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Aggression in Children with Conduct Problems and Callous-Unemotional Traits: Social Information Processing and Response to Peer Provocation

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Abstract Callous/unemotional traits (CU) moderate children's conduct problems (CP) in numerous domains, including social functioning. The present study examined whether CU traits also moderate the aggressiveness of children's social information processing (SIP) and responses to varying intensities of peer provocation. Sixty elementary school-age children (46 males) were grouped into those without CP or CU (controls, $n=32$), those with CP but not CU (CP-only; $n=14$), and those with both CP and CU (CPCU, $n=14$). Participants completed a task that measured two aspects of SIP (response generation and hostile attribution bias) and a computerized reaction time task (CRTT) that measured behavior, affect, and communication before and after provocation under instrumental and hostile aggressive conditions. Children with CPCU generated more aggressive responses than controls on measures of SIP. On the CRTT, all children exhibited reactive aggression following high provocation, but only children with CPCU exhibited proactive aggression, and reactive aggression following low provocation; no differences in affect were found. In a series of exploratory analyses, CPCU children communicated antisocially, while CP-only communicated prosocially. Finally, children with CPCU did not seem to hold a grudge following the final instance of provocation, instead gradually returning to baseline like their non-CU peers. These distinct social cognitive and behavioral profiles hint at different etiologies of CP and CPCU, underscoring the variability of aggression in these populations.

Keywords Callous-unemotional traits · Conduct problems · Aggression · Social information processing

In an effort to understand the observed heterogeneity amongst children who exhibit conduct problems (CP), researchers have increasingly focused on callous-unemotional traits (CU), which include shallow affect, deviant goals in interpersonal situations, and a lack of guilt or empathy. Recent estimates indicate that 20 to 50 % of children with CP also have high CU traits (CPCU; for review see Frick et al. 2014). This is concerning because high CU traits are associated with more severe forms of aggression and higher rates of antisocial behavior than are typically seen in children with CP-only (Christian et al. 1997; Frick et al. 2003a). Children with high CU traits utilize aggressive strategies in interpersonal situations as a means of obtaining their desired outcome and achieving social dominance, often with little or no regard for the social consequences of their behavior (Pardini and Byrd 2012). Indeed, both developmental theory and empirical evidence point to the key role that interpersonal aggression plays in distinguishing between subgroups of children with CP with or without CU traits. Though many studies have examined the role of CU in aggression, relatively few have considered social cognitive components or used performance tasks that distinguish different aspects of aggression, such as motivation or peer provocation. The present study sought to address these gaps by comparing children with CPCU, CP-only and controls on measures of aggression and social cognition.

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Accordingly, we first discuss different conceptualizations of aggression. Next, we review studies that have examined the role of CU traits in understanding different cognitive aspects of aggression. Finally, we consider evidence from experimental tasks that examine children's real-time interpersonal aggression.

Reactive versus Proactive Aggression

Within the literature on CU, the dominating conceptualization of aggression distinguishes between reactive and proactive aggression (Dodge and Coie 1987). Proactive aggression occurs in the absence of provocation and is generally characterized as intentional and unemotional; examples might include threatening or hurting others in order to win a game, or picking on smaller children to obtain social dominance. In contrast, reactive aggression occurs in response to some perceived threat or provocation and is characterized as visceral and angry aggression. Importantly, these two types of aggression are conceptually distinct but correlated in nature; a recent meta-analysis sampling 51 studies found reactive and proactive aggression correlated at a mean effect size of $r = 0.64$ (Polman et al. 2007). Even so, researchers often report important differences between reactive and proactive aggression. Reactive aggression has been consistently linked to clinical populations exhibiting CP, and is theorized to develop as a result of CP-related deficits in social information processing (SIP; Crick and Dodge 1996). For example, CP youth often interpret ambiguous peer behavior that results in a negative outcome as intentionally hostile rather than as accidental, demonstrating a hostile attribution bias (Dodge and Coie 1987; Hubbard et al. 2001). Youth with CP then formulate a response based on that faulty perception, responding to a perceived provocation when there was none, causing them to overreact in an emotional and aggressive manner. Proactive aggression aligns well with theoretical conceptualizations of individuals with high CU traits, who have little regard for the rights and welfare of others (Frick and Ellis 1999). Indeed, youth with CU traits seem built for proactive aggression: they operate under malicious social schemas that maximize the personal benefits of aggression and minimize the consequences experienced by their victims, positioning them to employ more calculating, merciless, proactive forms of aggression than their non-CU peers.

Several empirical studies have examined the associations between CP, CU, and reactive and proactive aggression. The majority of this research has relied on self- or adult-report measures of youth aggression, and has produced mixed findings. Though some studies of nonclinical child and adolescent populations found CU was *exclusively* associated with proactive aggression (Fanti et al. 2009; Kerig and Stellwagen 2010; Marsee and Frick 2007; Thornton et al. 2013), most studies have reported significant associations between CU traits and *both* reactive and proactive aggression (Barry et al. 2007; Frick et al. 2003a; Kimonis et al. 2008; Stickle et al. 2012; Van Baardewijk et al. 2011; Waschbusch and Willoughby 2008). Though heavily weighted toward undiagnosed adolescents, this body of ratings-based evidence supports clear associations between CU and proactive aggression and CP and reactive aggression, with growing evidence linking CU and reactive aggression. Extending this line of research to younger and/or clinically diagnosed populations may help researchers better distinguish subgroups of youths with CP with or without CU traits.

