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Cognitive flexibility impairments in children with autism spectrum disorders: Links to age, gender and child outcomes

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ABSTRACT

There are still many questions about the cognitive flexibility in autism spectrum disorder (ASD) that remain unanswered. The goal of current study was to evaluate cognitive flexibility patterns and their demographic, clinical and behavioral correlates in large sample of children with ASD. A total of 123 children (94 boys and 29 girls) with ASD aged 7–14 years were assessed on the Wisconsin card sorting test (WCST). Findings showed that gender but not age was associated with the cognitive flexibility performance in ASD. Individuals who had more parent-reported language deficits, lower level of intelligence and education, and showed lower daily sleep time or more engagement in solitary instead of social daily activities were more likely to demonstrate perseveration. Findings provide tentative evidence of a link between cognitive flexibility deficits and sociodemographic or clinical child outcomes in ASD.

1. Introduction

There has been ongoing concerns that deficits in executive functions (EF) may link to various social and behavioral impairments in individuals with autism spectrum disorders (ASD), such as deficits in the theory of mind, communication skills and maladaptive behaviors (Gousse et al., 2002; Griffith, Pennington, Wehner, & Rogers, 1999; Happé, Booth, Charlton, & Hughes, 2006; Hill, 2004; McEvoy, Rogers, & Pennington, 1993). Executive function is an umbrella term for initiating and controlling functions such as planning, response inhibition and cognitive or mental flexibility (Anokhin, Golosheykin, Grant, & Heath, 2010; Kaland, Smith, & Mortensen, 2008). It is generally associated with frontal lobe structures of the human brain (Gousse et al., 2002; Kaland et al., 2008).

The EF problems are not exclusively seen in autism, though severity and profile of deficits differ across developmental disorders (Geurts, Corbett, & Solomon, 2009; Pennington & Ozonoff, 1996). The experimental data are rather controversial on EF measures particularly in ASD (Happé et al., 2006; Sergeant, Geurts, & Oosterlaan, 2002) which can be due to inconsistencies in definitions as well as the complexity and difficulty of assessments (Kenworthy et al., 2008). Some evidence highlight impairments in key aspects of EF in autism: inhibition, set shifting and cognitive flexibility (Hill, 2004; Hughes, 1998; Russo et al., 2007). Wisconsin card sorting test (WCST) is a standard neuropsychological measure of prefrontally mediated executive functions including cognitive flexibility, set maintenance and problem solving (Kaland et al., 2008; Rhodes, 2004). Several studies in which WCST were investigated in ASD, suggested that individuals with ASD are highly

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perseverative in comparison with typically developing (TD) children or other developmental disorders such as attention-deficit hyperactivity disorder (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Ozonoff & Jensen, 1999; Ozonoff, Pennington, & Rogers, 1991; Rumsey, Rapoport, & Sceery, 1985). In other words people with ASD have difficulty in rule shifting even when they knew the rule was wrong.

Some previous research showed that there is no significant difference between individuals with ASD or developmental language disorders in making perseverative errors. The authors suggested that there may be a relationship between perseverative tendencies and language deficits (Liss et al., 2001). Furthermore the cognitive flexibility may be affected by other cognitive variables related to language such as education or learning abilities. Keeping in mind that children with ASD have different learning styles and show pervasive language impairments, examining cognitive flexibility in ASD will be worth it to make this relationship more clear (Lowe & Reynolds, 1999).

Among demographics, age is an important variable that can account for the different measures of EF (Lowe & Reynolds, 1999). While age is evidenced to alleviate perseverative errors in TDs (Happé et al., 2006), there has been little agreement on a significant relationship between age and cognitive flexibility in ASD (Happé et al., 2006; Ozonoff & Jensen, 1999; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009). For example, some previous studies reported that older participants outperformed the youth with ASD on a battery of EF measures including response inhibition, working memory, cognitive flexibility and planning (Happé et al., 2006; Ozonoff & Jensen, 1999). However authors cannot provide a satisfactory explanation for it and the finding was not supported by later observations in individuals with ASD. Robinson et al. (2009) suggest that children with ASD may fail to exhibit typical age-related gains in self-monitoring that may contribute to their cognitive performance. Overcoming a major limitation of previous research about age range, the Ozonoff et al. (2004) study with participants aged 6–47 years also showed no age related improvement in performance on the set shifting task. Addressing other limitations, we were trying to investigate a large sample of children with ASD.

