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Neurocognitive functioning in young offenders with Fetal Alcohol Spectrum Disorder☆

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1. Introduction

Fetal Alcohol Spectrum Disorder (FASD) is a life-long disability that can include a myriad of physical, neurological, cognitive, socio-emotional, and behavioral impairments (Chudley et al., 2005), as well as numerous comorbid conditions (Popova, Lange, Shield, et al., 2016). The term "primary disabilities" refers to impairments that are directly related to the central nervous system (CNS) damage caused by prenatal alcohol exposure (PAE) and include deficits in cognition, learning and memory, academics (especially math), language and communication, visuo-spatial processing, motor ability, attention problems and hyperactivity, and executive functioning (EF) (see Mattson, Crocker, & Nguyen, 2011 for a review). EF describes complex cognitive processes that oversee thought and action under conscious control (Zelazo & Müller, 2002), and guide adaptive responses to new situations (Hughes, 2011). In other populations, difficulties with EF are associated with negative life outcomes such as substance abuse, trouble with physical health and financial well-being, and criminality (Moffitt et al., 2011). Although EF as a clinical construct has limitations due to varying definitions and assessment measures, as well as overlap with multiple diagnostic entities (e.g., Attention Deficit Hyperactivity Disorder, learning disabilities, memory impairments), it remains of interest for the FASD population as a hallmark area of impairment (Kodituwakku, 2009) and an important predictor of functional outcomes such as adaptive functioning (Ware et al., 2012).

Individuals with FASD tend to show *less* impairment relative to other groups on cognitive tasks that are more isolated or simpler in nature, such as simple language (McGee, Bjorkquist, Riley, & Mattson, 2009), visual-perception (Kodituwakku, 2009), and processing speed tasks (Burden, Jacobson, & Jacobson, 2005); fine motor skills; and some aspects of attention and areas of academics (Vaurio, Riley, & Mattson, 2011). However, these individuals may experience *more* impairment relative to other groups with integrated skill sets that require processing of complex information and reliance on EF (Aragon et al., 2008; Kodituwakku, 2009; Mattson et al., 2011; Rasmussen & Bisanz, 2009), such as inhibition (Burden et al., 2009), decision-making (Kully-Martens, Treit, Pei, & Rasmussen, 2013), working memory (Burden, Jacobson, Sokol, & Jacobson, 2005), cognitive flexibility (Coles et al., 1997), complex visual-perceptual reasoning, and mathematics (Rasmussen & Bisanz, 2011).

Age and gender trends in neurocognition in the FASD population are understudied, and the existing literature in this area is mixed. One group of researchers found that adolescents with FASD showed worse performance (relative to the norm) with increasing age on a verbal EF task (Rasmussen & Bisanz, 2009), and other researchers have reported that adolescents with FASD failed to improve with increasing age (as controls did) on a measure of decision-making (Kully-Martens et al., 2013). Others have reported that deficits in neuropsychological and behavioral functioning become more pronounced with age in adolescents with FASD, though this may also be true for some non-alcohol exposed children and youth (Panczakiewicz et al., 2016).

Post-natal adversities such as neglect, abuse, exposure to substance abuse, parental separation, poverty, and trauma are also commonly reported in the FASD population. The combination of neurocognitive impairment and environmental adversities may place individuals with FASD in "double jeopardy," increasing their risk for adverse outcomes (Olson, Oti, Gelo, & Beck, 2009). Common adverse outcomes reported in FASD include disrupted school experiences, mental health problems, confinement (hospitalization or incarceration), inappropriate behaviors, substance use issues, and trouble with the law (Clark, Lutke, Minnes, & Ouellette-Kuntz, 2004; Streissguth, Barr, Kogan, & Bookstein, 1996). There is also a critical lack of interventions for adolescents and adults with FASD, compounding the risk of negative outcomes (Petrenko, Tahir, Mahoney, & Chin, 2014). Interventions geared towards supporting residential stability may be especially important given the risks associated with placement in care, and the protective influence of a stable and nurturing home environment for individuals with FASD (Streissguth et al., 2004).

1.1. FASD and the justice system

Conflict with the justice system among individuals with FASD is a significant issue garnering increasing attention in research and the media. In one large study of over 400 adolescents and adults with

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FASD, 60% of those individuals reported experiencing arrests, charges, convictions, and other forms of conflict with the law, and 35% reported being criminally incarcerated, with elevated rates among males (Streissguth et al., 2004). Alarmingly, the prevalence estimates of FASD in correctional settings range from 10 to 23% in both youth (Popova, Lange, Bekmuradov, Mihic, & Rehm, 2011) and adult populations (MacPherson, Chudley, & Grant, 2011), which greatly exceed the estimated prevalence rates of 1 to 4% for FASD in the general population (Stade et al., 2009; Thanh, Jonsson, Salmon, & Sebastianski, 2014). The economic burden of FASD in the Canadian correctional system is substantial, at an estimated cost of over $375 million annually, or more than $1 million per day (Popova, Lange, Burd, & Rehm, 2016).