Hostile Versus Instrumental Aggression

Though the reactive-proactive classification system has dominated CP and CU research, parallel research linking violence and psychopathy, a multifactor construct in which CU is one component (see Blais et al. 2014), instead categorizes aggression by its intended outcome. In this system, instrumental aggression provides the aggressor some advantage toward achieving a goal (Atkins and Stoff 1993), while hostile aggression does not advance progress toward a goal but instead inflicts pain or injury on others (Bushman and Anderson 2001; King and Waschbusch 2010). This system has been conceptualized as distinct from the reactive-proactive system, despite evidence that the two systems may overlap to some degree (e.g., Vitiello and Stoff 1997). Indeed, these two systems are not mutually exclusive but instead describe different aspects of interpersonal aggression; the focus of reactive/proactive aggression is on the eliciting stimuli (i.e., whether or not aggression is used in response to provocation), whereas the focus of instrumental/hostile aggression is on the intended purpose of the aggression (i.e., whether or not aggression is used to achieve a specific outcome). Although instrumental/hostile aggression has not yet been studied in youth with CU traits, there is indirect evidence that it may be a relevant distinction. In particular, youth with CU traits are known to favor aggressive strategies to achieve social outcomes, which suggests high rates of instrumental aggression, yet they also disregard the consequences or suffering they cause (Pardini and Byrd 2012), which suggests high rates of hostile aggression. These findings, along with the fact that aggression is known to have multiple motivating factors (Anderson and Bushman 2002), underscore the value of examining both instrumental/hostile and reactive/proactive aggression when seeking to understand the role of CU traits in children with CP.

Social Information Processing and Aggression

Just as there is a growing need to conceptualize aggression more broadly in research, there is a parallel need for greater

diversity in the methodologies researchers employ to explore interpersonal aggression. Cognitive researchers have long utilized hypothetical peer scenarios to assess how differences in SIP map on to reactive/proactive aggression (Dodge and Coie 1987). Specifically, the hostile attribution bias is thought to activate reactive aggression, while deviant social decision-making (i.e., aggressive response generation and decision) has been linked to proactive aggression (Crick and Dodge 1994, 1996). Surprisingly, research comparing SIP in youth with CP-only and CPCU is very limited. Only one study (Frick et al. 2003b) compared groups of children with and without CP and CU on measures of the hostile attribution bias. Although the results of this study were somewhat complicated by the unusual finding that the control group had higher bias scores than all other groups, researchers reported that children higher on CU traits made fewer hostile attributions than their non-CU peers. Though only one component of the larger model proposed, this finding suggests that the hostile attribution bias may be more influential in youth with CP-only than CPCU, and is generally consistent with other studies that support an association between CP and reactive aggression.

Other SIP research suggests that CU traits may influence how favorably youths view aggression, which is hypothesized to promote the selection of proactive aggressive strategies (Fontaine and Dodge 2006). When asked to consider possible consequences of using aggressive strategies in hypothetical peer scenarios, incarcerated teens higher on CU traits made more positive and less negative evaluations of socially aggressive responses (Pardini et al. 2003). A similar study of pre-adjudicated adolescent girls found proactive aggression was uniquely associated with biased positive outcome expectations and CU traits, while reactive aggression was associated with the constellation of emotion regulation deficits typically seen with CP-only (Marsee and Frick 2007). This general preference towards aggressive strategies likely accounts for some of the increased interpersonal aggression seen in high CU populations, but more work is needed to clarify the associations between CU traits and other SIP mechanisms, like the hostile attribution bias, to determine the relative deviance of CU social cognitive styles.

Behavioral Tasks and Aggression

Just as hypothetical peer scenarios have been used to assess cognitive components of aggression, simulated peer interaction tasks have been used to measure behavioral components of aggression within specific social contexts, the most notable being adaptations of Taylor's aggression task (Taylor and Gammon 1975). These adaptations have assessed many theoretical components of CP and CU, by manipulating anything from the salience of peer distress (Van Baardewijk et al. 2009) to the impact of peer provocation (Waschbusch et al. 2002). Muñoz et al. (2008) tested the theorized association between CU traits and proactive aggression (Frick and Ellis 1999) by examining the trials prior to the introduction of provocation. Their non-diagnosed sample of detained adolescent boys fell into increasingly aggressive subgroups: low aggression, reactive-only, and reactive-proactive combined. Surprisingly, both the reactive-only and combined groups had higher CU traits than the low aggression group, but they did not differ from each other. The authors indicated that this unexpected finding could have resulted from their analytic approach, but noted that the reactive-only group exhibited significantly higher levels of proactive aggression than the low aggression group, indicating they could be considered a high reactive, low proactive group with high CU traits. Another intriguing line of research has used these measures to study how certain children hold on to their aggression long after they were last provoked, acting as though they held a grudge. Though no research has examined the impact of CU traits on the dissipation of aggression, evidence suggests that unmedicated children with ADHD (King et al. 2009b) and comorbid CP (Waschbusch et al. 2002) are slower to dissipate their aggressive response than their typically developing peers. Extending this research to populations with CU could clarify whether CU is associated with increased aggression across all contexts, regardless of provocation or intent, or an immediate but not enduring reaction to peer aggression.

Communication and Aggression

Finally, one component of interpersonal aggression that has been somewhat neglected by researchers is the tone and content of peer-to-peer communication. Past research has shown that aggressive behavior is associated with higher rates of verbal dominance (e.g., taunting, threatening, teasing) in childhood peer interactions (Lochman and Dodge 1998). Importantly, no research (that we know of) has examined whether verbal aggression toward peers differs between CP-only, CPCU, and controls. Computerized tasks, like the computerized reaction time task (CRTT; Muñoz et al. 2008; Waschbusch et al. 2002), present a unique opportunity to meet this research need because they can easily record children's peer-to-peer communications, allowing researchers to assess if and how communication changes in important social contexts, like the presence of peer provocation or a defined competitive goal. Analyzing peer-to-peer communications during such tasks could better capture the nuance of social interactions and further distinguish the response patterns of children with CP and CU.

