Affective theory of mind impairments underlying callous-unemotional traits and the role of cognitive control: A pilot study

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Abstract

Affective theory of mind (aToM) impairments predict antisocial behavior above clinical rating of the youth antisocial phenotype callous-unemotional (CU) traits. Adolescents with CU traits demonstrate specific impairments in cognitive control; and cognitive control modulates aToM. Adolescents with CU traits specifically demonstrate aToM impairments during complex, but not basic, emotions, which require greater cognitive control to process. What is less understood is how cognitive control impacts complex aToM in relation to CU traits. Such investigations demonstrate promise for understanding modifiable mechanisms underlying core impairments of CU traits. To examine this, 81 participants (ages 12-14, Female = 51.8%, Male= 48.2%) were recruited to complete a behavioral paradigm that involved an initial aToM task followed by placing additional demands on cognitive control and a final repeat of the same aToM task. Results indicate higher CU traits associated with greater sensitivity to cognitive demands and that placing demands on cognitive control resulted in additional decrements in complex aToM. These preliminary results suggest that the cognitive control vulnerabilities associated with CU traits impact complex aToM. This may partially explain why youth with CU traits persist in antisocial behavior and warrants further investigation.

Keywords: callous-unemotional traits, cognitive control, affective theory of mind, adolescents

Antisocial behavior (e.g., violent criminal behavior) amongst adolescents with callous-unemotional (CU) traits is predicted by impairments in affective theory of mind (aToM) above clinical ratings of CU traits alone [1-4]. CU traits are a youth antisocial phenotype [5] that maps on to the affective dimension of adult psychopathy [6, 7]. What separates youth with CU traits from those with conduct problems are profound interpersonal and socio-affective impairments, such as deficits in aToM [8]. Impairments in aToM associated with CU traits are specific to complex emotions [2, 8-10]. Complex emotions are nuanced and context dependent [11] and require greater cognitive resources to detect and process [12]. Specifically, deficient resources for cognitive control associated with CU traits may largely explain impairments in processing other's emotions [13-17]. Given that cognitive control modulates theory of mind [for reviews see: 18, 19], youth with CU traits may not have a complete deficit in aToM but rather a more general impairment in cognitive control resources necessary for processing complex emotional stimuli, which may explain CU traits association with aggressive criminal acts [8]. However, the dearth of analyses on how cognitive control impacts complex aToM amongst youth with CU traits prevents understanding a plausibly critical mechanism underlying antisocial outcomes. The present study employs a behavioral paradigm to understand how cognitive control impacts complex aToM in adolescents with CU traits.

Processing the emotional states of others via theory of mind provides critical information about the social environment and guides prosocial behavior [for meta-analysis: 20], whereas its impairment can lead to antisocial behavior. Theory of mind, which broadly involves inferences about others' mental states and beliefs, is divided into cognitive and affective components [21]. *Cognitive theory* of mind involves the inference of other people's thoughts and beliefs, whereas *affective theory of mind* (aToM) involves making inferences about others' emotions [21]. Both cognitive theory of mind and aToM associate with prosocial behavior similarly across studies [for meta-analysis: 20]; and impairments in theory of mind predicts antisocial behavior above clinical ratings of CU traits [1-4]. Adolescents with CU traits show the ability for cognitive theory of mind [22], but, when compared to typically developing peers, they demonstrate impairments in aToM during complex emotions [2, 8-10]. Emotions such as happy, sad, and angry are considered basic emotions whereas more nuanced emotions such as nervousness, boredom, and shame are considered complex emotions [23, 24]. Complex emotions require more cognitive control resources to process [12] because their subtlety requires processing more contextually relevant social information [11]. Taken together, this suggests that youth with CU traits have a general impairment in cognitive control resources necessary for processing complex emotional stimuli during aToM [8].

Cognitive control impairments are demonstrated among youth with CU traits and adults with psychopathy, which may impact aToM. Cognitive control is the capacity to monitor and regulate goal directed behaviors by evaluating contextual information [25], which involves attention control [26, 27] and inhibition [28]. Inhibition plays an important role in where attention is placed [29-31] and limiting the information attended to [i.e., perceptual bottleneck; 32], which is where cognitive control is critical [33] and adolescents with CU traits demonstrate impairments [17, 34]. These impairments are exacerbated under lower cognitive demands than normative peers [35]. This evidence is consistent with the response modulation hypothesis of psychopathic traits, which posits that errors in this bottleneck blocks processing secondary information necessary to evaluate new contextual information [36]. Consistent with this perspective, youth with CU traits over-allocate cognitive resources to stimuli unrelated to the current context [17], which, like adults with psychopathy [37], depletes resources for cognitive control. Cognitive control depends on the amount of available cognitive resources [33] and cognitive control modulates aToM [for reviews see: 18, 19]. Specifically, the subset of cognitive control processes of inhibition is necessary for aToM [19, 38]. This suggests that it is plausible that resource limitations for cognitive control associated with CU traits impact aToM; thus, placing additional demands on cognitive control could accentuate the underlying cognitive control limitations and reveal additional decrements in aToM.