An individual with FASD may become even more vulnerable once entering the justice system. Researchers have suggested that individuals with FASD may be suggestible and at risk for giving false confessions or false testimonies (Brown, Gudjonsson, & Connor, 2011), become targets for exploitation, struggle to conform to custodial settings, lack understanding about why they are incarcerated, learn more criminal behaviors, engage in a higher number of institutional incidents, acquire more institutional charges, and be less likely to complete correctional programming or be granted parole (Byrne, 2002; Conry & Fast, 2000; Mullins, MacPherson, Moser, & Matheson, 2014). Due to the "invisibility" of FASD, affected individuals may show no physical symptoms and appear to have strong expressive vocabularies (Malbin, 2004; Page, 2001). Compared to adult offenders without FASD, those with FASD have more convictions as juveniles and adults, are more likely to fail under community supervision, experience more disciplinary problems during incarceration, and have higher re-incarceration rates (MacPherson et al., 2011). Offenders with FASD report a myriad of behavioral, cognitive, mental health, and social factors that contribute to their entry into the justice system, as well as difficulties leaving the system (Pei, Leung, Jampolsky, & Alsbury, 2016).

Some youth with FASD have reported their onset of trouble with the law at as early as 12 years of age (Streissguth et al., 2004). Youth with FASD receive criminal charges earlier in life, acquire more charges, and have a greater risk of re-offending than those without FASD (McLachlan, 2012). The neurocognitive, adaptive, and social difficulties associated with FASD may influence a youth's ability to navigate legal processes, with high rates of psycho-legal impairment among young offenders with FASD related to understanding arrest, interrogation, and trial proceedings (McLachlan, Roesch, Viljoen, & Douglas, 2014).

1.2. Neurocognitive functioning in offenders with FASD

Brain function plays an important role in one's propensity to engage in delinquency and criminality. Deficits in EF may increase the risk for antisocial behavior (Ogilvie, Stewart, Chan, & Shum, 2011) and are common among offender populations, with particularly marked difficulties with attention, cognitive flexibility, working memory, inhibition, and problem-solving (Meijers, Harte, Jonker, & Meynen, 2015). Notably, there is considerable overlap between areas of neurocognitive impairment among offender populations and individuals with FASD (e.g., inhibition, decision-making, working memory, cognitive flexibility).

1.3. Present study

Given the very limited research on neurocognitive functioning among young offenders with FASD, we sought to explore the neurocognitive profile of young offenders with FASD compared to those without. It was hypothesized that young offenders with and without FASD would show similar levels of functioning on measures of simple neurocognitive functioning (i.e., verbal ability; visual scanning; *simple* processing speed, visuo-motor tasks, and focused attention; motor skills; and academic domains *other* than mathematics), but those with FASD would show greater impairment on more complex neurocognitive skill sets (i.e., verbal, visual, and working memory; cognitive flexibility; inhibition; visual-perceptual reasoning; and math). Level of functioning was determined by examining both the profile of scores on neurocognitive measures, as well as the proportion of youth who fell in the clinically significant range, defined as lower than two standard deviations below the mean. Furthermore, because crime rates are highest among youth who are older and males (Statistics Canada, 2013) in both general (Dauvergne & Turner, 2010) and FASD populations (Streissguth et al., 2004), we hypothesized that young offenders with and without FASD who are older (16–20 years) would show greater impairment relative to the norm than younger youth (12–15 years), and males would show greater impairment than females across all areas of neurocognitive functioning.

Increasing our knowledge of the neurocognitive strengths and areas of difficulty among offenders with FASD is important for understanding one of the factors potentially underlying criminal behavior in this population, and for informing approaches to remediation. Such research may also help to better identify FASD in the criminal justice system, which may guide the development of screening protocols or appropriate justice interventions to identify and support the needs of this vulnerable group.

2. Material and methods

2.1. Participants

A retrospective file review was conducted on clinical data from clients aged 12 to 20 years (76.5% male, 23.5% female) with and without an FASD diagnosis who attended a treatment program in Alberta offering support for youth in conflict with the law. Youth who attend the program are complex, typically struggling with multiple life adversities including mental illness and behavioral problems. The program prioritizes services for youth who have committed violent or sexual offenses, and treatment may involve assessment, therapy (individual, group, family), psychiatric and medical assistance, community outreach, residential advocacy, and life skills training. Many youth are referred to the program for a court-ordered assessment under Canada's Youth Criminal Justice Act and some of these youth come with a specific query of FASD, however the program does not offer routine screening for the disorder.

In order to identify potential participants for this study, 396 youth were identified who had undergone a psychological assessment between 2000 and 2014, and health records for 265 of the youth were available for preliminary review. First, information was collected on demographic information and indicators of prenatal alcohol exposure (PAE) or FASD through review of information in sources such as previous psychological reports, court-mandated referrals, maternal reports, and presentence reports. Forty-seven youth were identified with an FASD diagnosis (previously designated or diagnosed through the program) and targeted as a potential FASD group; 129 had no documented PAE or FASD query apparent in their records and were identified as a potential Comparison group. Twenty-four youth with documented PAE but no FASD diagnosis, and 65 with unknown or suspected PAE were excluded from the study. The second phase of file review involved accessing the psychological data archives to collect clinical test results. Within these archives, 81 files were available for review (38 FASD, 43 Comparison). Group matching was ensured by comparing age and gender of both groups, which revealed no significant differences. All FASD assessments were conducted following the 2005 Canadian Guidelines (Chudley et al., 2005), to derive a 4-digit diagnostic code based on the University of Washington FASD assessment system (Astley, 2004).

