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Cognitive functioning and aggressive antisocial behaviors in young violent offenders

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ABSTRACT

Studies have shown that offenders have impaired cognitive abilities yet it is unclear if cognitive dysfunction per se contributes to aggressive antisocial behaviors. Our aims were to (1) determine associations between cognitive functioning and different forms of aggressive antisocial behaviors, (2) describe prevalence of, and covariates to, uneven intellectual profiles, and (3) investigate associations between cognitive functioning and age at onset of aggressive antisocial behaviors. A cohort (n = 269) of 18–25 years old male violent offenders were assessed for general intellectual functioning with the Wechsler Adult Intelligence Scales–third edition, and for executive functions with the Cambridge Neuropsychological Test Automated Battery. Only one measure of cognitive functioning – slower reaction times in a response inhibition test – was significantly correlated with higher occurrence of aggressive, but not exclusively antisocial, behaviors. Furthermore, offenders with even intellectual profiles showed more aggressive antisocial behaviors than offenders with uneven intellectual profiles. Finally, increased errors in tests of cognitive flexibility and slower reaction times in a response inhibition test were associated with a younger age at onset of general, but not exclusively violent, criminality. Overall, effect sizes were small. The findings emphasize the need of research investigating how cognitive functioning in offenders affects susceptibility to treatment interventions.

1. Introduction

A majority of aggressive antisocial behaviors in society, e.g., violent offenses, are perpetrated by a small group of offenders (Elonheimo et al., 2009; Falk et al., 2014; Loeber et al., 1999). Moffitt (1993) early described a group of offenders, life-course-persistent offenders, with early onset antisocial behavior that persists through every stage of life (Moffitt et al., 2002; Jennings et al., 2016). According to Moffitt (1993), this persistent antisocial behavior originates in an interaction between deficient cognitive functioning (i.e., verbal and executive deficits) and unfavorable environments in childhood. Since then, several studies have supported cognitive functioning as important for the development of aggressive antisocial behaviors (Fairchild et al., 2013; King et al., 2018; Ogilvie et al., 2011; Piquero, 2001; Raine et al., 2005; Tuominen et al., 2014).

1.1. General intelligence and aggressive antisocial behaviors

Previously, a negative association between intellectual functioning and aggressive antisocial behaviors has been demonstrated, where individuals with lower IQ scores show a greater propensity towards aggressive antisocial behaviors compared to those with higher IQ scores (Beaver et al., 2013; Nixon et al., 2017; Schwartz et al., 2015). These findings have been replicated across different types of aggressive antisocial behaviors (Cantor et al., 2005; Dwyer and Frierson, 2006) as well as different geographical and cultural contexts (Rushton and Templer, 2009), and remain to a great extent when controlled for potential confounders (Frisell et al., 2012). An increased prevalence of intellectual disability (ID) and borderline intellectual functioning in offenders compared to the general population has also been demonstrated (Crocker et al., 2007; Hayes et al., 2007; Haysom et al., 2014; Herrington, 2009; Murphy et al., 2017; Søndenaa et al., 2008), especially in younger offender populations. However, a systematic review

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found prevalence rates of 0.5–1.5% of ID in prisoners (Fazel et al., 2008), on par with the prevalence expected in the general population (Maulik et al., 2011) and recent studies on offenders (Ali et al., 2016; Billstedt et al., 2017). These varying prevalence rates might seem contradictory, but could be explained by variations in measures of intelligence and how strict diagnostic criteria for ID have been applied (Herrington, 2009). In general, screening measures produce higher prevalence rates compared to full-scale IQ measures and measures that include adaptive functioning (Murphy and Mason, 2014). Also, to fully understand varying prevalence rates in different studies, careful consideration of the type of offender sample (forensic psychiatric, prison, young offenders) studied as well as the contextual circumstances (e.g., differing welfare and school systems in different countries) affecting the identification and management of ID is needed.

1.2. Intellectual profiles in offenders

Another finding regarding intelligence and offenders has been that offenders, especially young offenders, score higher on Performance tests than Verbal tests (performance IQ > verbal IQ) on the Wechsler Intelligence Scales (Isen, 2010; Tuominen et al., 2014; Wechsler, 1958), henceforth described as an uneven intellectual profile. Several studies have reported an association between verbal deficits/delayed language development and antisocial behavior, especially aggressive antisocial behaviors (Barker et al., 2007; Snow and Powell, 2011; Stattin and Klackenberg-Larsson, 1993). However, the nature of this relationship has been debated as to whether verbal deficits are a marker of antisocial behavior or whether it demonstrates learning disabilities and not antisocial behavior per se (Isen, 2010). In general, uneven intellectual profiles have been described as a marker of pathology and studied mostly in relation to ADHD and autism (Kanai et al., 2017; Mouga et al., 2016; Theiling and Peterman, 2016). However, the knowledge on the relation between uneven intellectual profiles and aggressive antisocial behaviors is limited, even though pathology such as ADHD has been reported as overrepresented in offenders (Billstedt et al., 2017). Also, more knowledge on the effect of education level on this relation is required, since research suggests that school failure is overrepresented in offenders and related to aggressive antisocial behaviors (Isen, 2010; Wallinius et al., 2016), and the question of whether this is associated with early learning difficulties in offenders remains unanswered.

