Do neurocognitive deficits in decision making differentiate conduct disorder subtypes?

Kostas A. Fanti, Eva R. Kimonis, Maria-Zoe Hadjicharalambous & Laurence Steinberg
Your article is protected by copyright and all rights are held exclusively by Springer-Verlag Berlin Heidelberg. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your article, please use the accepted manuscript version for posting on your own website. You may further deposit the accepted manuscript version in any repository, provided it is only made publicly available 12 months after official publication or later and provided acknowledgement is given to the original source of publication and a link is inserted to the published article on Springer’s website. The link must be accompanied by the following text: “The final publication is available at link.springer.com”.
Do neurocognitive deficits in decision making differentiate conduct disorder subtypes?

Kostas A. Fanti1 · Eva R. Kimonis2 · Maria-Zoe Hadjicharalambous1 · Laurence Steinberg3,4

Received: 2 November 2015 / Accepted: 18 January 2016
© Springer-Verlag Berlin Heidelberg 2016

Abstract The present study aimed to test whether neurocognitive deficits involved in decision making underlie subtypes of conduct-disorder (CD) differentiated on the basis of callous-unemotional (CU) traits. Eighty-five participants ($M_{age} = 10.94$ years) were selected from a sample of 1200 children based on repeated assessment of CD and CU traits. Participants completed a multi-method battery of well-validated measures of risky decision making and associated constructs of selective attention and future orientation (Stroop, Stoplight, and Delay-Discounting Tasks). Findings indicated that impaired decision making, selective attention, and future orientation contribute to the antisocial presentations displayed by children with CD, irrespective of level of CU traits. Youth high on CU traits without CD showed less risky decision making, as indicated by their performance on the Stoplight laboratory task, than those high on both CD and CU traits, suggesting a potential protective factor against the development of antisocial behavior.

Keywords Conduct disorder · Decision making · Executive functioning · Future orientation · Callous-unemotional traits

Introduction

Children with conduct disorder (CD) show a persistent and repetitive pattern of major rule-breaking behavior and harm to others. Much of contemporary research on CD focuses on psychopathic traits, which is termed callous-unemotional (CU) traits in youth, owing to the distinct ability of this deficient affect dimension to differentiate among antisocial youth [1]. The presence of CU traits (i.e., lack of empathy/guilt, uncaring attitudes) designates a unique subgroup of antisocial children showing a more severe, persistent and early starting subtype of CD [2]. The distinction between CU/non-CU dimensions has proven so clinically useful that a specifier to the diagnosis of CD (with “limited prosocial emotions”) has been added to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [3]. This distinction also serves to identify antisocial children characterized by a unique combination of clinical features and neurocognitive disturbances [4].

Three neurocognitive impairments are proposed to selectively underlie the clinical symptoms of the CU subtype of CD: deficient empathy, reduced threat sensitivity, and impaired decision making [4]. Whereas a large body of research evidences insensitivity to others’ distress and to threat among the CU subtype of CD [5, 6], decision making has been subject to far less study. For example, reduced aversive conditioning that is evident among CD youth generally, and also adult psychopaths, has not been examined in relation to the CU subtype specifically [7, 8].

Poor decision making among individuals with CU traits is thought to result from their impaired ability to represent and use expected value information [4, 9]. In other words, the aversive reinforcement of a victim’s distress cues does not become associated with the representation of the
antisocial action that induced this distress. As a result, previously punished behaviors are repeated because the individual fails to anticipate a negative outcome when choosing between whether to engage in the same antisocial action. This neurocognitive deficit has not yet been examined among youth with and without CU traits may show similar social behavior and poorer performance in their presence. Decision-making deficits are also common among youth with attention-deficit hyperactivity disorder (ADHD) [12, 13], and some attribute the association between CD symptoms and executive dysfunction to comorbid ADHD symptoms [14, 15]. The present study aims to elucidate to what extent neurocognitive deficits in decision making are unique to conduct problems, CU traits, or their co-occurrence, while also accounting for any association with ADHD.

