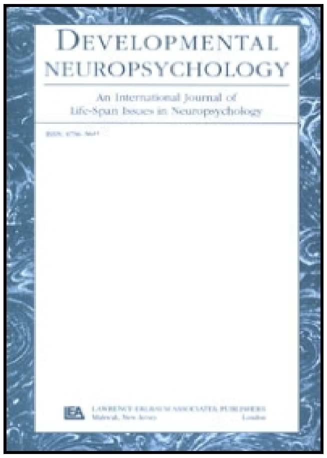

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Disorganization: The Forgotten Executive Dysfunction in High-Functioning Autism (HFA) Spectrum Disorders

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Disorganization: The Forgotten Executive Dysfunction in High-Functioning Autism (HFA) Spectrum Disorders

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Executive function (EF) abilities were investigated in 72 children with high-functioning autism (HFA) spectrum disorders through the collection of parent ratings and performance on laboratory measures of EF. In addition, discrepancy analysis was used to isolate executive functioning on tasks that carry multiple demands.

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Comparison of HFA and Asperger Disorder (AD) groups did not reveal consistent differences in EF. Results did indicate global EF deficits in the combined group of children with HFA and AD. Within the EF domain, specific deficits in flexibility and organization were most prominent.

High-functioning autism (HFA) and Asperger Disorder (AD) are autism spectrum disorders characterized by: cognitive impairments affecting social relatedness and communication, restricted interests/repetitive behaviors, and average or better intelligence. AD is differentiated from HFA by the presence of intact basic language and imaginative play abilities (American Psychiatric Association [APA], 1994). Autism is considered a brain-based, multigene disorder (Folstein & Rosen-Sheidley, 2001). Various brain regions have been implicated in autism, including the cerebellum (Bauman, 1999) and the frontal lobes (Herbert, Harris, Adrien, Ziegler, Makris, & Kennedy, 2002; Murphy et al., 2002). This evidence for brain differences in the frontal lobes, subcortical structures, and cerebellum is consistent with disruption of neural networks that subserve executive function (EF) abilities (Robbins, 1998; Tamm, Menon, & Reiss, 2002).

Although the claim of executive dysfunction as a causal factor in autism spectrum disorders (ASD; Russell, 1997) is controversial (Griffith, Pennington, Wehner, & Rogers, 1999; Liss et al., 2001), it is clear that executive dysfunction plays a role in the social and cognitive deficits observed in school-age children with ASD (e.g., Hughes, 1996). Deficits in *flexibility and planning* are well-documented in ASD (e.g., Ozonoff et al., 2004; Rumsey, 1985). In their extensive review, Pennington and Ozonoff (1996) found larger effect sizes for the Wisconsin Card Sorting Test and tower tasks in studies of autism than for any executive dysfunction measures in other developmental disorders (i.e., attention deficit hyperactivity disorder [ADHD], conduct disorder, and Tourette's syndrome). Six years later, Sergeant, Geurts, and Oosterlaan (2002) reported similar findings in their review. Hughes, Russell, and Robbins (1994) specifically identified "stuck-in-set" perseveration on the computerized intradimensional/extra-dimensional set-shifting task in children with autism. Findings of deficits shifting from one approach to another when problem solving are consistent with the repetitive behaviors and over-focus on specific areas of interest that are typical of ASD. Ozonoff (1998) demonstrated equally robust deficits on tower tasks, which are described as reflecting planning difficulties (Ozonoff, Pennington, & Rogers, 1991).

Although they have received less attention, deficits in *organization* are suggested by difficulty copying and remembering the Rey–Osterrieth Complex Figure (ROCF; Minshew, Goldstein, & Siegel, 1997), in the context of adequate ability to copy its component parts (Rumsey & Hamburger, 1988). The ROCF requires visuospatial construction, planning, and organization (Bernstein & Waber, 1996). Verbal organization deficits are also reported in individuals with high-functioning

ASD (Tager-Flusberg, 1991). Impaired verbal fluency (e.g., Turner, 1999) and verbal list learning (Mottron, Morasse, & Belleville, 2001) may reflect disorganized retrieval of information from the verbal lexicon. Examination of the organization of words into sentences and sentences into paragraphs also reveals deficits in ASD groups (Jolliffe & Baron-Cohen, 2000).