1.3. Executive functions and aggressive antisocial behaviors

Another set of cognitive functions that have been related to aggressive antisocial behaviors are executive functions. Executive functions can be defined as the capacity to control thought processes and behaviors in an adaptive and goal-directed way (Jurado and Rosselli, 2007; Hofmann et al., 2012), and aggressive antisocial behaviors can thus be conceptualized as a result of deficient executive functions, specifically impaired ability to inhibit violence impulses (Blair, 2001). Meta-analyses have reported deficient executive functions in offenders (Morgan and Lilienfeld, 2000; Ogilvie et al., 2011), with executive functions predicting both frequency and severity of past violent offending (Hancock et al., 2010). Specific executive deficits that have been reported in different groups of offenders are impulsivity/impaired response inhibition, poor cognitive flexibility, reduced planning ability, inferior (verbal) working memory, and poor decision-making (Bergvall et al., 2001; De Brito et al., 2013; Dolan, 2012; Hancock et al., 2010; Miura and Fuchigami, 2017; Ross and Hoaken, 2011).

1.4. Purpose and hypotheses

In sum, cognitive functioning in the form of general intelligence (especially the verbal domain) and executive functions seem highly relevant for not only the development, but also the persistence, of aggressive antisocial behaviors (Poland et al., 2016; Raine et al., 2005). However, research needs to address the differential impact of cognitive functions, including intellectual profiles, on aggressive antisocial behaviors, since previous findings indicate different associations for aggressive vs. antisocial behavior (Barker et al., 2007). Also, more knowledge is needed on the relation between onset of aggressive antisocial behaviors and cognitive functions, especially research that does not rely on pre-established groups of offenders (e.g., life-course-persistent, adolescent-onset), to test established theories of deficient cognitive functioning and persistence in aggressive antisocial behaviors (e.g., Moffitt, 1993).

The aims of the present study are three-fold: 1) to determine associations between cognitive functioning and different forms of aggressive antisocial behaviors, 2) to describe prevalence of, and covariates to, uneven intellectual profiles, and 3) to investigate the association between cognitive functioning and age at onset of aggressive antisocial behaviors in young violent offenders. We hypothesize that verbal intelligence will be negatively associated with aggressive antisocial behaviors, and that a similar association will be found for measures of executive functions, specifically planning ability and response inhibition. We also expect uneven intellectual profiles to be relatively common in the young offenders. Furthermore, we hypothesize that a younger age at onset of aggressive antisocial behaviors will be associated with greater deficits in cognitive functioning.

2. Methods

2.1. Subjects

Subjects were recruited from a large multi-center prison study, called the Development of Aggressive Antisocial Behavior Study (DAABS), investigating all young adult offenders (18–25 years of age) convicted of hands-on violent (including sexual) crimes that were incarcerated in the Western region of the Swedish Prison and Probation Service during the period March 2010 – July 2012. During the inclusion period, 421 offenders fulfilling inclusion criteria were available at the participating prisons, of which 23 (5%) were excluded because of insufficient language skills and 19 (5%) because of placements of insufficient duration. Of the remaining 379 offenders, 109 (29%) declined participation in the study. One of the remaining, eligible offenders had two different sentences for violent crimes and subsequent prison stays in the region during the study period, why he was excluded from participation on the second prison stay. In sum, the final study group consisted of 269 offenders with a participation rate of 71%. The age range varied from 18 years and 7 months to 25 years and 11 months, with a mean age of 22.3 years (SD = 1.9). The sample is considered representative for young male violent offenders within the Swedish Prison and Probation Service, and the sample, including procedures, is described in detail in previous publications (Billstedt et al., 2017; Hofvander et al., 2017; Wallinius et al., 2016).

2.2. Procedure

All male young adult violent offenders, serving time between March 2010 to July 2012 at any of nine prisons in the Western region of the Swedish Prison and Probation Service, were invited to participate in the study. Offenders with insufficient knowledge in Swedish, defined as when an interpreter would have been needed for full participation, and offenders with a stay at the prison of less than four weeks were also excluded due to not being able to participate in the full study. After receiving oral and written information on the study, eligible offenders were asked for informed consent. Participation was compensated with a SEK 200 payment (approximately $20).

Offenders who agreed to participate were consecutively assessed according to a preset protocol, including file reviews, semi-structured diagnostic instruments, self-reports, and neuropsychological assessments. All clinical assessments were performed during a full day by a

licensed psychologist with clinical experience from the field and special training in the instruments used. Prior to clinical assessment, the assessor had read all file information, including prison medical records, detailed reports on previous living circumstances and criminal history, and incidents during ongoing sanction, available from the Swedish Prison and Probation Service.

