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BRIEF REPORT

Brief Report: An Exploration of Cognitive Flexibility of Autistic Adolescents with Low Intelligence Using the Wisconsin Card Sorting Task

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Abstract
Cognitive flexibility (CF) is the ability to shift between concepts or rules. Difficulty with CF is associated with autism (i.e., ASD) as it contributes to repetitive behaviours. However, little is known about CF skills of autistic adolescents with low intelligence. This study uses the Wisconsin Card Sorting Task (WCST) to assess the CF of 36 adolescents, all with a Weschler full-scale IQ between 50 and 85, 14 of whom had an ASD diagnosis. The results indicated no statistically significant differences in WCST performance between those with and without ASD. It was also found that performance IQ significantly contributed to the WCST performance in the ASD group only, suggesting an autism-specific role of non-verbal cognitive functioning in CF.

Keywords WCST · Cognitive flexibility · Low intelligence · Autism · Adolescents

Introduction

Cognitive flexibility (CF) is a key constituent of executive functions (Gioia et al., 2000), that enables individuals to disengage and engage freely from one feature, topic or activity to another (Chan et al., 2008; Marcovitch et al., 2008). CF also orients individuals to relevant information in the environment and enables them to decipher relationships to solve problems (Ionescu, 2012), ultimately allowing them to adapt to changes, switch perspectives and adjust behaviours according to contexts (Dajani & Uddin, 2015). Challenges with CF are argued to, at least partially, explain the occurrence of restricted and repetitive behaviours in autism (Faja & Darling, 2018; Kenny et al., 2019; Miller et al., 2015; Wallace et al., 2016; Yerys et al., 2009). Understanding the CF skills in autism is necessary for understanding their behaviours (Kenny et al., 2016; Russo et al., 2007) given their difficulty adapting to changing environments and detaching from specific activities or objects (Chen et al., 2016; Kenworthy et al., 2008; McLean et al., 2014).

CF difficulties in autism have been well-documented, as indicated in four review articles over the past two decades (Hill, 2004; Kenworthy et al., 2008; Landry & Al-Taie, 2016; Leung & Zakzanis, 2014). Both performance-based tasks and questionnaires concluded that autistic individuals have more CF difficulty than neurotypical individuals and individuals with other neurodevelopmental conditions (Hill, 2004; Kenworthy et al., 2008; Landry & Al-Taie, 2016; Leung & Zakzanis, 2014). Landry and Al-Taie (2016) further examined relationships between WCST performance and intelligence, which they found that perseveration may be a function of performance IQ among those with autism. Despite these consistent findings, these were based on studies of autistic individuals with at least average intelligence. Thus, the current understanding of how CF relates to behaviour in autism is biased towards individuals with at least average intelligence, echoing a similar trend in broader autism research (Thurm et al., 2019).

A recent meta-analysis highlighted that selection bias against low intelligence was common in autism research (Russell et al., 2019), resulting in concerns regarding

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the generalizability of findings, including those regarding CF, across the autism spectrum. For example, studies have shown that autistic individuals with lower-than-average intelligence display more behavioural rigidity and face more challenges than those with average intelligence (Bishop et al., 2007; Matson & Shoemaker, 2009). Research findings concluded that autistic individuals with at least average intelligence may not accurately describe the functioning of those with lower than average intelligence (Rommelse et al., 2015). This is particularly concerning given that autistic individuals with lower-than-average intelligence represent a significant portion of the autistic population (Mannion et al., 2014; Srivastava & Schwartz, 2014).

Approximately 33% of autistic children in the United States are diagnosed with intellectual functioning within the intellectual disability (ID) range (IQ $\leq$ 70), and another 24% within the borderline ID range (IQ = 71–85) (Maenner et al., 2020). In addition to intelligence, another consideration when assessing CF in autism is the developmental period of the individual. As CF skills continue to develop through childhood and tend to stabilize in adolescence, understanding CF skills of autistic adolescents is especially informative (Best & Miller, 2010). To our knowledge, only one study examined CF of autistic adolescents with lower-than-average intelligence who fall within the range of moderate to severe ID (Didden et al., 2008). Didden et al. (2008) concluded that autistic adolescents were more inflexible than intelligence- and age-matched non-autistic peers (including adolescents with Down syndrome and Angelman syndrome).

