Cognitive and Emotional Profiles of CU Traits and Disruptive Behavior in Adolescence: a Prospective Study

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Published online: 7 December 2018
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Abstract

In this study we followed 82–90 adolescents, 50% boys, from 15 to 16 years, investigating CU traits and disruptive behaviors as predictors of cognitive skills and arousal to emotional pictures. At age 15, CU traits were rated by adolescents and disruptive (aggregated ADHD-ODD-delinquent) behaviors were rated by parents and adolescents. At age 16, executive function, reaction time variability (RTV), IQ and arousal to negative pictures were assessed. The results showed that, with control for disruptive behaviors, CU traits predicted lower RTV, higher IQ and lower arousal to negative pictures. With control for CU traits, disruptive behaviors predicted lower spatial working memory, lower interference control and higher RTV. Our findings are of theoretical and clinical relevance as they point to highly diverging cognitive and emotional profiles of CU traits and disruptive behaviors.

Keywords CU traits · Disruptive behavior · Adolescence · Executive functioning · IQ · Arousal to emotional pictures

Within the area of child and adolescent externalizing behavior problems, callous-unemotional (CU) traits, primarily characterized by low levels of guilt and empathy and lack of responsibility for own behavior (Barry et al. 2000; Frick et al. 2000, 2005) has been in focus during the last decades. CU traits have mostly been identified in children and adolescents with conduct disorder (CD; Frick et al. 2005; Hawes et al. 2014) and were included as a specifier of CD in DSM V (APA 2013). CU traits have also been associated with oppositional/defiant (ODD) and hyperactive/inattentive (ADHD) behavior and are thus related to disruptive behaviors more generally, in both children (Barry et al. 2000) and adolescents (Graziano et al. 2017; Herpers et al. 2012). The joint study of different aspects of disruptive behaviour and CU traits is therefore a relevant issue throughout development and particularly in adolescence, which is the focus of the current study.

Importantly, CU traits and disruptive behaviors are related but separate phenomena as shown by the fact that a limited portion of disruptive children have high levels of CU traits (Barry et al. 2000). There are also children and adolescents high in CU traits without disruptive behaviors (Frick et al.

2003; Herpers et al. 2012; Rowe et al. 2010). As verification of the distinction of disruptive behaviors and CU traits, three separate statistical factors for CU traits, antisocial behaviors and hyperactivity emerged in a community study of elementary school children (Dadds et al. 2005). Further, it has repeatedly been demonstrated that children with conduct disorder and other disruptive behaviors who also exhibit high levels of CU traits, are at heightened risk for persistent, severe antisocial behavior (Frick et al. 2003, 2005; Loeber et al. 2002; Pardini et al. 2006). As demonstrated in a recent review (Frick et al. 2014), this pattern of results survived control for the severity of conduct problems. Finally, treatment response may differ depending on the presence or absence of CU traits. A review covering studies of children and adolescents found evidence for unique associations between CU traits and poor treatment outcomes for conduct problems (Hawes et al. 2014). There are also indications that CU traits and conduct problems are uniquely associated with different treatment outcomes (Haas et al. 2011). For example, it has been shown that in addition to psychological treatment, adolescents with CU traits require medication in order to improve behaviorally (Waschbusch et al. 2007).

Thus, investigating distinguishing characteristics of CU traits and disruptive behavior seems highly important in order to increase knowledge about the possibly different backgrounds to two troublesome aspects of child- and adolescent problems. The present prospective study examined predictive relations from CU traits and disruptive behaviors to cognitive

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processing skills, such as executive functioning and IQ, and emotional functioning in terms of arousal in response to negative stimuli, in adolescence. We chose to focus on this age group for two important reasons: 1) this active period of transition from childhood to adulthood is particularly relevant for cognitive and emotional functioning and the links to CU traits and disruptive behaviors 2) this age group has been empirically overlooked in terms of the distinctiveness of cognitive and emotional profiles related to CU traits and disruptive disorders, respectively.

Relations between CU Traits, Disruptive Behaviors and Cognitive Functioning

One important aspect regarding the distinctiveness between CU traits and disruptive behaviors regards profiles of impaired cognitive processing, which have been related to disruptive behaviors rather than to CU traits among children (Waller et al. 2015). In contrast, it has been observed that behavior characterizing individuals with high levels of CU traits, such as successfully charming and conning others, would require good intellectual capacities (Salekin et al. 2004). Indeed, there is a body of research to support a link between adequate social cognition and CU traits. For example, as summarized in the review concerning children and adolescents by Frick et al. (2014), youngsters with disruptive behaviors and high levels of CU traits seem unbothered by others' plight but do not show deficits in cognitive empathy compared with disruptive youngster with low CU levels, i.e., they seem to understand how others feel and think in social situations. Regarding non-social cognitive functioning, the picture is less clear.

Executive Functioning Fundamental separate, but correlated, aspects of executive dysfunction are low inhibitory control, i.e., inhibition of pre-potent responses and the more complex function of interference control, i.e., overriding the tendency to produce a more dominant response, as well as problems in updating and monitoring of working memory (Miyake et al. 2000). Another important, but non-executive cognitive process, is reaction time variability (RTV), particularly as demonstrated in repetitious tasks. Importantly, the literature on the relation between CU traits and executive functioning is very scarce and particularly so in adolescent samples. However, there are a few studies available on the topic in preschool and school-aged children. For example, Bohlin and colleagues (Bohlin et al. 2012) found that when controlling for externalizing symptoms, longitudinal relations between poor inhibitory control and CU traits from five to seven years disappeared. Further, a longitudinal study by Fanti et al. (2017) showed that school-aged children high in CU traits had poorer executive functioning two years later compared to children low in CU traits, with no control for disruptive behaviors. In another

longitudinal study Wall et al. (2016) found that school-aged children high in CU traits, but without conduct problems had better executive functioning one year later compared to children high in both types of problems. In the latter two studies, executive dysfunction was measured using parental ratings, and as parents reported also on CU traits and disruptive behaviors, method variance such as reporter bias, may partly explain the associations. There are two studies available on the association between CU traits and interference control as measured by the color word Stroop-test. In the study by Fanti et al. (2016), no longitudinal association was found between CU traits and interference control across one year when controlling for conduct disorder and ADHD. However, testifying to the importance of executive skills, one recent study identified an interaction effect demonstrating that adolescents high in CU traits and conduct problems and who also had adequate interference control reported the highest number of violent acts (Baskin-Sommers et al. 2015). In sum, knowledge about executive function in relation to CU traits is scarce and needs further empirical attention, especially in the teenage years.