2.1.1. Participant characteristics

Data was collected on demographics, mental health, comorbid diagnoses, and personality assessment to describe and characterize participants. The Global Assessment of Functioning (GAF) score from the Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition, Text Revision (DSM-IV-TR) was collected as a broad indicator of mental

Table 1
Neurocognitive areas and data sources.

Area/test	Data source[a]	Skills assessed
Intelligence	• Wechsler Intelligence Scale for Children (WISC) – 3rd or 4th Edition • Wechsler Adult Intelligence Scale (WAIS) – 3rd or 4th Edition	• Verbal ability; visual-perceptual skills; working memory; processing speed
Academics	• Wide Range Achievement Test – 4th Edition (WRAT-4) • Wechsler Individual Achievement Test – 2nd Edition (WIAT-II)	• Single word reading; reading comprehension; math calculation; spelling
Verbal memory	• California Verbal Learning Test (CVLT) (child version or second edition) • Five subtest scores were collected: list learning, short- and long-term free recall, short- and long-term cued recall	• Verbal learning and memory
Visual memory	• Benton Visual Retention Test – 5th Edition (BVRT-5) • Two main scores were collected: number of designs correctly reproduced, and number of errors on incorrectly reproduced designs • Types of errors were also recorded	• Visual-spatial perception, construction, and memory
Trail making test (TMT)	• Trails A and B	• Visual scanning; simple processing speed; visuo-motor tracking; cognitive flexibility
Stroop test	• Color, Word, and Color/Word conditions (child or adult version)	• Simple processing speed; focused attention; inhibition
Motor function	• Finger Tapping Test (FTT) • Grooved Pegboard Test (GPT) • Hand Dynamometer Test (HDT) • Scores on right and left hands were collected for all measures	• Motor speed and control; motor dexterity; hand grip strength

[a] The edition and version depended on the date of assessment and age of the youth at testing.

health. This score reflects an individual's functioning across psychological, social, and occupational realms (American Psychiatric Association, 2000), with higher scores reflecting better functioning. To further characterize the mental health of participants, data was collected on comorbid diagnoses. Information on personality profiles was derived from the Personality Assessment Inventory (PAI) Adolescent and Adult versions, the Minnesota Multiphasic Personality Inventory – Adolescent Version (MMPI-A), and the Adolescent Psychopathy Scale (APS). On all of these personality measures, a higher score signifies greater clinical concern. See Table 2 below for all descriptive participant data.

2.2. Measures

Data was collected on numerous neurocognitive test tools (see Table 1). Raw scores were not available for most measures, therefore data was in the form of standardized scores.

2.3. Data analysis

2.3.1. Descriptive statistics

Descriptive data from the neurocognitive scores were used to illustrate the overall profile of each group. Not all of the tests used are normed on the same scale, thus standard scores were transformed into standardized z-scores, allowing us to compare performance across tests on the same scale (see Fig. 1 below). One exception was the Benton Visual Retention Test, 5th Edition (BVRT-5), which only produces raw scores. To examine whether there were group differences in the proportion of young offenders with neurocognitive test scores in the clinically significant range (i.e., lower than two standard deviations below the mean), Pearson chi-squared tests were conducted for all measures except the BVRT-5.

2.3.2. Multivariate analyses

To compare group differences in neurocognitive functioning, a series of multiple analysis of variance (MANOVA) was used with group membership (FASD versus Comparison), age group (younger [12 to 15 years] versus older [16 to 20 years]), and gender (male versus female) as independent variables, and subtest scores as dependent variables. Separate MANOVAs were conducted for each test, for a total of 7 analyses.

Alpha was set at 0.05 and effect size was determined using partial-eta squared (ηp^2). IQ scores were not used to match groups because evidence in the neurodevelopmental disability literature suggests that matching groups on IQ has the potential to create an unrepresentative sample, where either the neurodevelopmentally impaired group has elevated IQ scores, or the typically-developing group has scores below what is expected in the general population (Dennis et al., 2009). Furthermore, IQ was not included as a covariate in any analyses because researchers argue against the notion that IQ tests measure an individual's aptitude or potential, and suggest rather that they more accurately reflect achievement and performance, which may change across the lifespan (Dennis et al., 2009). Also, the statistical and methodological considerations of analysis of covariance are such that a variable should ideally only be used as a covariate when certain conditions are met: the independent variable is assigned randomly, the relationship between the covariate and the outcome is of no significance to the research question, and the covariate is unrelated to the independent variable (Dennis et al., 2009). In this study, groups were not assigned randomly, and IQ may indeed be related to the independent variable considering that intellectual functioning is often impaired in FASD populations. Additionally, many of the impairments common in FASD persist even in comparison with IQ-matched populations (e.g., Lewis et al., 2015; Thomas, Kelly, Mattson, & Riley, 1998; Vaurio et al., 2011).