This study aims to assess the CF skills of autistic adolescents with lower-than-average intelligence, defined by full-scale IQ score falling between 50 and 85 (falling between mild ID or borderline ID) (American Psychiatric Association, 2013; Nouwens et al., 2017). A computerized version of Wisconsin Card Sorting Task (WCST), one of the most widely used CF tasks in autism research (Landry & Al-Taie, 2016), was used to objectively assess the CF skills of participants; the computerized version was used to reduce the social demand and need for verbal responses during administration. The meta-analysis by Kopp et al. (2019) demonstrated differential correlations between WCST performance to verbal IQ (VIQ) and performance IQ (PIQ), suggesting the possibility of distinct contribution of each type of IQ to WCST performance in our participants. Hence, the relationships between WCST, VIQ and PIQ will also be assessed in both autistic and non-autistic participants. It is hypothesized that, controlling for full-scale IQ, autistic individuals would under-perform on the WCST (i.e., with more perseverative errors and/or less conceptual responses on WCST) than those without autism. It is also hypothesized that PIQ would correlate with the WCST performance of the autistic individuals, but not of the non-autistic individuals.

Methods

Participants

All participants were recruited from the Summit Centre for Education, Research, and Training (SCERT), a research branch of Summit School in Montreal, Canada. Summit School is an alternative educational facility with specialized instruction for students of all socioeconomic levels with developmental disabilities that result in cognitive, social, behavioral or adaptive difficulties.

Thirty-six adolescents (n = 36) aged between 11 and 18 years participated in the study, $M_{age} = 14.9$, $SD_{age} = 1.23$. The intellectual functioning of all participants, measured using the Full-Scale IQ of the Wechsler Abbreviated Scale of Intelligence—2nd Ed. (WASI-II), was within the borderline to mild ID range, $M_{FSIQ} = 64.23$, $SD_{FSIQ} = 9.27$. Among the 36 participants, 14 had a autism spectrum disorder (ASD) diagnosis. The ASD diagnosis of each participant was verified by the codes established by Ministère de l'Éducation de l'Enseignment Supérieur (MEES or the Ministry of Education and Higher Education). The MEES sets out specific criteria and code to identify students with neurodevelopmental conditions and educational needs (Fombonne et al., 2006). Students who received the code 50, denotes a "Pervasive Developmental Disorder" which includes ASD, would have been evaluated in structured observation and standardized assessment by a "psychologist who has expertise in this field and who works with a multidisciplinary or interdisciplinary team" and that they must demonstrate limitations in at least of one of the following domains "communication, socialization, and learning at school" (Gouvernement du Québec, 2007, p.21).

For the non-ASD group, participants with known medical or genetic conditions (e.g., Down Syndrome) were excluded. Twenty-two participants (n = 22) were recruited in the non-ASD group who were matched on chronological age, $F(1, 34) = 0.310$, $p = 0.581$, and full-scale Wechsler IQ, $F(1,34) = 2.515$, $p = 0.122$. The male-to-female ratio (n_{male}:n_{female}) was higher for the ASD group (12:2) than that of the non-ASD group (12:10), which was consistent with the higher autism prevalence in male than female (Maenner et al., 2020).

Procedure and Measures

All participants were tested at SCERT, which was housed at the school. Each participant was administered the WASI-II and completed the computerized version of WCST (see descriptions below). The entire evaluation session took approximately 1 to 1.5 h, divided into two to three sessions of 20 to 30 min in the same day or over a few days in the same week depending on the participants' class schedule and level of fatigue. All participants completed all 128 trials, which were used as a proxy measure to indicate understanding of the task. Research assistants were in the same room to ensure that participants remain attentive to tasks.

Wechsler Abbreviated Scale of Intelligence—Second Edition (WASI-II)

The WASI-II is a brief, experimenter-administered task to measure general intelligence for individuals aged 6 to 89 (Wechsler, 1999). It comprises of two indices called VIQ and PIQ. The VIQ measures the abilities to reason with words and explain verbal concepts, whereas the PIQ measures the abilities to solve problems using pictures and understand relationships between shapes. Together, both Verbal and Performance IQ provide a general estimate of intelligence called Full-Scale IQ (FSIQ). Each participant was administered with the WASI-II and it took approximately 30 to 40 min to complete.

