

Assessment of Executive/Attentional Performance in Asperger's Disorder

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Abstract

Objective: Deficient executive functioning (EF) has been reported in several neurodevelopmental disorders, including autistic spectrum disorders; however, many studies included heterogeneous groups and few have focused on EF in individuals with Asperger's disorder (AD) in relation to attentional performance. The aim of the present study was to compare executive/attentional performance in children and adolescents with AD to that in controls, and to assess the influence of comorbid attention deficit-hyperactivity disorder (ADHD) on that performance.

Method: In total, 21 individuals with AD aged between 8 and 16 years (diagnosed according to DSM-IV criteria) and 18 age-, gender-, education-, and IQ-matched volunteer controls were administered the Continuous Performance Test (CPT), Wisconsin Card Sorting Test (WCST), Stroop Test, and verbal fluency tests.

Results: The participants with AD had more perseverative responses and errors, and fewer conceptual level responses, and generated fewer categories on the WCST. They also had lower phonological fluency scores, but were similar to the controls in terms of semantic fluency, CPT, and Stroop scores. Comparison of those with comorbid ADHD and those without ADHD (AD+ADHD and pure AD, respectively) revealed that the AD+ADHD subgroup had lower CPT, semantic fluency, and Stroop interference scores.

Conclusion: The present study indicated a clear profile of a dysexecutive syndrome among the participants with AD and that ADHD comorbidity exacerbated deficits in attentional tasks.

Key Words: Asperger's disorder, attention deficit-hyperactivity disorder, neuropsychology, executive function, attention.

INTRODUCTION

Asperger's disorder (AD) is a pervasive developmental disorder (PDD) characterized by reciprocal social deficits and ritualistic interests, without cognitive or language developmental delays (American Psychiatric Association, 1994). There is an increasing number of studies examining the neuropsychological characteristics of AD, including executive functions (EF). Briefly stated, EF is the set of abilities necessary for goal-directed behavior to achieve a goal that can not be immediately achieved, but can only be reached after a temporal delay, which is usually set in novel situations in which interference from competing, often habitual but contextually erroneous

response alternatives exist (Fuster, 1997). Under the rubric of EF, one can include such behaviors as planning, set maintenance or working memory, resistance to interference, and inhibition of prepotent responses, as well as inappropriate response tendencies, organized search, and flexibility of thought and action (Weintraub, 2000). As such, the need for sameness (difficulty in novel or ambiguous situations coupled with intact performance on routine or over-learned tasks), and the existence of circumscribed interests, impulsivity, and difficulties with self-regulation and self-monitoring, which are all very common in AD may indicate EF deficits (Ozonoff, 1991a; Manjiviona and Prior, 1999).

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Previous studies have yielded inconsistent results, some finding evidence of EF impairment in AD (Szatmari et al., 1990; Ozonoff et al., 1991b; Nyden et al., 1999; Miller and Ozonoff 2000; Kleinmans et al., 2005; Ambery et al., 2006; Hill and Bird, 2006; Verte et al., 2006), while others have not (Blackshaw et al., 2001; Weimer, 2001; Rinehart et al., 2002; Shamay-Tsoory et al., 2002). These inconsistencies may be due to confusion over diagnostic criteria (Ozonoff, 1991a; Nyden, 1999), limited numbers of cases (Ozonoff et al., 1991b; Shamay-Tsoory et al., 2002; Weimer, 2001; Kleinmans et al., 2005), and lack of appropriate controls (Szatmari et al., 1990; Miller and Ozonoff, 2000; Kleinmans et al., 2005).

A study by Szatmari and et al. (1990) compared the performance of individuals with autism or AD to that of normal controls, which was one of the first of its kind. Although the groups were not matched for age, IQ, or sex, the patient group exhibited impaired EF on the Wisconsin Card Sorting Test (WCST). In two separate studies, both of which did not require normal language development for diagnosing, individuals with AD exhibited deficient EF on the WCST, Tower of Hanoi, and go-no-go tasks, as compared to age- and IQ-matched controls (Ozonoff et al., 1991b; Nyden et al., 1999). Miller and Ozonoff (2000) evaluated 14 children with AD that were diagnosed according to DSM-IV criteria and reported that the AD group scored below the published population-based WCST norms.