3. Results

3.1. Demographics and group characteristics

Participant age, gender, and full scale IQ scores are presented in Table 2. There were no significant group differences in age or gender, but the FASD group had significantly lower full scale IQ scores than the Comparison group. Participants with FASD scored significantly lower on the GAF than youth without FASD. The most common comorbidities across groups were Conduct Disorder (CD), Substance Abuse/Dependence, and Personality Disorder (or features). The FASD group had significantly higher rates of CD and Intellectual Disability than the Comparison group. Youth with FASD showed some elevated scores relative to the Comparison group on personality measures, but none of these differences were statistically significant (Table 2).

3.2. Neurocognitive test score comparison

Subtest performance (except the BVRT-5) is shown in standardized z-scores in Fig. 1. Table 3 includes a full list of scores; *p*-values and effect sizes are reported only for subtests where overall group MANOVA results were significant or approached significant.

There was a significant overall group effect on the Wechsler intelligence scales, $F(4, 69) = 3.13$, $p = 0.020$, $\eta p^2 = 0.15$, and a post-hoc ANOVA revealed significantly lower scores in the FASD group than the Comparison group in verbal ability, working memory, and processing speed. There was also a group difference approaching significance

Table 2
Participant demographics, mental health, and personality characteristics.

Demographic	FASD (n = 38)	Comparison (n = 43)	*p*
Age in years (range)	15.7 (12.4–18.5)	16.2 (12.6–20.3)	0.18
Gender	73.7% male	79.1% male	0.61
Full scale IQ (range)	76.0 (45–102)	88.9 (63–127)	<0.001
Global assessment of functioning (range)	42.0 (25–63)	53.9 (15–83)	<0.001
Mean number of comorbidities (range)	2.3 (0–6)	1.8 (0–5)	0.13
% of group with comorbid diagnoses			
Conduct disorder	55.3	30.2	0.03
Substance abuse/dependence	52.6	34.9	0.12
Personality disorder (or features)	21.1	25.6	0.79
ADHD	21.1	11.6	0.36
Borderline IQ	18.4	11.6	0.53
Intellectual disability	15.8	0	<0.01
PTSD (or features)	2.6	2.3	1.00
RAD	2.6	0	0.47
Depression	0	4.7	0.50
Learning disorder	0	2.3	0.37
ODD	0	2.3	1.00
Schizophrenia	0	2.3	1.00
Anxiety	0	0	–
Other[a]	13.2	23.3	0.04
Personality t-scores (range)[b]			
Somatic complaints	55.8 (41–101)	53.0 (40–84)	0.32
Anxiety	56.1 (36–90)	52.9 (30–82)	0.29
Depression	56.8 (40–96)	56.2 (40–90)	0.84
Mania	52.7 (34–77)	52.8 (39–72)	0.95
Schizophrenia	57.5 (38–99)	53.6 (36–82)	0.26
Antisocial	58.3 (39–81)	54.9 (36–78)	0.18

Note. ADHD = Attention Deficit Hyperactivity Disorder; PTSD = Post-Traumatic Stress Disorder; RAD = Reactive Attachment Disorder; ODD = Oppositional Defiant Disorder.

[a] "Other" diagnoses include medical conditions (e.g., arthritis, asthma, mononucleosis, diabetes), pervasive development disorder, adjustment disorder, impulse control disorder, alcohol-induced mood disorder, dysarthria, and dysthymia.

[b] Data was available for 28 youth in the FASD group and 38 youth in the Comparison group on these personality domains.

in visual-perceptual reasoning with the FASD group scoring lower than the Comparison group. On academic tests, the overall group difference approached significance, $F(4, 68) = 2.50$, $p = 0.050$, $\eta p^2 = 0.13$, where youth with FASD scored lower in word reading, reading comprehension, and spelling.

No overall group difference was found on the CVLT, $F(5, 66) = 1.76$, $p = 0.113$, $\eta p^2 = 0.12$, though the FASD group had lower mean scores than the Comparison group across tasks, especially on list learning and free recall conditions. Furthermore, on the BVRT-5, there were no overall group differences on the main scores (number of correct responses or number of errors), $F(2, 71) = 2.32$, $p = 0.115$, $\eta p^2 = 0.06$ or the types of errors made on incorrectly reproduced designs, $F(6, 67) = 1.59$, $p = 0.163$, $\eta p^2 = 0.13$.

There was a significant overall group difference on the TMT, $F(2, 68) = 5.40$, $p = 0.007$, $\eta p^2 = 0.14$, with youth in the FASD group scoring significantly lower than youth in the Comparison group on Trail B but not Trail A. Another significant overall group difference was found on the Stroop test, $F(3, 69) = 4.08$, $p = 0.010$, $\eta p^2 = 0.15$, with lower scores in the FASD group than the Comparison group on the Stroop Word and Color conditions, but not the Color/Word condition. Lastly, there were no significant group differences identified on any motor test (see Table 3).