In contrast, *inhibition* appears to be relatively intact in most studies of autism (Ozonoff & Strayer, 1997), with comparative studies finding greater inhibitory deficits in children with ADHD (e.g., Gioia, Isquith, Kenworthy, & Barton, 2002). *Working memory* abilities in individuals with ASD may diverge depending on the modality or complexity of the task, with more robust differences reported on verbal (Bennetto, Pennington, & Rogers, 1996) than visuospatial (Ozonoff & Strayer, 2001) tasks.

HFA and AD are reportedly equally affected by executive deficits (Manjiviona & Prior, 1999; Ozonoff et al., 1991), but these investigations were not comprehensive in their coverage of EF subdomains and many have been hampered by methodological weaknesses, including inconsistent diagnostic criteria (Macintosh & Dissanayake, 2004). Ozonoff, South, and Miller (2000) used strict *Diagnostic and Statistical Manual of Mental Disorders* (4th ed. [*DSM–IV*]; APA, 1994) criteria and found no differences in EF, but did report a milder developmental course and better outcome in their AD group. There is also some evidence of better AD than HFA performance on theory of mind tasks, which may tap EF, as well as language abilities (Ziatas, Durkin, & Pratt, 1998).

Three methodological problems with the measurement of EF interfere with validly defining the EF profile in HFA, AD, and ASDs generally. Whether comparing HFA and AD or looking at children with ASDs as a whole, most studies of EF in autism sample just a few of the multiple components that fall under the umbrella of EF. If one or two subdomains of a complex construct such as EF are sampled in a study, failure to find deficits or differences may not be conclusive. In addition, EF abilities are hard to isolate from basic cognitive capacities for language, motor output, nonverbal reasoning, and so forth. In Denckla's (2002) words: "our established 'executive' tasks still suffer from the problem of failure to control for content (the 'what' of the task) when we are purporting to tap approach-to-task or formatting of procedure (the 'how' of the task)" (p. 305). As a result, variability in a group's capacity to manage the content, or the modality of a task, may obscure information about that group's ability to manage the executive, or process, requirements of the task. Finally, EF is hard to capture outside of realistic, "true to life" settings (Bernstein & Waber, 1990).

This investigation attempts to address two questions: are there any differences between EF profiles in children with HFA and AD, and does the combined group of school-age high-functioning children with ASDs have executive dysfunction? It describes a range of EF domains and complements standard laboratory measures of EF with parent report of EF in the everyday home environment to assure ecological validity. Finally, discrepancy scores (Denckla, 1996) are used for those laboratory tasks of EF that have major non-EF content demands.

METHOD

Participants consisted of children with HFA (*N* = 44) and AD (*N* = 28) consecutively evaluated through a hospital-based pediatric neuropsychology service. The participants' diagnoses were confirmed through independent chart review by two experienced clinicians using *DSM–IV* (APA, 1994) criteria. Participants with evidence of a neurological or a known genetic disorder were excluded. The participants ranged in age from 5 to 17 years ($M = 10.3 \pm 2.76$). As shown in Table 1, HFA and AD groups did not differ on age, socioeconomic status (SES; Hollingshead, 1975), gender (40 HFA boys, 25 AD boys), or Wechsler Intelligence Scale for Children–Third Edition (WISC–III) Performance IQ. All participants had a Full Scale IQ (FSIQ) of at least 70 and the mean IQ for both groups was in the average range.