The Present Study

In an effort to clarify the relationship between CU traits and different subtypes of aggression, we re-analyzed data from

two previously published studies that examined effects of stimulant medication on social cognition and response to peer provocation in children with ADHD (King et al. 2009a, b). In the present study, we methodologically controlled for ADHD (by restricting the clinical groups to children who meet criteria for both CP and ADHD) and statistically controlled for medication status (by including medication status as a covariate in all analyses), and instead examined effects of CU traits on measures of aggression by comparing children with CPCU, CP-only, and neither CP nor CU (controls). In addition, we explored dissipation of aggression and present new data on children's social communication that has not (to our knowledge) been examined in previous studies of children with CU traits.

Based on previous research, we formulated four hypotheses. On the measure of SIP using hypothetical peer scenarios, we hypothesized that: (1) children with CP-only would demonstrate greater hostile attribution bias than children with CPCU or controls, who would not differ; and (2) children with CPCU would generate significantly more aggressive responses than children with CP-only and controls, who would not differ from each other. On the measure of response to provocation, we hypothesized that: (3) children with CPCU would show more aggressive behavior prior to and in response to peer provocation – particularly after low levels of provocation – than children with CP-only, who would in turn be more aggressive than controls; but (4) aggressive behaviors would be accompanied by significantly increased anger and more hostile communications in children with CP-only but not in children with CPCU. We also compared the dissipation of participants' aggression over time across groups; that is, whether groups differed in the extent to which they held a grudge after being provoked. No hypotheses were offered for these data because no previous research (that we are aware of) has examined this construct as a function of CU traits.

Methods

Participants

Participants were 60 children (46 boys, 14 girls) between the ages of 6 and 12 years (M=9.04, SD=1.98) recruited from local communities using flyers posted in public places (i.e., grocery store, library, health centers) as well as radio and TV ads. Using measures and procedures described below, participants were divided into three groups: (1) CP-only (n=14), defined as those who met diagnostic criteria for oppositional defiant disorder (ODD) or conduct disorder (CD) and who had low CU traits; (2) CPCU (n=14), defined as those who met diagnostic criteria for ODD or CD and who had high CU traits; and (3) controls (n=32), defined as those who did not meet criteria for ODD or CD and who had low CU traits. All participants were in one of two previous studies that examined the effects of stimulant medication on SIP (King et al. 2009a) and response to provocation (King et al. 2009b). Children in the CP-only and CPCU groups also met criteria for ADHD, whereas none in the control group did; children with ADHD completed these tasks after receiving a controlled dose (0.3 mg/kg) of methylphenidate. Table 1 summarizes demographic and rating scale measures for the included participants, separately for each group.[1]

ADHD, ODD and CD were evaluated using DSM-IV criteria (American Psychiatric American Psychiatric 2000) as determined by parent and teacher ratings on the Disruptive Behavior Disorders Rating Scale (DBDRS; Pelham et al. 1992) and a structured diagnostic interview with parent(s) on the parent-report version of the Diagnostic Interview Schedule for Children—Fourth Edition (DISC-IV; Shaffer et al. 2000). Diagnoses were made by doctoral level clinicians, based on information gathered from rating scales and a clinical interview. The study was approved by an institutional review board. Parents of all children gave written informed consent and children gave verbal assent to participate. Parents were given the choice to have the experimenters debrief children about the deception used in the provocation task upon completion of the study, but all declined.

Diagnostic Measures

Disruptive Behavior Disorder Rating Scale (DBDRS) The DBDRS is a widely used rating scale that consists of 45 questions designed to measure DSM-IV symptoms of ADHD, ODD and CD (Pelham et al. 1992). DBDRS items were rated using Likert scales ranging from 0 (*not at all*) to 3 (*very much*). Following recommended procedures, items rated *pretty much* or *very much* were scored as endorsement of a symptom; symptom counts were then computed for ADHD-inattention, ADHD-hyperactive/impulsive, ODD, and CD (alphas≥0.70).

NIMH Diagnostic Interview Schedule for Children (DISC-IV) The DISC-IV (Shaffer et al. 2000) is a structured clinical interview comprised of approximately 3000 questions designed to provide DSM-IV diagnoses of major mental health disorders in children ages 6–17, including ADHD, ODD, and CD. The majority of questions on the DISC-IV require a simple yes or no response. For this study the computerized version of the DISC-IV was self-administered by

[1] Fifteen additional participants were excluded from this study because they met criteria for ADHD but not ODD or CD (n=8), they had high CU but not ODD or CD (n=2), or they were missing data on the measure of CU traits (n=5). Excluded participants did not differ from included participants on age or gender (ps≥0.309).

