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Interactions between Callous Unemotional Behaviors and Executive Function in Early Childhood Predict later Aggression and Lower Peer-liking in Late-childhood

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Abstract Callous unemotional (CU) behaviors are linked to aggression, behavior problems, and difficulties in peer relationships in children and adolescents. However, few studies have examined whether *early childhood* CU behaviors predict aggression or peer-rejection during *late-childhood* or potential moderation of this relationship by executive function. The current study examined whether the interaction of CU behaviors and executive function in early childhood predicted different forms of aggression in late-childhood, including proactive, reactive, and relational aggression, as well as how much children were liked by their peers. Data from cross-informant reports and multiple observational tasks were collected from a high-risk sample (N = 240; female = 118) at ages 3 and 10 years old. Parent reports of CU behaviors at age 3 predicted teacher reports of reactive, proactive, and relational aggression, as well as lower peer-liking at age 10. Moderation analysis showed that specifically at high levels of CU behaviors and low levels of observed executive function, children were reported by teachers as showing greater reactive and proactive aggression, and were less-liked by peers. Findings demonstrate that early childhood CU behaviors and executive function have unique main and interactive effects on both later aggression and lower peer-liking even when taking into account stability in behavior problems over time. By elucidating how CU behaviors and deficits in executive function potentiate each other during early childhood, we can better characterize the emergence of severe and persistent behavior and interpersonal difficulties across development.

Keywords Antisocial behavior · Callous unemotional · Conduct problems · Executive function · Prevention

Abbreviations
CU callous unemotional

Studies have demonstrated that childhood behavior problems, including aggression and rule-breaking, emerge as early as age 2 (Campbell 1995; Shaw et al. 2003). However, most young children will naturally desist from early behavior problems and aggression (Côté et al. 2006). Thus, the goal of preventative efforts is to identify those children at risk for *stable* behavior problems, particularly behavior problems that persist beyond the preschool years (Dishion et al. 2008). However, these efforts are hampered by heterogeneity in the etiology and treatment responsivity of behavior problems, spurring attempts to classify children with behavior problems into meaningful subgroups and better guide etiological and treatment research (Frick et al. 2014). One approach to identify a subgroup of children at risk for persistent behavior problems has focused on the presence of callous unemotional (CU) traits (Frick et al. 2014). CU traits represent a downward extension of the interpersonal/affective components of psychopathy (Patrick et al. 2007). Measures of CU traits assess empathy and guilt deficits, as well as reduced interpersonal sensitivity (Frick et al. 2014). Across late-childhood and adolescence, CU traits robustly predict behavior problems, including

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violence, theft, and substance use, and are a risk factor for adult psychopathy and antisocial behavior (see Frick et al. 2014). However, most research has focused on CU traits in late-childhood and adolescence, and less is known about its predictive effects beginning earlier in childhood.

Callous-Unemotional (CU) Behaviors in Early Childhood

To address this question, studies have recently begun to examine CU *behaviors* in the preschool period (i.e., around ages 3–5 years old) as risk markers for later CU *traits* (Waller et al. 2015b). The age period of 3–5 years old has emerged as a focal point for understanding the emergence of early CU behaviors, because it heralds rapid transitions in children's physical and cognitive abilities that challenge parents' abilities to respond to and manage corresponding child behaviors (Shaw and Shelleby 2014). Moreover, core characteristics related to CU behavior emerge at ages 2–3 years old, including the capacity for empathic concern (Eisenberg and Fabes 1990), sharing (Fehr et al. 2008), and conscience and rule-compliant behavior (Kochanska 1997). Finally, treatment research suggests that interventions implemented prior to school age, when behavior is potentially more malleable, are particularly efficacious (Reid et al. 2004). Similar to CU traits in adolescence, CU behaviors measured as early as age 3 are uniquely related to lower guilt and empathy (Waller et al. 2015a) and predict later behavior problems (Longman et al. 2016; Waller et al. 2015a). CU behaviors in early childhood also predict CU traits in late childhood (Waller et al. 2016). For example, in a study of 731 low-income youth, early CU behaviors at age 3 predicted CU traits at age 9.5 as assessed by the widely-used Inventory of Callous-Unemotional Traits (ICU; Frick 2004). Moreover, this pathway accounted for other forms of early behavior problems at age 3, the overlap between CU traits and behavior problems at age 9.5, and even informant biases, indicating specific prediction and stability from early CU behaviors to later CU traits (see Waller et al. 2016). Overall, therefore, there is growing evidence for the construct and predictive validity of the CU construct from early to late-childhood (also see Waller et al. 2015b for a review of this literature).

However, while studies have begun to show that CU behaviors assessed at age 3 predict later antisocial behavior, fewer studies exist that have examined specific dimensions of aggression as an outcome. For example, a major distinction in research on childhood aggression is that between aggressive acts that are proactive versus reactive in nature (Dodge and Coie 1987). Based on studies of older children and adolescents, we might expect that early CU behaviors, in addition to predicting more reactive aggression, would be uniquely related to proactive, overt, or planned forms of aggression, as well as relational or interpersonal acts of aggression committed against others a social context (Frick et al. 2003). An important issue in this research is the high correlation between reactive, proactive, and reactive aggression (Polman et al. 2007). Thus, studies investigating the predictive effects of early childhood CU behaviors need to take into account the fact that these different outcomes are correlated, by modeling the overlap between these constructs.

Beyond leading to later aggression, early CU behaviors may also disrupt peer relations. Research among older children suggests that both reactive and proactive forms of aggression are related to bullying and victimization (Salmivalli and Nieminen 2002). Moreover, Camodeca and colleagues suggested that children who bully other children might use proactive or relational aggression to manipulate or coerce others, but may also bullied by others themselves and respond with reactive aggression when victimized (i.e., bully-victims; Camodeca et al. 2002). Thus, early CU behaviors that put children at risk for reactive, proactive, and relational aggression could in turn could make them more likely to become bully-victims and thus, less-liked by their peers. Alternatively, early CU behaviors may signal poor interpersonal skills, low empathy, and uncaring, which make children less liked by others irrespective of potential aggression. However, studies have yet to test whether CU behaviors uniquely predict low peer-liking, taking into account the overlap of low peer-liking with covert and overt forms of aggression.