3.3. Age and gender trends

There was a significant overall effect of age on the TMT, $F(2, 68) = 12.10$, $p < 0.001$, $\eta p^2 = 0.26$, with the younger group performing significantly better than the older group on Trail A, $F(1, 69) = 24.55$, $p < 0.001$, $\eta p^2 = 0.26$ ($M = 0.82$, $SD = 1.09$ in the younger group and $M = -0.37$, $SD = 0.71$ in the older group) and Trail B, $F(1, 69) = 11.06$, $p = 0.001$, $\eta p^2 = 0.14$ ($M = -0.28$, $SD = 2.20$ in the younger youth and $M = -1.91$, $SD = 1.86$ in the older group). A significant but reverse age effect was found on the Stroop test, $F(3, 69) = 5.67$, $p = 0.002$, $\eta p^2 = 0.20$, with younger youth ($M = 43.37$, $SD = 8.95$) performing worse than older youth ($M = 49.42$, $SD = 8.65$) on the Color/Word condition, $F(1, 71) = 6.52$, $p = 0.013$, $\eta p^2 = 0.08$. No other significant age or gender trends were found. The scores used in these analyses are standardized, thus age differences do not suggest that one group scored lower than the other *absolutely*, but rather *relative to the norm for their age*.

3.4. Comparison with normative data

A greater proportion of the FASD group than the Comparison group had clinically impaired scores (i.e., lower than two standard deviations below the mean) in working memory IQ, Trail B, verbal IQ, processing

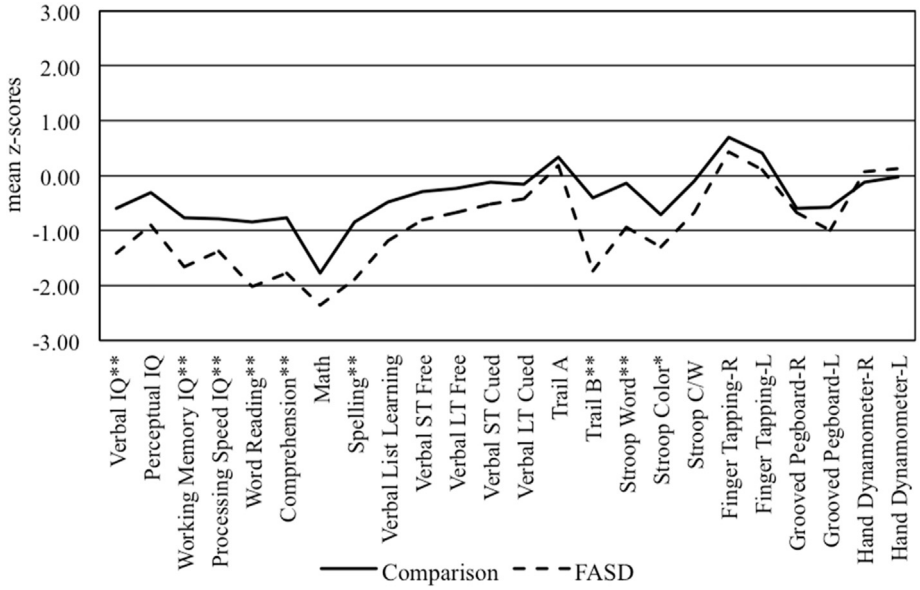

Fig. 1. Neurocognitive subtest profile (excluding the BVRT-5) (*$p < 0.05$, **$p < 0.01$). *Note.* ST = short-term; LT = long-term; C/W = Color Word; 'R' and 'L' designate scores from the right and left hands, respectively. *p*-Values are shown only for subtests where overall group MANOVAs were significant or approached significance.

Table 3
Neurocognitive subtest scores.

Subtest	Group	Mean[a]	SD	*p*	ηp^2
Intelligence					
Verbal ability	FASD	78.75	12.99	0.009	0.091
	Comparison	90.93	14.77		
Visual-perceptual	FASD	86.57	15.86	0.065	0.046
	Comparison	95.33	17.99		
Working memory	FASD	75.22	12.85	0.003	0.117
	Comparison	88.42	15.40		
Processing speed	FASD	79.49	13.54	0.007	0.095
	Comparison	88.37	15.15		
Academics					
Word reading	FASD	69.92	22.77	0.007	0.097
	Comparison	87.42	17.48		
Reading comprehension	FASD	73.25	16.34	0.004	0.113
	Comparison	88.65	16.77		
Mathematics	FASD	64.56	11.92	0.138	0.031
	Comparison	73.35	14.75		
Spelling	FASD	71.72	17.70	0.005	0.104
	Comparison	87.47	18.11		
Verbal memory					
CVLT list learning	FASD	38.14	11.00	–	–
	Comparison	45.20	13.26		
CVLT short-term free	FASD	−0.80	1.15	–	–
	Comparison	−0.30	1.10		
CVLT long-term free	FASD	−0.68	1.11	–	–
	Comparison	−0.23	1.28		
CVLT short-term cued	FASD	−0.51	1.10	–	–
	Comparison	−0.12	1.32		
CVLT long-term cued	FASD	−0.43	1.11	–	–
	Comparison	−0.15	1.16		
Visual memory (raw scores)					
BVRT-5 total correct	FASD	6.42	1.77	–	–
	Comparison	7.21	1.69		
BVRT-5 total errors	FASD	5.92	3.72	–	–
	Comparison	4.00	2.64		
Trail making test (z-scores)					
Trail A	FASD	0.18	1.12	0.161	0.028
	Comparison	0.34	1.09		
Trail B	FASD	−1.73	2.45	0.002	0.127
	Comparison	−0.41	1.73		
Stroop test					
Word condition	FASD	40.57	11.03	0.002	0.131
	Comparison	48.62	8.87		
Color condition	FASD	37.05	8.93	0.016	0.079
	Comparison	42.86	8.64		
Color/word condition	FASD	43.30	9.10	0.458	0.008
	Comparison	48.90	8.69		
Motor ability					
Finger tapping - right	FASD	0.44	1.26	–	–
	Comparison	0.70	1.13		
Finger tapping - left	FASD	0.10	1.26	–	–
	Comparison	0.42	1.19		
Grooved pegboard - right	FASD	−0.68	1.42	–	–
	Comparison	−0.60	0.93		
Grooved pegboard - left	FASD	−1.00	1.31	–	–
	Comparison	−0.57	0.86		
Hand dynamometer - right	FASD	0.07	1.08	–	–
	Comparison	−0.12	0.82		
Hand dynamometer - left	FASD	0.12	0.95	–	–
	Comparison	−0.03	0.90		