More recent studies that used DSM-IV criteria more strictly for the diagnosis of AD again reported mixed findings for EF impairment. Some (Blackshaw et al., 2001; Weimer et al., 2001; Rinehart et al., 2002; Shamay-Tsoory et al., 2002) observed that there wasn't a statistically significant difference between those with AD and normal controls based on various measures. Hill and Bird (2006) reported that adults with AD were similar to controls in terms of 'classical' measures of EF, such as the WCST, Stroop, and verbal fluency tests (VFT); however, differences were noted in planning, abstract problem solving, and multitasking based on newer measures of EF. Ambery et al. (2006) reported that their AD group exhibited significant impairment on 'classical' EF tasks measuring flexibility (WCST) and generativity (VFT), but were similar to controls in terms of inhibition, as measured with the Stroop test. Verté et al. (2006) observed that children with AD had difficulty with cognitive flexibility, planning, verbal fluency, inhibition of a prepotent response, and interference control, reporting that the inhibition problems in the patient group might

have been partly due to ADHD. These results suggest that individuals with AD might be impaired primarily in some aspects of EF, but unimpaired in others. Additionally, age-, task-, and comorbidity-related differences between studies might have resulted in inconsistent findings.

The relationship between ADHD and PDD is increasing as an area of neuropsychology research and a handful of studies directly compared groups with ADHD and PDD to normally developing individuals. Two earlier studies did not exclude comorbid ADHD. Ozonoff and Jensen (1999) (first of the two) observed that children with autism had difficulty in planning and cognitive flexibility, but not in inhibitory control, whereas children with ADHD exhibited the reverse pattern. In the other study (Nyden et al., 1999) this double dissociation was not observed; both groups were deficient in response inhibition and only the children with ADHD had deficits in flexibility.

In one of three studies that excluded comorbidity Geurts et al. (2004) showed that the ADHD group had deficits in inhibition and verbal fluency, whereas the high-functioning autism (HFA) group had deficits in a wider range of tasks, including inhibition, verbal fluency, cognitive flexibility, and planning, while Goldberg et al. (2005) (second of three) did not observe any abnormality in these domains in either disorder. Happé et al. (2006) (third of three) included a larger AD sample (26 AD and 6 HFA) in their PDD group, which performed similar to controls on tests of inhibition, cognitive flexibility, fluency, and planning, whereas the ADHD group had lower performance scores, and were more deficient in inhibition and planning.

The only study that specifically investigated the impact of comorbid ADHD in children with ASD (75% AD and 25% HFA) confirmed previous studies that reported children with ADHD had more severe impairment in inhibition, whereas children with ASD exhibited more severe deficits in planning and flexibility. In addition, the researchers observed that comorbid ADHD exacerbated the deficits in inhibitory performance in children with ASD (Sinzig et al., 2008).

Sustained attention is the endogenous ability to mindfully and consciously process stimuli whose non-arousing qualities would otherwise lead to habituation and distraction (Robertson et al., 1997). EF includes the ability to maintain goal-directed behavior, and in that sense the concept of EF overlaps with that of sustained attention. Attentional abilities are conceived by

some researchers as markers of EF, yet are considered by others as a different set of neuropsychological functions (Pennington and Ozonoff, 1996). Despite the ongoing debate, it can be concluded that any impairment in sustained attention has the potential of effecting EF, and that it would be better to evaluate EF and attentional ability together.

Sustained attention to repetitive visual information is generally considered to be intact in autism (Tsatsanis, 2005), whereas a preliminary study of attention in AD was suggestive of an attention deficit based on a sustained visual attention test (Schatz et al., 2002). Moreover, problems with sustained attention are observed more consistently (77% of 30 studies) in ADHD using the CPT (Willcutt et al., 2005). Among two recent studies, one reported that sustained attention was intact in the HFA group, but deficient in the ADHD group. The other study noted similar deficits in sustained attention and inhibition in both the HFA and ADHD groups, but suggested that the deficits in the ASD group were due to comorbid ADHD rather than to the fundamental deficits of autism (Johnson et al., 2007; Corbett et al., 2009).

The present study aimed to determine if children and adolescents with AD (diagnosed according to DSM-IV criteria) exhibit deficient EF, as compared to age-, gender-, intellectual level-, and level of education-matched controls, and if so to identify those aspects of EF that are affected most. An additional aim was to determine how comorbid ADHD affects the performance of children and adolescents with AD.