Executive Function Deficits and CU Behaviors in Early Childhood

Beyond examining CU behaviors alone, we also need to consider the role of other salient factors in early childhood linked to aggression and peer-rejection across development. In particular, executive function, "*a general-purpose control mechanism, often linked to the prefrontal cortex of the brain*" (Miyake and Friedman 2012) is critical to cognitive and social development (Eisenberg et al. 2010). Children who exhibit deficits in executive function from the early preschool to late-childhood period (i.e., ages 3–11), including showing low persistence, high levels of impulsivity, and poor attention regulation, have been shown to have poorer mental health, physical health, and social outcomes 30 years later as adults when compared to children with better executive function (Moffitt et al. 2011). Deficits in executive function are also robustly related to aggressive behavior in older children and adolescents (Morgan and Lilienfeld 2000). Similar to CU behaviors which are related to developmental milestones in the preschool period, improvements and growing stability in executive function and effortful control are evident from ages 3–5 years old (Jacques and Zelazo 2001; Kochanska et al. 2000), enabling children to regulate their thoughts, emotions, and

actions. This literature highlights early childhood as a critical time to examine the predictive effects of executive function. In support of this notion, longitudinal studies beginning in early childhood have shown that poor executive function predicts negative peers exchanges (Hay et al. 2004), poor emotion regulation (Kochanska et al. 2000), externalizing problems (Olson et al. 2005), worse social understanding (Hughes et al. 2000), and lower social competence (Spinrad et al. 2006).

However, studies have yet to examine whether early childhood CU behaviors or executive function deficits uniquely predict later aggression or low peer-liking once their overlap is taken into account. Moreover, no studies have examined how CU behaviors and executive function deficits *interact* in early childhood. One possibility is that the combination of high CU behaviors and low executive function increases risk for later aggression. In contrast to this prediction, two studies of older children and adolescents have reported an intriguing interaction in which high CU behaviors and *high* executive function predicted higher risk for future violence (Baskin-Sommers et al. 2015; Muñoz et al. 2008). An explanation of these findings is that the enhanced cognitive control and working memory afforded by better executive function enables youth with CU behaviors to implement more effective strategies to obtain their desired goals (Baskin-Sommers et al. 2015). Thus, studies are needed to test whether these similar differential predictive effects exist for the interaction of early childhood CU behaviors and executive function. In particular, high CU behaviors and *low* executive function might predict aggression that is in response to provocation or threat (i.e., reactive aggression), consistent with evidence suggesting reactively aggressive children tend to be emotionally dysregulated and demonstrate social information processing deficits (Shields & Cicchetti, 1998). In contrast, the combination of high CU behaviors with high executive function may specifically predict aggression that takes planning prior to implementation (i.e., proactive aggression) or that requires social manipulation of others (e.g., relational aggression, peer-liking).

Current Study

The current study aims to address a number of gaps in our knowledge about how CU behaviors and executive function interact in early childhood to predict different dimensions of aggression and peer-liking in late-childhood. Adopting a multi-method, multi-informant approach, we assessed unique and interactive effects of parent-reported CU behaviors and observed executive function at age 3 on teacher-reported proactive, reactive, relational aggression, and peer-liking at age 10 (Fig. 1). By using observed and parent-reported measures in early childhood to assess the predictors, we could minimize the risk that shared method variance inflated the magnitude of effects found for the prediction of teacher-reported outcomes in late-childhood at age 10. We focused on late-childhood as a critical time to study aggression and peer-liking prior to the onset of more severe forms of delinquency in adolescence (Moffitt 1993). Consistent with prior literature, we hypothesized that early CU behaviors would predict higher aggression and lower peer-liking. We also hypothesized that executive function deficits would specifically predict higher reactive aggression. Finally, based on findings from studies of older children and adolescents (Baskin-Sommers et al. 2015), we anticipated divergence in the predictive effects of CU behaviors depending on the level of executive function. Thus, we hypothesized that the interaction of high CU behaviors and low executive function would predict more reactive aggression and lower peer-liking. In contrast, we hypothesized that the interaction of high CU behaviors and *high* executive function would predict more proactive and relational aggression.

Methods

Participants

Participants were 240 children (118 girls) part of a longitudinal study of young children at risk for school-aged conduct problems (Olson et al. 2005). Families were recruited through preschools, newspaper advertisements, and pediatrician referrals. Once parents indicated interest in participating, a screening questionnaire and short telephone interview were conducted to explain the study procedure and determine eligibility of the family. Children with serious health problems, mental retardation, or pervasive developmental disorders were excluded. Children represented the full range of externalizing symptom severity on the Child Behavior Checklist 2–3 (CBCL/2–3) (Achenbach 1992), with an oversampling of toddlers in the medium high to high range of the Externalizing Problems scale ($T > 60$; 44 %). The study consisted of two time points: children were aged 3 at time 1 and 10 at time 2 ($M = 125.52$, $SD = 7.20$ months). Families self-identified as European American (85 %), as well as 5 % self-identifying as African American, 8 % biracial, and 2 % other racial-ethnic groups. Income was recoded as a semi-continuous variable for inclusion as a covariate in models on a 13-point Likert scale (1 = < $10,000; 7 = $40,000–50,000; 13= > $100,000). The median family income was $52,000. At time 1, mothers and fathers answered questionnaires about demographic information and child behavior. At time 2, 91 % of families continued to participate in the study. Families who left the study did not differ on any measures, except that they reported a lower average annual income than families who remained in the study ($p < .05$). Thus, family income was included as a covariate