Selective attention (i.e., sustaining focus on goal-directed behavior) and future orientation (i.e., ability to plan ahead and envision long-term consequences of decisions and actions over short-term consequences) are executive functions that have an important influence on decision making. They are also similarly impaired among antisocial youth. First, selective attention deficits are observed among youth with CD and those engaging in delinquency, as indicated by high interference levels, slow reaction time, and poor accuracy on the Stroop test [16]. Juvenile offenders scoring high on psychopathy also showed greater Stroop interference than those scoring low, although it is unclear to what extent their more severe conduct problems accounts for this difference [17].

Second, on a delay discounting task, youth with CD were poorer at pitting long-term benefits against immediate gains [18, 19]. When considering psychopathic traits, results are equivocal: one study found that juvenile offenders high on CU traits showed poorer future orientation than those scoring low [20], whereas a second study found that community adolescents (N = 45) high on psychopathy performed better on a delay discounting task than low scorers, suggesting a stronger future orientation [21]. These conflicting findings leave open the possibility that CU traits relate to better future orientation in the absence of antisocial behavior and poorer performance in their presence. Altogether, these preliminary findings suggest that antisocial youth with and without CU traits may show similar executive functioning impairments known to contribute to risky decision making. The present study aimed to fill this gap in knowledge.

The present study

The majority of prior studies examining decision making and executive functioning among antisocial youth employed a variable-centered over a person-centered approach. As a result they cannot inform the question of whether subtypes of children with CD differ from one another on decision making. This study of community-based children aimed to advance knowledge about the extent to which multidimensional impairments in decision making might underlie subtypes of CD differentiated on the basis of stable CD symptoms and CU traits, operationalized using DSM-5’s ‘with limited prosocial emotions’ diagnostic criteria.

The present study expands on prior research using several validated measures of decision making and related constructs, covarying ADHD symptoms, and using repeated assessment of CD symptoms and CU traits to capture more stable behaviors and subtypes. We aimed to clarify whether deficits in risky decision making constitute a third divergent mechanism differentiating antisocial children with CU traits from those without CU traits, in addition to deficient empathy and insensitivity to threat. We tested two competing hypotheses that CD youth with and without CU traits would either significantly differ from one another in risky decision making and executive functioning or alternatively, show similar levels of impairment. In accordance with prior work, we also included a group of children high on CU traits but low on CD symptoms to evaluate main effects of CD, CU traits, and possible CD × CU interactions [22]. We explored whether less risky decision making might explain why the understudied group of youth scoring high on CU alone fails to engage in antisocial behaviors despite deficient empathy levels.

Method

Participants

Preliminary examination of longitudinal reports on CD symptoms and CU traits were used to identify high-risk and low-risk youth for the laboratory-based assessment. Screening (N = 1200 families; M_age at study commencement = 9.38, SD = 1.04; 53.4 % female), which is described in detail elsewhere [23], was based on a longitudinal three-wave data collection (6 months apart) during which mothers and fathers completed the Checkmate plus Child Symptom Inventory-4 (CSI-4) [24], measuring CD symptoms, and the Inventory of Callous-Unemotional Traits (ICU) [25]. Following approval of the study by the Cyprus Ministry of Education and Bioethics committee,
Table 1 Demographic information per group, total N = 85

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Gender</th>
<th>Age (mean)</th>
<th>IQ (T score)</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>28</td>
<td>15 boys/13 girls</td>
<td>11.00 (1.15)</td>
<td>49.68 (8.72)</td>
<td>13.32 (1.49)</td>
</tr>
<tr>
<td>CU-only</td>
<td>23</td>
<td>13 boys/10 girls</td>
<td>11.09 (1.04)</td>
<td>48.37 (9.12)</td>
<td>12.35 (1.86)</td>
</tr>
<tr>
<td>CD-only</td>
<td>17</td>
<td>9 boys/8 girls</td>
<td>10.76 (0.97)</td>
<td>46.68 (9.59)</td>
<td>12.32 (2.65)</td>
</tr>
<tr>
<td>CD + CU</td>
<td>17</td>
<td>10 boys/7 girls</td>
<td>10.82 (1.01)</td>
<td>48.03 (11.08)</td>
<td>12.79 (1.44)</td>
</tr>
</tbody>
</table>

Means (Standard Deviations); Education is based on an average of parents' education, which was coded as follows: 1–6 refer to elementary school grades, 7–12 refer to middle and high school grades, 13 = some college, 14 = college, 15 = master level and above.