In comparison to CU traits, executive dysfunction in youth with disruptive behavior problems has been extensively investigated. Poor executive functioning and high RTV in ADHD have been demonstrated for decades in samples of various ages (Kofler et al. 2013; Willcutt et al. 2005). Although not as consistently found, deficits in executive functioning and high RTV levels have also been related to ODD and CD and general externalizing problems in studies covering preschool to adolescence (Bohlin et al. 2012; Fanti et al. 2016; Scholtens et al. 2012; Wall et al. 2016; Wiggs et al. 2016; see Sergeant et al. 2002, for a review).

IQ There has been a widely held view, perhaps spurred by early writings on psychopathy, that high levels of psychopathic traits are associated with high intelligence (for a review, see Allen et al. 2013). However, as regards the CU dimension, research points to levels of average intelligence. There have also been reports of non-significant associations between full-scale, non-verbal and verbal IQ estimates and CU traits in detained/delinquent and typical samples of adolescents (Pardini 2011; Salekin et al. 2004) and children (Fanti et al. 2016; Jezior et al. 2016).

Normal IQ has also been found in relation to CU traits when controlling for conduct disorder in adolescence (Loney et al. 2006). Moreover, in a comprehensive enquiry into this issue, Allen et al. (2013) found no associations between verbal or non-verbal intelligence and CU traits when controlling for hyperactivity and antisocial behavior in a large sample of various ages, including adolescents. Without these controls, CU traits were associated with lower IQ. However, in one study, IQ and CU traits interacted, as detained adolescents high in CU traits and in verbal ability reported most violent delinquency (Munoz et al. 2008). Thus, as in the case of executive functioning, there are

some empirical indications that IQ is important to consider in relation to CU traits, but the association is complex and needs further investigation, controlling for co-occurring disruptive behavior. Importantly, in the above reported studies one or two aspects of disruptive behavior were accounted for, but a broader and simultaneous take on disruptive behavior is necessary to clarify the picture of associations between IQ and CU traits. As regards IQ and disruptive behaviors, the picture is quite coherent. ADHD has been associated with lower levels of IQ in children (Langley et al. 2010) and adults (Bridgett and Walker 2006). Deficits in IQ have also been linked to other disruptive problems such as ODD, CD and delinquency in adolescence (Keyes et al. 2017; Murray and Farrington 2010). However, it should be noted, that the IQ – conduct disorder relation is not as clear cut as is the one between IQ and ADHD (see Burke et al. 2002 for a review).

Relations between CU Traits, Disruptive Behaviors, and Emotional Arousal

A phenomenon of interest when separating CU traits and disruptive behavior is how individuals react to aversive stimuli. It has been put forward that an explanation to the low anxiety and fear associated with CU traits (Kahn et al. 2016; Roose et al. 2011) may originate in low reactivity to aversive stimuli (see Herpers et al. 2014 for a review). Specifically, slow and reduced reactions to distress pictures, negative words and violent films, and poor recognition and low recall of distress emotions and emotional stimuli have been associated with CU traits in samples of mixed ages (Blair and Coles 2000), young adults (Fanti et al. 2015) and adolescents (Dolan and Fullam 2010; Keyes et al. 2017; Loney et al. 2003; Pihet et al. 2015).

As regards disruptive behaviors, normative or even high arousal to negative stimuli has been indicated. Associations to low autonomic arousal in response to empathy-eliciting film clips have been mainly driven by CU traits, and disruptive behavior disordered and non-disordered youth did not differ in self-reported arousal in response to negative pictures, controlling for CU traits in mixed and adolescent samples (de Wied et al. 2012; Masi et al. 2014). Furthermore, when taking CU traits into account, disruptive problems have been associated with higher reactivity to negative words, and with higher startle response and higher rated fear in response to violent films in young adult and adolescent samples (Kyranides et al. 2016; Loney et al. 2003). There are reports of autonomic physiological arousal in relation to ADHD in child samples. Generally, the picture is one of elevated levels of sympathetic or parasympathetic arousal, assessed in response to various laboratory tasks, relative to controls (Griffiths et al. 2017; Musser et al. 2011; Ward et al. 2015). Also self-or adult ratings of elevated negative arousal have been found in ADHD (for a review, see Graziano and Garcia 2016). The potential

importance of arousal has been demonstrated as low sympathetic arousal has been found in relation to poor treatment response among preschoolers with ADHD (Beauchaine et al. 2013). However, reduced autonomic arousal has also been found in individuals with ADHD (Conzelmann et al. 2014). The indication of heterogeneity in the ADHD dimension may be related to CU traits, which were not assessed in the above studies. In line with this reasoning are findings by Musser and colleagues (Musser et al. 2013) suggesting that children with ADHD categorized as low in pro-sociality, with low pro-sociality treated as a proxy for CU traits, had low levels of autonomic arousal, whereas ADHD children categorized normative in pro-sociality had high autonomic arousal. Thus, low versus high/normative arousal in response to negative stimuli may distinguish CU traits from disruptive behaviors, which may well impact a variety of important social and behavioral outcomes and therefore should be further investigated.