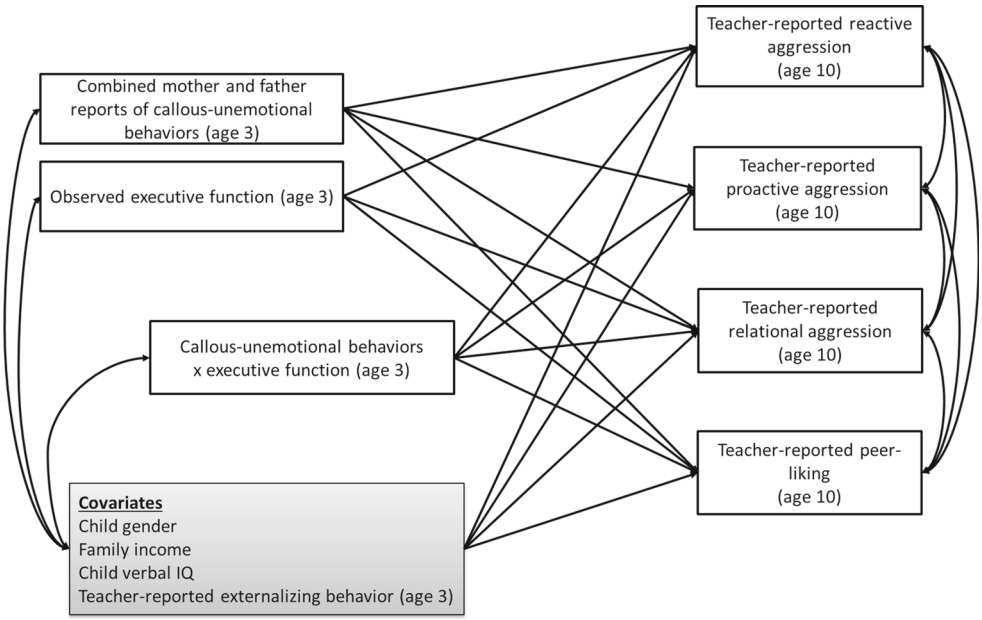

Fig. 1 Multivariate model tested to examine unique main and interactive effects of CU behaviors and executive function at age 3 on teacher-reported reactive, proactive, and relational aggression, and peer-liking at age 10

Note. We examined the main effects and two-way interaction of CU behaviors and executive function simultaneously in a single model. We modeled the covariance of outcome variables because of their correlation, which allowed us to test unique pathways from CU behaviors and executive function after taking into account this overlap. We also included pathways to account for the effects of covariates on predictor and outcome variables in the model: child gender and verbal IQ, family income, and teacher-reported externalizing behavior at age 3.

in all analyses (see Olson et al. 2005 for more details about this sample).

Procedures

This study was approved by the Institutional Review Board at the University of Michigan. Written consent was obtained from parents and teachers and verbal assent was obtained from the children. At times 1 and 2, children were observed during a laboratory session at a preschool while completing a series of cognitive and self-regulatory tasks (Olson et al. 2005). Parents completed questionnaires to assess children's behavioral adjustment in homes and given $100 for participation. In the current study, preschool teacher reports were included (time 1, 88 %; time 3, 83 %). Teachers were given gift certificates for participating.

Measures

CU Behaviors (Age 3; Parent-Reported) Mothers and fathers completed the Child Behavior Checklist for ages 2–3 (Achenbach and Rescorla 2000), a widely-used 99-item measure of child behavior using a 3-point scale (0 = *not true*; 1 = *somewhat or sometimes true*; 2 = *very true or often true of the child*). CU behaviors were assessed using a five-item measure ("shows lack of guilt after misbehavior", "seems unresponsive to affection", "shows too little fear", "punishment doesn't change behavior" and "shows a lack of affection to others"), previously shown to factor separately from other dimensions of externalizing behavior (i.e., oppositional and attention-deficit behaviors) in five independent samples of children during the age period from 2 to 4 years old, including in the current sample (Kimonis et al. 2014; Waller et al. 2015a, b; Willoughby et al. 2011; Willoughby et al. 2014). Moreover, in support of its construct and predictive validity, CU behaviors as measured with these items have been uniquely related to lower parent-reported moral regulation, empathy, and guilt (Waller et al. 2015a), and predicted more teacher-reported externalizing problems at ages 6 (Waller et al. 2015a) and 10 (Song et al. 2015) within the current sample. To create a valid cross-informant measure of early CU behaviors, we computed the mean of items across mother and father reports (r = .35, p < .01; combined measure, α = .66). The internal consistency for our CU behaviors measure is consistent with previously reported alphas by other studies using the same items (e.g., α = .55; Willoughby et al. 2014).

Observed Executive Function (Age 3; Observed) Executive function was assessed using six tasks from a toddler-age behavioral battery developed by Kochanska et al. (1996). Lower scores on executive function as assessed by these tasks have been shown to correlate with externalizing behavior problems in both this (Olson et al. 2005) and other samples (e.g., Kochanska et al. 1996). In brief, the six tasks were: *(1) the turtle and rabbit game* assessing the child's ability to slow

down motor activity; *(2) the tower task* assessing the child's ability to suppress and initiate activity in response to a signal; *(3) the whisper task* assessing the child's ability to lower his/her voice, and *(4) the delay test*, *(5) tongue task*, and *(6) lab gift task*, which assessed the child's ability to suppress a reward-related action. As recommended by Kochanska et al. (1996), a total score was computed by summing standardized individual subtest scores across the six tasks (α = .70). To provide a check on accuracy of recording, 15 test administrations were videotaped and independently scored. Reliability was excellent (*mean* k = .95, range = .92–.98; see Olson et al. 2005 for more details).

Teacher-Reported Aggression (Age 10) Teachers completed a questionnaire that combined items from the Inventory of Peer Relations (Dodge and Coie 1987) and items from the Children's Social Behavior Scale-Teacher Form (CSBS-TF; Crick, 1996). The Inventory of Peer Relations includes 20 items on a 5-point scale (1 = *never true*; 5 = *always true*) and provides measures of reactive ("when teased or threatened, this child gets angry easily and strikes back"; α = .90) and proactive ("this child threatens or bullies others in order to get his/her way"; α = .89) aggression. In addition, teachers completed the 7-item relational aggression subscale of Crick's (1996) Children's Social Behavior Scale-Teacher Form (CSBS-T) (e.g., "this child spreads rumors or gossips about peers"). The CSBS-T showed high internal consistency (α = .93).

Teacher-Reported Peer-Liking (Age 10) Teachers provided ratings of how much children were liked by peers using a 6-item subscale from the Inventory of Peer Relations (Dodge and Coie 1987). Items assessed the teacher's perception of how much classmates accepted and liked the child (e.g., "this child is accepted by their peer group" and "other children like this child and seek him/her out for play"). The scale showed high internal consistency (α = .92).