In addition, there is not much information about sex differences in neuropsychological performance in general, and cognitive flexibility in specific, in ASD (Lemon, Gargaro, Enticott, & Rinehart, 2011; Thompson, Caruso, & Ellerbeck, 2003). While Lemon et al. (2011) indicated a significant poorer inhibition in girls with ASD than boys with ASD, Bolte, Duketis, Poustka, and Holtmann (2011) could not show any gender differences on a cognitive flexibility task. Interestingly it has been suggested that the greater prevalence ratio of males to females (4:1) (Gray & Tonge, 2005) is partially caused by sex differences in the expression of ASD symptoms which may result in misdiagnosis among females (Attwood, 2008). Girls with ASD may be able to hide their symptoms by having greater early communication abilities (Attwood, 2008); though findings generally support the hypothesis that the females with ASD show more severe symptoms (e.g. social deficits) than males with ASD (Hartley & Sikora, 2009; McLennan, Lord, & Schopler, 1993). In contrast, a group of girls with ASD (mean age = 28 months) showed higher nonverbal problem solving abilities and better visual perception (Carter et al., 2007). Although current studies suggest that there may be neurobehavioral and cognitive gender differences responsible for clinical appearance in ASD (Lemon et al., 2011), it is unclear to what extent cognitive differences in autism can be attributed to the gender. Thus we were trying to investigate the gender differences in cognitive flexibility of children with ASD.

The picture of executive functions in ASD is essentially complex. This can be in part due to the complexity of underlying brain structures of cognitive flexibility. Among those, frontal cortex is an area uniquely positioned and designed to exert control over a wide array of social and environmental information processing (e.g. repetitive behaviors) (Ozonoff et al., 2004). Examining different social/environmental (e.g., education or daily activities) and clinical factors (e.g., language skills) in parallel with cognitive flexibility can provide an interpretation that accurately reflects the frontal lobe functions in children with ASD (Bigler, 1988).

Expectedly, cognitive flexibility plays an important role in the development of flexible behaviors (e.g., daily social activities). On the other hand, children with poor social and behavioral outcomes are more likely to live in substandard situations with difficulties in health care. They are less likely to have access to stimulating learning materials, and receive adequate parental support or educational services. These factors, in turn, contribute to an overall risk for negative cognitive outcomes in these children (Bradley & Corwyn, 2002; Evans, 2004). Children with poor social or behavioral profile are also at risk to experience cognitive developmental delays (Duncan & Brooks-Gunn, 2000). Several studies indicate that delayed cognitive skills are a marked presentation of children with ASD. Furthermore children with ASD show obvious impairment or delay in daily adaptive activities. Thus performance in daily activities (e.g., social activities) might be associated with the cognitive ability of autistic children to switch between environmental signals (i.e., cognitive flexibility).

The aim of this study was to investigate cognitive flexibility in children and adolescents with ASD and underlying factors together with the sociodemographic correlates such as child age, gender, daily activities and parent profile in addition to autism clinical features. We then hypothesized that the nature of the cognitive flexibility impairment differs across gender but not age in ASD. Furthermore, we presumed that social and behavioral skills deficits are directly associated with impairments in cognitive flexibility of autistic children.