All participants completed a comprehensive neuropsychological evaluation that included assessment of general intellectual functioning, EF, language abilities, visual perceptual/visual motor skills, learning and memory, social cognition, and adaptive functioning. Because this is a clinic-referred sample, not all participants completed every test instrument. Relevant test data from this comprehensive battery are reported later.

HFA and AD participants were first compared on all EF and comparison tasks with a series of *t* tests. Where no between-group differences were found, a combined ASD group was formed for subsequent analyses. Analyses revealed the expected difference in verbal ability in favor of the AD group (Table 2). Analysis of covariance (ANCOVA) and matching were both considered to address this difference. However, Miller and Chapman (2001) argued that attempting to covary for

TABLE 1
Demographic Characteristics of High-Functioning Autism (HFA; *N* = 45) and Asperger Disorder (AD; *N* = 28) Groups

	HFA		*AD*			
Variable	*M*	*SD*	*M*	*SD*	*Statistic*	*p*
Age	10.4	3.06	10.2	3.28	$F(1, 72) = 0.1$	*ns*
Gender (% male)	89		89		$\chi^2 = .003$	*ns*
Hollingshead SES	27.4	13.13	22.0	11.78	$F(1, 60) = 2.47$	*ns*
FSIQ[a]	96.8	16.30	111.4	13.81	$F(1, 69) = 15.10$	<.001
VIQ[a]	99.0	18.03	119.7	16.38	$F(1, 69) = 24.03$	<.001
PIQ[a]	95.0	17.74	100.4	15.29	$F(1, 69) = 1.70$	*ns*

Note. SES = socioeconomic status; FSIQ = Full Scale IQ; VIQ = Verbal IQ; PIQ = Performance IQ.
[a]Standard scores.

TABLE 2
High-Functioning Autism (HFA) and Asperger Disorder (AD) Group Differences on Executive Functioning and Comparison Tasks

	HFA		*AD*			
Variable	*M*	*SD*	*M*	*SD*	*t*	*p*
EF tasks						
Global EF tasks						
BRIEF–Metacognition Index[b]	68.5	10.10	64.7	12.00	1.18	*ns*
BRIEF–Behavior Regulation Index[b]	66.7	12.88	68.8	11.53	0.55	*ns*
VABS–Composite[a]	65.8	15.10	70.5	15.31	1.14	*ns*
VABS–Communication[a]	77.0	20.73	88.0	15.78	2.12	.04
Attention tasks						
BASC–Attention[b]	66.5	9.50	59.7	11.04	2.74	<.01
TOVA: Ommisions[a]	85.5	26.35	88.1	23.06	0.40	*ns*
TOVA: RT Variability[a]	80.9	24.59	89.8	27.13	1.30	*ns*
Inhibition tasks						
BRIEF–Inhibit[b]	64.8	14.34	64.1	13.52	0.17	*ns*
TOVA: Commisions[a]	89.6	20.72	90.5	21.59	0.17	*ns*
Working Memory tasks						
BRIEF–Working Memory[b]	69.4	11.32	61.9	12.98	2.12	.04
WISC–III DS: Digits Backward[c]	8.8	3.45	12.4	4.72	2.59	.01
Flexibility tasks						
BRIEF–Shift[b]	71.5	11.99	72.0	12.47	0.14	*ns*
BASC–Adaptability[b]	64.4	8.47	63.7	7.02	0.32	*ns*
Organization tasks						
BRIEF–Planning/Organization[b]	68.0	11.18	63.4	14.74	1.22	*ns*
ROCF–Copy Organization[a]	85.9	15.01	88.9	14.17	0.81	*ns*
COWA[a]	85.0	19.69	95	17.43	2.15	.04
WRAML–Story Memory[c]	6.6	3.67	9.0	3.23	2.79	<.01
WISC–III–Object Assembly[c]	8.7	4.28	9.9	3.84	1.10	*ns*
Comparison tasks						
WISC Verbal Comp Index[a]	100.0	18.06	120.0	15.62	4.60	<.001
WISC Vocabulary[c]	10.0	3.80	14.2	3.44	4.70	<.001
WRAML Sentence Memory[c]	8.1	3.57	11.9	3.35	4.46	<.001
WISC Block Design[c]	10.3	4.03	11.5	3.66	1.23	*ns*
WISC DS: Digits Forward[c]	8.8	3.45	12.1	4.54	2.52	.02
VMI[a]	90.1	14.85	95.0	13.87	1.38	*ns*