Wisconsin Card Sorting Task

The WCST (Berg, 1948; Heaton, 1981) is a neuropsychological task used, for ages six and above, to measure the ability to shift mindsets flexibly depending on changing contexts. In each trial, the participant was presented with four cards aligned in a row, with those cards varying in colours, shapes and number of shapes. The participant then sorted a single card to the four cards presented, and received feedback on whether the sort was correct or wrong. After six consecutive correct sorts, the rule changed unbeknown to the participant. An adapted computerized version of WCST was used with the Inquisit interface, consisted of a total of 128 trials that took 10–15 min to complete. CF skills were measured in terms of perseverative errors and conceptual responses, both of which were commonly used in review articles on CF skills of autistic individuals. Percentage of perseverative errors (i.e., % perseverative errors = ratio of the number of errors that were perseverative to the number of trials completed), and percentage of conceptual responses (i.e., % conceptual responses = ratio of the number of correct responses that were made consecutively for at least three trials to the number of trials completed) were used in this study (Heaton et al., 1993, p. 12).

Analysis

All analyses were performed with SPSS version 24.0 for Mac. Normality for % perseverative errors and % conceptual responses for each group were tested using Shapiro–Wilk test. Given the different sample sizes in both groups, Levene's test was conducted to determine homogeneity of variance. To determine if there is any between group difference in WCST performance, the one-way analysis of variance (ANOVA) was used to compare each WCST measure (i.e., % perseverative errors and % conceptual responses) of the ASD and non-ASD groups. To determine the relationships between WCST performance with the VIQ and PIQ in both groups, Pearson correlation and linear regressions were used for each group to examine the extent to which VIQ and PIQ can account for the variance in each of the WCST measures assessed.

Results

Mean WASI-II scores and WCST performance of both groups were shown in Table 1, which included confidence intervals (Cumming, 2014). Shapiro–Wilk test indicated that the % conceptual responses of both groups were normally distributed, $W_{\%conceptual\_ASD}(14) = 0.97$, $p = 0.87$; $W_{\%conceptual\_non\text{-}ASD}(22) = 0.98$, $p = 0.88$. However, % perseverative errors of both groups showed a statistically significant departure from normality, $W_{\%perseverative\_ASD}(14) = 0.85$, $p = 0.02$; $W_{\%perseverative\_non\text{-}ASD}(22) = 0.60$, $p < 0.001$. Thus, a log10 transformation of % perseverative errors of both groups was conducted, $W_{log10\_\%perseverative\_ASD}(13) = 0.90$, $p = 0.13$; $W_{log10\_\%perseverative\_non\text{-}ASD}(20) = 0.97$, $p = 0.78$.

Table 1 WASI-II and WCST scores of the ASD and non-ASD groups

		ASD group (n = 14) Mean [95% CI]	Non-ASD group (n = 22) Mean [95% CI]
WASI-II	Full-Scale IQ	67.29 [61.27, 73.30]	62.36 [58.76, 65.97]
	Verbal IQ	65.29 [57.53, 73.04]	61.64 [56.52, 66.75]
	Performance IQ	65.29 [57.53, 73.04]	61.64 [56.52, 66.75]
WCST	% perseverative errors	17.15 [8.06, 26.25]	14.02 [4.24, 23.80]
	% perseverative errors (log 10)	1.13 [.91, 1.35]	91 [.68, 1.13]
	% conceptual responses	52.58 [43.98, 61.19]	45.95 [41.07, 50.83]

Table 2 One-way ANOVA results

WCST performance	Sum of squares	df	Mean square	F	Sig.
% perseverative errors (log10)					
Between groups	0.393	1	0.393	2.024	0.165
Within groups	6.017	31	0.194		
Total	6.410	32			
% conceptual responses					
Between groups	376.176	1	376.176	2.353	0.134
Within groups	376.176	1	376.176	2.353	0.134
Total	5811.847	35			

Table 3 Correlation between WCST measures and VIQ/PIQ in both ASD and non-ASD groups