2.3. Measures

2.3.1. General intelligence

The Wechsler Adult Intelligence Scales–third edition (WAIS-III; Wechsler, 1997) was used to measure general intellectual functioning. In this study, administration was restricted to subtests generating the General Ability Index (GAI), an alternate measure of general intellectual ability proposed by Tulsky et al. (2001). The GAI is comprised of six subtests that also constitute a Verbal Comprehension Index (VCI; Information, Similarities, and Vocabulary), and a Perceptual Organization Index (POI; Block Design, Matrix Reasoning, and Picture Completion). The mean GAI score among the offenders was normally distributed and within the range of average intelligence (scores 90–109; Wechsler, 1997), while POI scores were somewhat higher than VCI scores (approx. ½ *SD*) but still within the average intelligence range (Table 1). For the six subtests, the offenders scored below average on the Vocabulary and Similarities test and within the average range on the Information, Block Design, Matrix Reasoning, and Picture Completion tests (Table 1). We defined an uneven intellectual profile as a difference of 15 points or more (i.e., ± 1 *SD*) between the VCI and POI indexes. Data on GAI, POI and VCI was available for 264 offenders, while data on the included subtests were available for 263–265 offenders.

2.3.2. Executive functions

The Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition Ltd., Cambridge, UK), a computerized neuropsychological test battery, was used to elicit measures on executive functions. From the CANTAB, four measures of executive functions were used for this study: the Intra-Extra Dimensional Set Shift (IED), the Spatial Working Memory (SWM), the Stockings of Cambridge (SOC), and the Stop-Signal Task (SST). For all outcome measures except the SST measures (n = 216) and SOC MITT5 (n = 240), data were available for 241 offenders. Due to non-normal distributions in the CANTAB outcome measures, only medians and minimum and maximum values are presented (Table 2).

The IED, based on the classic neuropsychological test Wisconsin Card Sorting Test (Heaton et al., 1993), measures cognitive flexibility, i.e., the ability to change strategy and adapt to changing feedback.

Table 1
General intelligence (WAIS-III) in young adult violent offenders (n = 263–265).

	Mean (*SD*)	0.95 CI	Min–Max
WAIS-III index scores Mean = 100, *SD* = 15			
GAI	93.6 (11.0)	92.3–94.9	67–126
VCI	90.8 (10.8)	89.5–92.1	64–121
POI	98.4 (14.5)	96.7–100.2	62–133
WAIS–III subtest scores Mean = 10, range 1–19			
Verbal subtests			
Information	10.2 (2.4)	9.9–10.5	1–16
Similarities	7.4 (2.4)	7.1–7.7	1–16
Vocabulary	7.4 (2.1)	7.1–7.6	1–13
Perceptual subtests			
Block Design	9.8 (2.6)	9.5–10.1	3–18
Matrix Reasoning	10.4 (3.3)	10.0–10.8	0–17
Picture Completion	9.3 (2.9)	8.9–9.6	1–18

*WAIS-III = Wechsler Adult Intelligence Scales–third edition; GAI = General Ability Index; VCI = Verbal Comprehension Index; POI = Perceptual Organization Index.

Table 2
Executive functions (CANTAB) in young adult violent offenders (n = 216–241).

	Median	Min–Max
IED Pre-EDS Errors	6	3–42
IED EDS Errors	12	0–34
IED Stages	9	1–9
SWM Strategy	33	0–47
SWM Total errors	20	0–121
SOC PS	8	2–12
SOC MITT5 (ms)	4601.8	0–29,379
SST PSS	0.50	0–1
SST SSRT (ms)	175	68–736

*CANTAB = Cambridge Neuropsychological Test Automated Battery; IED = Intra-Extra Dimensional Set Shift; Pre-EDS Errors = Pre-Extra Dimensional Shift Errors; EDS Errors = Extra Dimensional Shift Errors; SWM = Spatial Working Memory; SOC = Stockings of Cambridge; PS = Problems Solved in the minimum number of moves; MITT5 = Mean Thinking Times before the first move in a problem requiring at minimum five moves; SST = Stop-Signal Task; PSS = Proportion of Successful Stops; SSRT = Stop-Signal Reaction Time.

Learning and working memory in the form of rule acquisition, and attention capacity are lower order cognitive components of the test. First, the subject's ability to consistently recognize a category is assessed, known as the Intra-Dimensional Stage. Errors made in this stage are referred to as Pre-Extra Dimensional Shift Errors (Pre-EDS Errors). In the following Extra-Dimensional Stage, the subject must switch attention to a previously unimportant perceptual dimension. Errors at this transition are known as Extra-Dimensional Shift Errors (EDS Errors), similar to Perseverative Errors in the Wisconsin Card Sorting Test. The number of stages completed (IED Stages), comparable to categories completed in the Wisconsin Card Sorting Test, can be used as a broad outcome measure of cognitive flexibility. Outcome measures used in this study were Pre-EDS Errors, EDS Errors, and IED Stages (Table 2).

