits x inhibitory control". (Note that the three-way

interaction of "CU traits x emotion understanding x inhibitory control" and the two-way interaction of "inhibitory control x emotion understanding" were not significant and did not change the pattern of significance so were dropped from the model for reasons of parsimony; see Table S1). We probed significant interactions by examining simple slopes for children with low versus high CU traits (binary) and low, mean, and high levels of CU traits (continuous) (Preacher, Curran, & Bauer, 2006). Importantly, we included covariates to establish that effects were specific to age 3 emotion understanding, inhibitory control, and CU traits. Results were unchanged following the inclusion of gender, family income, ADHD and ODD symptoms, and age 3 ToM. The model was tested in Mplus vs. 8.0 (Muthén & Muthén, 2017) using maximum likelihood estimation (MLR). While the amount of missing data was low (*covariance coverage*=.76-.98), MLR estimation accommodates and produces unbiased estimates in the presence of missing data (Enders & Bandalos, 2001).

Results

Bivariate associations

Descriptive statistics and bivariate correlations are presented in Table 1.

Emotion understanding and pathways to ToM. Consistent with our hypotheses, emotion understanding at age 3 was significantly related to ToM at age 6 (see Tables 1 and 2; Figure 1; See Supplemental Tables S2-S3 for models including covariate effects and see Tables S4-S7 & Figures S1-S3 for a breakdown of effects for individual emotion understanding tasks). Further, consistent with our hypotheses, there was a significant interaction with CU traits at age 3 for both binary and continuous scoring approaches (see Table 2). To probe this interaction, we examined simple slopes and regions of significance (Preacher et al., 2006). We found that for both scoring approaches, emotion understanding was related to ToM only among children with low CU traits (binary: B=0.61, SE=0.21, p=0.003; continuous: B=0.43, SE=0.20, p=0.03) but not high or mean levels of CU traits (binary: high, B=-0.24, SE=0.39, p=0.54; Figure 2A. Continuous: mean, B=0.19, SE=0.16, p=0.22, high, B=-0.04, SE=0.21, p=0.84; Figure 2B).

Regions of significance analyses indicated that in the binary approach, children with low CU traits had better ToM than children with high CU traits at high levels of emotion understanding, but worse ToM at low levels of emotion understanding. In the continuous approach, the regions of significance indicated that children with low CU traits had significantly worse ToM than children with high CU traits at low levels of emotion understanding, but the slopes did not differ from each other at high levels of emotion understanding.

Inhibitory control as a mechanism of developing ToM. There was no significant main effect of inhibitory control at age 3 on ToM at age 6 (Table 2). Although there were significant interactions between CU traits (binary- and continuously-scored) and inhibitory control at age 3 in relation to the development of ToM at age 6, probes of the interactions found that simple slopes contingent on the level of CU traits were not statistically significant.

Discussion

Consistent with prior theoretical and empirical work (Gopnik & Wellman, 1994; Hughes & Dunn, 1998; LaBounty et al., 2008; O'Brien et al., 2011), we found that emotion understanding supports the development of ToM. Importantly, emotion understanding at age 3 significantly predicted ToM at age 6 even in a stringent model that controlled for verbal IQ and age 3 ToM. These results lend empirical support to the notion that emotions serve as an entry point to gain a more complex understanding of others' minds. Specifically, children may first develop the ability to recognize emotion faces (Walker-Andrews & Dickson, 1997), which allows them to understand and predict emotional responses to external cues (e.g., being given a present makes someone smile). This assertion is supported by Appendix S2 establishing a similar pattern of findings among the subscales of the overall emotion understanding composite, including the ability to understand emotion facial expressions and stereotypical emotional reactions. The argument that external, observable cues are specifically important is strengthened by the non-significance of the component of the task that involves predicting non-stereotypical emotional reactions. Linking emotions to *external* cues allows children to begin to recognize the emotions and emotional responses of others to external stimuli (Denham, 1986), prompting children to consider the internal cognitive beliefs of others (Harris et al., 1989). This progression is "Theory-theory" in action (Gopnik & Wellman, 1994); namely that ToM involves multiple theories of

mind, that begin with observable external cues of emotion that iteratively build on themselves to advance children's understanding of complex, internal phenomena centered on thoughts. The current study provides support for this model by associating early emotion understanding with later ToM within a prospective longitudinal design.