The next critical step in this line of research is testing how placing additional demands on cognitive control impacts complex aToM amongst adolescents with CU traits. The literature cited above indicates impairments in both cognitive control and in complex aToM. Moreover, multiple lines of research converge on cognitive control modulating aToM [19, 39]. What we do not yet know is how resources for cognitive control contribute to further decrements in complex aToM in adolescents with higher CU traits. Given that adult psychopathy is considered a neurodevelopmental disorder [40], it is critical to examine early adolescents, the age theory of mind for other's emotions is consistently accurate [41], to identify mechanisms when affective theory of mind's association with behavior is strong [42]. The available treatments for antisocial phenotypes demonstrate limited efficacy [43], which highlights a critical need for work that defines mechanisms that may be further refined and potentially used to inform future intervention development. Because the failure to process complex emotional states via aToM may explain how those with CU traits callously harm others and engage in criminal acts [8], it is critical to examine cognitive control's impact on aToM amongst youth with CU traits in the context of cognitive control resources as a potential mechanism for further investigation.

The present study takes the next step to advance this line of research by implementing a behavioral paradigm to examine the impact that cognitive control has on aToM. First, we hypothesize that, prior to a cognitive load, we would replicate findings by Sharp, Vanwoerden [9] that CU traits negatively associated with complex aToM but did not significantly associate with basic aToM. Next, given the literature on impairments in cognitive resources, we hypothesized that higher CU traits would associate with a lower level a cognitive control measured by duration of inhibition capacity. Finally, given the importance of inhibition for aToM [19, 38], we hypothesized that placing an additional demand on cognitive control via an inhibitory processing task would negatively impact complex aToM accuracy at higher levels of CU traits. This important next step in this line of research can evidence a mechanism for better understanding aToM impairments in CU traits.

Methods

A Priori Power Analysis

Using G*Power [44, 45], we conducted a priori power analyses for CU traits effects and the impact of a cognitive load on theory of mind as a function of CU traits. Basing an effect size from Sharp, Vanwoerden [9], testing the effects of CU traits using a two-tailed test, $F^2 = 0.10$, and alpha of 0.05 suggested a sample of 81 is required to achieve 80% power. Additionally, basing an effect size from a related but different study by Steinbeis [46], testing the effects of a cognitive load with a two-tailed random effects test, a sample correlation coefficient p^2 of .3, and alpha of 0.05, our power analysis suggested a sample of 57 participants was required for 80% power.

Sample

The study protocol, participant recruitment, and consents were approved by the Colorado Multiple Institutional Review Board. All participants were early adolescents between the ages of 12-14 and we obtained both consent and assent in writing for all participants prior to participation. Participants were recruited using online advertisements and required a responsible adult to upload identification to ensure we did not have repeat participants as well as a safeguard for verifying participants identity and age. Participants were selected based on age (12-14 years) and qualification for recruitment numbers involving equal numbers across sex (male and female) and level of CU traits (qualifying for the low prosocial emotion [LPE] specifier and normative CU traits). Participants were identified as qualifying for the low prosocial emotion (LPE) specifier if they met criteria based on nine-items on the inventory of callous-unemotional traits using the split-item coding method [47, 48]. Beyond not meeting these inclusion criteria and requirements for recruitment, we excluded participants if they did not complete the consent and assent process after a follow up and if after acceptance they did not complete within a month. We recruited a total of 81 adolescents (ages 12-14: 12.86±0.76) that were relatively balanced between sex (female 51.8%, male 48.2%), predominately White (White = 69.1%, Black = 17.3%, Pacific Islander = 10%, American Indian = 1.2%, Asian = 1.2%, other race = 1.2%) with 16% reporting Latinx ethnicity, and a slightly higher number qualifying for LPE versus normative CU traits (LPE = 56.9%, normative = 43.1%; Table 1).