Informed consent was obtained from parents of all participating children.

As described in Fanti et al. [23], using Latent Class Growth Analysis distinct CD trajectories were identified based on mother and father reports: The majority of children exhibited low CD symptoms across time (81.1 %; 434 boys/539 girls), 12.8 % scored at average levels (84 boys/70 girls), and 6.1 % scored consistently higher (>1 SD) on these problems relative to the other groups (42 boys/31 girls). Among children with either low or high/stable CD symptoms, groups scoring high or low on CU traits were identified based on longitudinal parent reports. To do so, items from the ICU that represent the DSM-5 limited prosocial emotions (LPE) specifier to CD were used (i.e., Lack of Remorse or Guilt; Callous-Lack of Empathy; Unconcerned about Performance; and Shallow or Deficient Affect) [3]. To be consistent with DSM-5 LPE criteria, children with a parent-reported symptom score of 2 or greater during at least 2 assessment periods received the LPE specifier.

Among the 73 participants with high/stable CD symptoms, 19 met LPE specifier criteria and 18 did not (zero LPE criteria), after taking longitudinal and multi-reporter (mother/father and child) agreement into account. These children were invited to complete the lab tasks and 34 accepted the invitation resulting in the CD-only (n = 17) and CD + CU (n = 17) groups. Next, 60 randomly selected participants with low CD symptoms differentiated on their levels of CU traits were invited to participate, resulting in 23 participants in the CU-only and 28 in the control groups. Children in the CU-only and CD+CU groups scored consistently higher on the total (>1 SD) ICU scale compared to CD-only and control groups. The final study included 85 children (Mage = 10.94, SD = 1.05; 44.7 % girls) who completed lab tasks after completion of the longitudinal study. Table 1 shows demographics separately for each group. As shown in Table 1, the four groups were similar in terms of gender, χ² (3, N = 85) = .17, p = .98, age, F(3,81) = .40, p = .75, η² = .01, IQ (based on the Wechsler Abbreviated Scale of Intelligence), F(3,81) = .36, p = .78, η² = .01, and parental education, F(3,81) = 1.53, p = .21, η² = .05, which was used as a proxy for socio-economic status.

Measures

Risky decision making: In the computerized Stoplight Task [10, 26], participants control the progression of a car from the driver’s vantage point through 20 intersections to a distant location before time runs out. Each time the participant approaches an intersection the traffic signal turns yellow, and he/she must decide whether to use the space bar to stop the car and wait for the green light (low-risk option) or attempt to cross the intersection (high-risk option). The participant cannot control the speed of the car and if he/she decides to drive through the intersection there is a chance of crashing with another vehicle. The time delay is based on the timing of the traffic signals and the probability of a crash (e.g., 3 s are lost if the participant chooses to wait for the green light, while 6 s are lost if the participant chooses not to apply the brakes and the car crashes into a crossing vehicle). The primary outcome variable is the number of intersections the participant chooses to enter without applying the break, indexing risk taking. According to Reilly et al. [26] this risk/cost factor is what makes this task “similar to real-life situations and increases its external validity,” making it an appropriate measure for risky decision making among youth. Youth high on impulsivity or sensation seeking, characteristics closely aligned with antisocial behavior, showed less careful performance, faster response latencies, and less avoidance of punishment on this task than those scoring low [10].

The Risk Perception Questionnaire [27] is a self-report measure that presents respondents with eight potentially dangerous activities (e.g., smoking cigarettes, vandalism, getting into a fight). For each risky activity, participants respond to the following questions: How risky the activity is (1 = not risky at all to 4 = very risky); How much the risks associated with the activity outweigh its benefits (1 = more positive than negative to 4 = more negative than positive); How serious the consequences of the activity would be if something “bad” happened as a result (1 = not serious at all to 4 = very serious); If he or she has previously engaged in the activity (1 = yes, 2 = no); and how often he or she has engaged in the activity in the past 6 months (1 = none, 2 = 1–2 times, 3 = 3–5 times, 4 = more than 5 times). The latter two sets of items were excluded from the total score to avoid overlap with the CD measure used to create groups and focus on risk perception instead of engagement in risk. Higher scores on this measure indicate greater risk perception.