Qualification of main effects by CU Traits

Consistent with hypotheses, we found that the relationship between emotion understanding and later ToM was qualified by an interaction with CU traits. Specifically, only children with low CU traits showed this developmental pathway. In contrast, emotion understanding was not related to ToM among children with high CU traits. Indeed, based on the regions of significance, CU traits appeared to be protective against poor ToM among children with low emotion understanding, albeit for five children. Further, we had hypothesized that children high on CU traits might use enhanced inhibitory control as a compensatory mechanism through which to develop ToM. However, while we found a significant interaction between CU traits and inhibitory control at age 3 in relation to ToM at age 6, the simple slopes of the interaction were not significant. One explanation for these findings is that our measure of inhibitory control did not fully assess the cognitive mechanisms that might be more directly responsible for children high on CU traits developing intact ToM, including those linked to children as young as 12 months old inferring unseen states based on others' actions in goal-directed paradigms (see Scott & Baillargeon, 2017 for a review). Nevertheless, the ToM profile observed in children with CU traits may still be a target for early intervention by helping children to integrate emotion understanding into ToM and therefore be less likely to enact relational and proactive aggression or other forms of harmful interpersonal behaviors.

Strengths and limitations

The current study had several strengths, including the use of well-established observational assessments of ToM, emotion understanding, and inhibitory control, and a prospective longitudinal design. Nevertheless, the findings should be considered alongside several limitations. Because participating families were mostly middle-class and white with intact family structures, the generalizability of the findings may be limited to those experiencing relatively low

sociodemographic risk. Second, it is plausible that the association between earlier emotion understanding and later ToM could be picking up on longitudinal bidirectional associations, rather than any causal link. Unfortunately, we did not have a measure of emotion understanding at age 6 to test this alternative pathway, however, prior longitudinal work has suggested that early emotion understanding contributes to later ToM but not vice-versa (e.g. Hughes & Dunn, 1998). Third, the CU traits measure used items not originally developed to assess this construct and has relatively low reliability. Although its predictive and construct validity has been supported by previous studies in the current sample (Waller et al., 2015), future studies are needed that examine pathways to ToM in children with or without CU traits using purpose-developed measures of CU traits, such as the Inventory of Callous-Unemotional Traits (Frick, 2004), which has been utilized in samples of young children and typically shows higher internal consistency (Kimonis et al., 2016). Perhaps because of this, we did not find significant group differences in emotion understanding at age 3 (Table S7). Finally, we used a broad assessment of inhibitory control-type skills, albeit via a widely-used measure (Kochanska et al., 1996). Nevertheless, future studies are needed to examine more specifics indices of sociocognitive skills, cognitive flexibility or manipulation, or executive function (O'Brien & Frick, 1996).

Conclusions and implications

Consistent with theory, our findings strongly support a developmental model where children use emotion understanding to develop theories about behavior and thoughts of others to support the emergence of ToM. Moreover, we demonstrated that children with high CU traits develop their ToM outside of this emotional context, perhaps using other cognitive skills as compensatory mechanisms. Importantly, children with CU traits are unique in showing intact ToM despite deficits in emotion understanding or sensitivity (Dadds et al., 2009; Waller et al., 2015). Thus, emotion understanding represents a developmental marker and potential intervention target to ameliorate harmful pathways to CU traits and more severe forms of aggression (Waller & Hyde, 2017). Further work is needed to better understand ToM in children with CU traits in order to better tailor early interventions to their specific socioemotional skills and understandings of themselves and the people around them.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of this article.

Appendix S1. Supplemental methods.

Appendix S2. Supplemental results.

Table S1. Results of the path model examining main and interactive effects of age 3 emotion understanding, inhibitory control, and CU traits on age 6 ToM.

Table S2. Full results of the path model examining main and interactive effects of age 3 emotion understanding, inhibitory control, and dichotomously-scored CU traits on age 6 ToM.

Table S3. Full results of the path model examining main and interactive effects of age 3 emotion understanding, inhibitory control, and continuously-scored CU traits on age 6 ToM.