Self-report measures

Callous-Unemotional Traits*.* CU traits was assessed using the 24-item self-report measure Inventory of Callous-Unemotional Traits [ICU; 49]. Previous research demonstrates two items on the ICU have poor psychometric properties and were removed from our analyses, consistent with previous studies [47]. We found adequate reliability for this measure in our current sample (α = 0.78). The ICU consists of three subscales for callousness (e.g., "I do not care who I hurt to get what I want"), uncaring (e.g., reverse scored: "I care about how well I do at school or work"), and unemotional (e.g., "I do not show my emotions to others"). Although previous research indicates that the unemotional subscale does not associate with antisocial behavior or the other subscales [50], the unemotional subscale is critical for capturing the affective and interpersonal features of this construct that is independent of antisocial behavior; thus, removing these items would diminish the overall measure for the construct of interest [51]. We included the unemotional subscale in our analysis. Participants rate items on a four-point Likert scale from 0 ("not true at all") to 3 ("definitely true"). Higher scores indicate greater level of CU traits.

Conduct Problems*.* Conduct problems were assessed using the conduct problem subscale of the Strengths and Difficulties Questionnaire [SDQ; 52, 53]. The SDQ is a brief behavioral screening with versions to assess youth between 3-16 years old that demonstrates test-retest reliability, internal consistency, and cross-informant correlation. The conduct problem subscale consists of 5 items that had adequate reliability in our current sample (α = 0.86). Participants rate items such as "I take things that are not mine from home, school or elsewhere" on a scale of 0 ("not True") to 2 ("Certainly True"). Higher scores indicate greater conduct problems.

Affective Valence. Affect valence can impact cognitive performance [54]. Thus, Affective valence was assessed using a self-report measure where participants rated the question “how annoyed are you?” on a visual analog scale from 0-100 (neutral to annoyed) prior and after cognitive load. Higher scores indicate higher level of annoyance either prior to or after the cognitive load. Because increased cognitive demands may increase affective valence that impacts ToM performance, we calculated a rate of change score between the beginning and end of the cognitive load task to be used as a control.

Behavioral Tasks

Affective Theory of Mind Task. Affective theory of mind was assessed using the child version of the mind in the eyes task [55], an adaption of the original mind in the eyes with child-level vocabulary [24], where participants are presented with 28 trials with images of human eyes along with four options of what that person is feeling. Participants responded with the emotion they feel best represents the eyes presented. Of these trials, 11 involve basic emotions (e.g., happy, sad, scared, angry), and 17 involve complex emotions [e.g., nervousness, boredom, shame; 23, 24]. This task demonstrates test-retest reliability [56] suggesting learning effects are of minimal concern for the repeated instance of the task in our design. Correct responses were summed for each condition and total score so that higher scores indicate greater accuracy for affective theory of mind judgments.

Inhibitory Processing Task. Participants completed a version of the stop signal task used in prior studies to tax the inhibitory component of cognitive control in youth[46, 57]. Participants were presented a go signal (blue squares) for 120 trials and 30 of those trials were followed by a stop signal (green triangles; inter-trial interval 3000ms). Following Steinbeis [46] protocol, participants were asked to hold their response to see if a stop signal follows the initial go signal. To maximally tax cognitive control for each participant, the stop signal delay increased or decreased by an increment of 50ms per trial depending on whether the response was successfully inhibited or not (interstimulus interval range 50ms -1600ms, starts at 150ms and increases/decreases 50ms if correct/incorrect). We recorded the maximum interstimulus delay reached to indicate the maximum cognitive load for each participant. Higher maximum cognitive load score indicates a higher duration of a cognitive load they can endure suggesting greater cognitive control.

Additional Variables and Covariates

Careless Respondents. Highly patterned responses to surveys and tasks indicate participants that responded carelessly. Careless participants were identified statistically using the ‘careless’ package in r [58]. We created a variable indicating level of carelessness to be entered into the model to regress out variation due to carelessness. To determine respondent carelessness, we assessed 1) long-string: how long of a string of the same response the participant had [i.e., how long the participant pressed the same response each time; 59], 2) item-variability: the variability of response [i.e., how much participants responses varied from question to question with low variability suggesting carelessness; 60], and 3) even-odd: the extent to which even and odd responses were similar [e.g., level of consistency between even and odd responses with more consistency indicating carelessness; 59]. This three-pronged approach was used to capture multiple sources of careless responding, which results in a continuous variable indicating the level of carelessness for each participant.

We used the median and median absolute deviation (MAD) to define those with extremely careless responses. The MAD is more effective than other approaches (e.g., interquartile range and standard deviation) at detecting outliers as it is not strongly affected by outliers in the data, sample size, and is more robust [61]. Preliminary investigation revealed variation in these scores; so we used a highly conservative criteria of MAD*3 [61] to ensure we were only identifying careless respondents. Specifically, we used a criterion of median – MAD*3 for item-variability of and median + MAD*3 for both long-string and even-odd. Regressing variation from careless respondents allows us to remove spurious results while retaining power by not removing these participants.