Selective attention: In the Stroop test [28], participants identify the color in which word stimuli are printed, while ignoring the meaning of the word. There are three types
of trials: (1) neutral words that are not color-related (e.g., chair), (2) congruent words in which the color word corresponds to the ink color and (3) incongruent words where the color word is different than the ink color (i.e., the word “red” written in blue ink). In incongruent trials participants must focus on the target stimuli (i.e., ink color) while simultaneously inhibiting their pre-potent response to irrelevant stimuli (i.e., word meaning). Words are viewed in six blocks of 16 trials, each of which lasts 2500 ms: 300 ms fixation cross, 1500 ms word stimulus presentation, and 700 ms inter-stimulus interval [29]. Participants pressed the button corresponding to the word’s color via a 4-coloured-button response device. The outcome variables are reaction time and accuracy of response. The delay in color naming indicates Stroop interference, reflecting poor selective attention.

**Future orientation:** The computerized Delay-Discounting Task [18] requires participants to choose an amount of money between immediate or delayed reward along 6 different blocks of time delays (1 day, 1 week, 1, 3, 6 months, and 1 year), presented in a random order. For each block, the starting value of the immediate reward is €200, €500, or €800, randomly determined for each participant, while the amount of the delayed reward is held constant at €1000. Participants must choose between rewards by pressing 0 (immediate reward) or 1 (delayed reward) on a button response device. If the participant chooses the immediate reward, the subsequent question presents an immediate reward midway between the prior one and zero (i.e., a lower figure). If the delayed reward is preferred, the subsequent question presents an immediate reward midway between the prior one and €1000 (i.e., a higher figure). Participants have nine ascending and descending choices until the subjective value of the immediate and delayed reward is equal, referred to as the “indifference point” [30]. For each individual, the primary outcome measure is the average amount accepted, or indifference point, for each delay interval. Higher indifference points indicate stronger orientation toward the future than the immediate. The task has been previously used with children, adolescents, and adults (age 10–30) [18].

The Future Orientation Questionnaire [18] is a 15-item self-report measure that requires respondents to choose between two statements to identify which best describes him or her (e.g., “Some people like to think about all of the possible good and bad things that can happen before making a decision BUT Other people don’t think it’s necessary to think about every little possibility before making a decision”). Participants are then asked whether the description is “Really True” or “Sort of True” of them. Items are grouped into three 5-item subscales: time perspective, anticipation of future consequences, and planning ahead. In the current study, subscale scores were averaged to create an overall score, with higher scores indicating greater future orientation ($\alpha = .80$).

**Covariates**

**ADHD symptoms:** The Checkmate plus Child Symptom Inventory for Parents-4 (CSI-4) [24] assesses ADHD symptoms of inattention and hyperactivity (18-items; $\alpha = .87$; e.g., “I have trouble paying attention”) on a four-point scale. Since youth with ADHD show similar impairments in decision making to CD [12], we covaried ADHD in analyses.

**Intelligence:** The Matrix Reasoning subtest of the Wechsler Abbreviated Scale of Intelligence (WASI) [31], administered via laptop, was used as an estimate of nonverbal intellectual ability. The WASI has been normed for individuals between the ages of 6 and 89 years; an age-normed score ($T$ score) was computed for each child.

**Procedure**

Measures were administered in the native language, Greek, following forward- and back-translation of measures by translators fluent in English and Greek, to resolve any item-by-item ambiguities in linguistic or semantic content [32]. Translators were asked to note items that did not translate well, were culturally insensitive, were inappropriate for the participants, or elicited multiple meanings, which were reviewed and modified appropriately. Participants individually completed computerized tasks in an average of 40 min. Research assistants were present to monitor participants’ progress, read aloud instructions for each new task, and provide assistance as needed. In order to maintain participants’ interest in the study questionnaires and tasks, they were told they would receive a base payment (€20) for participating in the study, but that they could earn a bonus (equal to 50 % of the base payment; €15) based on their performance on the computer tasks (in actuality, all participants received this bonus).