Note. EF = executive functioning; BRIEF = Behavior Rating Inventory of Executive Function; VABS = Vineland Adaptive Behavior Scales; BASC = Behavior Assessment System for Children; TOVA = Test of Variables of Attention; RT = reaction time; WISC–III DS = Wechsler Intelligence Scale for Children–Third Edition Digit Span; ROCF = Rey–Osterrieth Complex Figure; COWA = Controlled Oral Word Association; WRAML = Wide Range Assessment of Memory and Learning; VMI = Beery–Buktenica Developmental Test of Visual-Motor Integration.

[a]Standard scores. [b]*t* scores, [c]Scaled scores.

true differences between groups is a violation of assumptions implicit to the use of ANCOVA. ANCOVA is appropriate for addressing nuisance variables, such as age or SES that are not expected to systematically vary between groups. On the contrary, the discriminating feature between HFA and AD is language development and good early language ability is the single greatest predictor of positive outcome among individuals with ASD. So, attempting to control for verbal ability in the context of ANCOVA is in a sense attempting to take away variance due to a predefined difference. Similarly, a matching strategy is also intended to reduce the variance between groups on nuisance variables (e.g., age, gender, SES status) and make it easier to detect true differences on variables of interest. Therefore, group effects were directly examined in all relevant analyses. With this approach, differences in verbal ability between the HFA and AD groups were explicitly addressed and any potential relation with EF was examined.

Most of these analyses were conducted on the combined high-functioning ASD group. On the measures where a difference between HFA and AD participants was found, group membership was incorporated as a variable in the analysis. Three basic sources of data were used:

1. Parent report behavioral inventories (e.g., Behavior Rating Inventory of Executive Function). Standard scores (*t* scores) were used to compare this sample to the standardization sample ($t = 50$) using a one-sample *t* test. Scores that are significantly higher than the standardization sample indicate impairment. In addition, the proportion of participants whose scores indicated clinical impairment was also calculated.

2. Laboratory tests that are purported to be relatively direct measures of EF (e.g., Test of Variables of Attention). On such measures, performance was compared to normative data based on the standardization sample for each measure using a one-sample *t* test as described earlier. Significantly lower than average performance was indicative of a deficit in EF. Scores were interpreted based on both statistically and clinically meaningful differences (i.e., > 1 standard deviation below the mean).

3. A discrepancy analysis approach (Denckla, 1996; Frith & Happé, 1998) was used to isolate and better assess EF on tasks that carry multiple demands. This was accomplished by identifying two tasks that assess functioning within a particular modality. The primary difference between the two tasks was that one had a heavy EF demand and the other did not. Evidence of executive dysfunction was assumed if a significant within-subject decrement in performance was found on the task that includes an EF demand relative to performance on the comparison task. For example, the Beery–Buktenica Developmental Test of Visual-Motor Integration (VMI), which is primarily a visual-motor task, was compared to the ROCF task, which includes an organizational component in addition to the visual-motor components. Executive dysfunction is indicated by significantly worse ROCF than VMI standard

scores. Repeated measures analysis of variance was used to complete within-subject discrepancy analyses. In some cases, tests from different standardization samples were used in the same discrepancy analysis. Potential differences in performance across different standardization samples could contribute to differences in discrepancy analyses. However, there is no reason to believe that such differences would systematically favor one outcome. To mitigate possible misinterpretation of findings, a convergent pattern of results across multiple analyses was sought. Nonetheless, because interpretation could be compromised, discrepancy analyses utilizing tests based on separate standardization samples are highlighted as exploratory with an *.