In sum, prior research points to distinct cognitive profiles for CU traits and disruptive behaviors. However, the relation between cognitive functioning and CU-traits, particularly executive functioning, is understudied and the few studies that exist have looked at the occasional EF-test, rather than a battery of tests to clarify possible relations to separate EF-components. For example, differential associations with simple versus complex inhibition may enhance our understanding of CU traits. In addition, disinhibition and low working memory as well as high RTV are particularly relevant to explore in relation to CU traits. These aspects are fairly well researched in relation to disruptive behavior, allowing for comparisons of cognitive correlates of CU traits and disruptive behavior. On the other hand, arousal to emotional stimuli is well documented in relation to CU traits but little investigated in relation to disruptive behaviors, again affording fruitful comparisons. Further, while there are studies on adolescence relating cognitive dysfunction to disruptive behaviors, a gap of knowledge exists when it comes to the association between EF and CU traits in this particular age group, an age in which CU traits and disruptive behavior are particularly linked to unfavorable outcomes. Finally, and perhaps most importantly, there is a shortage of longitudinal studies simultaneously investigating CU traits and broad aspects of associated disruptive disorders in relation to these cognitive and emotional factors, to our knowledge none in adolescence. Longitudinal studies are necessary to assess the robustness of associations between cognitive and emotional factors and these common child/adolescent problems. Providing answers to the above outlined questions should therefore have strong clinical as well as theoretical value.

The Present Study

In the present prospective study, we aimed to extend the understanding of CU traits and disruptive behavior (an aggregate

of ADHD-ODD-and delinquent behavior) in adolescence by asking the question whether distinctive profiles of cognitive functioning and arousal in response to negative stimuli are predicted by the two when controlling for their co-variation. Given the associations between CU traits and all three aspects of problem behavior mentioned above and current conceptualizations of child and adolescent disorders (Drabick et al. 2015; Golmaryami and Frick 2015), we focused on disruptive behaviour broadly rather than on specific aspects. Based on theoretical formulations and prior research, we expected that CU-traits at 15 years would primarily predict low arousal to negative stimuli whereas disruptive behavior would predict cognitive problems (i.e., disinhibition, low working memory, high RTV and low IQ level) at 16 years. Finally, in supplementary analyses, we investigated whether using two separate aspects of disruptive behavior as predictors, ADHD symptoms and antisocial/oppositional behaviors, respectively, would render a similar pattern of associations to cognitive and emotional functioning, controlling for CU traits, as that found in the main analyses.

Method

Participants and Procedure

Participants were recruited from an ongoing longitudinal project focusing on disruptive behavior problems. Ninety adolescents, 50% boys, living in and around a major university town in Sweden were studied at ages 15 and 16. The majority, 66% lived with both biological parents and for 79% both parents were born in Sweden. Of the 34 immigrated parents (15 mothers, 19 fathers), 12 were born in Europe, 12 were born outside Europe (Asia, the Middle East, Northern Africa, the USA and Australia) and the remainder had not supplied information about their country of birth. Four adolescents were born abroad. One was adopted as an infant by two Swedish-born parents and the others had immigrated with their families between ages five to ten years, one from Europe and two from non-European countries. Based on reports of highest level of schooling (the 9-year compulsory school or less, 12 years of schooling including high school, post-high school education), parental education was found high, as 68% of mothers and 58% of fathers held a college or university degree.

The recruitment process was as follows: Parents of 1206 ten-year old children recruited from a population based register responded to a mailed questionnaire, including ratings of child ODD- and ADHD-symptoms (for a description of the sample, see Rydell 2010). At adolescent age 15, both parents and adolescents in 602 families in which parents at the first data wave had agreed to be contacted again responded to a web-based questionnaire. In the questionnaire, parents and adolescents had indicated that they could be approached for

follow-ups, which was a requirement for inclusion in the study. This sample did not differ in the levels of ODD- and ADHD symptoms at age 10 from those who did not participate, $p > 0.10$. At age 15, parents rated the adolescent's ADHD- and ODD symptoms and CU traits. Adolescent questionnaires contained background information and ratings of CU traits, ADHD symptoms, and delinquency. A security server was used and the questionnaires contained no identifying information. Two reminders were sent out and each respondent received a movie ticket worth five Euros as compensation for his/her participation. After data collection, the questionnaires were transferred to a project computer and each respondent's personal project number was added, after which all information was erased from the server.

A year later, at adolescent age 16 years, the parent ratings of ODD- and ADHD symptoms were used to select a subsample for a laboratory study of cognitive and emotional functioning, as funding could support the costly lab procedure for only part of the sample. To ensure a variation in disruptive symptoms, equal numbers of adolescents, balanced for sex, were recruited from those with ODD- and ADHD symptom ratings above and below the median. Given the relations between disruptive behaviors and CU traits (Golmaryami and Frick 2015), we expected to achieve variation in CU traits as well. Constituting a pool of prospective participants, one hundred and ninety adolescents received a letter inviting them to visit the department lab, stressing the voluntary nature of participation. The invitation letters were sent in batches of twenty to secure that each adolescent could be contacted by phone within two weeks by a research assistant, who followed a standardized manual for the conversation. If the adolescent accepted to participate, an appointment was scheduled. Ninety-one adolescents participated in the lab procedure, but one person chose to stop halfway through the session. Twenty-one adolescents could not be reached and the remainder declined participation, most of them claiming lack of time. The 90 participants did not differ from the rest of the sample at age 15 in the level of ADHD- or ODD symptoms, delinquency, CU traits, or gender, $p > 0.10$. The two hour procedure included tests of executive functions, RTV, IQ and arousal in response to emotional pictures. One graduate - and two undergraduate psychology students administered the tests individually to each adolescent. The students had been trained in the manualized procedure and had performed and been evaluated on three-to four test trials before the commencement of data collection. The procedure included nine cognitive and emotional arousal tests and was run according to two alternative orders, composed with the goal that tests should not appear in the same temporal position in the two orders. The tests used in the present study were positioned as no 3/8, 6/4, 7/3, 8/2, 9/1 in the two versions of the procedure. Using a computer random number generator, the tester randomized which order for each participant. There were no differences in the group mean of

any test depending on order, $p > 0.15$. Cognitive tasks and tasks tapping arousal to emotional pictures were presented on a computer screen. The computerized tasks were programmed using the E-Prime version 2.0 and were performed on a HP laptop with a 15, 6' screen and a 1366×768 pixel resolution. Due to technical failure, data on arousal to emotional pictures, disinhibition and spatial working memory was missing for two to four participants, who were omitted from analyses on these measures. The adolescents received a gift voucher worth approximately 50 Euros as an appreciation of their participation.