2. Methods

2.1. Participants

The total sample for the current study included 123 high functioning children with ASD, (94 boys and 29 girls) with an age range of 7–14 years (9.6 ± 1.9 years). These children participated in the health survey of autism, which was a university-based research study in Tehran, Iran and included families with at least one child in specific schools for autism spectrum disorders. All children met criteria for a diagnosis of autism spectrum disorders (Autism ($n = 42$), Asperger's syndrome ($n = 68$), pervasive developmental disorder not otherwise specified ($n = 13$)) on both the DSM-IV (American Psychiatric Association, 2000) and the autism diagnostic interview – revised (ADI-R) from licensed professionals. The diagnoses were established by either a child psychologist or psychiatrist.

Participants were excluded if they had evidence of mental retardation ($IQ < 70$), severe co-morbidities (e.g. intractable epilepsy, severe self-injury and aggression) and if a participant could not complete the testing. Psychotropic medications were frequently (80%) used by participants (56% on atypical antipsychotics, 33.5% on antiepileptics/mood stabilizers, 13.1% on stimulants and 7.9% on antidepressants with some overlaps among the categories). Indeed psychotropic medication was not considered as an exclusion criteria since this was a representative sample of ASD group and they had no chance to stop medication even for a short period (Memari, Ziaee, Beygi, Moshayedi, & Mirfazeli, 2012). Moreover, primary analysis showed no significant influence of pharmacotherapy on dependent cognitive variables.

Examining the possible association of IQ with cognitive flexibility performance; all participants were examined regarding non-verbal IQ by Raven's progressive matrices or the Wechsler intelligence scales for children-IV (Performance IQ). Primary analysis showed that the boys and girls participants were largely comparable regarding age (9.6 ± 1.9 vs. 9.7 ± 1.6; $t = 0.2$, $p = 0.8$) and non-verbal IQ (89.9 ± 8.3 vs. 87.6 ± 9.8; $t = 0.3$, $p = 0.6$). To examine developmental aspects of cognitive flexibility, participants were classified into four age groups based on Piaget developmental substages: 7–8 (M = 26 and F = 8), 9–10 (M = 28 and F = 4), 11–12 (M = 25 and F = 7) and 13–14 (M = 22 and F = 5).

The child's parent or caregiver completed written informed consent and each child assented to study participation. The study was approved by the Medical Ethics Committee of Tehran University of Medical Sciences.

2.2. Measures

2.2.1. Wisconsin cart sorting test (WCST)

The 64-response card set of the WCS, was used in all the administrations. The test that measures set shifting abilities (cognitive flexibility) required children to sort cards according to one of three possible rules including shape, color and number (Bishara et al., 2010; Robinson et al., 2009). The child was not told how to sort the cards (by which rule). However, s/he received a feedback whether a particular match is right or not. Following raw scores were used: (1) perseverative errors and (2) number of categories achieved. A perseverative error was defined as an incorrect response due to failure to change sorting strategy after negative feedback. A category achieved was defined as keeping the found correct rule till ten sorts (maximum 6 categories).

2.2.2. Other assessments

Parents completed a brief form that consisted of child age, gender, weight and height, education (grade level), medical history and the medications child has been using as well as parental education (As 17.9% upto diploma or low, 41.5% upto bachelor degree or medium and 40.6% above bachelor degree or high). Furthermore parents were asked to complete an activity log for children (on a weekly basis; two weekdays and one weekend) which was designed to obtain information about each child on their hourly engagement during a typical day (Venkatesan, 2005). Daily activities were presented in nine headings and each one stands for a separate variable. Among those, social play (i.e., time spent on playing with peers vs. solitary activities or non-social play), total sleep time and TV time (i.e., time spent watching TV and playing video games) were used for analysis. Indeed the measures show the time (minutes) that children spend in each activity during each day then the average scores of all days have been provided for analysis. This instrument showed a good content validity and test–retest reliability was satisfactory ($ICC = 0.69$, $p < 0.001$). Moreover, this measure was previously used in children and adolescents with ASD successfully (Memari, Ghaheri, et al., 2013).