Note. *p*-Values and effect sizes are reported only for subtests where overall group MANOVAs were significant or approached significance.

[a] Normative scores for the Wechsler intelligence and academic subtests have a mean of 100 and standard deviation of 15. The CVLT verbal list learning trial produces t-scores (mean = 50, SD = 10) and recall trials are in z-scores (mean = 0, SD = 1). BVRT-5 scores are raw. Stroop subtests are in t-scores. All remaining tests are in z-scores.

speed IQ, Stroop Word and Color conditions, as well as word reading, reading comprehension, and spelling (see Fig. 2).

4. Discussion

Youth with FASD are reportedly 19 times more likely to be incarcerated than youth without FASD (Popova et al., 2011), and represent over 23% of some youth justice populations (Fast, Conry, & Loock, 1999). This over-representation, as well as the vulnerability of individuals with FASD in the justice system, have sparked important questions about how to best identify, understand, and support these individuals. Given the substantial cost of FASD in the correctional system – over $1 million per day (Popova, Lange, Burd, & Rehm, 2016) – research on FASD prevention, identification, and diagnosis is well justified. One of the "fundamental" factors related to criminal behavior in FASD is thought to be neurocognitive impairment (Institute of Health Economics, 2013), thus in the current study we explored neurocognitive functioning among young offenders with FASD compared to those without.

4.1. Differences between young offenders with and without FASD

One area that showed an especially notable difference between groups was cognitive flexibility (Trail B), consistent with our expectation that this skill would be significantly more impaired in the FASD group. This finding adds to the research documenting cognitive flexibility impairments in the general FASD population (Vaurio, Riley, & Mattson, 2008), and indicates that it may be especially relevant in terms of criminal behavior. Clinically, cognitive inflexibility could impair one's adaptability or ability to break chronic patterns of delinquent behavior.

Contrary to our hypothesis, the FASD group showed significantly worse performance and greater proportions of clinical impairment than the Comparison group on several simple processing speed subtests (Stroop Color and Word conditions, Wechsler processing speed). These findings are also contrary to previous research showing that for some children with FASD simple processing speed is relatively unaffected (Burden, Jacobson, & Jacobson, 2005). Trail A also measures simple processing speed but did not differentiate groups. Considering the relative simplicity of the Trail A task, processing speed impairments experienced by young offenders with FASD may be limited to more effortful cognitive speeded tasks, as has been proposed in previous research with the general FASD population (Burden, Jacobson, & Jacobson, 2005). In youth who are justice-involved, difficulties with effortful speeded processing may be especially detrimental in fast-paced or high-pressure situations or settings such as arrests, interrogations, or courtrooms, particularly in light of psycholegal deficits evident in many of those with FASD (McLachlan et al., 2014).

Youth with FASD group showed significantly lower scores and a greater degree of clinical impairment than the Comparison group on working memory, congruent with our hypothesis and previous research in the general FASD population (e.g., Rasmussen, 2005). In the context of criminal behavior and offender rehabilitation, working memory may have implications for an individual's ability to weigh risks and benefits, remember rules of probation, follow multi-step instructions, and consider the consequences of past choices to inform present decision-making.

The FASD group showed differences approaching significance and a significantly greater proportion of clinical impairment than the Comparison group in all areas of academics but math, contrary to our hypothesis. Given the neurological, behavioral, and social difficulties experienced by those with FASD, there are likely various mechanisms underlying the relationship between school experiences and criminal behavior, which is an important area for future research.