The SWM was used as a measure of the subject's short-term memory for visual stimuli in conjunction with strategic thinking and sustained attention. Outcome measures in this study were the number of errors (SWM Total errors), and strategy score (SWM Strategy) (Table 2), a measure of optimal strategy where high scores correspond to poor use of strategies (Owen et al., 1990).

The SOC, similar to the common neuropsychological "tower" tests such as the Tower of London (Shallice, 1982), was used as a test of planning, problem solving and multi-step forward thinking. In the test, subjects are required to move balls of different sizes from a starting arrangement in order to achieve a goal arrangement, adhering to the rule that a ball can never be placed on top of a smaller ball. The subject is required to think ahead in order to achieve a goal state in as few moves as possible. Outcome measures in this study were Mean Thinking Times (in milliseconds) before the first move in a problem requiring at minimum five moves (SOC MITT5), reflecting impulsivity, and the number of problems solved in the minimum number of moves (SOC PS), measuring the subject's planning ability (Table 2).

The SST was used as a measure of the subject's ability to inhibit a response when given auditory feedback. Outcome measures used were the Proportion of Successful Stops (SST PSS; varying between 0, indicating no successful stops, and 1, indicating 100% successful stops), and Stop-Signal Reaction Time (SST SSRT, measured in milliseconds), a covert measure of inhibitory control, with longer times (i.e., a slower response) associated with poorer inhibitory control (Verbruggen and Logan, 2008). See Table 2 for descriptive statistics.

2.3.3. Aggressive antisocial behaviors

The Life History of Aggression (LHA; Brown et al., 1982) was used as a continuous measure of lifetime aggressive antisocial behaviors. The LHA assesses the lifetime occurrence of aggressive antisocial behaviors in 11 items scored on a 5-point Likert scale, summing as a Total score

(range 0–55) and in three subscales (Aggression, range 0–25; Self-directed aggression, range 0–10; Antisocial behavior, range 0–20). In this study, only the Total, Aggression, and Antisocial behavior scales are used for analyses. Previously, the LHA has been shown to have high inter-rater and test-retest reliability, good internal consistency with the exception of Self-directed aggression (alpha coefficient 0.48), and high concurrent validity (Coccaro et al., 1997). In this study, the assessors rated the LHA based on all information available from interviews and files. LHA scores were available for 267 offenders (for descriptives, see Wallinius et al., 2016).

Data on age at onset of aggressive antisocial behaviors and number of previous convictions were collected by a structured protocol that covered all previous criminality including the index offense, both self-reported (from interviews) and noted in files. If the offender reported more aggressive antisocial behaviors and a younger age of onset than what was noted in the files, the information from the interviews was used for the analyses as long as it was considered credible by the assessor. This made it possible to include information on the onset of aggressive antisocial behaviors before the age of 15, which is the age limit for official registration of criminality in Sweden. Age at onset of aggressive antisocial behaviors was analyzed in two different measures: age at onset of violent criminality, and age at onset of general criminality.

2.3.4. Psychiatric comorbidity and educational background

Information on educational background was collected from file information and interviews by means of a structured protocol.

DSM-IV (American Psychiatric Association, 2000) diagnoses of psychiatric morbidity (lifetime prevalence) were assigned in consensus between the clinical psychologist and a senior clinician and researcher on the basis of a Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I; First et al., 1996) together with the information from files and registers. To assess ADHD, an amendment including a lifetime DSM-IV symptom checklist of individual criteria or symptom definitions was added.

2.4. Statistical analysis

Statistical analyses were performed using IBM SPSS 24. Due to non-normal distribution of LHA, CANTAB, and data on aggressive antisocial behaviors, non-parametric statistical methods were applied to analyses of these measures while normally distributed data (e.g., WAIS scores) were analyzed with parametric methods. Spearman's rank correlation test was used to investigate associations between continuous variables, and Mann–Whitney *U*-test, Student's *t*-test or χ^2-tests were used for group comparisons. For χ^2-tests, *p*-values with Yates correction for continuity are presented. Scatterplots for significant correlations are presented for ease of interpretation (see Fig. 1). Effect sizes were calculated with Cohen's *d* (WAIS-III) or *r* (LHA, previous criminality) for variables on scale level (see Table 3), and with the Phi coefficient for variables on nominal level (education, mental disorders; see Table 3). The acceptable level for Type I error, alpha, was set to 0.05. For all descriptive analyses, valid percentages are provided.

2.5. Ethics

All subjects provided informed, written consent before participation, and were given the opportunity to receive feedback on the preliminary, clinical results from the participation. Subjects showing symptoms of severe psychopathology were offered referral to the prison doctor (a psychiatrist, if possible) for continued assessment. The study was performed according to the Declaration of Helsinki and approved by the Research Ethics committee at Lund University (Dnr: 2009/405).

3. Results

3.1. Cognitive functioning and aggressive antisocial behaviors

In general, the offenders scored 7.6 points lower on the VCI compared to the POI (Table 1). When measures on cognitive functioning (WAIS-III and CANTAB) were tested against the LHA scales, no significant correlations were found except for SST SSRT, which displayed a small, statistically significant positive correlation to the LHA Total score ($r_s = 0.14$, $p = 0.046$; Fig. 1A) and Aggression scale ($r_s = 0.15$, $p = 0.029$; Fig. 1B).