Furthermore, autism symptom severity in children was assessed via autism treatment evaluation checklist (ATEC) (Rimland & Edelson, 1999). Parents were asked to complete ATEC based on present status of their child. This is an effective tool to assess the severity of symptoms of ASD, as well as the effectiveness of autism treatments (Memari, Shayestehfar, et al., 2013). It consists of 4 subtests: (1) speech/language/communication (14 items; for simplicity named language); (2) sociability (20 items); (3) sensory/cognitive awareness (18 items); and (4) health/physical/behavior (25 items; for simplicity named physical). ATEC total score is based on the sum of individual scores and ranges from 0 to 180; higher scores mean the ASD condition is more severe. Internal consistency analysis on more than 1300 checklists reported to be high (0.94 for the total score; 0.81–0.92 for sub-scale scores); ATEC showed good validity in addition.

2.3. Procedure

Children were tested individually in a quiet room at their school by an expert psychologist and an assistant (a child speech therapist). Sessions were set according to free times offered by child, family and teachers in order to minimize family and school disruptions. Children were given positive comments in order to encourage them throughout the testing session. Participants were informed that they could discontinue the testing at any time.

2.4. Statistical analysis

First, correlation analysis was conducted to examine relationships between cognitive flexibility and symptom severity, social or behavioral variables controlling for non-verbal IQ as a potential confounder (Bolte et al., 2011). To investigate the age and gender patterns of cognitive flexibility deficits in children with ASD, we did a multivariate analysis of covariance (MANCOVA) on the WCST measures with a fixed factor, either age group or gender. The non-verbal IQ was inserted as covariate in the general linear model (GLM) to adjust for the remaining cognitive effect, since this was correlated with the dependent measures (i.e. perseveration and completed categories). In examining gender differences, age and education were also added as covariates. Also, of the results those were significant, independent analyses of covariance (ANCOVA) were performed on dependent measures. Furthermore multiple linear regression was conducted to determine the best-fitting models for perseveration or number of categories achieved. Sociodemographics, IQ and clinical factors that were first shown to be correlated with dependent variable were entered into the models as the predictor variables. Data management and analysis was performed using SPSS 17 (SPSS Inc, Chicago, Illinois, USA). To ensure that the overall chance of making a *type I error* is still less than 0.05; we applied the Bonferroni correction by adjusting the *p*-values for multiple comparison and post hoc analysis.

3. Results

Descriptive characteristics of the 123 participants are shown in Table 1. The results obtained from correlation analysis showed that when controlling for the non-verbal IQ, perseveration were inversely correlated with social play ($r = -0.31$, $p = 0.001$), sleep time ($r = -0.34$, $p < 0.001$), child education level ($r = -0.30$, $p = 0.001$) and parental education level ($r = -0.26$, $p = 0.004$). For instance, as the amount of sleep per night went up, the number of perseverative errors went down. However categories achieved was positively associated with child education level ($r = 0.40$, $p < 0.001$) and parental education ($r = 0.30$, $p = 0.001$). Data showed that higher levels of education were associated with higher number of categories achieved. Furthermore, in the case of autism symptoms, the measures are positively *correlated* with perseveration and inversely correlated with categories achieved scores as can be seen in Table 2. Data indicated that children with higher autism severity scores showed lower performance on WCST measure.

Strong evidence of gender differences was found when a MANCOVA was performed to investigate cognitive flexibility scores between boys and girls; $F(4, 117) = 3.567$, $p = 0.009$; Wilks lambda = 0.89. The results of ANCOVA as shown in Table 3 indicate that girls made significantly more perseverative errors: ($F(1120) = 6.44$, $p = 0.012$) and completed fewer categories

Table 1
Characteristics of children with autism spectrum disorders (ASD).