Identifying Participants that did not receive a cognitive load. To ensure the integrity of the data used in the analysis, we statistically identify participants that did not receive a cognitive load. To do this we used the logic that those who were both 1) a high outlier on no stop signal conditions (i.e., all trials were correct) and 2) a low outlier on responding to the stop signal condition (i.e., most all trials were incorrect) indicates a participant that was not responding to the task on either condition and did not receive a cognitive load (i.e., not pressing a button for either condition). We had to do this separately from the careless responses because there was no variability of choice (i.e., only space button was pressed). Preliminary data investigation revealed most participants did well on the non-stop signal and many did well on the stop signal condition; so we choose a moderately low conservative criteria to detect outliers of median±2*MAD [61] to identify participants that met both conditions. We created a dichotomous variable indicating participants that met both criteria that were removed from the analysis. Removing these participants helps us to ensure we are measuring the impact of a cognitive load and not a spurious result due to task inattention.

Covariates. In all analyses we controlled for sex, age, race, careless respondents, and conduct problems; and, in analyses that examined the impact of cognitive load, we controlled for the rate of change in affective rating from before until after the cognitive load task. Race may account for variation in identifying emotions in faces outside of one's racial category [62], thus we controlled for race. We dichotomized race to indicate the primary racial category (White) and other races because 1) stimuli used in the aToM task were exclusively White faces, thus variation was expected to differ from White participants and, given the lack of sample diversity, 2) to have adequate representation of racial categories to account for this variation. The primary interest of the present study is to examine CU traits association with outcomes of interest; thus, we controlled for conduct problems in our analyses. Conduct problems are often comorbid with CU traits but are distinct and associate with different outcomes [e.g., 63, 64, 65]. Thus, to prevent conflating antisocial behavior with the callous-unemotional dimension of interest, we used the conduct problem subscale of the SDQ as a covariate. But, to ensure this does not cause a suppression effect [e.g., 66, 67], we also ran all models without controlling for conduct problems to assess suppression concerns. Because estimates did not change and no evidence of suppression effects were found, we only report on models that control for conduct problems.

Study Procedure

Participants completed a behavioral paradigm where all participants were exposed to the same conditions. Participants completed an initial affective ToM task followed by an inhibitory processing task before completing a final instance of the same affective ToM task. Participants completed these tasks completely online using the behavioral task platform testable [68]. This design allows us to examine the impact of taxing cognitive control on affective ToM.

Analysis

Assessing whether Bias was Introduced by Removing Participants. We assessed if any bias was introduced by excluding cases that did not receive a cognitive load from those included in the final analysis. We constructed a set of t-tests for continuous variables and chi-square tests for binary variables to see if the group we excluded was statistically different on demographics and variables in the model. To ensure this was not due to sampling variability and differences in group sizes, these tests were bootstrapped using the 'MKinfer' package [69]. Importantly, we only removed participants that met criteria for not receiving a cognitive load on analyses that included the cognitive load task.

Assumption Checking. We assessed for assumptions of multicollinearity, normality of residuals, auto correlation, and linearity. We detected no violations to these assumptions, and we had no missing data in our sample. Thus, we designed our analytic approach without needing to account for non-normality, non-linear associations, or missing data.

Analytic Approach. We conducted analyses to test CU traits association with 1) aToM, 2) maximum cognitive load achieved, and 3) the impact of taxing cognitive control on aToM. For the first two analyses, we fit a path model using the 'lavaan' package [70], which provides two advantages for statistical inference. First, this allowed us to estimate multiple outcome variables simultaneously in one model that reduces error introduced by estimating multiple models. Second, this approach allowed us to model the correlation between related outcomes and estimate model parameters on the unique variance of each outcome, which improves the inference of estimated parameters. These path models were estimated using maximum likelihood estimation. We conducted an analysis of CU traits on basic and complex ToM simultaneously. For all analyses we obtained bias corrected bootstrapped confidence intervals for each parameter using 5000 resamples of the data.

To test the impact of a cognitive load on affective ToM as a function of CU traits, we used the ‘lme4’ package [71] to estimate a random effects model accounting for repeated measures of affective theory of mind (before and after a cognitive load) as a function of CU traits. We included random effects for individuals and fixed effects for time, CU traits, and their interaction. We orthogonalized interaction terms from the model using the residual centering approach by Little, Bovaird [72], which retains model assumptions of residual independence while allowing us to interpret interaction and direct paths in one model [72]. Our approach involved first modeling total CU traits as the independent variable then we conducted follow up analyses to examine which subscale may account for significant associations. Prior to interpreting, we assessed if adding random effects improved model estimation using a likelihood ratio test to compare a fixed effects regression with the random effects model. We used ‘lmerTest’ [73] to obtain correct p values for the parameters of the random effects model and ‘lmersampler’ [74] to obtain bootstrapped confidence intervals for all parameters with 5000 resamples. We choose mixed effects modeling for our repeated measure analysis because it addresses common biases due to omitted variables [75-78], improves generalizability and reproducibility of results [79], and overcomes many barriers of traditional analyses with repeated measures data [e.g., ANOVA; 80] by modelling individual variation, thus bolstering statistical inferences on repeated measure outcome effects.