METHOD

Subjects

The AD group consisted of 18 boys and 3 girls aged between 7 and 16 years that presented to the Istanbul University Faculty of Medicine, Child Psychiatry Outpatient Clinic. The subjects were initially evaluated by a child and adolescent psychiatry resident (AK) with at least 3 years of experience working with children with PDD, and the patients' teachers were asked to complete a "general school questionnaire". In all, 26 subjects were diagnosed with AD following a detailed psychiatric assessment, developmental history, and a review of the data provided by their teachers. These subjects were then evaluated by the second author (NMM, the director of the PDD unit of the department with 15 years of clinical experience with individuals with AD), and 21 fulfilled the DSM-IV criteria for AD and were adminis-

tered additional assessments. Mean age of the AD group was 12.44 ± 2.87 years. None of the subjects in the AD group had a history of delayed speech development (absence of words and sentences by age 2 and 3 years, respectively) or a previous diagnosis of autism, and all were in the non-retarded range based on the Wechsler Intelligence Scale for Children-Revised (WISC-R). Although the DSM-IV does not support the diagnosis of ADHD in the course of any PDD, the additional diagnosis of ADHD was given to AD subjects that fulfilled the criteria. Mean, standard deviation and range of the full scale, verbal and performance IQ scores were 105.52 ± 14.74 (range: 86-136), 111.17 ± 14.05 (range: 92-134), and 98.35 ± 15.21 (range: 78-133), respectively. Exclusion criteria for patients included WISC-R full scale IQ <80, chronic medical illness, substance abuse, and any sensory-motor disability.

The control group consisted of 18 volunteers recruited from local schools (15 boys and 3 girls) in the same age range. Mean age of the control group was 11.96 ± 2.36 years and they reported no history of neurological, psychiatric, or learning problems. Mean, standard deviation and the range of the full scale, verbal and performance IQ scores were 107.27 ± 13.39 (range: 82-138), 106 ± 13.10 (range: 83-144), and 107.44 ± 13.57 (range: 82-131), respectively.

Oral and written informed consent was obtained from all participants and one of their parents, and the research protocol was approved by the Istanbul University Faculty of Medicine, Child Psychiatry Department Academic Committee.

All subjects were attending mainstream classes at school. A "general school questionnaire", developed by the authors and comprised of 20 open-ended questions covering the child's academic performance, classroom behaviors, attention, teacher and peer interactions, verbal and non-verbal interaction, and personality traits, was completed by the participants' primary teachers, which aided in excluding cases from the control group with any attentional, learning, behavioral, or emotional problems, and in obtaining additional information on the AD group concerning social and communication problems, ritualistic interests, and features associated with ADHD.

In all, 13 of the 21 AD subjects were positive for a comorbid psychiatric disorder (62%); 9 had a positive history of ADHD, 6 were diagnosed as OCD, 1 had tics, and 1 had depression. Two of the AD patients had 2 comorbid diagnoses (one had ADHD with OCD and

TABLE 1. Comorbidity and medication status at the time of neuropsychological evaluation.

Subject	Comorbidity	Medication*	Subject	Comorbidity	Medication
1	OCD	None	12	Depression	None
2	ADHD	Sertraline 50mg	13	ADHD	None
3	None	None	14	ADHD	None
4	None	None	15	ADHD	None
5	None	None	16	ADHD+OCD	None
6	ADHD	None	17	None	None
7	None	Citalopram 20 mg	18	ADHD+OCD	None
8	OCD	None	19	None	None
9	OCD	Fluvoxamine 100 mg	20	OCD	Paroxetine 20mg
10	None	Sertraline 50 mg	21	ADHD	None
11	ADHD+Tic	Trazodone 25 mg			

*Daily medication doses.

ADHD: Attention deficit hyperactivity disorder; OCD: obsessive compulsive disorder.

the other ADHD with tic disorder). Comorbidity and medication status of the AD group is given in Table 1. Three children that had been prescribed short-acting methylphenidate were required to be off the medication for at least 24 h prior to administration of neuropsychological testing; other medications were continued for ethical reasons.