Table 1 Demographic and rating scale data as a function of group

	Control n=32	CP-only n=14	CPCU N=14	ANOVA or Chi-square
Males	21 (65.6 %)	13 (92.9 %)	12 (85.7 %)	4.87
Age in years	8.8 (1.9)	9.3 (1.8)	9.3 (2.3)	0.36
Medicated during tasks	0 (0.0 %)$_a$	9 (64.3 %)$_b$	5 (35.7 %)$_b$	24.06*
Racial minority	1 (3.1 %)	3 (21.4 %)	2 (14.3 %)	4.00
DBDRS symptoms				
ADHD-inattentive	0.3 (0.6)$_a$	7.3 (1.9)$_b$	6.4 (2.3)$_b$	140.46*
ADHD-Hyp/Imp	0.2 (0.6)$_a$	6.7 (1.7)$_b$	5.9 (2.3)$_b$	129.56*
ODD	0.1 (0.3)$_a$	5.1 (2.3)$_b$	6.0 (1.8)$_b$	112.35*
CD	0.0 (0.0)$_a$	1.0 (1.3)$_b$	1.8 (1.4)$_c$	20.47*
APSD CU scale - parent				
Raw score	2.1 (1.4)$_a$	3.7 (1.1)$_b$	7.1 (1.2)$_c$	71.29*
T-score	48.1 (6.7)$_a$	55.4 (5.4)$_b$	71.0 (6.4)$_c$	63.25*
DBDRS diagnoses				
ADHD	0 (0 %)$_a$	14 (100 %)$_b$	14 (100 %)$_b$	60.00*
ODD	0 (0 %)$_a$	13 (92.9 %)$_b$	12 (75.0 %)$_b$	49.13*
CD	0 (0 %)$_a$	3 (21.4 %)$_b$	5 (35.7 %)$_b$	11.79*

Values in the tables are means with standard deviations in parentheses, or frequency counts with percentages in parentheses

DBDRS Disruptive Behavior Disorders Rating Scale (Pelham et al. 1992), *APSD* Antisocial Process Screening Device (Frick and Hare 2001)

*$p<0.05$. In rows with significant ANOVA or Chi-Square values, groups with different subscripts differ at $p<0.05$

parents unless the parent had reading or language problems, in which case the computerized version was administered by a clinician or trained research assistant.

Antisocial Process Screening Device (APSD) The APSD consists of 20 questions designed to measure CU, narcissism, and impulsivity (Frick and Hare 2001). Only the six items from the CU scale were used in the current study. Items on the APSD were rated using Likert scales that ranged from 0 (*not at all true*) to 2 (*definitely true*). The internal consistency (alpha) of the CU scale in this sample was 0.69, which is typical for this scale (Lochman et al. 2014; Pardini et al. 2003). Using published norms (Frick and Hare 2001), the CU scale was converted into T-scores. Participants with T-scores ≥65 were assigned to the high CU group and participants with T-scores <65 were in the low CU group.

Procedures

Social Information Processing (SIP) SIP was measured using eight hypothetical peer scenarios that were drawn from previous studies (Dodge et al. 2002, 1997). The hypothetical peer scenarios consisted of a cartoon picture and a short story about at least two children participating in various social interactions and were based on the SIP model proposed by Crick and Dodge (1994). Stories depicted either group entry or provocation scenarios, with four stories of each type included in this task. The experimenter read the story aloud and asked the participant to pretend he/she was a child portrayed in the scenario. Examples of the peer scenarios included in this series included being hit in the back with a ball thrown by another child (i.e., Provocation) and asking to join a baseball game and being denied (i.e., Group Entry). Immediately after each picture/story was presented to the participant, he/she was asked (a) why he/she thought the other child(ren) in the picture behaved the way they did (i.e., Hostile Attribution Bias) and (b) what he/she would do in the same situation (i.e., Response Generation).

Responses to parts (a) and (b) of the social information processing scenarios were recorded and coded immediately by the research assistant. Responses to part (a) were coded as either 1 (*non-hostile*) or 2 (*hostile*) and responses to part (b) were coded as 1 (*nothing*), 2 (*ask again/ask why*), 3 (*command*), 4 (*seek adult punishment*), or 5 (*retaliate*), with 0 (*don't know*) coded as missing. A second coder, blind to the condition of the participants, coded 22 of the interviews (26 %) for reliability purposes. Inter-rater correlations for interpretation of intent were 0.77 for peer entry and 0.73 for provocation scenarios. Inter-rater correlations for response generation were 0.80 and 0.96, respectively, for group entry and provocation scenarios.

The Competitive Reaction Time Task (CRTT) The CRTT (Muñoz et al. 2008; Waschbusch et al. 2002) consisted of a reaction-time game in which participants thought they were competing over the Internet against a same-age opponent to

win points to exchange for prizes. In truth there was no opponent—all win and loss trials were determined a priori and all messages from the opponent were pre-programmed to be consistent across all participants.

The CRTT included two separate conditions designed to measure instrumental aggression and hostile aggression. Instrumental aggression was operationalized as aggression used for the purpose of attaining a goal (i.e., facilitated winning the game), while hostile aggression was operationalized as aggression used to upset the opponent (i.e., did not alter the score of the game). In the instrumental condition, the researcher told the participant they would be playing a game against another child over the Internet; they were to press a red button on a joystick as fast as possible whenever a bull's eye target appeared on the screen. Participants were told that if they pressed the button faster than their opponent, they would win 10 points and would be given the opportunity to: (1) take between 0 and 10 points away from their opponent, (2) send their opponent a message over an instant messenger program built into the game, (3) do both, or (4) do nothing. They were also told that if their opponent won, he/she would have the same opportunities to take points and/or send a message using instant messenger. In the hostile condition, instead of having the opportunity to take points from their opponents, participants were given the opportunity to: (1) send a buzz (aversive white noise) lasting from 0 to 10 s to their opponent, (2) send an instant message to their opponent, (3) do both, or (4) do nothing. Immediately after informing participants of each trial's outcome, the researcher prompted participants to respond or conveyed the opponent's response; researchers typed all messages participants sent to their opponent and read aloud all messages from the opponent in a neutral voice. Messages sent from each participant were saved as text files and later coded for content (see below). Between trials, participants were asked to indicate how they felt, using a five-point Likert scale. Possible responses ranged from 0 (*very happy*) to 4 (*very angry*) and were anchored by drawings of happy, neutral, and angry faces.