Table S4. Results of the path model examining main and interactive effects of age 3 emotion expressive labeling, inhibitory control, and CU traits on age 6 ToM.

Table S5. Results of the path model examining main and interactive effects of age 3 emotion receptive labeling, inhibitory control, and CU traits on age 6 ToM.

Table S6. Results of the path model examining main and interactive effects of age 3 stereotypical emotion understanding, inhibitory control, and CU traits on age 6 ToM.

Table S7. Results of the path model examining main and interactive effects of age 3 non-stereotypical emotion understanding, inhibitory control, and CU traits on age 6 ToM.

Table S8. Comparisons of age 3 emotion understanding between the low and high CU traits groups.

Figure S1. Higher emotion expressive labeling at age 3 predicts higher ToM at age 6 only for children with low CU traits.

Figure S2. Higher emotion receptive labeling at age 3 predicts higher ToM at age 6 only for children with low CU traits.

Figure S3. Higher stereotypical emotion understanding at age 3 predicts higher ToM at age 6 only for children with low CU traits.

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Table 1. Descriptive statistics and bivariate correlations between study variables

	1. Age	2. Income	3. Verbal IQ	4. ToM Age 3	5. ADHD	6. ODD	7. CU Traits	8. EU	9. IC	10. ToM Age 6
1. Age	-									
2. Income	.05	-								
3. Verbal IQ	.07	.09	-							
4. ToM (age 3)	.18**	.08	.28**	-						
5. ADHD (age 3)	-.05	-.02	-.15*	-.11	-					
6. ODD (age 3)	-.05	-.03	-.07	-.03	.58**	-				
7. CU Traits (age 3)	-.14*	-.04	-.09	-.16*	.52**	.46**	-			
8. Emotion Understanding (age 3)	.18**	.18**	.41**	.33**	-.12	-.00	-.08	-		
9. Inhibitory Control (age 3)	.25**	.04	.23**	.33**	-.23	-.09	-.16*	.33**	-	
10. ToM (age 6)	.08	.01	.07	.16*	-.01	.00	-.08	.17*	.20**	-
M	41.4	9.31	11.35	1.59	4.18	4.04	1.48	.00	.00	.00
(SD)	(2.09)	(3.02)	(3.35)	(2.14)	(2.73)	(2.72)	(.50)	(.76)	(.55)	(.55)

Note: Independent-samples t-tests showed that at age 3, girls (M=2.01, SD=2.44) had significantly higher ToM scores than boys (M=1.22, SD=1.77; t=-2.803, p=.006), and that girls (M=.15, SD=.54) had significantly higher inhibitory control scores than boys (M=-.13, SD=.53; t=-3.99, p<.001). See Table S8 for comparisons of age 3 emotion understanding between the low and high CU groups.

Table 2. Results of the path model examining main and interactive effects of age 3 emotion understanding, inhibitory control, and CU traits scored dichotomously (left) and continuously (right)

	Outcome variable: ToM (age 6)							
	Binary-scored CU traits				**Continuously-scored CU traits**			
Predictors (age 3)	***B***	***SE***	***β***	***p***	***B***	***SE***	***β***	***p***
Main effects								
CU traits	-.36	.26	-.12	.17	-.07	2.54	-.02	.77
Emotion Understanding	.63	.20	.29	.002	.20	.16	.10	.20
Inhibitory Control	-.18	.37	-.06	.63	.34	.28	.12	.22
Interaction terms								
CU traits x Emotion Understanding	-.89	.32	-.26	.006	-7.03	3.17	-.22	.03
CU traits x Inhibitory Control	1.14	.49	.26	.02	.30	.13	.21	.02

Note: To account for significant skew, we log-transformed the continuous CU traits score. Results were unchanged including age, sex, income, verbal IQ, earlier ToM at age 3, and ADHD and ODD behaviors at age 3 (Tables S5 and S6)

Figure 1. Higher emotion understanding at age 3 is related to higher ToM at age 6