MEASURES

Wisconsin Card Sorting Test (WCST)

The WCST was developed to measure abstraction, mental flexibility, and set maintenance skills (Heaton et al., 1993). It is composed of two 64-response card decks and 4 stimulus cards. The subject is instructed to match the response card with one of the stimulus cards according to a certain rule, which should be inferred (or “abstracted”) by the subject. The sorting rule changes spontaneously and persistence of the previous rule is rated as perseveration. A computerized version was used and the number of completed categories, number of perseverative responses, percentage of perseverative errors, failure to maintain set score, and conceptual level response score were evaluated. Standardization studies for the Turkish population and Turkish elementary school children were conducted by Karakaş (2004) and Sahin-Aközel et al. (2006).

Verbal Fluency Test (VFT)

The VFT (Lezak, 1983) is comprised of letter (lexical) and category (semantic) fluency tasks. For successful performance it requires flexible scanning of the mental lexicon together with sustained attention. For the letter fluency task the subject is asked to generate as many words as possible beginning with certain letters (K, A and S) within

a given time period and for the category fluency task the total number of words generated from a specific category (animals) in one minute period is evaluated.

Stroop Test (ST)

The ST (Stroop, 1935) was used to assess inhibition, or the interference effect. For the interference task the subject was required to name the color of a color-word instead of reading it (e.g. to say red for “blue” written in red ink instead of reading the word “blue”). Considering that the time for completing the interference card might be influenced by individual variations, such as slow psychomotor speed, perceptual problems, etc., the interference score was calculated by subtracting the time taken to name just the color dots from the time required to complete the interference card. The test measures the ability to suppress an automatic, prepotent response (reading the word) in order to achieve the required performance (saying the color). The Turkish standardization of the TBAG form, which was used in the present study, was conducted, and reliability analysis and norm values were reported for elementary school-aged children (Kılıç et al., 2002; Karakaş, 2004).

Continuous Performance Test (CPT)

The CPT (Rosvold et al., 1956) is primarily regarded as a measure of sustained and selective attention and inhibition. The participants were required to press a key in response to seeing the target letter “A” on the computer screen if it was preceded by the letter “Z”. Total number of correct responses, errors of commission (pressing the key before seeing the target letter), and omissions (failure to press after the appearance of the target letter) were

TABLE 2. Mean scores and standard deviations, and t-test and Mann-Whitney U test results for the AD and control groups based on the neuropsychological tests.

	AD Group (n = 21) Mean $\pm$ SD	Control Group (n = 18) Mean $\pm$ SD	Analysis			Effect Size
			t	df	P	
CPT						
Correct responses ^a	45.90 $\pm$ 7.82	49.44 $\pm$ 6.42			0.09	r = 0.27
Commission errors ^a	9.24 $\pm$ 10.74	3.83 $\pm$ 5.31			0.11	r = 0.25
Omission errors ^a	8.09 $\pm$ 7.82	5.44 $\pm$ 6.49			0.31	r = 0.16
WCST						
Categories ^{a,c, **}	3.35 $\pm$ 2.70	5.78 $\pm$ 2.13			0.003	r = 0.48
Perseverative responses ^{a, c, *}	32.40 $\pm$ 18.73	19.33 $\pm$ 7.71			0.024	r = 0.37
Perseverative errors (%) ^{a,c,**}	21.64 $\pm$ 10.42	13.80 $\pm$ 5.43			0.01	r = 0.42
Failure to maintain set score ^a						
Conceptual level response score ^{b, c, **}	1.60 $\pm$ 1.23	1.78 $\pm$ 1.31			0.70	r = 0.06
	43.83 $\pm$ 21.05	62.76 $\pm$ 14.27	-3.27	33.6	0.002	η^2 = 0.20
Verbal Fluency Test						
Letter fluency ^{b, c, *}	30.33 $\pm$ 15.33	40.39 $\pm$ 9.58	-2.41	37	0.017	η^2 = 0.11
Category fluency ^b	18.86 $\pm$ 5.88	21.17 $\pm$ 3.07	-1.57	31.05	0.16	η^2 = 0.04
Stroop						
Interference measure (s) ^a	18.30 $\pm$ 14.48	16.94 $\pm$ 10.09			0.85	r = 0.03

^a Mann-Whitney U test, ^b independent sample t test, ^c medium to large effect size.