Measures¹

Parent Ratings at Ages 10, 15, and Adolescent Ratings at Age 15

All scale scores were computed as the mean of items.

CU Traits Parent reports of CU traits at age 15 were used to validate adolescent self-reported CU traits. Parents rated 12 items reflecting CU traits from the YPI self-report (see below), e.g., “Does not express guilt when he/she has done something not allowed”, “Seems completely calm when others are upset”, “Is not bothered if others come to harm”, $\alpha = 0.88$. Adolescent CU traits were rated using items from the Youth Psychopathic Traits Inventory (YPI; Andershed et al. 2002). The YPI has demonstrated adequate psychometric properties and is extensively used in research (Andershed et al. 2002, 2007). The CU traits scale comprised the average of three 5-item subscales measuring remorselessness, un-emotionality and callousness (e.g., “I have the ability not to feel guilt and regret about things I think other people would feel guilty about”, “To be nervous and worried is a sign of weakness”, “When other people have problems, it is often their own fault, therefore, one should not help them”). A 4-step response format was used, from 1 = *Does not apply at all* to 4 = *Applies very well*, $\alpha = 0.80$. Adolescent self-reports were related to parent ratings of CU traits, $pr = 0.37$, $p < 0.01$, controlling for gender.

Disruptive Behaviors Parents and adolescents rated adolescent's ODD- and ADHD symptoms from DSM-IV (APA 2000) using two widely used scales, the 8-item scale for ODD symptoms (Bussing et al. 2008; $\alpha = 0.88$ and 0.90 at ages 10 and 15, respectively) and the 18-item ADHD scale (DuPaul et al. 1998; $\alpha = 0.94$ and 0.94). Items had a 4-step response format, from 1 = *Does not apply at all* to 4 = *Applies very well* to the child. Ratings at age 10 were used to assess possible differences in distributions between the original sample and the sample of 602 at age 15. Adolescents rated

ADHD-symptoms from DSM-IV with 18 items (Kessler et al. 2005). Items had a 5-step response format, 1 = *Never happens to me* to 5 = *Happens to me very often*, $\alpha = 0.87$. Delinquency was measured with 14 well-used self-report items (Kerr et al. 2012) and validated among Swedish youth through police reports (Magnusson et al. 1975). Adolescents answered questions about the extent to which they had performed various acts during the last year, e.g., vandalizing property, taking money at home, breaking into someone's house, stolen money, bikes or cars, street fighting, carrying a weapon, threatening another person, forcing another person, coded 0 = *Never happened*, 1 = *Happened once*, 2 = *Happened 2–3 times*, 3 = *Happened 4–10 times* and 4 = *Happened more than 10 times*, $\alpha = 0.72$. To compose a measure of disruptive behavior, parent and adolescent ratings of ADHD symptoms were aggregated, $a = 0.64$, after which the standardized ADHD symptom scores were averaged with standardized parent rated ODD-scores and standardized adolescent self-reports of delinquency. Correlations between the three components were $r = 0.43$ to $r = 0.56$, $p < 0.01$, $\alpha = 0.74$.

Cognitive Functioning and Arousal to Emotional Stimuli at 16 Years Throughout, standardized instructions were given according to a manual. Before the session began, the tester welcomed the adolescent and informed that the visit would include computerized tasks dealing with memory, thinking and attention. The adolescent was reminded of his/her right to stop participation at any time without explanation.

Executive Functioning To assess *spatial working memory*, beach balls of different sizes, ranging from 0, 4–2, 4 cm in diameter, were presented on a circular yellow frame (2.5 cm in diameter) on a red background (Forssman et al. 2010). Validity has been established in relation to short-term memory, verbal working memory and IQ (Tillman et al. 2008). Participants were informed that they would be presented with balls of different sizes, one at a time, at different locations on the screen. This was illustrated with a print out of a screen with two balls. After a series of balls had been shown, the screen would turn blue, and the task was to indicate with the computer mouse the location on the screen of each ball in order of size, starting with the smallest. There would be more balls as the test went on, making it more difficult. Each presentation lasted 1 millisecond with blank intervals of 1 millisecond between presentations. All responses within a radius of 14 mm from the perimeter of the yellow circle were considered hits. The test had four levels with three trials per level, i.e. a total of 12 trials. The first level had two beach balls per trial and for each level one ball was added, giving five locations to recall at level four. For each consecutive pair of locations remembered in the correct order, one score was given. Therefore, a trial with two balls could give a score of one and a trial with five balls could give a score of 4. The score total was calculated as

¹ All reliability estimates below refer to the present sample

the sum of scores across trials, with a theoretical minimum of 0 and a theoretical maximum of 30. Split-half reliability using the Spearman-Brown formula was 0.77.

Response Disinhibition A computerized go/no-go task was used to measure response disinhibition (Forssman et al. 2010). The go/no-go task has been used extensively in research and has repeatedly shown associations to ADHD and other disruptive symptoms (Brocki et al. 2007; Scholtens et al. 2012). In this task, participants viewed five different geometrical figures appearing at the center of a computer screen. Participants were told that they would see figures on the screen, one at a time, and were instructed how to respond to figures by pressing a button except when the figure was a triangle. The tester ascertained that the adolescent had understood when to press and when not to press the button, informed that the task would take some time, and that the adolescent should try to press the button as quickly as possible, without making mistakes. The figures appeared for 750 ms (or until the button was pressed) with an inter stimulus interval of 1000 ms. Preceded by 15 practice trials, the task consisted of 150 trials, 26% ($n = 39$) of which were no-go trials. We used the number of commission errors (i.e., responding to no-go trials) as a measure of response disinhibition. Split-half reliability was $r = 0.70$, using the Spearman-Brown formula. RTV was measured as the standard deviation of reaction time to hits on the go stimuli from this task, with a split-half reliability coefficient of 0.73.