3.2. Intellectual profiles among young violent offenders

One third of the offenders ($n = 92$) obtained notably uneven result profiles, defined as a difference of 15 points or more (i.e., ± 1 *SD*) between the VCI and POI indexes. In this uneven IQ subgroup, a superior POI compared to VCI was found in the majority of cases ($n = 82$; 89.1%), see Table 3 for WAIS characteristics of the two groups. The group of offenders with even intellectual profiles showed significantly higher scores on the LHA Total and Antisocial Behavior scales and borderline significant for the Aggression scale, compared to the group with an uneven intellectual profile (Table 3). Further statistically significant differences between these groups could be seen regarding educational level and in the prevalence of substance use disorders (Table 3). Offenders with even intellectual profiles were more likely to have finished secondary school at the expected time, and had higher prevalence of substance use disorders, compared to the group with uneven intellectual profiles. In general, all effect sizes were small, with the exception of the WAIS scales (Table 3).

3.3. Cognitive functioning and age at onset of aggressive antisocial behaviors

Age at onset of violent criminality was not significantly correlated to any WAIS-III or CANTAB measures, while age at onset of general criminality was significantly, negatively correlated to IED Pre-EDS Errors ($r_s = -0.14$, $p = 0.027$) and SST SSRT ($r_s = -0.18$, $p = 0.007$). See Fig. 1 for scatterplots.

4. Discussion

This study investigated associations between varying aspects of cognitive functioning and different forms of aggressive antisocial behaviors, including age at onset, in a nationally representative sample of young adult violent offenders in Sweden. We found only one measure of cognitive functioning; slower reaction times in a response inhibition test (SST SSRT); to be significantly but weakly correlated to higher occurrence of aggressive, but not exclusively antisocial, behaviors. Furthermore, uneven intellectual profiles were found in one third of the offenders, with the offenders with even intellectual profiles demonstrating more aggressive antisocial behaviors, higher educational level, and more substance use disorders than offenders with uneven intellectual profiles. Finally, higher error rates in tests of cognitive flexibility (IED Pre-EDS Errors) and slower reaction times in a response inhibition test (SST SSRT) were weakly associated with a younger age at onset of general, but not exclusively violent, criminality. Overall, effect sizes were low, why the clinical value of the displayed associations between aggressive antisocial behaviors (including age at onset) and executive functions may be questioned, and our findings cannot be seen as confirmation of such associations.

4.1. General intelligence and aggressive antisocial behaviors in offenders

Even though not defined as a primary aim in this study, it can be noted that the general intellectual ability as measured by the WAIS GAI