	% perseverative errors (log10)		% conceptual responses	
	r	Sig.	r	Sig.
ASD group				
VIQ	0.400	0.176	0.287	0.320
PIQ	0.655	0.015*	0.621	0.018*
Non-ASD group				
VIQ	− 0.207	0.382	0.281	0.206
PIQ	0.236	0.315	0.193	0.389

*Indicates statistical significance at $p < .05$ (two-tailed)

Table 4 Linear regression results

	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	SE	β		
ASD group					
% perseverative errors (log10)					
VIQ	0.006	0.006	0.226	0.945	0.367
PIQ	0.017	0.007	0.589	2.457	0.034*
% conceptual responses					
VIQ	0.086	0.279	0.077	0.307	0.765
PIQ	0.690	0.293	0.593	2.358	0.038*
Non-ASD group					
% perseverative errors (log10)					
VIQ	− 0.011	0.010	− 0.267	− 1.151	0.265
PIQ	0.014	0.011	0.292	1.258	0.225
% conceptual responses					
VIQ	0.249	0.209	0.261	1.191	0.248
PIQ	0.184	0.250	0.160	0.733	0.473

*Indicates statistical significance at $p < .05$ (two-tailed)

Levene's test indicated that WCST performance of both groups had comparable variances, $F_{log10\_\%perseverative}(1,31) = 0.864$, $p = 0.36$; $F_{\%conceptual}(1,34) = 1.67$, $p = 0.21$.

One-way ANOVA test indicated no significant between-group difference for both % Perseverative errors, $F_{log10\_\%perseverative}(1,31) = 2.204$, $p = 0.165$, $\eta^2 = 0.061$, and % Conceptual responses, $F_{\%conceptual}(1,34) = 2.353$, $p = 0.134$, $\eta^2 = 0.06$, see Table 2.

Correlational analyses of WCST performance, VIQ and PIQ in each group indicated that only PIQ was significantly correlated with both WCST measures in the ASD group, $r_{PIQxlog10\_\%perseverative} = 0.655$, $p = 0.015$, $r_{PIQx\%conceptual} = 0.621$, $p = 0.018$. No other statistically significant correlations were found between VIQ and WCST of the ASD group, nor between VIQ or PIQ and WCST of the non-ASD group (see Table 3).

In order to assess whether whether VIQ and/or PIQ can account for the variance in each of the WCST measures for each group, linear regressions were conducted. Prior analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity. In order to parse out contributions of VIQ and PIQ to the WCST performance in each group, only the coefficients of predictors were described, see Table 4. Linear regressions indicated that only the PIQ of the ASD group significantly explained WCST performance ($\beta_{log10\_\%perseverative\_ASD} = 0.589$, $t(13) = 2.457$, $p = 0.034$; $\beta_{\%conceptual\_ASD} = 0.593$, $t(13) = 2.358$, $p = 0.038$).

Discussion

The present study explored CF skills of autistic adolescents with low intelligence by comparing their WCST performance with that non-autistic peers who were matched on age and FSIQ. There were two major findings in this study: (i) No statistically significant between-group differences in WCST performance, for either percentages of perseverative errors and conceptual responses, were demonstrated. This was unexpected given our hypothesis which the autism group may underperform on WCST compared to the non-autism group; (ii) Consistent with the hypothesis about the unique relationship between PIQ and WCST in the autism group, the linear regression analyses indicated that Wechsler-based PIQ significantly contributed to WCST performance in the ASD group only.

The similar between-group WCST performance found in the present study was consistent with previous studies assessing CF with autistic adults, but not with autistic children. Specifically, when CF skills were compared between autistic children with low intelligence and their non-autistic peers, autistic *children* made more perseverative responses, more errors and completed less trials on WCST and the intra-extra dimensional (IED) set-shift task (Hughes et al., 1994; Panerai et al., 2014). Importantly, studies using the same tasks to compare CF skills between autistic *adults* with low intelligence and their non-autistic peers revealed similar between-group performance (Roelofs et al., 2015; Visser et al., 2015). Our results bridge the developmental gap in the literature and suggest that the CF skills of autistic adolescents with low intelligence are congruous with that of adults, suggesting that autism-specific CF weakness, as defined by WCST, may be specific to childhood.