**Plan of analysis**

Initially, identified groups were compared on measures of IQ and ADHD to identify potential covariates to include in analyses. Separate ANOVAs were conducted in IBM SPSS 20.0 to examine the effect of CD and CU traits on the various dependent variables relating to risky decision making. For analyses involving the Stroop, Stoplight task, risk perception, and future orientation, separate $2 \times 2$ (low/high CD) × (low/high CU) between-subjects ANOVAs were conducted investigating main and interactive effects of CD and CU traits. Finally, we conducted repeated measures ANOVA, with CD and CU as the
independent variables, and the delay interval indifference points as the within-subjects factor. Post-hoc Bonferroni tests were used in all analyses. Significant interactions are depicted in figures, along with 95% confidence intervals (CI). Standardized mean difference effect sizes (Cohen’s $d = .20$ small, $d = .50$ medium, $d = .80$ large) [33] are reported in text.

**Results**

**Identifying possible covariates**

ADHD ANOVA results comparing the identified groups on ADHD symptoms suggested main effects for CU traits, $F(1,81) = 15.95, p < .001$, $\eta^2 = .16$, and CD symptoms, $F(1,81) = 76.24, p < .001$, $\eta^2 = .48$. Youth low on CU traits ($M = 15.21, SE = 1.08$) scored lower on ADHD symptoms compared to youth high on these traits ($M = 21.42, SE = 1.12; p < .001; d = .88$). Youth low on CD symptoms ($M = 11.53, SE = .99$) scored lower on ADHD symptoms compared to youth high on CD symptoms ($M = 25.10, SE = 1.20; p < .001; d = 1.95$). The CD by CU interaction was not significant, $F(1,81) = .23, p = .63, \eta^2 = .01$.

**Intellectual ability** No main effects of CD, $F(1,81) = .63, p = .43, \eta^2 = .01$, or CU, $F(1,81) = .01, p = .99, \eta^2 = 0$, nor interactive effects, $F(1,81) = .40, p = .53, \eta^2 = .01$, were associated with intellectual ability. As a result, intellectual ability was not included as a covariate in follow-up analyses.

**Comparing CD-subtypes on primary outcome measures**

**Stoplight task** Findings indicated that youth high on CD ($M = 4.63, SE = .33$) evinced higher risky decision making than youth low on CD ($M = 2.49, SE = .25; p < .001; d = 1.18$), $F(1,80) = 20.37, p < .001, \eta^2 = .20$. On the other hand, individuals high on CD traits ($M = 3.07, SE = .27$) scored lower than those low on CU ($M = 4.05 SE = .24; p = .01; d = .60$), $F(1,80) = 6.83, p = .01, \eta^2 = .08$. The interaction between CD and CU was also significant, $F(1,80) = 4.15, p < .05, \eta^2 = .05$. As indicated by moderate to large effect sizes, children in the CU-only group ($M = 1.65, SE = .33$) evinced less risk taking than children in the CD + CU ($M = 4.49, SE = .47; d = 1.67$), CD-only ($M = 4.77, SE = .39; d = 2.01$), and low CD/ CU ($M = 3.32, SE = .35; d = .98$) groups (see Fig. 1).

Children low on CD/CU also scored lower than children in the CD + CU ($d = .64$) and CD-only ($d = .84$) groups, although these differences only approached significance as indicated by the overlapping 95% CI. The CD-only and CD + CU groups scored similarly on the task ($d = .16$).

ADHD was not a significant covariate, $F(1,80) = 2.10, p = .15, \eta^2 = .03$.

**Self-reported risk perception** For risk perception, only the main effect for CD approached significance, $F(1,80) = 3.59, p = .06, \eta^2 = .04$, and as indicated by a moderate effect size, youth high on CD symptoms ($M = 3.57, SE = .08$) reported lower risk perception than youth scoring low on CD ($M = 3.78, SE = .06; d = .48$). ADHD was not a significant covariate, $F(1,80) = .43, p = .51, \eta^2 = .01$.