In reality, the game was programed so that participants lost on the same 8 of 28 trials in each condition. Of these, four loss trials were high provocation trials in which the opponent took 8, 9 or 10 points from the participant (or sent a buzz of 8, 9 or 10 s to the participant) and also sent a highly aversive message (e.g., "Nice try, speedo! What's the matter- is your hand stuck in cement? You lose another 10!"). The other four loss trials were low provocation trials in which the opponent took 0, 1 or 2 points from the participant (or sent a buzz of 0, 1 or 2 s to the participant) and sent a non-provocative message (e.g., "You lost, but you're getting better. I'll take 2 points"). The remaining 20 trials of each condition were win trials; the game always began with four consecutive win trials and ended with six consecutive win trials. Each loss trial was immediately followed by a win trial; that is, two loss trials never occurred in succession.

Within each condition, participants' aggression was measured relative to provocation; namely aggression in the absence of provocation (i.e., Proactive), in the presence of provocation (i.e., Reactive, at both low and high levels), and duration since the final provocation (i.e., Dissipation). Proactive aggression was operationalized as aggressive behavior that occurred before the participant had any experience with the opponent or with the task; that is, aggressive behavior that occurred in the first four trials the first time the participant played the task, each of which the participant won. Reactive aggression was operationalized as aggressive behavior that occurred on trials immediately following provocation; that is, the number of points taken away or the length of buzz sent immediately following a high or low provocation loss trial. Dissipation of aggression, analogous to holding a grudge as described by Waschbusch and colleagues (2002), was operationalized as reduction in aggressive responding in the last six win trials of the task immediately following a high provocation loss. The CRTT took 20–40 min to complete.

Research assistants with no prior knowledge of the study coded instant messages on a trial-by-trial basis. Coding consisted of rating each message using four point Likert scales that ranged from 0 (*not at all)* to 3 (*very much*). Likert ratings were designed to evaluate the content (i.e., prosocial, antisocial) and emotion words (i.e., anger, happiness, empathy) in participants' messages[2] as defined by operational definitions (for samples of actual participant responses, see online Supplementary Table S1). To reduce the number of analyses, the prosocial, happiness, and empathy counts were combined into a composite prosocial message score, and the antisocial and anger scores were combined into a composite antisocial message score, by counting the number of statements rated *pretty much* or *very much*. Internal consistency reliability for these sum scores was estimated by computing Cronbach's alpha and ranged from 0.60 to 81 (M=0.76). Inter-rater reliability was estimated by independently coding a randomly selected subset (20 %) of the transcripts and computing intraclass correlations (mixed model, absolute differences). Reliability was acceptable for prosocial (r= 0.83) and antisocial (r=0.94) scores.

Analytic Plan

Data were analyzed using mixed models with random intercepts to account for dependence of repeated trials nested within participants, using SAS Proc Mixed version 9.3 for windows (SAS Institute Inc. 2011). Group (Control vs. CP-only vs. CPCU) was

[2] Codes capturing passive and appeal to authority messages were also used but later dropped due to lack of variance; they were nearly always rated as *not at all*. Codes capturing unusual, fearful, and social competence of messages were also used but not analyzed because they were not theoretically relevant for this study.

included as a common predictor in all models, along with age, sex, and medication status (none vs. medication treatment) as covariates. Experimental conditions were also included as predictors in models, along with interactions between Group and experimental conditions, but these followed the experimental design and thus differed across types of dependent measures. Specifically, predictors for the different types of dependent measures were: (1) *Social Information Processing* – Scenario (group entry vs. provocation), Group, Group x Scenario, and covariates; (2*) Proactive Aggression* – Group, covariates; (3) *Reactive Aggression* – Group, Aggression (instrumental vs. hostile), Provocation (low vs. high), Group x Aggression, Group x Provocation, Aggression x Provocation, and Group x Aggression x Provocation, and covariates; and (4) *Dissipation of Aggression* – Group, Trial (first vs. middle vs. last), Aggression, Group x Trial, Group x Aggression, Aggression x Trial, Group x Aggression x Trial and covariates. The number of dissipation of aggression trials was reduced from six to three by averaging the first two trials, the middle two trials, and the last two trials because preliminary analyses that included all six trials failed to converge.[3] The final models were evaluated for robustness by re-estimating after dropping influential cases as identified by visually inspecting graphs of Cook's D values. Unless otherwise noted, influential cases were either not present or did not meaningfully change the findings and results are presented with all cases included. Significant effects were followed up with simple effects tests and/or pairwise comparisons. For simplicity and to avoid overlap with previously published results, only significant effects involving Group are reported. All means presented were adjusted for covariates. Sample sizes varied across dependent measures from 56 to 60 because of loss of data from equipment failure. Within task correlations are available online (see Supplementary Tables S2, S3, S4, and S5).

Results

Social Information Processing

There were no significant effects involving Group for hostile attribution bias, but Group x Scenario was significant for response generation, $F(2, 396)=8.97$, $p<0.001$. Simple effects of the interaction showed Group was significant for provocation, $F(2, 396)=3.72$, $p=0.025$, but not peer entry scenarios, $F(2, 396)=0.77$, $p=0.463$. As shown in Table 2, the CPCU group generated more aggressive responses to provocation than did the control group.

[3] A commonly recommended first step to address failure to converge is to simplify the statistical model by reducing the terms in the model (Kiernan et al. 2012). We successfully simplified our model by averaging trials; the reduction from six repeated measures to three allowed the parameters to be correctly estimated.