Covariates At time 1, information on child gender and family income was collected via parent interview, and children's verbal IQ was assessed with the Vocabulary subtest of Wechsler's Preschool and Primary Scale of Intelligence-Revised (Wechsler, 1989). We included these covariates to control for potential effects of these variables on later aggression or peer-liking. In order to more stringently examine the main and interactive effects of early CU behaviors and observed executive function at age 3 on teacher-reported and observed outcomes later in childhood, we controlled for earlier teacher-reported externalizing behavior at age 3 using the Caregiver/Teacher Report Form, Ages 2–5 (Achenbach, 1997) (α = .96). We removed the three items that overlapped with the CU behaviors scale from this measure.

Analytic Strategy

To account for the overlap of predictor and outcome variables and reduce the need to account for multiple comparisons, we tested a single multivariate model within a structural equation modeling framework to test unique and interactive effects of age 3 CU behaviors and executive function on teacher-reported proactive aggression, reactive aggression, relational aggression, and peer-liking at age 10. We included a two-way interaction term ("CU behaviors x executive function") in the model (Fig. 1). We probed significant interactions at mean levels and 1*SD* above and below the mean for executive function (Aiken and West 1991; Preacher et al. 2006). We accounted for the effects of the following covariates: child gender and verbal IQ, family income, and teacher-reported externalizing behavior at age 3. We ran the model using maximum likelihood estimation with standard errors and a chi-square statistic that are robust to non-normality (MLR) in Mplus 7th edition (Muthén and Muthén 2012). Although the amount of missing data across waves was low (covariance coverage = .65–.98), MLR estimation accommodates missing data and has been shown to produce unbiased estimates even in the presence of missing data (Enders and Bandalos 2001).

Results

Bivariate Associations

Descriptive statistics and bivariate correlations are presented in Table 1**.** Higher parent-reported CU behaviors at age 3 showed modest-moderate bivariate correlations with teacher-reported reactive, proactive, and relational aggression and peer-liking at age 10 (range, *r*s = .20–.38, $p < .01$). Lower observed executive function at age 3 was also correlated with reactive (r = .18 $p < .05$) and proactive (r = .20, $p < .05$) aggression at age 10. There were modest-moderate correlations between male gender and teacher-reported externalizing ($r = .17, p < .05$) and lower observed executive function at age 3 ($r = -.26, p < .001$), as well as teacher-reported reactive and proactive aggression at age 10 (range, r = .15–.19, $p < .05$). The correlations between teacher-reported reactive, proactive, and relational aggression and peer-liking at age 10 (range, *r*s = .42–.64, $p < .001$) reinforced the need to employ a multivariate framework to examine unique pathways (Table 2). Because of the modest-moderate correlations between age 3 teacher-reported externalizing and age 10 teacher-reported outcomes (range, *r*s = .20–.40, $p < .05$), we controlled for this earlier measure to account for autoregressive effects and assess unique effects of CU behaviors and executive function.

Table 1 Descriptive statistics and bivariate correlations between study variables

			Covariates			Predictors			Outcomes		
	N	*M (SD)*	Child gender	Family income	Child verbal IQ	Ext. behavior	CU behaviors	Executive function	Reactive aggression	Proactive aggression	Relational aggression
Covariates (age 3)											
Child gender	240										
Family income	235		−.12†								
Child verbal IQ	226	11.35 (3.35)	.04	.09							
Externalizing behavior (T)	188	9.34 (11.39)	−.17*	−.21**	−.09						
Predictors (age 3)											
CU behaviors (P)	235	.29 (.27)	−.07	−.05	−.12†	15*					
Executive function (O)	228	.00 (.55)	.26***	.04	.23**	−.27***	−.23*				
Outcomes (age 10)											
Reactive aggression (T)	194	4.90 (2.85)	−.15*	−.17*	.09	.40***	.38***	−.18*			
Proactive aggression (T)	194	3.48 (1.18)	−.19**	−.08	.11	.38***	.27***	−.20**	.70***		
Relational aggression (T)	193	10.10 (4.66)	.06	.05	.04	.20*	.20**	−.09	.61***	.64***	
Peer-liking (T)	194	25.38 (4.23)	−.04	.03	.05	−.23**	−.20**	.08	−.58***	−.46***	−.42***

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$. P = parent-reported; T = teacher-reported; O = observed

Multivariate Model

Reactive Aggression As hypothesized, CU behaviors at age 3 uniquely predicted more reactive aggression ($\beta = .39$, $p < .001$). Although there had been a significant zero-order correlation, there was no significant main effect of executive function after accounting for the main effect of CU behaviors within the multivariate model (Table 2). However, there was a significant interaction between CU behaviors and executive function predicting reactive aggression ($\beta = -.27$, $p < .001$). Higher levels of age 3 CU behaviors were related to higher age 10 teacher-reported reactive aggression at low (B = 5.89, SE = .95, $p < .001$) and mean (B = 3.62, SE = .74, $p < .001$) levels of executive functioning, but not high levels (B = 1.32, SE = .94, $p > .16$) (Fig. 2).

Proactive Aggression Consistent with findings for reactive aggression, there was a main effect of higher CU behaviors at age 3 on higher proactive aggression at age 10 ($\beta = .22$, $p < .01$). Moreover, CU behaviors and executive function interacted to predict proactive aggression ($\beta = -.22$, $p < .05$). CU behaviors at age 3 predicted higher proactive aggression at age 10 at low (B = 1.73, SE = .36, $p < .001$) and mean (B = .96, SE = .28, $p < .001$) levels of executive functioning, but not at high levels of executive functioning (B = .18, SE = .35, $p > .61$; Fig. 3).

Relational Aggression CU behaviors at age 3 predicted relational aggression at age 10 ($\beta = .27$, $p < .01$). There was also a main effect of gender, such that girls had significantly higher relational aggression than boys ($\beta = .28$, $p < .05$). However, there was no main effect of executive function and no interactions between CU behaviors, executive function, or gender.

Peer-Liking Overall, there was a main effect of higher CU behaviors, but not executive function, on lower peer-liking ($\beta = -.17$, $p < .05$). There was also a significant interaction between CU behaviors and executive function ($\beta = .37$, $p < .001$). Higher CU behaviors at age 3 predicted *lower* peer liking at age 10 at low (B = −5.98, SE = 1.80, $p < .01$) and mean (B = −2.71, SE = 1.34, $p < .05$) levels of executive function, but not at high levels of executive function when children appeared to be more liked by peers (B = .56, SE = 1.79, $p > .50$; Fig. 4).