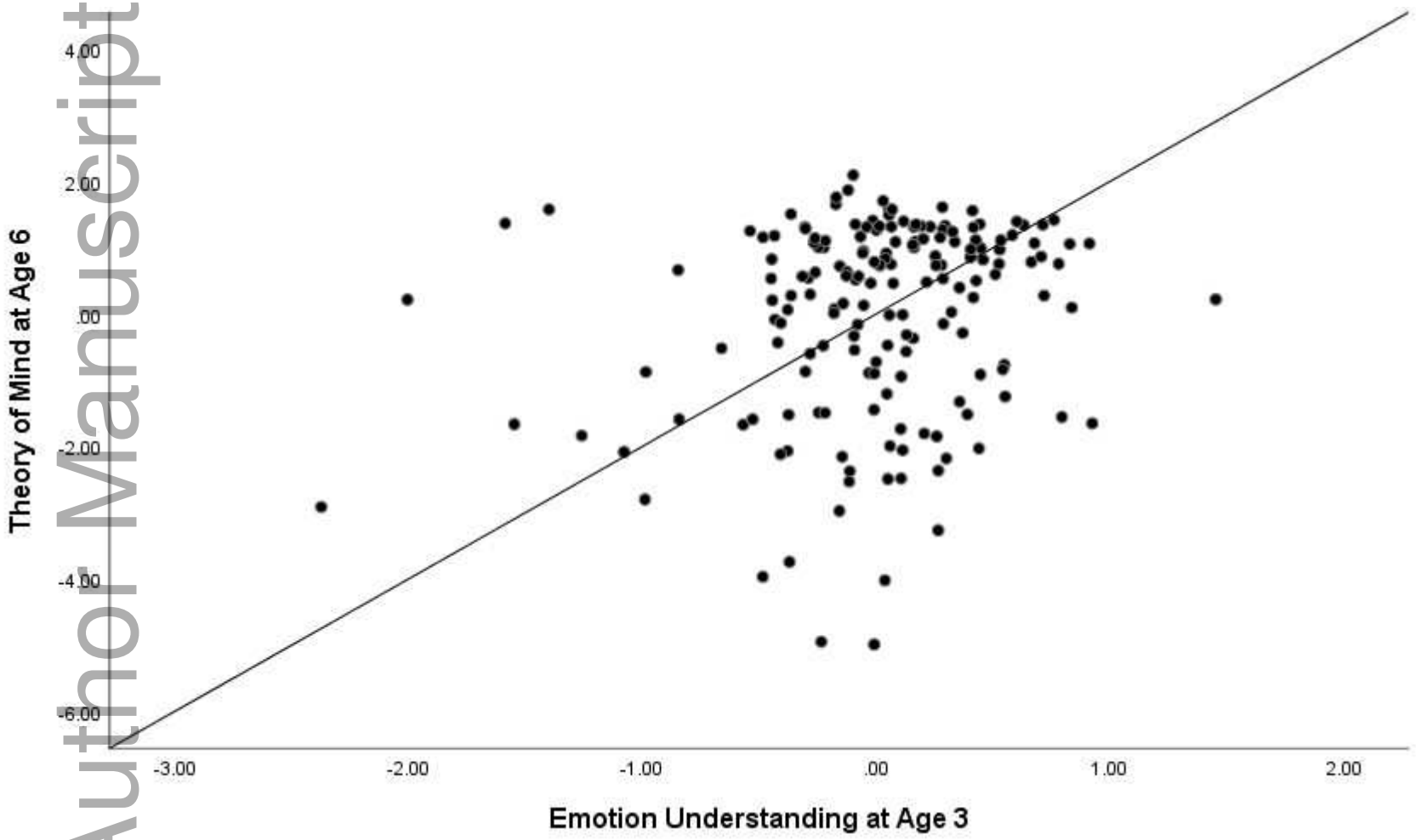
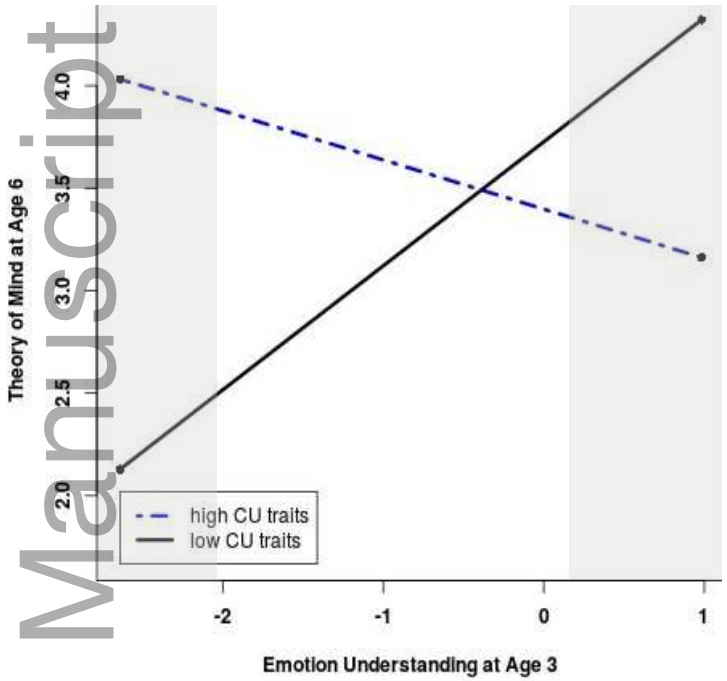
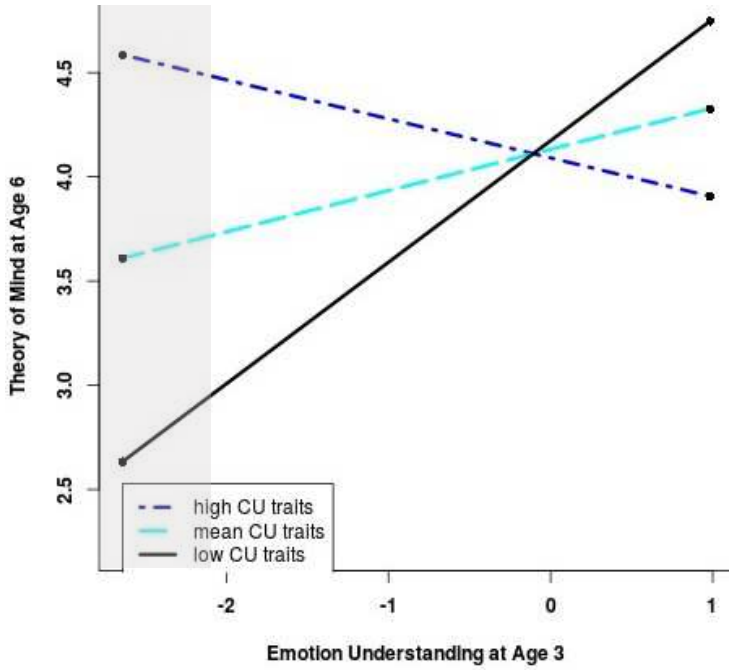