Interference Control A more complex aspect of inhibition, interference control, was assessed with a version of the Antisaccade task (Carr et al. 2010). Poor performance on antisaccadic tasks has been related to ADHD-symptoms in samples of various ages (Carr et al. 2010; Soncin et al. 2016). The task involved a fixator, a cue and a target stimulus. The fixator was a small black square appearing on a white background in the middle of the computer screen for 1500–3500 ms (a loop with a consecutive increase of 250 ms). The cue was a small black arrow appearing for 225 ms to the left or to the right of the fixator. 50 ms after the disappearance of the cue, the target stimulus (an identical arrow) was presented for 150 ms on the opposite side, after which the cue was covered by a checkered mask for 3000 ms or until a button was pressed. The procedure was explained and demonstrated in detail. Participants were instructed to focus on the fixator and when seeing a flash (the cue) to either the left or the right, to look toward the *opposite* side of the screen, where the target stimulus would appear. They were asked to indicate in which direction the target arrow was pointing (either to the left, to the right or upward) by pressing one of three buttons marked with corresponding arrows. The tester informed that the stimuli would present in rapid succession, and again stressed that it was the direction of the arrow, not the side of the screen on

which it was presented, that should be indicated, and that the main thing was to try to press the right button, and not to speed through the task. The session started with twelve practice trials, and the task had two blocks of 42 trials, with a short break between blocks. A score of one was given for each correct response and summed to produce a total score, with a maximum of 82. Split-half reliability was 0.92.

IQ was measured by Raven's Standard Progressive Matrices, a reliable measure of non-verbal fluid intelligence (Raven et al. 2000). The test has five sections (A-E) with 12 problems each, and has no time limit. Standard instructions from the manual were used. Problems 1 and 6 from Set A were used as training items. The score was computed as the sum of correctly solved problems (maximum 12 in each set) from sets B to E, the split-half reliability coefficient being 0.76.

Arousal in Response to Emotional Stimuli Emotional responding was measured with 50 pictures from the International Affective Picture System (IAPS; Lang et al. 2005) viewed on a computer screen. The selection of pictures was guided by norms from the manual, in order to compose a set with variation in arousal (Lang et al. 2005). Twenty-three pictures were emotionally neutral (e.g., coffee mug, a neutral or happy face) and 27 pictures were aversive (e.g., close-ups of a pointed gun or a crying child). Participants were told that we were interested to learn how people react to depictions of incidents and objects one might encounter in real life or on TV or other media. Each picture was displayed for 6000 ms, and, after a 500 ms pause, the participant was asked to indicate on a keyboard, by pressing the appropriate key, the level of arousal while viewing the picture, 1 = *completely calm* to 9 = *highly aroused/on edge*. There was no preset response time, but participants were instructed not to think too long and to stick with the choice that first came to mind. There was a 3000 ms pause between the response slide and the next picture. The order of the stimuli pictures was the same for each participant. Each session began with three practice trials. Based on factor analyses, three arousal scores were composed as the mean of items: one for emotionally neutral pictures e.g., neutral face, dancing women, hands cupping a deck of cards; 21 pictures; one for threatening pictures, e.g., pointed gun, soldiers fighting, hooded men led by soldiers, man strangling a girl; 14 pictures, and one for distress pictures, e.g., close-up of crying child, old woman in bed with old man beside her with face turned away, a couple by a tombstone; 8 pictures, $\alpha = 0.91$ – 0.88 . For the sample as a whole, arousal was higher in response to threatening and distress pictures, respectively, compared to neutral pictures, $t = 17.3$ and 12.9 , $p < 0.01$. Self-reports of arousal have been positively related to physiological indices of arousal (Hetzel-Riggin and Wilber 2010). *Response time* in ms to each picture was recorded in order to validate self-reports of arousal. A difference score was computed as the mean response time to neutral pictures *minus* the response

time to emotional (threat and distress pictures collapsed), $M = -71.20$ ($SD = 370.40$), difference scores ranging from -973.26 to 1015.64 . Positive values indicate longer response times to neutral than to emotional pictures, indicating being less alerted by them than by the emotional pictures. There was a negative relationship between the difference score and the level of arousal to emotional pictures, $r = -0.34$, $p < 0.05$, i.e., quicker responding to emotional than to neutral pictures was associated with higher ratings of arousal.

Results

As seen in Table 1, there was variation in all variables. Boys were higher than girls in CU traits, $t(88) = 3.34$, $p < 0.01$ and marginally higher in interference control, $t(86) = 1.72$, $p < 0.10$, but lower than girls in arousal in response to distress and threat pictures, $t(86) = 2.25$, and $t(86) = 2.54$, $p < 0.05$. Parental education and family composition were unrelated to disruptive behavior and CU traits, $t(88) = 0.19$ – 1.63 , $p > 0.10$. Adolescents with one or two foreign born parents had higher levels of disruptive behavior than adolescents with two Swedish born parents, $t(83) = 2.24$, $p < 0.05$, but this variable was unrelated to all other measures, $t(79$ – $83) = 0.21$ – 1.63 , $p > 0.10$. Analyses involving CU traits, interference control and arousal to distress and threat pictures were controlled for gender.

Controlling for gender, CU traits were correlated with disruptive behavior, $r = 0.48$, $p < 0.01$, and with all three components of disruptive behavior (i.e., ADHD- and ODD symptoms and delinquency), $r = 0.32$ – 0.44 , $p < 0.10$. There were correlations between the cognitive variables, see Table 2. Interference control was positively correlated with IQ and negatively with RTV. IQ was negatively correlated with

RTV. Spatial working memory was negatively correlated with RTV. The two arousal variables were highly correlated but unrelated to cognitive skills, with the exception of spatial working memory, with which there were negative correlations, especially with arousal to distress pictures.