CPT: Continuous Performance Test; WCST: Wisconsin Card Sorting Test; s: second.

*P < 0.5, **P < 0.01, r = correlation coefficient, and η^2 = eta squared.

evaluated. Computer adaptation of the test was performed by Zaimoğlu et al. (1995).

These tests were administered to all the subjects individually as part of a comprehensive neuropsychological test battery that also included tests for visual-verbal memory and visuospatial perception. They were administered to each participant by the same researcher (GSK) in the same order during two sessions, each of which lasted about 50 min; there was a 15-min break between the sessions.

Statistical Analysis

Initially, performance on all test measures was subjected to group analysis (AD group [n = 21] and control group [n = 18]) using independent t-tests or the Mann-Whitney U test, according to the nature of the distribution of scores on each test. Partial eta-squared (η^2) and the correlation coefficient (r), which was calculated as the Z value (of the Mann-Whitney U test) divided by $\sqrt{N}$ (N= total number of subjects evaluated by the tasks), were reported as effect size measures in order to reflect the relative strength of the difference between groups. Cohen (1988) suggests that η^2 = 0.01 or r = 0.1 constitutes a small effect size, η^2 = 0.06 or r = 0.3 is a medium effect size, and η^2 = 0.14 or r = 0.5 is a large effect size.

Correlation analysis was then used to explore the relationships between EF/attention task performance.

Although the groups did not differ with respect to age or IQ scores, in order to assess possible interactions between task scores, and age and IQ, additional correlation analyses were conducted. When a significant relationship existed the groups were again compared for statistically significant variables covarying for age and the IQ measures. For data that met the assumptions of ANCOVA standard ANCOVAs and for those that failed (especially violation of normal distribution), ANCOVA based on rank-transformed data (Canover and Iman, 1981) was performed.

For exploratory analysis the AD group was divided into two subgroups, according to ADHD comorbidity and the lack thereof in order to assess the affect of ADHD comorbidity on the performance of the patient group. The ADHD subgroup (AD+ADHD, n = 9) and the non-ADHD subgroup (pure AD, n = 12) were compared with each other for the same measures and covariance analysis was conducted as described above. Data analysis was conducted utilizing SPSS v.13.0.

RESULTS

Two-tailed independent t test results showed that there weren't any significant differences between the AD and control groups in terms of age (t = 0.57, df = 37, P = 0.57), level of education (t = 0.27, df = 37, P = 0.79), full scale IQ (t = -0.37, df = 33, P = 0.71), verbal IQ (t =

TABLE 3. Intercorrelations between attentional/executive function measures, and age and WISC-R measures.

	1	2	3	4	5	6	7	8
1 CPT correct	—	-.77**	-.93**	.29	-.29	.51**	.39*	-.45**
2 CPT commission		—	.72**	-.37*	.27	-.33*	-.46**	.07
3 CPT omission			—	-.22	.24	-.52**	-.34*	.48*
4 WCST categories				—	-.73**	.37*	.16	-.17
5 WCST % Per. Error					—	-.45	-.15	.18
6 Letter fluency						—	.50**	-.45**
7 Category fluency							—	-.14
8 Stroop interference								—
Age	.34*	-.21	-.38*	.18	-.18	.56**	.25	-.34*
WISC-R total	.09	-.14	-.05	.27	-.22	-.39*	.02	-.11
WISC-R verbal	-.09	.02	.09	.05	-.07	-.40*	.02	-.09
WISC-R performance	.22	-.25	-.13	.41*	-.25	-.30	.02	-.12

Two-tailed Pearson's product-moment correlation coefficients or Spearman's rho values, * $p < 0.05$ ** $p < 0.01$

1.12, $df = 33$, $P = 0.26$), or performance IQ ($t = -1.86$, $df = 33$, $P = 0.07$). Fisher's exact test showed that the two groups did not differ with respect to gender ($P = 1$).

Wisconsin Card Sorting Test

While the AD group performance in terms of the number of categories, number of perseverative responses, percentage of perseverative errors, and conceptual level response score was lower than that of the control group ($P = 0.004$, $P = 0.02$, $P = 0.01$, and $P = 0.002$, respectively, with medium to large effect sizes), the failure to maintain set scores was similar in both groups (Table 2). Significant correlations were observed between the number of WCST categories, CPT commission, letter fluency and PIQ scores but not between other WCST measures and any other variables (Table 3). When covaried for PIQ and Bonferroni correction was applied, both groups remained different ($P = 0.05$, $\eta^2 = 0.12$).