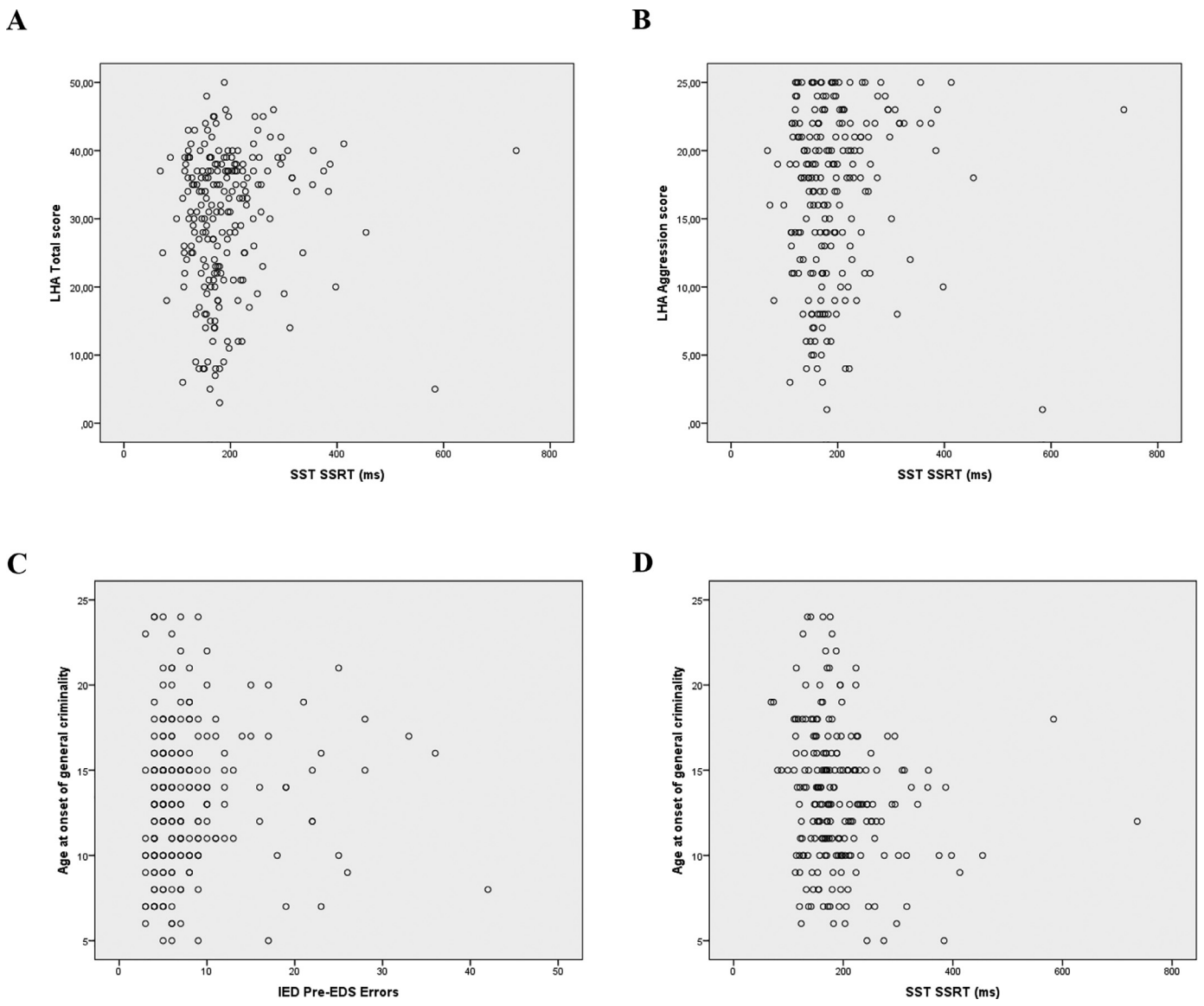

Fig. 1. A–D. Scatterplots for Spearmans' rho correlations between aggressive antisocial behaviors and measures of executive functions. * LHA = Life History of Aggression; IED Pre-EDS Errors = Intra-Extra Dimensional Set Shift Pre-Extra Dimensional Shift Errors; SST SSRT = Stop-Signal Task Stop-Signal Reaction Time.

was within the range of average intelligence, yet almost half a standard deviation below the general population. These findings are in agreement with other studies on offenders using the Wechsler Scales (e.g., Hayes et al., 2007; Søndenaa et al., 2008). However, it is important to remember that the GAI does not include indexes of working memory or processing speed. Although GAI has been found to correlate highly with full-scale IQ in neuropsychiatric and forensic inpatients, there is evidence that GAI scores might be higher than full-scale IQ scores (Iverson et al., 2006). Also, the high rates of developmental disorders (especially ADHD) and substance abuse in the current study group (Billstedt et al., 2017; Hofvander et al., 2017) might have affected the results, producing a GAI that is higher than what a full-scale IQ would have been. Our findings on associations between general intelligence and aggressive antisocial behaviors were, however, not in accordance with our hypotheses as no measure of general intelligence was associated with aggressive antisocial behaviors. This is in contrast to previous research demonstrating that lower general and verbal intelligence are related to higher levels of aggressive antisocial behaviors (Barker et al., 2007; Beaver et al., 2013; Nixon et al., 2017; Schwartz et al., 2015). However, we did see a pattern where the young offenders scored approximately half a standard deviation lower on verbal domains of intelligence, compared to performance-related domains of general intelligence (Table 1; mean difference POI > VCI = 7.6), in line with findings by Tuominen et al. (2014) in a study of verbal IQ and performance IQ in Finnish offenders. In the Swedish normative sample for the corresponding age group, a difference of 9.71 points between the VCI and the POI is considered statistically significant at the 0.05 level (Psykologiförlaget, 2003). Similar to Tuominen et al. (2014), we cannot confirm that domains of general intelligence are related to specific types of offending behaviors. There are several possible explanations for these findings. First, we used only the GAI, VCI and POI indexes from the WAIS-III. It is possible that using the full-scale IQ from the WAIS-III could have provided other results, due to its incorporation of working memory, attention, and processing speed domains, domains that could be affected by the high prevalence of developmental disorders (especially ADHD; Billstedt et al., 2017) in the study group. Thus, our findings cannot be directly translated to previous research applying the full verbal and performance IQ measures. Second, the measure of aggressive antisocial behaviors used in this study, the LHA, originally designed for studying groups with less complexity concerning psychiatric symptoms and without current alcoholism or drug dependence (Coccaro et al., 1997), might not be optimal as an outcome

Table 3
Group differences between offenders with even and uneven intellectual profiles.