In Table 3, correlations between CU traits and disruptive behaviors and cognitive variables and arousal to emotional pictures a year later, respectively, are depicted. CU traits did not correlate with any cognitive measure. High levels of disruptive behavior were negatively correlated with spatial working memory scores, and positively with response disinhibition and RTV. CU traits were negatively correlated with self-reported arousal in response to distress and threat pictures, while disruptive behaviors did not correlate with arousal in response to emotional pictures. Attesting to the validity of the self-reported arousal ratings, arousal in response to neutral pictures were not correlated with neither CU traits nor disruptive behavior.

To respond to our main question, we further investigated the above associations in a series of regressions analyses, with CU traits and disruptive behavior as predictors and each of the cognitive variables and arousal to emotional pictures as outcomes, see Table 4. With control for disruptive behavior, CU traits predicted higher IQ and lower RTV. CU traits also marginally predicted higher interference control. With control for CU traits, bivariate associations with lower spatial working memory scores and higher RTV were confirmed for disruptive behaviors, and there was a marginally significant prediction of higher disinhibition. High levels of disruptive behavior also predicted lower interference control and, marginally, lower IQ. The regressions confirmed bivariate associations between CU traits and low self-reported arousal in response to, especially, distress pictures. The prediction of lower response to threat pictures was only marginally significant. Neither with control for CU traits did disruptive behaviors predict arousal to emotional pictures. Thus, the regressions further stressed distinctive patterns of associations between CU traits and disruptive behavior, respectively, and cognitive variables and self-reported arousal to emotional pictures.

Table 1 Distribution for all variables ($N = 82$ – 90)

Variables	M (SD)	Min	Max
Age 15			
CU traits	1.83(.43)	1.07	3.00
Disruptive behaviors	0.00(.81)	−1.14	2.21
Age 16			
Cognitive functioning			
Spatial working memory	17.42(5.47)	2.00	29.00
Response disinhibition	8.17(4.52)	2.00	29.00
Interference control	71.58(9.79)	37.00	84.00
RTV	87.85(24.67)	50.15	169.63
IQ	38.28(5.74)	19.00	48.00
Arousal to emotional pictures			
Distress pictures	5.37(1.67)	1.00	8.88
Threat pictures	6.22(1.77)	1.00	8.79
Neutral pictures	3.22(1.18)	1.00	5.52

Supplementary Analyses

Finally, to investigate how different types of disruptive behaviors were associated with the outcome measures, with control for CU traits, we separated the aggregated disruptive behavior measure into two domains; ADHD symptoms and aggregated ODD and delinquent behavior (antisocial/oppositional, AO behavior, $\alpha = 0.63$). The motivation for this split was that ADHD symptoms have solid theoretical and empirical connections with executive dysfunction, whereas delinquent behaviors and ODD symptoms express general externalizing problem behaviors and are less consistently associated with executive dysfunction (Bohlin et al. 2012; Fanti et al. 2016;

Table 2 Correlations between outcome variables at age 16 ($N = 86\text{--}90$)

	SpatialWM ^a	Response disinhibition	IFC ^b	RTV	IQ	Arousal to distress pictures
Response disinhibition	−0.01					
IFC ^b	0.21+	−0.18+				
RTV	−0.30**	0.15	0.54**			
IQ	0.12	0.09	0.49**	−0.38**		
Arousal to distress pictures	−0.26*	0.11	−0.08	0.04	−0.03	
Arousal to threat pictures	−0.19+	−0.12	−0.09	−0.02	0.00	0.87**

^a Working memory, ^b Interference control, + = $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Scholtens et al. 2012; Wall et al. 2016). Both measures were based on parent and self-reports (see Methods), giving them equal representation of data sources. By so doing, we tested the validity of using an aggregated disruptive behavior measure in this context. As seen in Table 5, the correlations were similar to those presented in Table 3. Both ADHD symptoms and AO behaviors were positively correlated with response disinhibition, although the latter was only marginally significant. Further, both domains were positively correlated with RTV, ADHD symptoms marginally so. AO behaviors were marginally negatively correlated with spatial working memory. As in analyses on the aggregated disruptive measure, neither ADHD symptoms nor AO behaviors were related to interference control or to self-reported arousal to negative pictures.

Next, we performed two sets of regression analyses; one with ADHD symptoms and CU traits as the predictors and one with AO behaviors and CU traits as predictors. This division was made to avoid that the common variance between ADHD symptoms and AO behaviors ($r = 0.58$, $p < 0.01$) should balance out the effect of each when used as predictor together with CU traits. Again, the pattern of results agrees with the findings from the main analyses in important respects, see Table 6. In none of these regressions did CU traits predict spatial working memory or response disinhibition, while ADHD symptoms predicted marginally higher levels of response disinhibition and AO behaviors predicted marginally lower spatial WM. Further, in correspondence with the main analyses, AO behaviors predicted lower interference control, higher RTV and lower IQ. ADHD symptoms predicted higher

RTV. In these analyses, CU traits were associated with lower RTV and with higher IQ in the regression with AO behaviors. Again, as in the main analyses, none of the ADHD symptom or AO behavior variables predicted self-reported arousal to negative pictures while CU traits independently and significantly predicted lower arousal to distress pictures in both regressions, as well as lower arousal to threat pictures, controlling for ADHD symptoms. In sum, the results when using separate aspects of disruptive behaviors were similar to the main results using a broad measure of disruptive behavior, although the coefficients tended to be lower and less often reached significance. To be more specific, disruptive behavior spectrum aspects were associated with poorer cognitive skills, whereas CU traits were primarily associated with low self-reported arousal when confronted with, especially, depictions of others' distress, and with higher cognitive skills. These analyses again stressed the importance of control for each other when investigating associated features of disruptive behaviors and CU traits.