The AD+ADHD and pure AD subgroups did not differ in terms of any of the WCST variables (Table 4).

Verbal Fluency Test

The AD group's performance level was lower than that of the control group ($P = 0.017$, $\eta^2 = 0.11$) on letter fluency, whereas they were comparable with respect to category fluency (Table 2). Most of the attentional/EF measures as well as age, total and verbal IQ score correlated with letter fluency. ANCOVA, controlling for age and IQ scores, revealed a more robust difference between groups ($P = 0.001$, $\eta^2 = 0.30$). In contrast, there was a statistically significant difference in category fluency ($P = 0.006$) between the AD+ADHD and the pure AD subgroups, but not in letter fluency.

Stroop Test

Based on the interference measure, the AD and control groups were comparable, whereas the AD+ADHD subgroup's performance was significantly lower ($P = 0.02$, $r = 0.52$) than that of the pure AD subgroup, and the difference remained significant after controlling for age ($P = 0.03$, $\eta^2 = 0.25$).

Continuous Performance Test

Although the AD group performed somewhat poorer in terms of all the CPT variables than the controls, the differences were not statistically significant (Table 2). The CPT variables generally correlated with age and the other neuropsychological test variables, except the WCST (Table 3). There was a statistically significant difference in all 3 CPT variables between the AD+ADHD and pure AD groups favoring the latter group (correct responses, omission, and commission errors: $P = 0.003$, $P = 0.003$, and $P = 0.04$, respectively) with medium to large effect sizes (Table 4). After covarying for age the differences between subgroups remained for CPT correct response and omission scores, but disappeared for commission scores (CPT correct response: $P = 0.007$, $\eta^2 = 0.34$; number of commissions: $P = 0.15$, $\eta^2 = 0.11$; number of omissions: $P = 0.007$, $\eta^2 = 0.34$ [Bonferroni adjustments applied]).

DISCUSSION

The present study confirmed the deficient performance of the patients with AD in some areas of executive functioning. They exhibited impaired cognitive flexibility and lexical fluency, but intact inhibition of prepotent responses, sustained attention, and semantic fluency.

TABLE 4. Mean scores, standard deviations, and t-test and Mann-Whitney U test results in the ADHD+AD and pure AD subgroups based on the neuropsychological tests.

	AD + ADHD Subgroup (n = 9) Mean ± SD	Pure AD Subgroup (n = 12) Mean ± SD	Analysis			Effect Size
			t	df	P	
CPT						
Correct responses ^{a, c, **}	40.11 ± 8.54	50.25 ± 3.19			0.003	r = 0.65
Commission errors ^{a, c, *}	16.33 ± 13.15	3.91 ± 3.45			0.04	r = 0.45
Omission errors ^{a, c, **}	13.89 ± 8.54	3.75 ± 3.19			0.003	r = 0.65
WCST						
Categories ^a	3.75 ± 3.01	3.08 ± 2.57			0.75	r = 0.07
Perseverative responses ^b	35.00 ± 20.78	30.67 ± 17.97	0.49	18	0.63	η ² < 0.01
% Perseverative errors ^b	23.14 ± 11.38	20.64 ± 10.11	0.52	18	0.61	η ² < 0.01
Failure to maintain set score ^b	1.63 ± 1.19	1.58 ± 1.31	0.07	18	0.65	η ² < 0.01
Conceptual level response score ^b	46.58 ± 22.85	41.99 ± 20.59	0.47	18	0.94	η ² < 0.01
Verbal Fluency Test						
Letter fluency ^{b, c}	24.00 ± 11.66	35.08 ± 16.46	-1.72	19	0.10	η ² = 0.09
Category fluency ^{b, c, **}	15.00 ± 4.21	21.75 ± 5.36	-3.12	19	0.006	η ² = 0.30
Stroop						
Interference measure (s) ^{a, c, *}	26.87 ± 18.28	12.58 ± 7.77			0.02	r = 0.52

^a Mann-Whitney U test, ^b independent sample t test, ^c medium to large effect size.