**Stroop** The ANOVA comparing groups on reaction time differences suggested only a main effect for CD symptoms, $F(1,80) = 4.79, p < .05, \eta^2 = .06$. Youth high on CD ($M = 17.28, SE = 15.18$) were characterized by lower reaction time compared to youth low on CD ($M = 30.22, SE = 11.49; p < .05; d = .57$). A main effect of CD was also identified for Accuracy, $F(1,80) = 4.25, p < .05, \eta^2 = .05$, indicating that youth high on CD ($M = -.02, SE = .016$) tended to be less accurate compared to youth low on CD ($M = .027, SE = .012; p < .05; d = .54$). ADHD was not a significant covariate for either reaction time, $F(1,80) = .03, p = .86, \eta^2 = 0$, or accuracy, $F(1,80) = 1.18, p = .28, \eta^2 = .01$.

**Delay discounting task** According to the repeated measures ANOVA, on average scores differed significantly between time delay blocks, $F(4,406, 352.449) = 3.28, p < .01, \eta^2 = .04$ (degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity, $\varepsilon = .88$), with the delay indifference point at day 1 ($M = 705.97, SE = 33.53$) being higher than delay indifference points at 6 months ($M = 559.17, SE = 40.01, p = .01$) and one year ($M = 569.17, SE = 41.74, p < .01$). The delay indifference point at 1 week ($M = 685.01, SE = 34.10$) was also higher than delay indifference points at 6 months ($p < .05$).
and 1 year ($p < .05$). These findings are reported in Fig. 2. No significant group differences involving the repeated measure were identified. A between-subjects effect was also identified, with children low on CD ($M = 752.68$, $SE = 41.93$) showing a higher indifference point on average compared to those high on CD ($M = 502.35$, $SE = 55.41$, $p < .01$; $d = .82$), $F(1,80) = 9.99$, $p < .01$, $\eta^2 = .11$. ADHD was not a significant covariate, $F(1,80) = 1.90$, $p = .17$, $\eta^2 = .02$.

**Self-reported future orientation** The ANOVA comparing groups on future orientation revealed a significant main effect for CD, $F(1,80) = 4.10$, $p < .05$, $\eta^2 = .05$. Youth high on CD symptoms ($M = 2.52$, $SE = .99$) anticipated fewer future consequences than youth low on CD ($M = 2.78$, $SE = .70$; $p < .05$; $d = .52$). No other main or interactive effects were identified. ADHD was not a significant covariate, $F(1,80) = .66$, $p = .42$, $\eta^2 = .01$.

**Discussion**

The present study aimed to shed light on whether neurocognitive deficits in risky decision making and related executive dysfunctions differentiate children with CD with and without limited prosocial emotions (i.e., CU traits). It also aimed to explore whether less risky decision making and better future orientation characterize children high on CU alone. This is an understudied group of children that share similar empathy deficits to their CD+CU counterparts. We specifically tested whether youth with stable CD symptoms, with versus without CU traits—operationalized by the DSM-5 LPE specifier [3]—could be differentiated on the basis of a multimethod assessment of risky decision making that included associated executive functions of selective attention and future orientation. While our findings support that decision making deficits contribute to the antisocial presentations displayed by children with CD, they also suggest that such processes may be important to both developmental pathways: the emotionally dysregulated pathway to impulsive CD symptoms, as well as the emotionally underaroused pathway to callous-unemotional CD [34].

Our results contribute two novel findings that shed light on the role of decision making in childhood antisocial behavior. First, risky decision making, selective attention deficits, and weaker future orientation characterized youth with CD both with and without non-normative levels of CU traits, even after covarying ADHD-symptoms. These findings were verified by both laboratory and self-report measures. They suggest that clinical descriptions of the psychopathic individual as giving “little serious thought to the future and worry[ing] about it even less” (pp. 58–59 [35]), lacking commitment to long-term goals and being susceptible to boredom [36], and being “(willing) to take risks even after considering the consequences” (p. 26 [37]), are not unique to this personality disturbance but rather characteristic of the broader antisocial population.