Results

Variable Descriptives

CU Traits and Conduct Problem Distribution. The current samples distribution of CU traits with the ICU (30.23±6.68) and conduct problems subscale of the SDQ (1.51±1.71) is within expected values of other studies on community samples [81, 82] and published large sample population norms respectively (https://sdqinfo.org/norms/USNorm1.pdf).

No cognitive load. We identified nine participants that met criteria for not receiving a cognitive load. These participants were removed from analyses that were related to the inhibitory processing task. Specifically, we removed these participants from analyses involving CU traits association with maximum cognitive load and the impact of a cognitive load on aToM.

Assessing bias from removing participants with no cognitive load. Results revealed that participants removed from the analysis due to not receiving a cognitive load were not significantly different on demographics of race, age, or sex, nor were their significant differences in callous-unemotional traits, outcome variables or control variables planned in the formal analysis test. These findings held with 5000 bootstrapped resamples.

Lower Baseline Complex ToM Associated with Greater CU traits

Higher CU traits negatively associated with complex ToM (β= --0.149(0. 042), $p< 0.001$, $R^2 = 0.166$; Table2), but did not significantly associate with basic ToM (β= 0. 001(0. 001), $p=0.991$, $R^2 = 0.048$; Table2; Figure 1). Age, race, sex, conduct problems, and careless responses did not significantly account for additional variance in the outcome variables.

Lower Cognitive Control Associated with Greater CU Traits

Higher CU traits associated with lower maximum cognitive load (β= -26.725(11.323), $p=0.018$, $R^2= 0.139$, Table 3, Figure 2). Age, race, sex, conduct problems, and careless responses did not significantly account for additional variance in the outcome variable.

ToM Decrements After a Cognitive Load Associated with CU and Unemotional Traits

Greater decrements in overall ToM accuracy associated with higher CU traits (β= -0.127(0.056), $p=0.026$) with a significant interaction between timepoint and CU traits (β= -0.100(0.047), $p=0.035$; Table 4, Figure 3). Follow up analyses revealed this interaction effect was primarily driven by the unemotional subscale (β= -0.386(0.144), $p=0.009$; Table 5, Figure 4). Age, race, sex, annoyance, and conduct problems did not significantly account for additional variance in the outcome variable.

Discussion

Results reveal that youth with higher CU traits have impairments in complex aToM and cognitive control, and that placing additional demands on cognitive control results in added decrements in complex aToM. These results extend previous work by evidencing cognitive control as a critical component of aToM impairments associated with CU traits. All results held even with bootstrapped confidence intervals suggesting our findings were not due to sampling variability. This novel finding sets the stage for defining an important mechanism underlying core impairments in CU traits.

Less Complex Affective Theory of Mind Associates with Callous-Unemotional Traits

Replicating findings by Sharp, Vanwoerden [9], we found that CU traits did not associate with basic aToM; but higher CU traits associated with less complex aToM accuracy. Although adequate for basic aToM, it is plausible that the cognitive capacity of those with higher CU traits fail due to the complexity of social information required for complex aToM [11] requiring greater cognitive demands [12]. Blakemore and Mills [83] and Burnett, Bird [84] suggest that more complex emotions (what they refer to as “social emotions”) require greater representation of another’s mental state, which, because cognitive control modulates ToM [for reviews see: 18, 19] and inhibition is required for ToM [19, 38], plausibly requires greater cognitive resources. These results suggest that cognitive resources during the less demanding basic aToM are adequate, but that these cognitive resources fail under aToM that requires higher cognitive demands.

Less Cognitive Control Associates with Higher Callous-Unemotional Traits

Higher CU traits associated with decreases in the maximum amount of cognitive load that a participant achieved. The task used adaptively increased or decreased the interstimulus interval to prolong the amount of time one had to respond as a measure of capacity for cognitive control. This capacity for cognitive control was lower as CU traits increased. This finding is consistent with the extent literature on cognitive control during conflict monitoring [e.g., 17] and extends these findings by evidencing impairments in another component of cognitive control – duration of response inhibition. Impairments in the inhibition component of cognitive control provides another layer of neurocognitive vulnerability that may in part explain difficulties with conflict adaption [17], selective attention [34], or attention control during social faces [85] related to the response modulation hypothesis [36]. Overall, this finding suggests that those higher in CU traits have a greater sensitivity to cognitive demands. Thus, it is plausible to further probe how placing additional cognitive demands on cognitive control may impact aToM.