CPT: Continuous Performance Test; WCST: Wisconsin Card Sorting Test; s: second.

*P < 0.5, **P < 0.01, r = correlation coefficient, and η² = eta squared.

On the WCST, which measures mental flexibility or set shifting, the AD group had more perseverative responses and errors, and fewer conceptual level responses, and generated fewer categories than the control group. Several studies reported a higher perseverative tendency in terms of perseverative responses and errors in both AD and HFA (Ozonoff et al., 1991a; Liss et al., 2001; Geurts et al., 2004; Ambery et al., 2006; Verté et al., 2006). The present study replicated and elaborated this notion with findings of the less presented measures of the WCST. The reduced conceptual level responses, which indicates that the AD group's overall understanding of the task was lower than that of the control group, was also reported by Ambery et al. (2006) in adults with AD. Our finding that the AD group correctly identified fewer categories than the control group is similar that of two previous studies (Liss et al., 2001; Shu et al., 2001) in children with ASD. Although the AD group performed poorer than the control group on most measures of the WCST, they had intact set maintenance, as measured by the failure to maintain set score, a variable logically and conceptually the opposite of perseveration (Pennington and Ozonoff, 1996). In a recent report Kaland et al. (2008) reported that adolescents and young adults with AD had higher failure to maintain set scores and suggested that this could be related to problems in focused or sustained attention in AD. On the other hand, Ozonoff

et al. (1991a) reported that even though 25% of their HFA patients had comorbid ADHD, they committed significantly fewer failures to maintain set than the control group. The high rate of perseveration together with the inability to detect significant CPT problems in our AD group supports our set maintenance finding.

The results of studies on fluency in ASD are more equivocal; some reported impaired performance compared to age- and ability-matched controls (Geurts et al., 2004; Kleinhans et al., 2005; Ambery et al., 2006; Verté et al., 2006), whereas others observed similar performance (Manjiviona and Prior, 1999; Happé et al., 2006; Hill and Bird, 2006; Corbett et al., 2009). Three studies (Kleinhans et al., 2005; Ambery et al., 2006; Verté et al., 2006) reported deficient performance in word generativity in AD populations. In the present study the AD group's lexical fluency performance was significantly worse than that of the control group, but category fluency test results were similar in both groups. One interpretation of this finding might be that lexical fluency requires greater organizational and strategic search skills, as well as effort to retrieve appropriate lexical items (Riva et al., 2000; Sauzeon et al., 2004) than category fluency does, which has already some structure and relies more on overlearned semantic knowledge. It could be that our AD cases failed the more difficult task when they had to impose their organizational strategies and initiate effi-

cient lexical retrieval strategies in letter fluency as similar dissociation had been previously shown in another study with AD (Kleinhans et al., 2005). An alternative hypothesis might be related to somewhat non-overlapping neural substrates of these two fluency tasks. Lexical fluency predominantly activates a neural network localized in the left dorsolateral prefrontal cortex (dlPFC), whereas category fluency primarily activates a neural network in the left temporopolar cortex (TP) that corresponds to the semantic memory neural network. This dissociation between fluency tasks manifests as impaired category fluency and intact lexical fluency in the early stages of Alzheimer's disease, which predominantly affects the tempoparietal heteromodal association cortex, including the TP (Henry et al., 2004), and the reverse pattern with intact category fluency and impaired lexical fluency in Parkinson's disease, which affects parallel frontostriatal circuits, including the dlPF (Baran et al., 2009). A similar double dissociation was reported in semantic dementia (mainly TP degeneration) and progressive non-fluent aphasia (mainly dlPF degeneration), which are subtypes of frontotemporal dementia (Libon et al., 2009).

In the present study there wasn't a consistent difference between the AD and control groups in inhibiting prepotent behavior, based on the ST. This finding is compatible with other studies that have suggested inhibition is a relatively spared domain in the entire autistic spectrum, including AD (Ozonoff, 1997; Ozonoff and Jensen, 1999; Hill, 2004; Goldberg et al., 2005; Kleinhans et al., 2005; Ambery et al., 2006; Hill and Bird, 2006).