Second, risky decision making differentiated those youth with CU traits who presented with CD from those who did not. Specifically, youth high on CU alone were less likely to make risky decisions on the Stop-Light task, an objective laboratory measure, than children with CD + CU. These intact neurocognitive abilities may be indicative of protective factors against the development of antisocial behavior among children that show comparably impaired development of moral emotions to children with CD + CU [22]. It is possible that the greater ability of CU only children to refrain from engaging in risky behaviors when making future choices may, in part, contribute to their absence of antisocial behavior.

There has been relatively little study of CU traits in the absence of co-occurring antisocial behavior. Existing studies suggest that this population is less disinhibited than their CD+CU counterparts, and are at risk for delinquency into adolescence but to a lesser extent [2, 22]. These findings have implications for the much-discussed but understudied notion of “successful” or non-criminal psychopathy, entail- ing core features of psychopathic traits in the absence of antisocial behavior [38]. Our findings align with adult literature suggesting that successful psychopaths show better executive control when faced with choices that may result in negative consequences to themselves, relative to unsuccessful psychopaths [39, 40]. Future research might examine whether this failure to engage in behavior that may be harmful to others is motivated more by a conscious desire to avoid punishment than a desire to avoid harming others due to empathetic concern experienced by the individual with successful CU/psychopathic traits.
An interesting finding was that ADHD symptoms did not differentiate between CD subtypes. Similarly, using a different sample to that reported here, Fanti [22] found that symptoms of inattention, hyperactivity, and impulsivity did not reliably differentiate between CD youth with versus without CU traits. Further, the identified group differences remained unchanged after controlling for ADHD symptoms, suggesting that ADHD symptoms are not the driving factor for CD/CU group differences in neurocognitive processes. With regard to selective attention, a recent meta-analysis similarly found that Stroop-measured interference control was more weakly linked with ADHD than other EF tasks (d = .35) [41], leading some to propose that it is a poor candidate for a primary EF deficit in ADHD [42]. Decision making and delayed discounting tasks included in this study capture the “hyperactivity-impulsivity” component of the ADHD syndrome that tends to overlap with CD rather than its distinct “inattention” component.

Strengths, limitations and implications

The selection of CD/CU groups based on longitudinal and multi-informant methodology and the use of a multi-method battery of well-validated decision making measures are key strengths of the current study. It is noteworthy that our identification of youth with CD was made on the basis of stable CD symptoms across multiple time points. Although the study extends prior findings suggesting that CD symptoms are associated with decision making impairments [11], results require replication with clinical and/or adjudicated populations of youth and using larger samples. The small cell size for experimental groups did not allow for testing gender differences. In addition to the neurocognitive deficits investigated in the current study, additional factors should be included in future investigations to understand differences between children with varying levels of CD and CU traits, such as parental psychopathology [43] and impairments in social cognition [44]. It will also be informative to study decision-making deficits in concert with impairments in empathic response and threat sensitivity to elucidate divergent mechanisms underlying developmental pathways to childhood antisocial behavior [4, 23]. Furthermore, ADHD and CD symptoms are not independent and show a high degree of comorbidity, and including ADHD as a covariate in analysis does not take into account children high on CD varying on levels of ADHD. Future research should identify heterogeneous groups differentiated on CU traits, CD, and ADHD symptoms in a randomized experiment to account for this heterogeneity.

Our results have important implications for understanding developmental processes contributing to CD and CU traits. They suggest that neurocognitive processes involving decision making might contribute to the antisocial presentations displayed by heterogeneous populations of children with CD. Further, intact decision making might serve as a protective factor against the development of antisocial behaviors, even among youth high on CU traits. Decision making, cognitive control, and future orientation may constitute potential treatment targets for reducing risky and reckless behavior among heterogeneous samples of antisocial youth [45].

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical standards All human studies have been approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

References

36. Cleckley H (1941) The mask of sanity; an attempt to reinterpret the so-called psychopathic personality. Mosby, Oxford