Proactive Aggression

Behavior There was a marginally significant main effect of Group, $F(2, 162)=2.50$, $p=0.086$, but one participant in the CPCU group had highly influential data (i.e., Cook's D value four times as large as the next most influential case). Unlike every other child in the CPCU group, this child had no aggressive behavior on these trials. After dropping this participant, there was a significant main effect of Group, $F(2, 160)=3.87$, $p=0.023$, which showed the CPCU group had significantly higher proactive aggression than the control and CP-only groups (see Table 3).

Affect There were no significant effects involving Group.

Message Content There was a significant main effect of Group for prosocial messages, $F(2, 173)=4.57$, $p=0.012$, which showed the CP-only group sent more prosocial messages than the other groups (see Table 3).

Reactive Aggression

Behavior There was a significant main effect of Group, $F(2, 829)=4.13$, $p=0.016$, and a significant Group x Provocation interaction, $F(2, 829)=3.06$, $p=0.048$, which were qualified by a significant Group x Aggression x Provocation interaction, $F(2, 829)=3.72$, $p=0.025$. Simple effects showed Group was significant in the low provocation-instrumental condition, $F(2, 829)=8.29$, $p<0.001$, but not in other conditions (low provocation-hostile condition, $F(2, 829)=2.79$, $p=0.062$; high provocation-instrumental condition, $F(2, 829)=1.32$, $p=0.267$; high provocation-hostile condition, $F(2, 829)=1.11$, $p=0.329$). In response to low provocation, the CPCU group was significantly more aggressive than others in the instrumental condition (see Table 3).

Affect There was a significant Group x Aggression interaction, $F(2, 844)=3.75$, $p=0.024$. However, simple effects tests and examination of means (see Table 3) showed that the interaction was the result of a crossover effect and that Group was not significant in either the instrumental, $F(2, 844)=1.00$, $p=0.370$, or hostile, $F(2, 844)=0.00$, $p=0.999$, conditions.

Message Content Examination of prosocial messages resulted in a significant Group x Provocation interaction, $F(2, 860)=8.07$, $p<0.001$. Simple effects showed a significant effect of Group at low, $F(2, 860)=3.05$, $p=0.048$, but not high provocation, $F(2, 860)=0.14$, $p=0.866$. As shown in Table 3, groups did not differ in response to high provocation, with all groups sending fewer prosocial messages as compared to low

Table 2 Means, standard errors, and effect sizes for the measure of social information processing

	Control		CP-only		CPCU		Effect sizes		
Dependent measure	M	SE	M	SE	M	SE	CPCU vs. control	CP-only vs. control	CPCU vs. CP-only
Hostile attribution bias									
Peer entry	0.44	0.08	0.51	0.09	0.56	0.09	0.24	0.14	0.10
Provocation	0.55	0.08	0.58	0.09	0.68	0.09	0.26	0.06	0.20
Aggressive response generation									
Peer entry	2.13	0.20	1.75	0.24	1.94	0.23	−0.14	−0.28	0.14
Provocation	2.56_{a}	0.20	3.00_{ab}	0.23	3.30_{b}	0.23	0.55	0.33	0.22

Effect sizes are standardized mean differences (Cohen's D). Within each row, means with different subscripts differed at $p<0.05$ in post hoc tests. Rows without subscripted means indicate that groups do not differ at $p<0.05$

Table 3 Means, standard errors, and effects sizes for the Competitive Reaction Time Task

	Control		CP-only		CPCU		Effect sizes		
Dependent measure	M	SE	M	SE	M	SE	CPCU vs. control	CP-only vs. control	CPCU vs. CP-only
Proactive aggression									
Behavior	5.82_{a}	0.91	5.72_{a}	1.01	8.61_{b}	1.03	0.66	−0.02	0.68
Affect	0.61	0.15	0.65	0.17	0.52	0.17	−0.11	0.05	−0.16
Prosocial messages	0.22_{a}	0.10	0.56_{b}	0.12	0.10_{a}	0.11	−0.24	0.67	−0.90
Antisocial messages	0.04	0.04	0.00	0.05	0.08	0.04	0.19	−0.18	0.37
Reactive aggression									
Behavior									
Low provocation									
Instrumental	4.58_{a}	0.57	3.53_{a}	0.72	7.03_{b}	0.66	0.58	−0.25	0.83
Hostile	3.97	0.57	4.74	0.72	5.85	0.66	0.44	0.18	0.26
High provocation									
Instrumental	7.92	0.57	8.96	0.72	9.16	0.66	0.29	0.25	0.05
Hostile	7.36	0.57	7.27	0.72	8.41	0.66	0.25	−0.02	0.27
Affect									
Instrumental	1.39	0.24	1.92	0.28	1.65	0.27	0.18	0.36	−0.18
Hostile	1.76	0.24	1.78	0.28	1.76	0.27	0.00	0.01	−0.01
Prosocial messages									
Low provocation	0.18_{a}	0.05	0.37_{b}	0.06	0.22_{a}	0.05	0.11	0.51	−0.41
High provocation	0.09	0.05	0.07	0.06	0.11	0.05	0.05	−0.05	0.11
Antisocial messages	0.00_{a}	0.05	0.14_{ab}	0.06	0.25_{b}	0.05	0.63	0.35	0.28
Dissipation of aggression									
Behavior									
Instrumental	7.09	0.72	6.84	0.87	8.14	0.79	0.29	−0.07	0.36
Hostile	5.52_{a}	0.72	6.49_{ab}	0.87	8.45_{b}	0.79	0.82	0.27	0.55
Affect									
Instrumental	0.92	0.15	0.98	0.18	1.01	0.16	0.10	0.07	0.03
Hostile	1.05_{a}	0.15	0.84_{ab}	0.18	0.56_{b}	0.16	−0.53	−0.23	−0.30
Prosocial messages									
First trials	0.11	0.05	0.00	0.06	0.11	0.06	0.00	−0.42	0.42
Middle trials	0.11	0.05	0.09	0.06	0.11	0.06	0.00	−0.08	0.08
Last trials	0.11	0.05	0.24	0.06	0.09	0.06	−0.08	0.50	−0.58
Antisocial messages	0.00_{a}	0.06	0.18_{b}	0.07	0.21_{b}	0.06	0.66	0.56	0.09