Verbal IQ was significantly more impaired in the FASD group relative to the Comparison group, counter to our expectation. Considering that verbal impairment is one of the most robust predictors of delinquency (Anderson, Hawes, & Snow, 2016), that language-based impairments are one of the most commonly diagnosed comorbidities in FASD (Popova, Lange, Shield, et al., 2016), and that youth with FASD in the current study showed notable impairments across language-based tasks, verbal deficits may be especially relevant to criminality and FASD. Clinically, deficits in verbal ability may be particularly concerning for those involved in the justice system, given the heavy emphasis

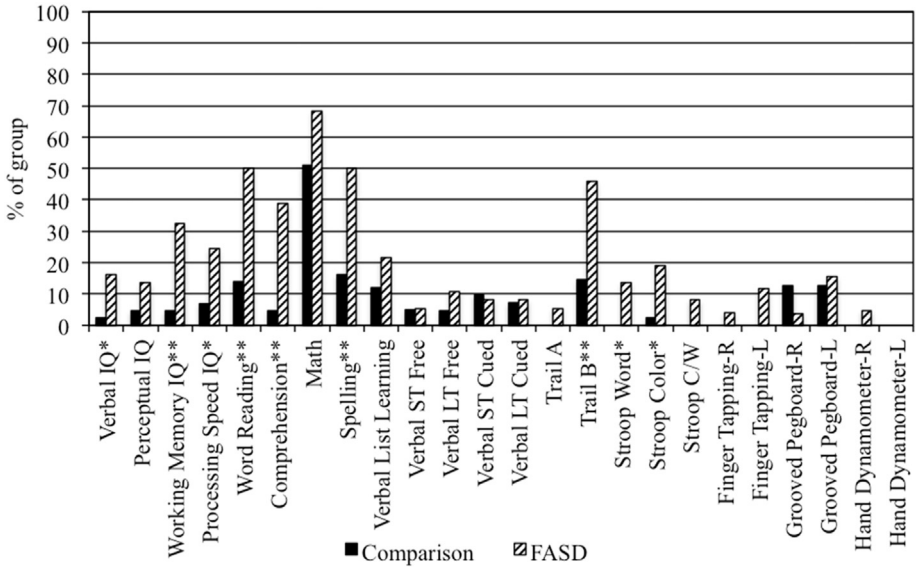

Fig. 2. Proportion of youth who were clinically impaired (lower than two standard deviations below the mean) on each subtest. *Note*. Group differences in impairment were determined using chi-squared tests (*$p < 0.05$, **$p < 0.01$). ST = short-term; LT = long-term; C/W = Color Word; 'R' and 'L' designate scores from the right and left hands, respectively.

on language-based interactions (e.g., court room proceedings, probation orders, rehabilitation programs). Additionally, the potential underlying influence of familial and environmental variables on the relationship between verbal ability and criminal behavior (Gibson, Piquero, & Tibbetts, 2001) may further complicate the situation for young offenders with FASD, thus more research in this complex area is warranted.

4.2. Similarities between young offenders with and without FASD

Consistent with our hypothesis, youth in both groups had comparable scores across motor measures, corresponding with previous research showing that fine motor skills are relatively unimpaired in FASD (Tamana, Pei, Massey, Massey, & Rasmussen, 2014; Vaurio et al., 2011). These findings suggest that motor ability may be an area of relative strength for young offenders with FASD, and may not be a strong indicator to distinguish those with and without FASD.

Contrary to our hypothesis, groups also showed similar performance on inhibition (Stroop Color/Word). Multiple studies have shown individuals with FASD to have significant deficits in inhibition (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000; Mattson, Goodman, Caine, Delis, & Riley, 1999; Rasmussen & Bisanz, 2009). Our findings suggest that inhibition may not distinguish young offenders with and without FASD, and it may represent another area of relative strength for this group to build upon in treatment and intervention.

Consistent with our hypothesis, scores on the relatively simple tasks of visual scanning, processing speed, and visuo-motor tracking (Trail A) were similar across groups. These findings are in keeping with research showing no significant impairments with this task specifically (Tamana et al., 2014; Vaurio et al., 2011), and suggest that these cognitive abilities may be additional areas of strength in young offenders with FASD.

Both groups showed similar performance on the visual-perceptual tasks of the Wechsler scales, suggesting another relative area of strength for young offenders with FASD, which is contrary to our expectation. Researchers have previously reported that individuals with FASD are relatively unimpaired on *simple* perceptual tasks, but more impaired on complex tasks requiring visuo-motor integration (Kodituwakku, 2009). Our finding that the FASD group was relatively unimpaired on complex perceptual tasks is in contrast with existing literature and suggests that further investigation with youth with FASD who are justice-involved specifically is warranted to determine whether the perceptual skills of this group are a true area of strength.

Groups performed similarly on tests of mathematical ability, yet math was still the lowest score within the FASD group, which is consistent with previous research (Rasmussen & Bisanz, 2011). In fact, both groups showed the most profound clinical impairments in this area.

Surprisingly, no significant group differences were found on verbal memory tests (CVLT), however, the FASD group appeared to perform worse on free recall than cued recall relative to the Comparison group, which may suggest that youth with FASD were able to encode but not retrieve verbal information on their own. In the broader FASD literature, researchers have demonstrated that verbal learning and memory deficits in individuals with FASD are attributable to encoding difficulties (Mattson et al., 2011), thus additional research is needed to clarify factors influencing verbal learning and memory among individuals with FASD who are justice-involved.