Discussion

The current study examined the effects of early childhood CU behaviors and executive function on a range of outcomes in late-childhood. Consistent with our hypotheses, we demonstrated unique, main effects of CU behaviors on later reactive, proactive, and relational aggression, although for proactive and reactive aggression these effects were qualified by interactions with executive function, in that high executive function protected against the effect of CU behaviors on outcomes. We also found an interaction between CU behaviors and executive function in the prediction of peer-liking: children high on CU behaviors were more liked when they had high executive function, but less liked when they had mean or low levels of executive function. These findings from a prospective longitudinal study using multi-method measures establish that the combination of early CU behaviors and executive function deficits predict poor adjustment across childhood particularly in relation to aggression and peer rejection.

Table 2 Results of single path model examining main and interactive effects of gender, CU behaviors at age 3, and executive function at age 3 on aggression and peer-liking at age 10, accounting for child gender, age, verbal IQ, family income, and earlier externalizing behavior problems

	Outcome variables (modeled simultaneously; see Fig. 1)							
	Reactive aggression (age 10)		Proactive aggression (age 10)		Relational aggression (age 10)		Peer-liking (age 10)	
	B (SE)	β	B (SE)	β	B (SE)	β	B (SE)	β
Covariates								
Family income	−.09 (.06)	−.10	−.003 (.03)	−.01	.22 (.13)	.14†	−.06 (.10)	−.04
Child verbal IQ	.10 (.06)	.12†	.05 (.03)	.15*	.07 (.12)	.05	.06 (.09)	.05
Child externalizing (age 3)	.08 (.02)	.31***	.03 (.01)	.31**	.09 (.04)	.23**	−.09 (.03)	−.25**
Gender	−.37 (.35)	−.07	−.25 (.16)	−.11†	1.29 (.70)	.14*	−.89 (.62)	−.10
Main effects								
CU behaviors (age 3)	3.61 (.74)	.34***	.96 (.28)	.22**	3.16 (1.10)	.18**	−2.71 (1.34)	−.17*
Executive function (age 3)	−.16 (.26)	−.03	−.17 (.13)	−.07	−.42 (.54)	−.05	.003 (.50)	.001
Interaction								
CU behaviors × executive function (age 3)	−4.136 (1.07)	−.27**	−1.41 (.41)	−.22*	−3.18 (1.91)	−.13	5.92 (2.17)	.26*
R^2	.34***		.24***		.12**		.17*	

*** $p < .001$, ** $p < .01$, * $p < .05$, † $p < .10$. We modeled all pathways simultaneously and accounted for overlap of outcome variables and predictor variables and for the effects of child gender and verbal IQ and family income on outcomes (see Table 1). Boys showed marginally higher proactive aggression ($p = .095$) and girls significantly higher relational aggression ($p = .047$). Note that we also examined gender as a moderator of any relationships between CU behaviors and executive function and later aggression or peer-liking. We found a significant interaction between CU behaviors and gender in the prediction of proactive aggression only ($\beta = -.22$, $p < .05$): the effect of CU behaviors at age 3 on later proactive aggression was significant for both boys and girls, but that the magnitude of the relationship was greater for boys (B = 4.23, SE = 1.07, $p < .001$) than girls (B = 2.91, SE = 1.24, $p < .05$). However, there were no other significant interactions between gender and either CU behavior or executive function

CU Behaviors robustly Predicts later Aggression

We found that parent-reported CU behaviors at age 3 robustly predicted teacher-reported proactive, reactive, and relational aggression at age 10, consistent with a growing number of studies demonstrating that early CU behaviors uniquely predict future behavior problems (Waller et al. 2015a, b; Willoughby et al. 2014). Thus, measures of CU behaviors assessed during the toddler and preschool period appear to identify children at risk for persistent behavior problems, including aggression that is in response to provocation, aggression that is planned, or aggression directed at others in a social context (Waller et al. 2016). Extrapolating from these findings, early childhood measures of CU behaviors may help to identify children most in need of intervention, which could enable treatment components to be tailored to fit the socioemotional needs related to CU behaviors (i.e., low empathic concern).

Executive Function Interacts with CU Behaviors to Predict Aggression

We also found that the combination of high CU behaviors and low executive function predicted the highest teacher-reported reactive aggression at age 10. This finding suggests that risk for reactive aggression across childhood is increased by characteristics that make children less likely to feel empathy or guilt (i.e., CU behaviors) combined with impulsivity, failure to plan ahead, or a lack of behavioral control (i.e., executive function deficits). This interaction in early childhood mirrors the description of interactions of interpersonal/affective deficits with disinhibition and low behavioral control in conceptualizations of adult psychopathy and severe antisocial behavior (e.g., Patrick et al. 2009). Moreover, when the construct of psychopathic traits was originally extended to youth samples, studies of older children and adolescents assessed both impulsive and narcissistic traits, which were typically highly correlated with CU behaviors (Christian et al. 1997; Frick et al. 1994). In particular, impulsivity, which overlaps with conceptualizations of executive function deficits, is thought to increase risk for aggression by increasing children's reactivity to provocation and dysregulating behavior (Frick and Hare 2001). However, because CU traits were found to so robustly predict severe and early-onset behavior problems (Christian et al. 1997; Frick et al. 1994), more recent studies of early childhood have focused solely on the predictive effects of CU behavior. The findings from the current study highlight that by returning to the foundations from which the CU behaviors construct was originally drawn and testing how CU behaviors and executive function deficits potentiate each other, we can better characterize a subgroup of children at