	Participants range	Mean ± SD
Age (year)	7.3–14	9.6 ± 1.9
Child education (grade)	1–7	2.4 ± 1.8
Non-verbal IQ	78–108	93.3 ± 11.1
WCST (raw data)		
• Perseveration	0–40	16.3 ± 9.2
• Categories achieved	0–4	0.8 ± 0.6
ATEC		
• Language score	0–23	11.2 ± 5.7
• Sociability score	0–32	12.6 ± 6.4
• Sensory-cognitive score	1–33	17.1 ± 6.1
• Physical score	4–57	22.5 ± 11.7
• Total score	7–128	63.2 ± 22.2
Daily activities (min/day)		
• Social play	5–35	11.8 ± 5.2
• Sleep time	344–651	491 ± 52.9
• TV time	30–320	90.9 ± 49.4

Autism treatment evaluation checklist (ATEC), Wisconsin card sorting test (WCST).

Table 2
Correlation analysis between WCST measures and autism symptom severity scores (ATEC) controlling for the non-verbal IQ.

	Language		Sociability		Sensory/cognitive awareness		Physical		Total score	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Perseverative errors	0.41	<0.001	0.24	0.006	0.21	0.016	0.1	0.24	0.29	0.001
Categories achieved	−0.31	<0.001	−0.14	0.11	−0.31	<0.001	−0.11	0.21	−0.26	0.003

Table 3
Analysis of variance across the gender for the cognitive flexibility measures (raw data).

	Male		Female		*F*	*P*	Eta-squared
	Mean	SD	Mean	SD			
Perseverative error	14.83	8.65	22.37	9.23	6.44	0.01	0.20
Categories achieved	0.83	0.88	0.08	0.28	10.11	0.002	0.25

Table 4
Means and standard deviations and analysis of variance across the age groups for the cognitive flexibility measures.

	7–8 years old $n = 34$		9–10 years old $n = 32$		11–12 years old $n = 29$		13–14 years old $n = 28$		*F*	*P*	Eta-squared
	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Perseverative error	18.34	8.50	13.43	10.64	17.66	7.49	14.66	7.82	2.33	0.07	0.16
Categories achieved	0.51	0.68	1.07	1.10	0.37	0.57	0.77	0.44	4.55	0.005[a]	0.19

[a] Post-hoc analysis showed significant between-group differences (7–8 < 9–10 and 9–10 > 11–12).

Table 5
Summary of multiple regression analysis predicting perseverative errors.

	B (unstandardized)	Beta (standardized)	*t*	*p*
Language (ATEC 1)	0.48	0.36	4.51	<0.001
Child education	−1.39	−0.27	−3.60	0.006
Social play	0.03	−0.25	−3.29	0.001
Sleep time	−0.043	−0.24	−3.20	0.001
Non-verbal IQ	−0.28	−0.23	−2.70	0.01

than boys (F (1120) = 10.11, $p = 0.002$). To control effect of possible confounders we entered the age and child education besides IQ as covariates but the findings were not significantly different.

Based on MANCOVA, there was only a small difference (eta-squared < 0.2) between the age groups for WCST measures while covaring for non-verbal IQ; F (12, 304.5): 1.943, $p = 0.02$; Wilks lambda = 0.82. ANCOVA results indicated no significant difference among age groups for perseveration, but only post hoc pairwise comparison for the categories achieved showed better performance in the group of 9–10 years compared with group of 7–8 years ($p = 0.03$), or group of 11–12 years ($p = 0.04$) (Table 4).

Table 5 renders the results of multiple regression on perseverative errors. The analysis showed that language score ($t = 4.51$, $p < 0.001$), child education ($t = 3.60$, $p = 0.006$), social play ($t = 3.29$, $p = 0.001$), sleep time ($t = 3.20$, $p = 0.001$) and non-verbal IQ ($t = 2.70$, $p = 0.01$) were the best predictors of perseveration. However age, gender and other variables with statistical significance in the univariate analysis were removed from the model. Our model explained 44% of variation in perseveration of children with ASD. For the categories achieved, child education score ($t = 4.1$, $p < 0.001$), language score ($t = 2.30$, $p = 0.02$) and non-verbal IQ ($t = 2.01$, $p = 0.03$) were the significant predictors. This model could explain only 21% of the total variation in categories achieved (not shown).