Taxing Cognitive Control Negatively Impacts Affective Theory of Mind

Taxing Cognitive control resulted in greater decrements on complex aToM at higher levels of CU traits; and follow up analyses revealed this effect was driven by the unemotional component of CU traits. Overall, these findings reveal a greater susceptibility to cognitive demands at higher levels of CU traits, which result in less accuracy during aToM. The unemotional subscale is relevant for the affective dimension of CU traits beyond the antisocial component [51]. The finding that the unemotional subscale drove these associations suggests that the affective impairment dimension of CU traits is the most susceptible to cognitive demands that impact complex aToM. This would further substantiate the importance of cognitive control resources for processing affective social information. This finding is consistent with the response modulation hypothesis indicating unique impairments in cognitive control that are specific to CU traits (i.e., psychopathic traits) in adolescents underlie profound social and interpersonal impairments beyond the antisocial component. This study provides evidence that cognitive control can be modified in youth with CU traits; therefore, it is plausible that interventions for these adolescents that improve cognitive control may improve aToM.

Limitations

The previous results must be interpreted under some limitations. First, all study participants were exposed to the same conditions, and we could not compare effects observed in a control group. Future studies could build on this result by including a control condition. Second, this study was conducted completely online and although explicit instructions were given on how to take the study, everyone completed the study in different environments. To mitigate spurious findings, we detected participants that had careless responses or likely did not receive a cognitive load. Future studies could build on this study by having participants complete the study in a controlled environment for all participants. Finally, this study did not assess level of anxiety. Psychopathic traits have been shown to take on primary and secondary characteristics that are subtyped by level of anxiety [86-88]. Future studies should assess for anxiety to parse if results are different for primary and secondary characterizations of CU traits.

Conclusions

The present study demonstrates youth with higher CU traits have a greater sensitivity to cognitive demands on cognitive control and that this negatively impacts complex aToM. This study reveals an important component underlying core impairments of CU traits. Impairments in aToM for complex emotions may explain how youth with CU traits engage in harmful and criminal behavior [8]; thus, understanding how to increase cognitive control in these youth may bolster aToM and attenuate antisocial behavior. The main conclusions are supported by the available literature but extend it to reveal a novel component of cognitive control is modifiable and it impacts how youth with CU traits infer other's emotions. This novel finding opens a path of future investigations to improve our mechanistic understanding of core CU trait impairments, which may indicate where to intervene to help these youth. Modeling cognitive control in relation to complex aToM impairments using a randomized control design in an fMRI may help identify a mechanism to target and help inform the development of new interventions to address persistent antisocial behavior in youth with CU traits.

Table 1. Demographics

Variable	Mean±SD (range) or n(%)
Age	12.89±0.76 (12-14)
CU traits	30.23±6.68 (18-44)
Conduct problems	1.51±1.71 (0-8)
Sex	
Female	42(51.8%)
Male	39(48.2%)
Race	
White	56(69.1%)
Black	14(17.3%)
Pacific Islander	8(10%)
American Indian	1(1.2%)
Asian	1(1.2%)
Other Race	1(1.2%)
Ethnicity	
Latinx	13(16%)
Non-Latinx	68(84%)

Table 2. Results of Theory of Mind as a Function of Callous-Unemotional Traits

						Bootstrapped CI_{95}	
	Std β	Unstd β	SE	z-value	p-value	Lower	Upper
Complex ~ (R^2 = 0.166)							
CU traits	-0.439*	-0.149	0.042	-3.513	< 0.001	-0.237	-0.062
Male	-0.193	-0.876	0.472	-1.855	0.064	-1.943	0.123
Age	0.040	0.120	0.308	0.389	0.698	-0.549	0.787
White	-0.088	-0.433	0.520	-0.833	0.405	-1.532	0.611
Conduct	0.249	0.330	0.169	1.949	0.052	-0.067	0.714
Careless	-0.072	-0.419	0.603	-0.695	0.487	-1.473	0.843
Basic ~ (R^2 = 0.048)							
CU traits	0.001	0.001	0.037	0.011	0.991	-0.075	0.068
Male	-0.048	-0.178	0.412	-0.431	0.667	-0.984	0.640
Age	0.031	0.075	0.269	0.278	0.781	-0.547	0.643
White	0.025	0.100	0.454	0.221	0.825	-0.791	1.025
Conduct	-0.187	-0.202	0.148	-1.367	0.172	-0.593	0.131
Careless	-0.122	-0.578	0.527	-1.097	0.273	-1.544	0.348

Note: n=81; Bootstrapped confidence intervals are bias corrected with 5000 resamples