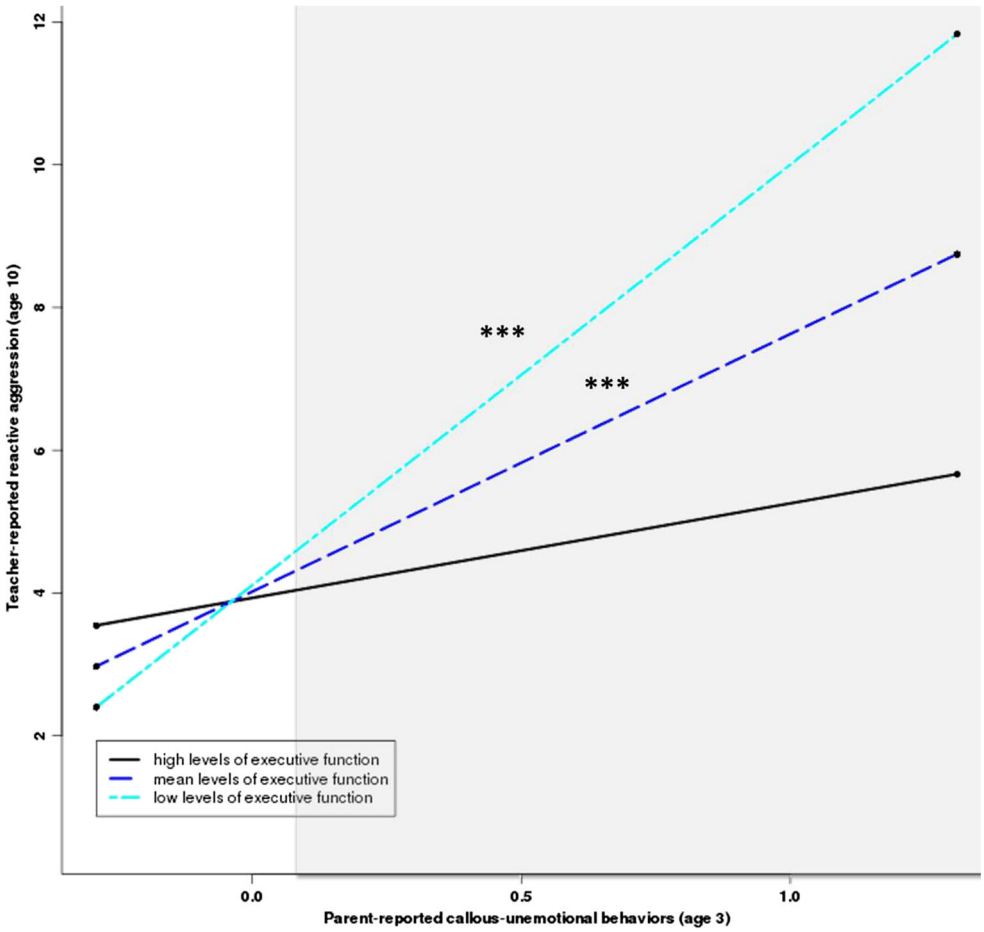

Fig. 2 Higher CU behaviors at age 3 only predict higher teacher-reported reactive-aggression at age 10 for children with low or mean levels of executive function at age 3

Note. *** $p < .001$. Simple slopes plotted at mean levels, 1 SD above the mean, and 1 SD below the mean for executive function, as recommended by Aiken and West (1991) and using an online computational tool (Preacher et al., 2006). Higher levels of age 3 CU behaviors was strongly related to higher age 10 teacher-reported reactive aggression at low (B = 5.89, SE = .95, $p < .001$) and mean (B = 3.62, SE = .74, $p < .001$) levels of executive functioning, but not at high levels of executive functioning (B=1.32, SE=.94, $p > .16$). Region of significance is shown in grey shading: specifically at centered values of CU behaviors higher than .09, the simple slopes are significantly different from zero.

risk for persistent and severe behavior problems across development.

We also found that this same combination of high CU behaviors and low executive function predicted more proactive aggression (i.e., premeditated or planned aggression). This finding contrasts with work reported in older children, where high CU behaviors and *high* executive function predicted greater likelihood of violence (Baskin-Sommers et al. 2015). These prior findings were interpreted as suggesting that the greater cognitive and behavioral control afforded by high executive function enables youth with high CU behaviors to more effectively plan and implement their proactive antisocial behaviors. There are a number of explanations for why we may have found a different pattern. One possibility arises because of methodological differences: we used teacher-reported proactive aggression, whereas prior studies assessed self-reported violence. The distinction between reactive versus proactive aggression may have been less pronounced because teachers were less able to identify motivation for the aggression. For example, children with high executive function and high CU behaviors could be better at hiding their motivation for planned aggression, such that their true motivation or reasons for aggression are missed by teachers and thus they are rated as being lower on proactive aggression. Alternatively, when comparing our findings with those of adjudicated adolescents or adults, there may be important age-related differences. For example the combination of high CU behaviors and low executive function may be implicated in both reactive and proactive aggression specifically in early childhood, but later in development, the combination of high CU behaviors and high executive function may emerge as a risk factor for more proactively motivated forms of aggression or rule-breaking. Indeed, beyond their interactive effects, there was a moderate cross-sectional correlation between high CU behaviors and low executive function, suggesting