4. Discussion

This paper is one of the few studies considered age and gender differences in cognitive flexibility of children with ASD in addition to examining influence of various child outcomes on this cognitive performance. So far there is only one study by Ozonoff et al. (2004) that precisely addressed cognitive parameters including flexibility in a large sample of individuals with ASD. Although comparison is hindered by the use of different methods of sampling or WCST scoring, enduring impairment in the number of perseverative errors by children with ASD in current study was comparable with previous findings (Liss et al., 2001) and even more prominent (Bolte et al., 2011), considering the sample characteristics or version of WCST. However current study by increasing the sample size and examining a community based population with ASD, attempts to extend previous works that have limited power to find significant patterns of cognitive flexibility in children with ASD (Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Happé et al., 2006).

Age, as a main focus of research in developmental disabilities such as ASD, has been frequently investigated in relation to cognitive development. It is suggested that crucial brain regions responsible for EF develop by age and it is expected that older individuals outperform younger ones. Indeed, previous literature (Benes, 2001; Diamond, 2002) showed that myelination and increase in volume of frontal cortex continues through childhood, adolescence and more into young adulthood. Additionally, previous studies in normal population showed significant relationships between WCST performance and volumetric measures of prefrontal cortex (Head, Raz, Gunning-Dixon, Williamson, & Acker, 2002; Raz, Gunning-Dixo, Hea, Dupuis, & Acker, 1998; Schretlen et al., 2000). However, our findings indicated that age may not help recovery in EF outcomes in ASD despite small differences seen among age groups (This may be partially due to fewer females in 9–10 years group). This result corroborates the earlier findings by Ozonoff and McEvoy (1994), which conducted a 3-year follow up of 23 autistic children and revealed that there is no significant age related improvements in EF tasks. Interestingly, 10 years later they found same results through a larger scale study (6–47 years) investigating planning and flexibility performance in individuals with ASD (Ozonoff et al., 2004). However there were different findings on association of age and executive functions rather than cognitive flexibility (Happé et al., 2006; Sigman & McGovern, 2005). Happé et al. (2006) suggested that older participants with ASD performed significantly better than younger participants in inhibition and spatial working memory. Although there are some inconsistencies due to differences in sampling methods, our data support the first hypothesis on age-consistent impairment of cognitive flexibility among children with ASD. Regarding the psychological and developmental aspects of the disorder, there are several factors that could confound and modify the exclusive role of age in different developmental stages of children with ASD. Future research is warranted to apply a biopsychosocial perspective to investigate the effect of age on cognitive flexibility in ASD.

Regardless of other associated factors, girls showed lower performance in WCST measures than boys with ASD. Earlier observations indicated that girls with ASD showed more impaired social and communication abilities (Carter et al., 2007) in addition to a rise in psychopathology (Holtmann, Bölte, & Poustka, 2007) compared to the boys. Consequently one can argue that these sex-dependent differences may be linked to their cognitive flexibility impairments. Furthermore our results in agreement with Lemon et al. (2011) indicated that there may be distinct neurobehavioral and cognitive profiles for boys and girls with ASD which can cause different ASD presentations. Presence of executive dysfunction beside its gender differences in a sample with ASD may bring two theories to mind: Executive dysfunction theory and sex-dependent theory of autism as empathizing systemizing theory. It is suggested that future studies may use both theories in parallel to reduce ambiguities in cognitive flexibility of individuals with ASD (Bolte et al., 2011). However it is worthwhile noting that based on previous studies particularly from normal population, authors argue that gender is not always significantly related to WCST performance once possible confounding factors (such as education) have been accounted for. Although we controlled these possible factors and showed the gender differences, our final regression model including social and behavioral factors but not gender left the question to be determined by further research.