The present study's findings of intact performance in sustained attention in AD and poorer performance in the ADHD comorbid subgroup is compatible with the literature. One study suggested the existence of attention deficit in AD according to the CPT based on higher variability score, but failed to show any difference in omission, commission, or reaction time (Schatz et al., 2002). Having not evaluated variability in the present study, a higher score in AD could be thought to reflect comorbid ADHD as half of the participants had a history of using stimulants in the above study. Additionally, the lack of correlation between the attentional indices and the WCST variables, and the fact that the difference between the AD and control groups in letter fluency persisted when covaried for omission errors indicate that the observed EF deficits were not biased by a putative attentional deficit.

In all, 62% of the AD patients in the present study had a comorbid psychiatric disorder, which is similar

to previous studies on AD (Ehlers and Gillberg, 1993; Ghaziuddin et al., 1998; Mukaddes and Fateh, 2009). The most common comorbid diagnosis in the present study was ADHD (43%). Neuropsychological studies of ADHD showed that the most consistent deficits were in sustained attention and inhibition tasks, while cognitive flexibility was primarily unaffected (Ozonoff and Jensen, 1999; Willcutt et al., 2005). The present study observed the previously reported deficient and intact areas by showing higher CPT omission and commission errors, and Stroop interference scores, and similar WCST performance in the ADHD comorbid subgroup.

The second most common comorbid diagnosis in the present study was OCD (29%). Although there seems to be a clearer picture for ADHD, the issue with OCD is controversial. Some adult studies reported deficits in fluency, set shifting, planning, and problem-solving abilities, with intact sustained attention and selective attention, whereas others did not (Kuelz et al., 2004). Beers et al. (1999) and Kucukyazici (2005) observed intact EF and attentional performance in children and adolescents with OCD. Along with the effect of comorbid OCD, the effect of medication use in the present study could not be controlled. While stimulant medication was withheld for a sufficient washout period (24 h) (Greenhill, 1998), 6 of the AD subjects continued taking their anti-depressants. Theoretically, none would be expected to have a significant effect on executive test performance (Mataix-Cols et al., 2002; Kleinhans et al., 2005), although little to no information is available on the effects of psychotropic medications on neuropsychological performance in individuals with AD.

Regarding the close overlap between the constructs of EF and intelligence, and age-related variability in the maturation of the frontal lobes (Engle et al., 1999; Duncan, 2001), some reports suggest controlling for age and IQ (Happé et al., 2006; Sinzig et al., 2008). As there wasn't a significant difference between groups (AD and control groups, in addition to AD+ADHD and pure AD subgroups) in terms of age or IQ level in the present study, we used them as covariants only for the variables that were significantly correlated. The finding that performance differences between the groups remained robust after covarying nullifies the possibility of age- and IQ-related changes in the relative profiles of EF/attention impairment shown by the groups.

Despite these findings the present study has some important limitations. As we used a clinical sample it remains unclear if the patients were truly representative of

most children with AD. In addition, we included a rather small sample, especially when the AD group was divided into AD+ADHD and pure AD subgroups; thusly, this should be considered a preliminary study and the results should be interpreted with caution until replicated in larger samples. Moreover, in order to investigate the impact of comorbid ADHD in children with AD, studies that employ a 4-sample design, including 2 AD groups (with and without ADHD) along with pure ADHD and control groups, should be conducted. This type of design would result in a greater understanding of the attention deficit associated with AD. Another important limitation of the present study is that the participants were selected based on clinical assessments, rather than on standardized clinical instruments for PDD or ADHD. Finally, we acknowledge that our inability to exclude other comorbid conditions other than ADHD and medication effects might have had some effect on the results.

To the best of our knowledge the present study is one of only a few on attentional and executive functioning in children and adolescents with AD (diagnosed according to DSM-IV criteria). In addition, it should be considered a preliminary effort to evaluate the effect of ADHD comorbidity on the neuropsychological characteristics of AD. Our hypothesis that individuals with AD would demonstrate greater impairment in cognitive flexibility and phonological fluency, but not in the inhibition of prepotent responses, and that the presence of comorbid ADHD would cause additional difficulties in the attention and inhibition domains was confirmed. The presence of comorbid ADHD, though contrary to current diagnostic practice of not providing a diagnosis of ADHD within a pervasive developmental disorder, seems to lead to additional neuropsychological burden and may cause greater treatment challenges in patients with AD.

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