Also contrary to our hypothesis, groups showed similar performance on visual-spatial memory (BVRT-5). This provides new evidence that young offenders with FASD may possess relative strengths in visual memory and may be more likely to understand and remember important justice-related information when verbal information is paired with visual images.

4.3. Age and gender effects

As hypothesized, older offenders across groups showed greater impairment relative to the norm than younger offenders on visual scanning, simple processing speed, visuo-motor tracking, and cognitive flexibility (Trails A and B). For the FASD group, these findings are consistent with previous research showing that adolescents with FASD perform worse relative to the norm than children on some measures of EF (Kully-Martens et al., 2013; Rasmussen & Bisanz, 2009; Tamana et al., 2014). Our findings suggest that these skills may be especially vulnerable among youth offenders and may represent important areas for early intervention.

To the contrary, older offenders across groups showed *less* impairment relative to the norm than younger offenders on an inhibition task (Stroop C/W condition). Previous researchers have shown that inhibitory control typically matures into adolescence (Luna, 2009), and then decreases with age into older adulthood (Lezak, Howieson, Bigler, & Tranel, 2012). However, in the FASD population, researchers

have reported relatively worse performance among older than younger children on an inhibition task involving flexibility (Rasmussen & Bisanz, 2009). Our finding that older youth across groups were *less* impaired than younger youth adds to the limited literature on age effects on neurocognition among offenders.

More research on age trends in youth and young adults who are justice-involved would help to clarify what abilities may be more vulnerable than others to age-related differences, especially longitudinal studies to ascertain developmental trajectories over time. Early interventions aimed at strengthening identified areas of difficulty in at-risk groups may help protect youth against the development of more severe deficits in adulthood.

No significant gender trends were evident in this study, contrary to our hypothesis that males would perform worse across tasks, and surprising given the existing literature on crime patterns in general and FASD populations. The lack of gender differences may be due to the limited power in this study related to modest samples size, thus further research is warranted.

4.4. Limitations and future research

Because this study was a retrospective file review, we were restricted by the number of records available for review, thus the relatively small sample size limits the statistical power and generalizability of findings. We were also limited by the measures used when participants were assessed. Relatedly, the multifactorial nature of assessment tools clouds our ability to establish "pure" measures of specific function. As well, test versions differed across participants, and some tests may have been updated and new norms may have been published during the assessment period. Fortunately, a single examiner conducted all assessments, ensuring some degree of consistency in administration and interpretation. We also lacked information about offense patterns, thus were not able to match groups on the nature of their crimes, or establish whether neurocognition may relate to the severity, pattern, or nature of criminal offending. More comprehensive information about criminal risk factors such as family history of offending, peers, school and recreational experiences, and exposure to adversity would help to narrow in on the specific influence of PAE on criminal behavior.

One issue that commonly arises in FASD research is the question of controlling for IQ. In the current study it was deemed appropriate not to control for IQ as per recommendations in the neurodevelopmental literature (Dennis et al., 2009), as well as evidence that intellectual functioning in FASD is highly varied and heterogeneous (Kodituwakku, 2009; Mattson et al., 2011) and not a strong predictor of functional outcomes (Mattson et al., 2011; Odishaw, 2007). Nonetheless, the finding that youth with FASD presented with full scale IQ scores significantly lower than youth without may suggest that IQ influenced the broader presentation of this group. Another general limitation in FASD research is the low diagnostic reliability across systems (Coles et al., 2016), where an individual who meets the criteria for FASD based on one system may not meet the diagnostic threshold if assessed using another system. However, in this study all youth were assessed by the same psychologist following the 2005 Canadian guidelines, which increases the consistency of the diagnostic process.

Another important area for future research with offenders with FASD would include measuring more "hot" cognitive processes, which are involved in situations with high levels of emotion and motivation and may have additional ecological validity in predicting recidivism (Beszterczey, Nestor, Shirai, & Harding, 2013). Behavioral reports may also provide a more comprehensive picture of how young offenders with FASD function in their daily life, and what areas of neurocognitive deficit render an individual most vulnerable to behavioral problems. Inclusion of youth with FASD who do *not* engage in crime would also allow us to make more direct conclusions about neurocognition in offenders with FASD. Exploring neurocognitive factors related to resilience in this group would glean important information about why some youth remain out of conflict with the law, and how to support this group to achieve positive outcomes.

5. Conclusion

Young offenders with FASD displayed a profile of neurocognitive functioning that is more severely impaired than young offenders without FASD across numerous tasks. Youth in the FASD group also presented with more complex mental health needs and comorbid conditions, suggesting that the relationship between mental illness, neurocognition, and criminality in FASD is a critical area for further exploration. Although youth in the Comparison group showed deficits in some areas relative to the norm, the degree and range of impairment in the FASD group was significantly more profound and pervasive. Importantly, young offenders with FASD also showed areas of relative strength. Although this study identified general trends among youth with FASD, the population in general is complex and heterogeneous, and therefore an individualized approach is always critical when working with this group. Characterizing the neurocognitive deficits and strengths of young offenders with FASD has important implications for screening, sentencing, and programming to support positive outcomes in this over-represented and vulnerable group.

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