Effect sizes are standardized mean differences (Cohen's D). Within each row, means with different subscripts differed at $p<0.05$ in post hoc tests. Rows without subscripted means indicate that groups do differ at $p<0.05$

provocation. However, the CP-only group sent significantly more prosocial messages than others in response to low provocation. Examination of antisocial messages resulted in a significant main effect of Group, $F(2, 860)=7.09$, $p<0.001$, showing the CPCU group sent significantly more antisocial messages than controls (see Table 3).

Dissipation of Aggression

Behavior There was a significant Group x Aggression interaction, $F(2, 263)=3.87$, $p=0.022$. Simple effects showed a significant effect of Group in the hostile, $F(2, 263)=4.83$, $p=0.009$, but not instrumental, $F(2, 263)=0.93$, $p=0.395$, aggression condition. As shown in Table 3, the CPCU group was significantly more aggressive than controls in the hostile condition.

Affect There was a significant Group x Aggression interaction, $F(2, 267)=5.43$, $p=0.005$. Simple effects showed a significant effect of Group in the hostile, $F(2, 267)=3.10$, $p=0.047$, but not instrumental, $F(2, 267)=0.12$, $p=0.888$, condition. As shown in Table 3, the CPCU group was significantly less angry than controls during the hostile aggression condition.

Message Content Examination of prosocial messages resulted in a Group x Trial interaction, $F(4, 275)=4.01$, $p=0.004$. Simple effects showed that groups did not differ at any trial ($ps\geq0.198$), but that Trial was significant for the CP-only group, $F(2, 275)=9.94$, $p<0.001$, but not the control, $F(2, 275)=0.03$, $p=0.966$, or CPCU groups, $F(2, 275)=0.08$, $p=0.925$. As shown in Table 3, the number of positive messages sent by the CP-only group increased as high provocation became more distal, whereas the control and CPCU groups did not change. Antisocial messages showed a main effect of Group, $F(2, 275)=5.87$, $p=0.003$, which indicated that the control group sent fewer antisocial messages than the CP-only and CPCU groups.

Discussion

Past research linking CP and CU to different patterns of aggression suggest that children with CP-only and CPCU may exhibit different responses to SIP and behavioral provocation paradigms. The present study examined these possibilities by testing four hypotheses and conducting a series of exploratory analyses. The first hypothesis, that children with CP-only would demonstrate a hostile attribution bias, was not supported, while the results partially supported the second hypothesis that children with CPCU would generate more aggressive responses. On the response to peer provocation measure (the CRTT), our third hypothesis predicted that children with CPCU would show significantly more aggressive behavior than children with CP-only, particularly prior to and in response to low provocation. Even so, the fourth hypothesis predicted that children with CP-only would exhibit significantly more anger and hostile communication than children with CPCU. Results partially supported the third hypothesis, but not the fourth; children with CPCU behaved much more aggressively than their peers, but no group differences in anger were found. Additionally, children with CPCU only communicated antisocially, while children with CP-only exhibited both prosocial and antisocial communication. Finally, we explored how participants dissipated their aggression following the final instance of provocation, finding that children with CPCU dissipated their aggression and antisocial communication rather than holding a grudge.

Social Information Processing

Though no SIP differences were found on the measure of hostile attribution bias, differences did emerge on the measure of response generation. As predicted, the CPCU group generated significantly more aggressive responses to hypothetical provocation scenarios than the control group, with the CP-only group between but not significantly different from either group (see Table 2). The absence of a hostile attribution bias in children with CPCU was expected and supports existing research (Frick et al. 2003b). One previous social cognition study (Waschbusch et al. 2007) also examined aggressive response generation in children with CPCU, but reported an inverse relationship (i.e., CPCU generated fewer aggressive responses to social problems than CP-only). The differing directionality of this relationship may be a measurement artifact; the present study used peer provocation scenarios, while Waschbusch and colleagues used object acquisition scenarios that align more with conceptualizations of proactive aggression. Given the possible theoretical and clinical implications of this area, future researchers should determine whether children with CPCU think about and act aggressively in social situations, or merely exhibit highly aggressive behavior.

Proactive Aggression

Several group differences also emerged on the CRTT. As hypothesized, children in the CPCU group exhibited significantly more proactive aggressive behavior than children in the control and CP-only groups (see Table 3). This result is consistent with one previous CRTT study (Muñoz et al. 2008) and numerous ratings scale studies (e.g., Marsee and Frick 2007; Muñoz et al. 2008). Importantly, all groups self-reported minimal anger during these proactive aggression trials. In other words, children with CPCU behaved significantly more aggressively than other children, and did so before being provoked by their opponent and despite an absence of self-

reported anger, which is consistent with theoretical conceptualizations of both CU (e.g., Frick and Ellis 1999) and proactive aggression (Dodge and Coie 1987). One unexpected result was that CP-only children sent significantly more prosocial messages to the peer opponent than did other groups (see Table 3). This suggests the CP-only group began the task positively inclined toward the peer, perhaps even more so than control children. If this interpretation is correct, it may suggest that CP-only and CPCU children had different motivations toward their peer opponent as they began the task; the increased rate of prosocial messages suggests the children with CP-only were motivated to affiliate with their peer opponent, whereas the increased rate of aggression suggests the that children with CPCU were motivated to dominate their peer opponent. This interpretation is admittedly speculative, but if confirmed by direct research, it could inform clinical interventions that target the poor social skills and peer rejection that are common among children with serious CP (Bierman et al. 1993).