Figure 2A and B. Emotion understanding at age 3 relates to ToM at age 6 only for children with low levels of CU traits

A.



B.



Note. Model A. Age 3 emotion understanding was significantly related to ToM at age 6 at low (*B*= 0.61, *SE*=0.21, *t*=2.93, *p*=0.004) but not high levels of CU traits (*B*=-0.24, *SE*=0.61, *t*=-0.39, *p*=0.70). Regions of sig4nificance shown in gray shading: for low CU children at centered values of emotion understanding below -2.09 and above .23, the simple slopes are significantly different from zero. Model B. Higher age 3 emotion understanding was significantly related to better ToM at age 6 at low (*B*= 0.58, *SE*=0.23, *t*=2.30, *p*=0.01) but not mean (*B*=0.20, *SE*=0.16, *t*=1.28, *p*=0.20) or high levels of CU traits (*B*=-0.19, *SE*=0.23, *t*=-0.81, *p*=0.42). Regions of significance shown in gray shading: low CU children at centered values of emotion understanding below -2.10, the simple slopes are significantly different from zero.

Key points

- Early emotion understanding is thought to support developing Theory of Mind (ToM), but few prospective longitudinal studies have established this association.
- Moreover, children with callous-unemotional (CU) traits challenge the model as they show impairments in emotion understanding but intact ToM.
- We found that emotion understanding at age 3 significantly predicted ToM at age 6, but only for children with low CU traits.
- Findings establish emotion understanding as a support to developing ToM.
- Further work is needed to examine potential cognitive compensatory mechanisms in children with high CU traits.

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