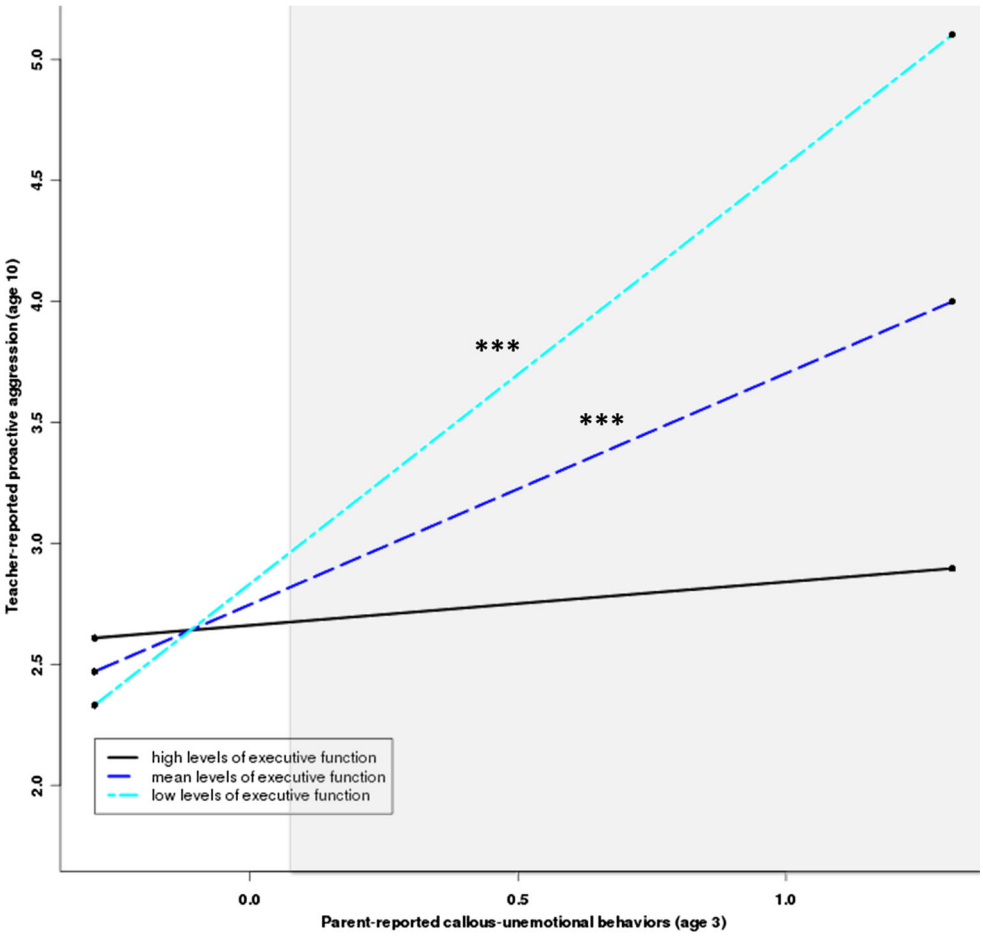

Fig. 3 Higher CU behaviors at age 3 only predict higher teacher-reported proactive-aggression at age 10 for children with low or mean levels of executive function at age 3

Note. *** $p < .001$. Simple slopes plotted at mean levels, 1 SD above the mean, and 1 SD below the mean for executive functioning, as recommended by Aiken and West (1991) and using an online computational tool (Preacher et al., 2006). Higher levels of age 3 CU behaviors were strongly related to higher age 10 teacher-reported reactive aggression at low (B = 1.73, SE = .36, $p < .001$) and mean (B = .96, SE = .28, $p < .001$) levels of executive functioning, but not at high levels of executive functioning (B=.18, SE=.35, $p > .61$). Region of significance is shown in grey shading: specifically at centered values of CU behaviors greater than .07, the simple slopes are significantly different from zero.

that these risk markers are somewhat comorbid in early childhood. Future studies could examine cross-lagged effects between CU behaviors and executive function deficits over time to better unpack their effects on the emergence of aggression over time.

CU Behaviors and Executive Function Interact to Predict later Peer-Liking

In the prediction of peer-liking, we also found interactive effects of CU behaviors and executive function. As before, there was a main effect of CU behaviors, such that children with high CU behaviors were less liked by peers, which fits with teachers reporting them as showing more proactive, reactive, and relational aggression. Consistent with studies of older samples (Fanti and Kimonis 2012), our findings from the early childhood period suggest that low empathy, guilt, and fear impair children's social relationships with classmates. Indeed, studies of older children have found that when children with high CU behaviors make friends, it tends to be with other rejected or delinquent peers (Kimonis et al. 2004), which might further undermine their ability to develop prosocial attitudes towards others and exacerbate risk for aggression (Dishion et al. 1991). We also found a significant interaction between CU behaviors and executive function, such that high CU behaviors and low executive function made children even less-liked. This finding is consistent with prior literature suggesting that children with behavior problems and emotional dysregulation problems lack appropriate social skills and often find themselves rejected by peers (Dodge and Coie 1987).

However, children with high CU behaviors and high executive function were *more* liked by their peers than children with mean or low levels of executive function. This is an interesting interaction to unpack, especially given the robust main effects of higher CU behaviors on

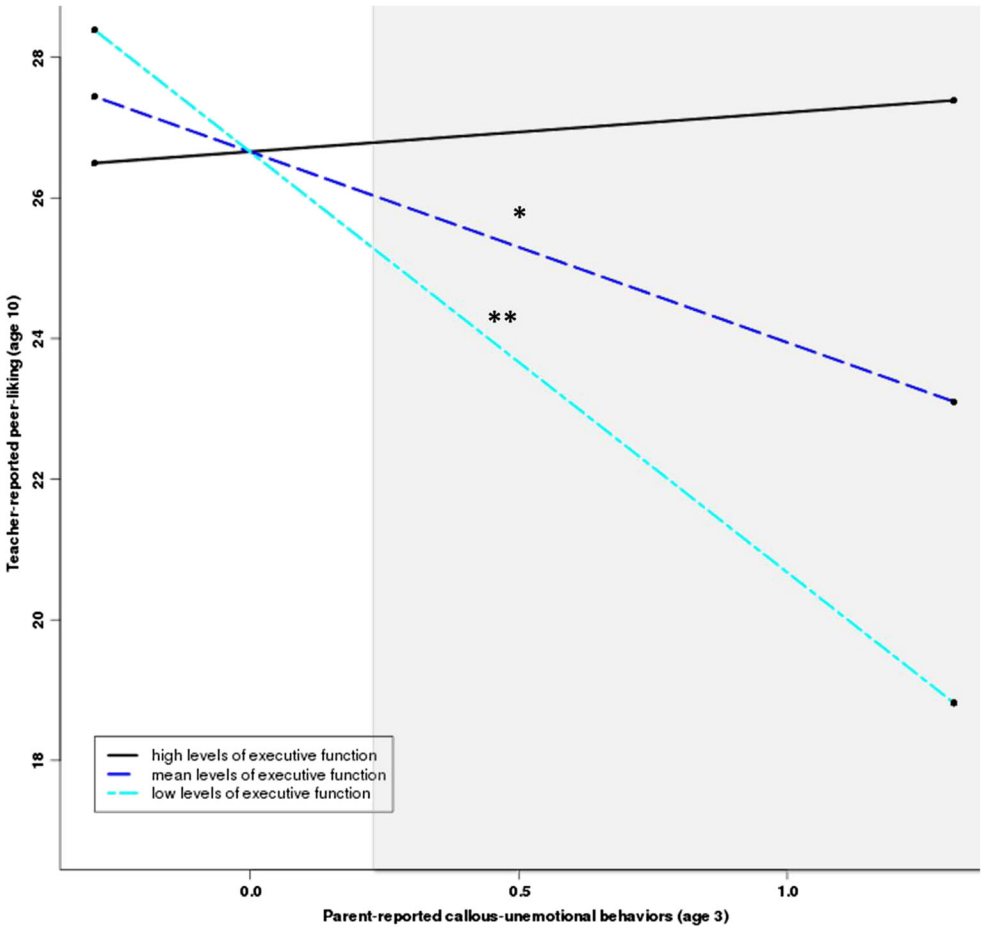

Fig. 4 Higher levels of parent-reported callous-unemotional behaviors at age 3 predict later teacher-reported peer-liking at age 10 for children with low or mean levels of executive function