EF deficits are attributable to planning problems, impairments in regulation of task performance and finally flexibility deficits in cognitive functions. Although, cognitive flexibility is a central part of children cognitive development, there has been little discussion about links between cognitive flexibility and child outcomes. In one of few studies that broach this gap, Berger, Aerts, Spaendonck, Cools, & Teunisse (2003) reported that social competence has a link to cognitive flexibility in ASD. Furthermore previous studies suggest that cognitive flexibility deficits are associated with repetitive behaviors in children with ASD (Ridley, 1994; Turner, 1999). Theses impairments could deeply influence children behaviors and social interactions. In current study we showed that perseveration is negatively connected to appropriate daily social play in a child with ASD. A possible explanation for this might be that children with low cognitive flexibility are less able to deal with conflicts with peers in a cooperative style than those with high cognitive flexibility (Bonino & Cattelino, 1999). Furthermore, it may be that children with higher perseveration showed higher communication-social (autistic symptoms) impairments and this may be in turn, a cause of link between social play and perseveration. Investigating links of cognitive flexibility and other key outcomes in children with ASD, our results indicated that cognitive flexibility and language are mutually dependent. In other point of view, cognitive flexibility is an adjustment to new circumstances and producing novel representations or action sequences (Deak, 2003). In that vein language and communication skills can enable and improve expression of flexible cognition. Another explanation might be due to the fact that language provides a framework for planning and generalization of the rules in different situations, circumstances; and even thoughts and believes (Deak, 2003). Given together, it can be hypothesized that children with social or language impairments can show concurrent developmental deficits in cognitive flexibility.

Previous research also shows a strong link between cognitive flexibility and physical or mental health (Ozonoff & Jensen, 1999). Our important finding was that daily activities such as the amount of sleep time may have a decreasing effect on perseveration. Although physical activity and sleep behaviors are markedly impaired in children with ASD (Memari, Ghaheri, et al., 2013), further studies are warranted to determine whether daily activities are directly linked to cognitive flexibility (Bryson et al., 2004; Wainwright-Sharp & Bryson, 1993), or there are a number of other variables that may mediate the relationship (e.g., socioeconomic status, language and sociocognitive abilities).

Furthermore in line with previous studies (Thompson et al., 2003), our results confirmed that children levels of education are correlated with cognitive flexibility in ASD. Thus it may be highly recommended to use adjusted scores of (e.g., education adjusted) WCST for children with ASD in future studies, and then we can examine other possible correlates independently. Our findings, we feel, add to the growing literature that suggests multidimensional approaches can improve our understanding of cognitive profile in children with ASD.

A number of caveats need to be considered regarding the present study. Firstly, the small sample size of girls and lack of control might limit the statistical power and suggests that these findings on gender differences must be considered as preliminary. Replication of this study among larger groups of females and inclusion of a control sample can lead to a better understanding of cognitive development in females with ASD. Although our findings showed that cognitive flexibility is not affected by age, future studies can examine autistic samples with broader age ranges particularly including adolescence years. Furthermore, comparability of these findings with previous data (particularly from normal population) is limited by the use of raw scores of WCST; thus generalizability should be made cautiously. There are also possible confounds that require further investigation including a variety of cognitive variables such as memory, processing speed and visuospatial ability as well as socio-cognitive measures. While examining effect of medications on cognitive flexibility was beyond the scope of current study, close monitoring of medications in addition to obtaining information from other cognitive domains, will be crucial to understand the role of medication in cognitive flexibility. The current study investigated cognitive abilities in an eastern population with ASD relatively unknown in the ASD literature. These findings could also serve as a base for future studies on cross-cultural variations of cognitive functions in ASD mediated by sociodemographics factors.

In conclusion, findings provide tentative evidence of a link between cognitive flexibility deficits and sociodemographic or clinical/behavioral variables in children with ASD. This study also provides important information for the researchers and practitioners about the patterns of cognitive flexibility impairments in children with ASD.

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