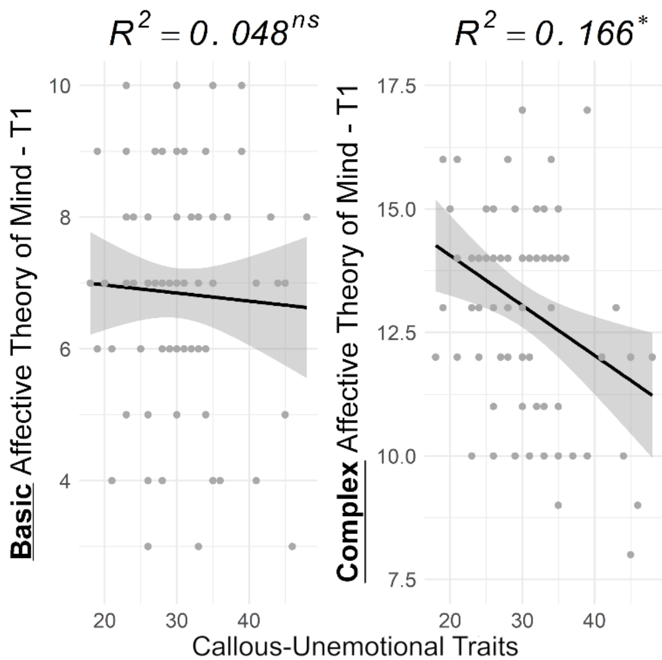

Figure 1. Depicting callous-unemotional traits association with basic and complex affective theory of mind

Table 3. Results of Maximum Cognitive Load as a Function of Callous-Unemotional Traits

						Bootstrapped CI_{95}	
	Std β	Unstd β	SE	z-value	p-value	Lower	Upper
Max load ~ (R^2= 0.139)							
CU traits	-0.296	-26.725	11.323	-2.360	0.018	-50.381	-0.335
Male	-0.152	-177.734	132.057	-1.346	0.178	-440.750	112.333
Age	0.152	118.942	87.609	1.358	0.175	-79.587	284.747
White	-0.149	-218.619	167.589	-1.305	0.192	-546.743	92.889
Conduct	0.135	50.812	50.687	1.003	0.316	-75.312	169.595
Careless	-0.087	-140.536	188.898	-0.744	0.457	-574.485	321.259

Note: n=72; removed 9 participants for not responding during Inhibitory processing task. Bootstrapped confidence intervals are bias corrected with 5000 resamples

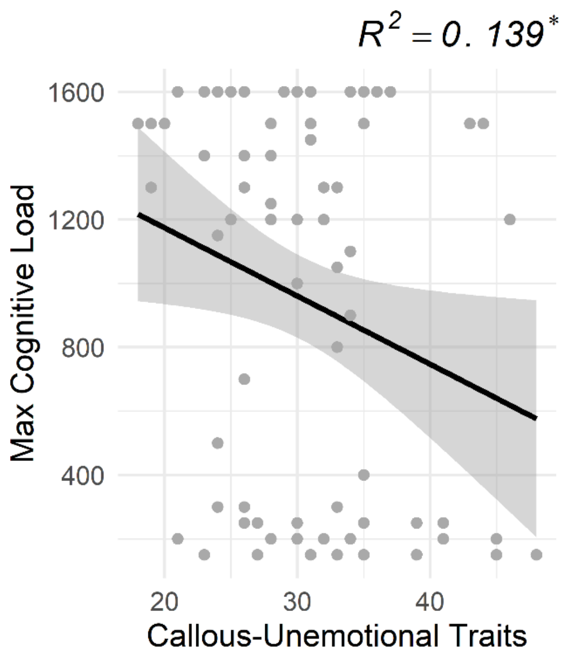

Figure 2. Depicting callous-unemotional traits association with maximum cognitive load

Table 4. Mixed effects model

					Bootstrapped CI_{95}	
Fixed effects	Unstd β	SE	t-value	p-value	Lower	Upper
Intercept	13.720*	5.466	2.510	0.015	3.404	24.037
CU Traits	-0.127*	0.056	-2.273	0.026	-0.232	-0.021
Time	-0.500	0.286	-1.747	0.085	-1.061	0.061
CU * Time [a]	-0.100*	0.047	-2.145	0.035	-0.191	-0.009
Annoyance	0.014	0.009	1.517	0.134	-0.003	0.031
Male	-0.899	0.576	-1.559	0.124	-1.987	0.189
Age	0.300	0.394	0.762	0.449	-0.443	1.043
White	0.059	0.219	0.271	0.787	-0.354	0.473
Conduct	-0.553	0.655	-0.844	0.402	-1.789	0.684
Random Effects (co-variances)						
Individual intercept	4.186	2.046			1.484	2.413
Residual	2.949	1.717			1.450	2.013