Note. ** $p < .01$, * $p < .05$. Simple slopes plotted at mean levels, 1 SD below the mean (low), and 1 SD above the mean for executive functioning using an online computational tool (Preacher et al., 2006). Higher levels of age 3 CU behaviors were related to lower age 10 teacher-reported peer-liking for children with low executive function (B=-5.98, SE = 1.80, $p < .01$) or mean levels of executive function (B=-2.712, SE=1.34, $p < .05$), but not for children with high levels of executive function who were more liked by their peers (B=.56, SE=1.79, $p > .50$). Region of significance is shown in grey shading: specifically at centered values of CU behaviors higher than .24, the simple slopes are significantly different from zero

more teacher-reported aggression and lower peer-liking. Although this is the first study to examine interactions between early childhood CU behaviors and executive function in the prediction of later peer relations, findings from studies examining older children are somewhat consistent. Specifically Hawley (2003) reported that school-aged children with high levels of "Machiavellianism" were noted by their teachers to be both aggressive and well-liked (Hawley 2003). Machiavellianism refers to the combination of high social skills and charm with very aggressive behavior. In our study, the combination of high CU behaviors with high executive function may have conferred social acuity and impression management, which helps children to commit aggressive acts in ways that did not harm their friendships with other children (Hawley 2003; Kerig and Stellwagen 2010) and in potentially manipulative ways that may lead to higher liking, even in the face of higher aggression.

Intervention Implications

The findings lead to several potential implications for intervention. First, consistent with other recent findings from the early childhood period, our results highlight that measuring CU behaviors as young as three years-old may help to identify children at heightened risk for behavior problems across childhood (see Waller et al. 2015b). These children and their families are likely to benefit from early-starting interventions that help reduce risk for aggression by increasing positive parenting, and improving parent-child cooperation and engagement (e.g., Hyde et al. 2016). Evidence to date suggests that parent-focused interventions implemented via regular contact with families in their communities, and that improve social support and increase motivation for change, can be effective at engaging families and reducing behavior problems even among children with high CU behaviors (Dishion et al. 2008; Hyde et al. 2013; Waller and Gardner 2013). Emerging evidence also suggests that therapeutic efforts working directly with

children can reduce CU behaviors by improving empathy, social skills, and emotion recognition, although more research is needed to examine the effectiveness of such interventions beginning in early childhood (see Wilkinson et al. 2015 for a review).

Our results also highlight that interventions to reduce CU behaviors and aggression may also be more effective by incorporating treatment protocols that improve children's executive functioning, working alongside treatment modules targeting empathy, social skills, and aspects of the parent-child relationship. Studies of children ranging in age from 4 to 12 years old provide evidence supporting the effectiveness of both computerized and behavioral training tasks that improve working memory, cognitive flexibility, self-control, and behavioral inhibition (for a review see Diamond and Lee 2011). Recent randomized control trial evidence also supports the effectiveness of a mindfulness intervention specifically for improving self-regulation among economically disadvantaged preschoolers (Poehlmann-Tynan et al. 2016). The current observational study provides further empirical and foundational support for the design and testing of such interventions.

Strengths and Limitations

The current study had several strengths including multi-informant methods, observations of executive function, control for the autoregressive effects of externalizing over time, and a prospective longitudinal design across seven years. However, 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. In addition, the five-item CU behaviors measure used items that were not originally developed to assess the CU construct. Although its predictive and construct validity has been supported by previous studies in the current sample (Song et al. 2015; Waller et al. 2015a), future studies are needed that examine interactions between early childhood CU behaviors and executive function deficits using "purpose-developed" measures, such as the Inventory of Callous-Unemotional Traits (Frick 2004). Moreover, although one study to date has examined the stability of CU behaviors from early to late childhood (Waller et al. 2016), more evidence is needed to confirm the homotypic continuity of the CU construct across childhood. Additionally, we used a broad assessment of executive function, albeit via a widely-used measure (Kochanska et al. 1996). Nevertheless, future studies are needed to isolate more specific subdomains of executive function that might interact with early CU behaviors (e.g., working memory vs. inhibition). Finally, we did not directly measure symptoms of attention deficit/hyperactivity to account for confounding effects on the link between low executive function and aggression. Indeed, children with attention deficits/hyperactivity disorder have been shown to exhibit robust deficits in executive function (Willcutt et al. 2005). Thus it is unclear the extent to which we isolated unique effects of executive function, or the effects of attention deficit/hyperactivity symptoms, which interacted with CU behaviors to predict worse outcomes. However, all models controlled for children's verbal IQ and an earlier broadband teacher-reported externalizing scale that included many items tapping attention-deficit/hyperactivity symptoms, which may alleviate concerns about the robustness of the unique and interactive effects of executive function on later aggression and peer-liking.

Conclusions and Implications

The present findings highlight the importance of considering how both CU behaviors and executive function deficits uniquely and jointly predict aggression and peer rejection in late-childhood. We demonstrated that CU behaviors at age 3 robustly predicted more aggression and peer rejection in late-childhood. Moreover, for reactive aggression, proactive aggression, and peer rejection, this effect was exacerbated at low levels of executive function. In contrast, high levels of executive function were protective and rendered the effects of early CU behaviors on later aggression non-significant, as well as making children more well-liked by their peers. Overall, the association between early CU behaviors and later aggression appears dependent on executive function. Interestingly, the relationship between CU behaviors and executive functions suggests that executive functions can assist with impression management, but not necessarily aggressive behavior. Extrapolating from these findings, early childhood measures of both CU behaviors and deficits in executive function may help to identify children most in need of intervention, which could enable development of treatment components to target both sets of needs (e.g., improving empathic concern and behavioral control).

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Compliance with Ethical Standards

Conflict of Interest No conflicts declared.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

Informed Consent Informed consent was obtained from all individual participants included in the study.

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