For a list of tasks by domain of EF, including global EF, attention, inhibition, working memory, flexibility, and organization, see Tables 2 and 3. A description for each discrepancy score calculated follows. These explanations include a brief description of both the EF task and the control task used to create the discrepancy score. For the discrepancy scores listed by executive subdomain, refer to Table 4.

Discrepancy: Vineland Adaptive Behavior Scales (VABS) Versus WISC–III FSIQ*

The VABS is a standardized, structured parent interview of adaptive behavior. The ability to apply discrete skills (as reflected by general intelligence) to adaptive behavior in everyday situations requires general EF ability. Previous research (Gilotty, Kenworthy, Sirian, Black, & Wagner, 2002) has reported that EF is an important predictor of adaptive functioning in autism. Thus, poorer performance on the VABS Composite than the FSIQ is consistent with a deficit in EF.

Discrepancy: VABS Communication Subscale Versus WISC–III Verbal Comprehension Index (VCI)*

The VABS Communication subscale provides information about adaptive communication skills. Such skills rely heavily on general EF ability. The WISC–III VCI provides a good index of crystallized verbal knowledge, verbal problem solving, and abstract reasoning skills; yet, there is relatively little EF load associated with these subtests. A discrepancy in performance between the VABS Communication subscale and the VCI would be consistent with a deficit in EF.

Discrepancy: WISC–III Digit Span—Digits Backward Versus Digits Forward

The digits backward portion of the Digit Span subtest requires the respondent to hold and manipulate the numbers in working memory to generate the correct response. By contrast, the digits forward portion of the Digit Span subtest does not

TABLE 3
Mean BRIEF,[a] BASC,[a] and TOVA[b] Scores: Significant Differences From Normative Sample and Percentage With Clinical Impairment for Combined AD/HFA Group[c]

Measure	*Mean t Score* *M*	*SD*	*t*	*p*	*z Diff*[d]	*% Clinically Impaired*[e]
Global EF–BRIEF						
Behavior Regulation Index	67.3	12.39	9.99	<.001	1.40	61
Metacognition Index	67.3	10.77	11.23	<.001	1.61	67
Global Executive Composite	68.6	10.63	12.34	<.001	1.75	70
Attention tasks						
BASC–Attention						
HFA	66.5	9.50	11.52	<.001	1.74	59
AD	59.7	11.04	4.58	<.01	0.88	37
TOVA–Omissions	86.6	24.81	–4.10	<.001	–0.54	na
TOVA–RT Variability	84.7	25.87	–4.50	<.001	–0.59	na
Inhibition tasks						
BRIEF–Inhibit	64.6	13.98	7.62	<.001	1.04	49
TOVA–Commissions	90.1	20.92	–3.70	<.001	–0.47	na
Flexibility						
BRIEF–Shift	71.6	12.02	12.86	<.001	1.80	73
BASC–Adaptability	64.1	7.82	12.73	<.001	1.11	54
Working Memory						
BRIEF–Working Memory						
HFA	69.4	11.32	10.39	<.001	1.71	64
AD	61.88	12.98	3.66	<.01	0.92	38
Planning/Organization						
BRIEF–Plan/Organize	66.6	12.44	9.52	<.001	1.33	69

Note. BRIEF = Behavior Rating Inventory of Executive Function; BASC = Behavior Assessment System for Children; TOVA = Test of Variables of Attention; AD = Asperger Disorder; HFA = high-functioning autism; EF = executive functioning; RT = reaction time.