Our similar WCST findings between autistic and non-autistic adolescents with low intelligence may be explained by the incremental development of pre-requisite skills (Kouklari et al., 2018). It was suggested that CF skills build on pre-requisite inhibitory control (i.e., suppression of impulses to respond to previously-learnt rule) and working memory skills (i.e., simultaneous maintenance and updating of relevant information based on feedback) (Best & Miller, 2010; Dick, 2014; Somsen, 2007). Following development of these two pre-requisite skills which typically reach maturity in childhood, CF skills continue to improve and follow a protracted development until adolescence (Buttelmann & Karbach, 2017; Dajani & Uddin, 2015). In other words, as the pre-requisite skills, upon which CF skills build, reach maturity in childhood, CF skills are able to develop and "catch-up" in adolescence. Thus, the developmental trajectory of CF may reconcile the findings of ASD-specific CF difficulty in childhood but lack of such difference in adolescence and adulthood among autistic individuals with low intelligence.

Another important result of this study was the finding of a significant contribution of PIQ to WCST performance in the ASD group only. Specifically, positive correlations were found between PIQ and the two WCST measures (higher PIQ correlates with higher % perseverative errors and higher % conceptual responses), indicating an interestingly mixed influence on overall WCST performance. While PIQ and perseverative errors in WCST was typically negatively correlated among autistics with at least average intelligence (Landry & Al-Taie, 2016), the positive correlation revealed in this current study may be unique to autistics with lower-than-average intelligence. It will be important for future studies to verify the mixed influence of PIQ on perseverative errors and conceptual responses in order to yield meaningful implications of these mixed relationships. Overall, these results highlighted the unique role of PIQ in contributing to CF skills, as measured by WCST in this study, and the importance to consider PIQ in assessing CF skills of autistics with lower-than-average intelligence.

Conclusion and Limitations

This study preliminarily addressed the void in the existing literature regarding CF skills in autism by assessing CF skills in autistic adolescents with lower-than-average intelligence. Our findings suggested that CF skills were more similar to autistic adults compared to autistic children with low intelligence. This may also suggest that CF skills as assessed by WCST may have been developed and matured during adolescence, following the developmental trajectory of CF among typically developing adolescents. By providing insights into CF skills of autistic individuals in their adolescence, this paper adds to a better understanding of CF skills across a wider age range. Another contribution is that this study highlighted the unique role of PIQ to WCST performance in autistic adolescents only, suggesting PIQ had a unique contribution to WCST performance among autistic adolescents. This relationship may be helpful in guiding future research in developing interventions to improve CF skills by targeting PIQ, considering the significant relationship between CF and restricted and repetitive behaviours in autism.

As an exploratory study, this study recognizes its methodological limit including small sample size and the use of a single task to measure CF. Although WCST was widely used in measuring CF of autistic individuals, the use of additional CF measures will significantly complement the current findings. This becomes especially important considering that CF skills are variable and can inter-relate with other executive functioning skills. In order to reduce potential floor effect, other measures with reduced task demands such as Flexible Item Selection Task (FIST) may also be considered in future studies. Given the significant difference in sex ratio in autism, future research with larger sample size can clarify the way which CF performance may be related to sex. Despite the small sample size and use of a single task in this study, the findings from this study provide preliminary impetus for future research to consider the nonverbal problem-solving skills (e.g., CF, PIQ) of autistic adolescents with low intelligence, a unique and under-represented population on the autism spectrum.

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Author Contributions Both authors contributed to the study conception and design. Material preparation, data collection and analysis was performed by Stephanie Lung, under the close supervision of Dr. Armando Bertone. The first draft of the manuscript was written by Stephanie, and iterative rounds of edits with Dr. Bertone. Both authors read and approved the final manuscript.

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Declarations

Conflict of interest Both authors have no relevant financial or non-financial interests to disclose.

Ethics Approval This research has been approved for ethics at McGill University (REBIII368-0118) on February 22nd, 2018 and at SCERT of Summit School of Montreal on November 22nd, 2018.

Informed Consent Informed assent and consent were obtained from all individual participants and their parents/caregivers included in the study.

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