Discussion

In this prospective study, we demonstrated that CU traits and disruptive behaviors predicted distinct profiles of cognitive functioning and arousal to emotional pictures across one year in adolescence. As hypothesized, CU traits were longitudinally associated with low arousal in response to emotional pictures. As also predicted, and with control for CU traits, disruptive behaviors were longitudinally associated with lower

Table 3 Correlations between CU traits and disruptive behaviors (DB) at Age 15 and cognitive functioning and arousal to negative and neutral pictures at age 16 ($N = 86\text{--}90$)

	Cognitive functioning					Arousal to negative and neutral pictures		
	Spatial WM ^a	Response Disinhibition	IFC ^b	RTV	IQ	Arousal to distress Pictures	Arousal to threat pictures	Arousal to neutral pictures
CU traits	−0.07	0.15	0.09 ^c	−0.10	−0.14	−0.26* ^c	−0.22* ^c	−0.02 ^c
DB behaviors	−0.22*	0.23*	0.15	0.29**	0.11	0.11	0.13	0.06

^a Working memory, ^b Interference control, ^c with control for gender + = $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Table 4 Regression Analyses on Cognitive Functioning and Arousal to Negative Pictures at age 16 with CU Traits and Disruptive Behavior (DB) at Age 15 as Predictors ($N = 86–90$)

		Cognitive functioning					Arousal to negative pictures	
		Spatial WM ^a	Response disinhibition	IFC ^b	RTV	IQ	Arousal to distress pictures	Arousal to threat pictures
Predictors								
Model	Adj R ²	0.04+	0.03+	0.06*	0.14**	0.04+	0.09* ^c	0.08* ^c
CU traits	β	0.04	0.05	0.22+	−0.30**	0.25*	−0.27*	−0.21+
DB behaviors	β	−0.27**	0.21+	−0.26*	0.44**	0.22+	0.02	0.02

^a Working memory, ^b Interference control, ^c with control for gender, + = $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

cognitive functioning and higher RTV. In addition, CU traits predicted higher cognitive functioning on most measures as well as higher IQ levels, which formed an open question in the current study.

Cognitive Functioning, CU Traits and Disruptive Behavior

The present study afforded some new insights regarding CU traits and cognition. A few previous studies have investigated CU traits in relation to executive functioning, finding no associations when controlling for conduct problems (Bohlin et al. 2012; Fanti et al. 2016). Using a battery of executive function tests we found positive predictive associations between CU traits and the more complex aspect of inhibitory control referred to as interference control, and associations between CU traits and lower RTV. In line with Bohlin et al. (2012) we found no associations to simple response disinhibition. Interestingly, these findings indicate that staying in focus and withstanding distractions may characterize individuals with higher CU levels, rather than managing to keep up a steady stream of accurate simple responses. Possibly, these skills may be instrumental in successful manipulation and conning practices, more so than skills in simple disinhibition.

Second, when accounting for the overlap with disruptive behaviors, CU traits predicted higher IQ. This finding is at odds with previous studies, which did not find associations between CU traits and full-scale verbal or non-verbal IQ, when controlling for disruptive disorders (Allen et al. 2013;

Loney et al. 2006). The discordant findings may be explained by measurement issues. We used a non-verbal IQ measure, whereas the studies referred to above used aggregated measures of verbal and non-verbal IQ or looked at the two aspects separately. There are suggestions that CU traits are differentially related to verbal and non-verbal IQ, with results on non-verbal IQ being somewhat higher (Allen et al. 2013). Our results indicate that higher levels of CU traits are associated with better logical thinking and problem solving skills, but clearly, the issue of CU traits and IQ is not settled.

As amply demonstrated in previous studies, disruptive behaviors have been associated with a range of cognitive problems, in terms of lower IQ (Bridgett and Walker 2006; Langley et al. 2010), EF deficits and high levels of RTV (Kofler et al. 2013). We found prospective links between disruptive behaviors and a range of lower cognitive skills, such as poor working memory and poor interference control, higher RTV and, although only marginally significant, higher disinhibition and lower IQ. These findings are by no means new, but contribute to the empirical knowledge base about components of, and possible backgrounds to, disruptive behaviors. Extending prior research, however, is our finding that when controlling for CU traits, cognitive flaws stand out as specifically predicted by the disruptive aspect of adolescent problems as measured one year earlier. Thus, our prospective analyses confirm the general picture in the literature, conveyed by previous investigations, that cognitive dysfunction is a prime and perhaps specific characteristic of disruptive behaviors.

Table 5 Correlations between ADHD symptoms and AO Behaviors at age 15 and cognitive functioning and arousal to negative pictures at age 16 ($N = 86–99$)

		Cognitive functioning					Arousal to negative pictures	
		Spatial WM ^a	Response disinhibition	IFC ^b	RTV	IQ	Arousal to distress pictures	Arousal to threat pictures
ADHD symptoms		−0.18	0.23*	−0.10	0.22+	−0.04	−0.09	−0.04
AO behaviors ^c		−0.20+	0.19+	−0.15	0.29**	−0.13	−0.11	−0.16

^a Working memory; ^b Interference control, ^c antisocial/oppositional, + = $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Table 6 Regression Analyses on Cognitive Functioning and Arousal to Negative Pictures at age 16 with CU Traits and ADHD Symptoms (Model 1) and CU traits and AO Behaviors (Model2) at Age 15 as Predictors (N = 86–90)

		Cognitive functioning					Arousal to negative pictures	
		Spatial WM ^a	Response disinhibition	IFC ^{bd}	RTV	IQ	Arousal to distress pictures ^d	Arousal to threat pictures ^d
Predictors								
<i>Model 1</i>	<i>Adj R²</i>	0.01	0.04+	0.03	0.07*	0.01	0.09*	0.09*
CU traits	β	0.00	0.06	0.17	−0.23*	0.19	−0.28*	−0.26*
ADHD symptoms	β	−0.18	0.21+	−0.19	0.32**	−0.11	0.04	0.09*
<i>Model 2</i>	<i>Adj R²</i>	0.02	0.02	0.05	0.12**	0.04+	0.09*	0.09*
CU traits	β	0.02	0.08	0.20	−0.27*	0.24*	−0.27*	−0.18
AO behaviors ^c	β	−0.21+	0.16	−0.24*	0.40*	−0.23*	0.00	−0.08