Reactive Aggression

After provocation was introduced, all participants behaved more aggressively in response to high provocation than to low provocation, with no between group differences found in high provocation. However, children in the CPCU group uniquely exhibited significantly higher reactive aggressive behavior than other groups in response to low provocation, particularly in the instrumental aggression condition (see Table 3). Though this same pattern has been found in past CRTT studies (e.g., Waschbusch et al. 2002), the present study extends existing literature in a number of ways. First, this study suggests that participants' unique patterns of response to low provocation are specific to children with comorbid ADHD, CP, and CU traits, which has not been examined in past research. Second, the present study used a self-report measure of affect collected after every trial, which indicated that the behavioral difference was not accompanied by an affective difference. Thus, as with the proactive aggression results, children with CPCU exhibited significantly more aggressive behavior which, according to self-report, was not accompanied by anger. Third, this study included both instrumental and hostile conditions, and the differences in response to low provocation emerged primarily in the instrumental condition. This finding is important because it indicates that children with CPCU may be prone to react aggressively to minimal provocation, especially if doing so is personally beneficial (i.e., exhibiting reactive-instrumental aggression). Finally, this study was the first to explore differences in prosocial and antisocial participant-to-opponent communication during the CRTT, providing new insight into the communicative nuance of children's interpersonal interactions.

As with the proactive aggression trials, the CP-only group communicated significantly more prosocially than others, particularly during low provocation instrumental trials, providing further evidence to support our speculation that this group was positively inclined toward the peer. In contrast, the CPCU group communicated significantly more antisocially than controls during reactive aggression trials, regardless of level of provocation or aggression condition. Despite reporting minimal anger, they behaved more aggressively and communicated more antisocially with the peer. This pattern is arguably evidence of a cold, uncaring interpersonal style and is thus highly consistent with the theoretical conceptualizations of the CU construct.

Dissipation of Aggression

Finally, participants were compared on dissipation of aggression after the final instance of provocation. Although groups did not differ over time on the behavioral or affective measures (i.e., all groups behaved less aggressively and reported less anger over time, but not differentially so), groups did differ overall. Specifically, the CPCU group reacted with significantly more hostile aggressive behavior yet significantly less angry affect than controls, with the CP-only group between but not different from other groups on both measures (see Table 3). Once again the CPCU group was more behaviorally aggressive even when experiencing less anger, this time in the hostile aggression condition. Importantly, groups did significantly differ over time on one metric: children with CP-only sent increasingly prosocial messages as the final high provocation trial became more distal, compared to other groups that sent consistently low levels of prosocial messages. On the other hand, both the CP-only and CPCU groups sent significantly higher rates of antisocial messages than the control group over the final trials. It appears, then, that immediately after being highly provoked, both CP-only and CPCU groups were more likely than controls to send antisocial messages to peers, but only the CP-only group offsets this pattern by sending increasingly prosocial messages to the same peer. These subtly different communication patterns suggest that CU traits may influence how children with CP affiliate with peers, with the CP-only group seeking to increase affiliation after sending antisocial messages and the CPCU showing little interest in doing so. Further examination of this hypothesis is warranted.

Limitations

The findings of the present study must be considered in light of several noteworthy limitations. First, the small sample used in this study may have reduced power to detect statistically significant differences between groups. It should be noted, however, that the sample size used in this study was similar to previous research (e.g., Waschbusch et al. 2002), at least for the diagnostic groups. The lack of an ADHD-only comparison group prevented any examination of the independent contributions of ADHD in the study. Given that ADHD is characterized by

inattention and impulsive behavior, which likely influence how children process and respond to peer provocation, future studies should seek to clarify its role in response to provocation. To assure that all children were exposed to the same stimuli, a researcher read all the opponent's responses aloud to each participant. This may have diminished the impact of the provocation, as compared to previous studies that used voice recordings of confederate children (e.g., Waschbusch et al. 2002). However, significant effects emerged in low and high provocation conditions, indicating that the manipulation was effective. Although the SIP and CRTT were designed to mirror real-life situations, it is unclear how closely responses on these measures, particularly SIP, might resemble children's actual behavior. Traditional paper and pencil SIP measures are widely accepted in the field, though future researchers may wish to utilize new technologies to maximize ecological validity. Finally, the nature of the CTRR may have changed as children gained experience with the task. Even so, several between-group differences detected, suggesting that this effect was minimal, if present.

Clinical Implications

Collectively, these SIP, behavioral, affective, and communicative results may suggest important differences in the interpersonal styles of children with CP with or without CU traits. The present study found children with CPCU were markedly different from their peers; they were always more aggressive than others, even when unprovoked, especially in response to minimal provocation and when aggression proved to be personally beneficial (i.e., instrumental aggression). Children in the CPCU group rarely communicated with their peer opponent unless provoked, which they responded to in a verbally hostile manner. Children with CPCU appear to employ a distinctly aggressive interpersonal style which may warrant a more personalized approach to treatment that accounts for the constellation of deficits associated with CU traits (e.g., Miller et al. 2014). For example, children with CU traits may benefit from social problem solving training, to learn less hostile and more effective ways of achieving their desired goal with fewer negative consequences. An emotion regulation curriculum could help children with CP without CU traits learn how to manage their response to highly confrontational peers. Both researchers and clinicians must consider the unique contributions of CU traits on the presentation of aggression in youths by utilizing multiple aggression classification systems to more clearly distinguish between youths with CP with and without CU traits.

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