Note: n=72; Bootstrapped confidence intervals are bias corrected with 5000 resamples
All p-values are two-tailed
Time is coded 0= baseline ToM and 2= second ToM after a cognitive load
[a]= orthogonalized from the model using residualized centering approach
Marginal R^2= 0.15 Conditional R^2= 0.65

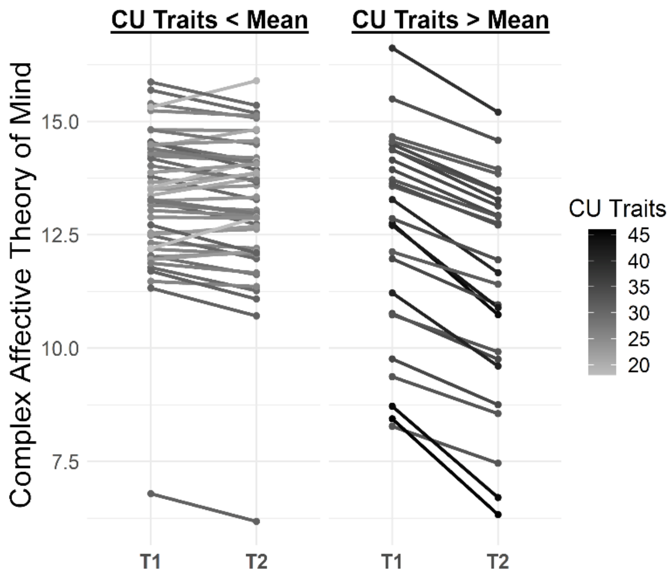

Figure 3. Depiction of changes in complex affective theory of mind after a cognitive load as a function of total callous-unemotional traits. Note: participants are separated by mean callous-unemotional traits to avoid over plotting. Darker line = greater callous-unemotional traits.

Table 5. Mixed effects

					Bootstrapped CI_{95}	
Fixed effects	Unstd β	SE	t-value	p-value	Lower	Upper
Intercept	11.877	5.423	2.190	0.032	1.641	22.114
Unemotional Traits	-0.269	0.161	-1.674	0.099	-0.572	0.034
Time	-0.500	0.281	-1.776	0.080	-1.051	0.051
Unemotional * Time [a]	-0.386*	0.144	-2.672	0.009	-0.669	-0.103
Annoyance	0.015	0.009	1.668	0.100	-0.002	0.033
Male	-0.853	0.586	-1.455	0.150	-1.958	0.253
Age	0.345	0.401	0.860	0.393	-0.413	1.103
White	-0.345	0.664	-0.520	0.605	-1.599	0.909
Conduct	-0.085	0.202	-0.421	0.675	-0.466	0.296
Random Effects (co-variances)						
Individual intercept	4.432	2.105			1.546	2.474
Residual	2.852	1.689			1.426	1.979

Note: n=72; Bootstrapped confidence intervals are bias corrected with 5000 resamples
All p-values are two-tailed
Time is coded 0= baseline ToM and 2= second ToM after a cognitive load
[a]= orthogonalized from the model using residualized centering approach
Marginal R^2= 0.13 Conditional R^2= 0.65

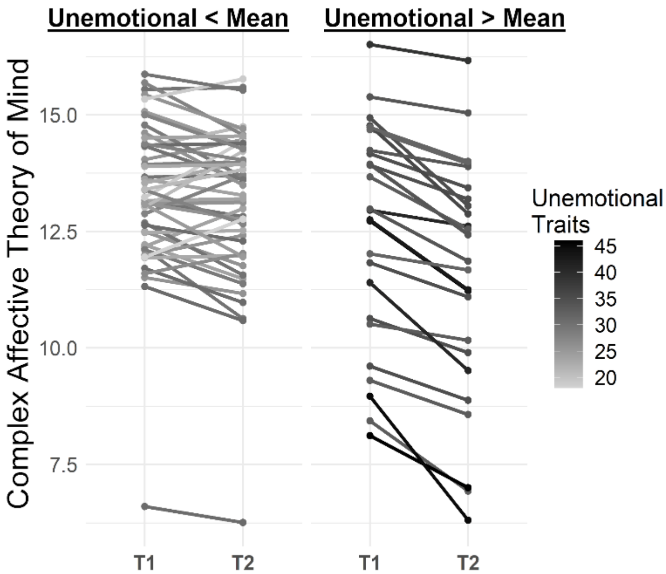

Figure 4. Depiction of changes in complex affective theory of mind after a cognitive load as a function of unemotional traits. Note: participants are separated by mean unemotional traits to avoid over plotting. Darker line = greater unemotional traits

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