	Even intellectual profiles (n = 173)	Uneven intellectual profiles (n = 92)	p-value	Effect size
Age, mean	22.3	22.4	N/A	N/A
Education, n (%)				
Completed secondary school	137 (79.2)	61 (66.3)	0.032	−0.141
Completed high school	38 (22.0)	15 (16.5)	0.371	−0.065
WAIS mean scores				
GAI	92.4	95.9	0.012	0.324
VCI	92.3	87.9	0.002	0.402
POI	94.1	106.5	0.000	0.903
LHA median scores				
Total	34	30	0.012	−0.155
Aggression	19	17	0.053	−0.119
Antisocial behavior	14	12	0.021	−0.141
Previous criminality				
No. previous convictions, median	4	3	0.606	−0.032
Age (median years) at onset, any criminality	13	14	0.132	−0.093
Age (median years) at onset, violent criminality	16	16	0.238	−0.074
Mental disorders, n (%)				
Affective disorders	102 (59.0)	42 (46.2)	0.063	−0.122
Anxiety disorders	96 (55.8)	40 (43.5)	0.075	−0.118
Childhood-onset ADHD, any type	117 (67.6)	51 (56.7)	0.105	−0.108
Substance use disorders	154 (89.0)	69 (75.0)	0.005	−0.183

*WAI39S-III = Wechsler Adult Intelligence Scales–third edition; GAI = General Ability Index; VCI = Verbal Comprehension Index; POI = Perceptual Organization Index; LHA = Life History of Aggression.

measure since the offenders scored very high on all scales regarding overt aggressive antisocial behaviors (Wallinius et al., 2016). Possibly, behaviors and experiences are so extreme across the offenders in the current study that the effects of cognitive functioning on aggressive antisocial behaviors are obscured by similarities in dimensions such as personality, mental disorders, substance abuse, psychosocial background and adverse childhood experiences. That is, the level of cognitive functioning is presumably not the decisive factor in the extent and severity of the offenders' aggressive antisocial behaviors. For instance, destructive personality traits known to be related to increased risk of offending, such as psychopathic traits, might obscure possible associations (Hampton et al., 2014).

4.2. Intellectual profiles among young violent offenders

In comparison to frequencies of uneven intellectual profiles in the age-appropriate (20–24 years) Swedish normative sample where a VCI-POI difference ≥15 points was reported in 23% (Psykologiförlaget, 2003), one third of the offenders in our study showed uneven intellectual profiles (predominantly verbal weaknesses). Since we did not study the impact of this difference, we cannot establish the implications of such a possible difference. However, our findings call for continued research investigating this matter, including impact on adaptive functioning. Interestingly, even though one third of the offenders demonstrated uneven intellectual profiles (predominantly lower verbal abilities), the group with even intellectual profiles showed more aggressive antisocial behaviors across the LHA Total and Antisocial behavior scales, with a similar effect size but borderline significant result for the LHA Aggression scale. To our knowledge, this has not been examined specifically in previous research even if uneven intellectual profiles previously have been related to comorbid developmental disorders, especially ADHD and autism (Kanai et al., 2017; Mouga et al., 2016; Theiling and Peterman, 2016). When we examined covariates to uneven intellectual profiles in our study sample, however, the prevalence of childhood ADHD was not significantly associated with evenness of intellectual profile. What we did see was that offenders with even intellectual profiles were more likely to have finished secondary school at the expected time, and had higher prevalence of substance use disorders compared to what would be expected if there had been no difference between the groups. Thus, we suggest that these variables may confound the association between intellectual profiles and level of aggressive antisocial behaviors. In fact, since substance use disorders is a well-established predictor of aggressive antisocial behaviors (Grann and Fazel, 2004; Pulay et al., 2008), the fact that this pathology was more common among the offenders with the even intellectual profiles than what would be expected could explain the association with aggressive antisocial behaviors. Yet, the overall small effect sizes needs to be considered, suggesting that the actual impact of the studied variables on the offender's functioning and behavior is small.

Unfortunately, our results do not provide clarity on whether verbal deficits are independently related to a lower level of aggressive antisocial behaviors, or if this relation is mediated by other variables. Also, it remains to be investigated if the verbal deficits, which are associated with a lower level of education, are in turn chiefly associated with learning disabilities or rather with other factors that affect school performance. Based on the cross-sectional data at hand, we cannot tease out causal relations between variables, hence this remains to be investigated in longitudinal studies of delinquency in childhood before any firm conclusions can be drawn. Further caution is warranted by the relatively small differences in LHA scores between the groups with even/uneven intellectual profiles, indicating that the clinical value of the demonstrated differences is small. However, our results point to the need of further investigations of the relevance of even/uneven intellectual profiles in relation to aggressive antisocial behaviors.

4.3. Executive functions and aggressive antisocial behaviors in offenders

When we examined executive functions, specifically spatial working memory, cognitive flexibility, planning and problem-solving ability, and response inhibition, we found only deficient response inhibition as indicated by longer reaction times on the SST task to be significantly associated with LHA Total and Aggression scores. Interestingly, we found the association only for aggressive, and not exclusively antisocial, behaviors. However, it must be noted that the correlations were small ($0.14 \leq r_s \geq 0.15$). Furthermore, the scatterplots in Fig. 1A and B show outliers affecting the analysis, and the majority of offenders are clustered in the lower part of the reaction time. Meijers et al. (2017) recently demonstrated deficient response inhibition in violent offenders compared to non-violent offenders in a test battery much similar to the one used in the current study. In the same study, no other executive functions differed between non-violent and violent offenders. Taken

together, our findings cannot be seen as confirmation of the growing evidence of response inhibition being especially important for aggressive behavior in offenders (Hancock et al., 2010; Meijers et al., 2017). Even though previous research indicates that executive functions, and especially response inhibition, are important for the understanding of aggressive antisocial behaviors (Morgan and Lilienfeld, 2000; Ogilvie et al., 2011), it is obvious that continued research on larger offender samples and distinct measures of aggressive and antisocial behaviors is needed.