^a Working Memory, ^b Interference control, ^c antisocial/oppositional behaviors, ^d with control for gender⁺ = $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

CU Traits, Disruptive Behavior, and Arousal to Emotional Pictures

As was expected, CU traits predicted lower levels of self-reported arousal to negative pictures. This finding agrees with several previous investigations in which low reactivity to aversive stimuli has been associated with CU traits (Blair and Coles 2000; Dolan and Fullam 2010; Fanti et al. 2017; Herpers et al. 2014; Kimonis et al. 2007; Loney et al. 2003; Pihet et al. 2015). Thus, the general picture suggests that low reactivity to aversive stimuli is associated with, and possibly constitutes, a contributing factor to CU traits. Longitudinal investigations with measures of arousal predicting later CU traits, initially controlling for CU traits, would shed light on this apparent link. Further, CU traits significantly predicted lower arousal to distress pictures whereas the prediction to low arousal to threat pictures was marginal, a finding that agrees with lower levels of empathy for others, which is a core characteristic of CU traits. (Barry et al. 2000; Frick et al. 2003). In contrast, no longitudinal associations were found between disruptive behaviors and level of self-reported arousal to negative picture, which corroborates reports of non-associations with arousal in response to empathy provoking stimuli when controlling for CU traits (de Wied et al. 2012; Kyranides et al. 2016; Masi et al. 2014). Still, higher reactivity to negative words in response to violent films has been related to disruptive behavior, controlling for CU traits (Kyranides et al. 2016; Loney et al. 2003). Perhaps, more engaging and threatening contexts, than were our still pictures, may be needed to trigger arousal in individuals with disruptive behavior problems. In sum, CU traits and disruptive behavior predicted distinct patterns of emotional responding.

Strengths and Limitations

Before drawing conclusions, some strengths as well as drawbacks of the present study should be mentioned. First, we used

a prospective design, with the specific associations from CU traits and disruptive behavior to cognitive and emotional phenomena spanning one year, attesting to the robustness of results. Our results thus give support to compatible findings gained in previous studies. Second, we focused on adolescents, which has rarely been done before in the context of CU traits, disruptive behaviors, and, especially, EF deficits. We secured a sample of 90 adolescents with similar levels of earlier disruptive problems as a large population sample, thus our results may be considered relatively representative of Swedish adolescents. However, the sample size was somewhat restricted, which is the rationale for our choice to report results on the $p < 0.10$ level. Although not significant according to standards, small effects may, especially if they fit into a pattern of significant results, add to the general picture of findings. Third, in contrast to previous studies on this issue, we investigated several aspects of executive functioning as well as IQ in relation to CU traits, thus enhancing knowledge about CU traits and specific dimensions of cognitive skills considered to be some of the core features of executive functioning (Miyake et al. 2000). Fourth, our measure of disruptive behaviors combined ratings by parents and adolescents and included manifestations of ADHD-ODD-delinquent behaviors, i.e., rendering a broad picture of disruptive behaviors. However, this strategy does not inform about how different aspects of disruptive behavior relate to outcomes. Importantly, in the supplementary analyses with the disruptive behavior measure split to form two aspects, the pattern of results was very similar to that of the main analyses, although the strength of the correlations were lower and did not reach significance in some cases. Thus, as our main purpose was to investigate the cognitive and emotional characteristics of CU traits and disruptive behaviors, controlling for each other, a broad measure of disruptive behaviors proved fruitful. Little information was lost, compared with analyses on separate disruptive behavior aspects in relation to CU traits and outcomes. Rather, the results were somewhat stronger. This is perhaps no

surprise, given the associations between the three dimensions of disruptive behavior investigated, and the association with CU traits with all three (Herpers et al. 2012).

There are also limitations. First, it should be noted that CU trait levels were low in this sample and the range somewhat restricted (see Table 1). We did not capture adolescents with maximum levels, which may perhaps not to be expected in a non-clinical sample. Still, the fact that we did find associations with outcomes at these levels of CU traits points to the robustness of findings. Second, the longitudinal effects from predictors to cognitive and emotional phenomena were modest in size. Possibly, this may be due to the one-year gap between measurements, naturally giving much room for other influences. On the other hand, it may indicate that, although obviously not without influence, most of the variation in cognitive skills and emotional arousal is explained by other factors than problematic behaviors. Third, we did not have a verbal IQ measure, which might have implications for the picture of IQ and CU traits. Fourth, the validity of the self-reports used to measure responses to pictures of various emotional content may be questioned. However, arousal was higher in response to emotional pictures, compared to neutral pictures, and, more importantly, response time was lower in response to emotional than to neutral pictures, which should attest to self-reports as indicating arousal.

Conclusions

The present study underscores the importance of taking both CU traits and disruptive behavior into account, when investigating either. By so doing we prospectively identified a distinctive cognitive and emotional profile for each of these two related but separate problem behaviors. An individual with high levels of disruptive behaviors seems to have a range of cognitive deficits, both executive and non-executive, but to have normative levels of self-reported arousal in the face of aversive stimuli, at least as assessed in a laboratory context. As CU traits were related to good cognitive functioning and low arousal to emotional stimuli, our findings suggest an individual with high levels of CU traits to fit the description of “cool and cunning”. Our findings support the notion that CU traits, in relation to disruptive problems, are specific in etiology and background factors. However, further studies on adolescent samples are called for to substantiate our findings. Finally, important further research venues within the field of adolescent externalizing problems would be prospective studies of how cognitive and emotional functioning predicts later problems, and investigations of how the individual’s cognitive make-up interact with disruptive behavior and CU traits in predicting adaptation. Targeted interventions for adolescent externalizing problems may be called for, depending on cognitive skills or lack thereof.

Compliance with Ethical Standards

Funding This research was supported by grant no 2009/2015–0167 from the Research Council for Health, Working Life and Welfare.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval The project was approved by the Regional Ethics Committee (No 2010/2013/122).

Informed Consent Informed consent was secured from all participants at each data wave of the project.

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