4.4. Cognitive functioning and age at onset of aggressive antisocial behaviors

In this sample of young adult violent offenders, two aspects of executive functions – deficient response inhibition and higher error rates in a test of cognitive flexibility – were weakly associated with a younger age at onset of general criminality. It should to be noted that the errors occurred prior to the strategy change in the IED test, why our results not should be seen as indication of deficit cognitive flexibility in young violent offenders. Instead, we suggest that plausible explanations of these (weak) associations may be found in deficient attention and working memory since these are lower order components of the IED test and seem relevant considering the previously reported high prevalence of ADHD in the offenders (Billstedt et al., 2017). Inspection of scatterplots (Fig. 1C and D) here show outliers and a clustering of the offenders in the lower part of the test scores. When testing age at onset of violent criminality, no significant associations with any of the measures of cognitive functioning were found. Young age at onset of criminality has repeatedly been demonstrated as an important predictor of continued and persistent aggressive antisocial behaviors (Falk et al., 2014; Farrington, 2007). Even though our findings can be related to developmental theories and research on antisocial behaviors, where deficient cognitive functioning such as executive deficiency has been proposed as interacting with unfavorable environments in childhood for individuals in the development of antisocial behaviors (Jackson and Beaver, 2016; Moffitt, 1993), they cannot be seen as confirmation of such an association since they are weak and we do not test interaction effects. Loeber et al. (2012) found different levels of intelligence to be differentially related to the development of aggressive antisocial behaviors, depending on level of cognitive impulsivity. Based on the current, cross-sectional, study design it is not possible to investigate causal relationships between cognitive functions and age at onset/development of criminality. Due to the characteristics of the study group, it is quite possible that offenders with an early onset of antisocial behaviors also have developed an early substance abuse and/or experienced severe head trauma, which might confound the results. Also, it must be noted that, once again, the correlations were small ($-0.14 \leq r_s \geq -0.18$), indicating that cognitive functions may be relevant, but not crucial, for the understanding of the early development of antisocial behaviors. Further studies within this area are needed before any conclusions can be drawn.

4.5. Limitations

There are several limitations to the current study affecting the generalizability of the findings. First, we used the GAI, not the full-scale IQ, of the WAIS-III, possibly rendering a bias towards higher total scores for the offenders than what the full-scale IQ would have provided. Considering the complex problem constellation of the current study group (Billstedt et al., 2017; Hofvander et al., 2017; Wallinius et al., 2016), a more diverse measure of general intellectual ability such as the full-scale IQ would have been preferable. However, in these contexts, focus needs to be not only on using the most advanced and correct measures, but also on enabling the offenders to participate. In this case, the measures of cognitive functioning were selected to provide sufficient information for the study, but also avoid an overwhelming work load for the offenders, considering all the other investigations required for active participation in the DAABS. Second, using the LHA as an outcome measure of aggressive antisocial behaviors in violent offenders might not be optimal, due to skewed distribution with most offenders scoring extremely high on both aggressive and antisocial behaviors (Wallinius et al., 2016). On the high levels of LHA Total and subscale scores, the differences between levels of the behaviors become less precise and the clinical meaningfulness of the results can be affected in groups already demonstrating high levels of aggressive antisocial behaviors. Also, there is the question of how a quantification of behaviors reflects a biological or psychological disposition, and to what extent. Third, the validity of test procedures that take place in a controlled environment with emotionally neutral stimuli can be questioned, especially in regard to offenders whose crimes are of an interpersonal nature as in the current study. The real-life capacity to process information and control behavior in social situations may vary widely in offenders with the same test results. Finally, the associations demonstrated in the current study were all small in terms of effect sizes. Clearly, cognitive functioning is an important aspect of the mental functioning of offenders, but might not be the most important explanation of aggressive antisocial behaviors within this multiply disadvantaged group.

5. Conclusions

In this large multicenter study of young adult violent offenders, we found that even intellectual profiles were associated with a higher level of aggressive antisocial behaviors, albeit with a small effect size. The findings emphasize the need of research investigating how cognitive functioning in offenders affects susceptibility to treatment interventions. Continued research would benefit from investigating cognitive functions as mediators or moderators, not predictors, in relation to aggressive antisocial behaviors. In summary, the present study points to the complexity involved in studying outcomes such as aggressive antisocial behaviors and indicate that, even though cognitive functioning might be important for the general functioning of offenders, perhaps cognitive deficits are less crucial for aggressive antisocial behaviors when other confounders are considered.

Conflicts of interest

All authors declare no conflicts of interest.

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Supplementary materials

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