[a]*t* scores. [b]Standard scores. [c]For measures on which the HFA and AD groups significantly differ, results are separately reported for both groups. [d]Difference from mean of standardization sample $[M_{(\text{standardization sample})} – M_{(\text{ASD sample})}/SD_{(\text{ASD sample})})$ reported as a *z* score. To be conservative and recognizing that the ASD sample was more variable than the standardization sample (i.e., larger standard deviation), the standard deviation for the ASD group was used in calculating *z* scores. [e]*t* score > 65.

require manipulation of information. It is used to control for the auditory memory span requirements of digits backward. Poorer performance on digits backward suggests a relative decrement in working memory. Raw scores for the digits backward and digits forward tasks were converted to standard scores using age-specific normative data provided in the WISC–III manual. Results are presented as scaled scores ($M = 10$; $SD = 3$), which is consistent with presentation of these data in clinical contexts.

TABLE 4
Results of Discrepancy Analyses for the Combined AD/HFA Group

Measure	*Mean Score*	*F*	*p*	*Partial* η^2
Global EF				
VABS Composite versus FSIQ[a,c]	67.0 (14.92) vs. 102.0 (17.70)	189.1	<.001	.78
VABS Communication versus VCI[a,c]	80.70 (19.67) vs. 106.1 (19.98)	73.6	<.001	.58
Auditory Working Memory				
Digits Backward versus Forward[b]	10.6 (4.66) vs. 10.5 (4.32)	0.05	*ns*	.001
Organization				
Object Assembly versus Block Design[b]	9.13 (4.12) vs. 10.6 (3.94)	17.24	<.001	.21
WRAML Story versus Sentence[b]	7.6 (3.68) vs. 9.6 (3.93)	18.24	<.001	.21
ROCF Copy Organization versus VMI[a,c]	86.9 (14.71) vs. 92.2 (13.84)	10.95	<.01	.15
COWA versus Vocabulary[c,d]	89.0 (19.38) vs. 108.0 (20.95)	41.93	<.001	.38

Note. AD = Asperger Disorder; HFA = high-functioning autism; EF = executive functioning; VABS = Vineland Adaptive Behavior Scales; FSIQ = Full Scale IQ; VCI = Verbal Comprehension Index; WRAML = Wide Range Assessment of Memory and Learning; ROCF = Rey Osterrieth Complex Figure; VMI = Beery–Buktenica Developmental Test of Visual-Motor Integration; COWA = Controlled Oral Word Association.

[a]Standard scores. [b]Scaled scores. [c]This discrepancy analysis compared tests with separate standardization samples and can be considered exploratory. [d]The Vocabulary score is presented as a standard score for the sake of ease of comparison to other tasks used in the discripancy analyses.

Discrepancy: WISC–III Object Assembly Versus WISC–III Block Design

The Object Assembly subtest requires organization abilities to visualize a whole object based on the puzzle pieces. The Block Design subtest requires good motor control and visuospatial and nonverbal reasoning abilities. Because the participant works from a model on the Block Design subtest, it requires less executive ability than Object Assembly and serves as a control for the visuoconstruction requirements of the puzzle task.

Discrepancy: Wide Range Assessment of Memory and Learning—Story Memory Versus Sentence Memory

The Sentence Memory subtest requires immediate recall of orally presented sentences. This task limits the amount of information to one sentence per trial and taps memory span for language. The Story Memory subtest requires participants to recall paragraph-length stories. Without good executive skills, participants can become overloaded by the volume of information presented, resulting in reduced recall. Because the sentence memory task requires the recall of semantic linguistic information, it serves as a control task for the Story Memory test.

Discrepancy: ROCF (Osterrieth, 1944) Versus The VMI*

On the ROCF, a child is asked to copy a complex geometric figure, making demands on visual motor and organization skills. The ROCF was administered and scored using the Developmental Scoring System (Bernstein & Waber, 1996) and the Copy Organization (Org) score was used. The Org score reflects "organizational goodness" or integration of the figure (Bernstein & Waber, 1996). The VMI provides an index of visual-motor ability and is used to control for the visual-motor integration component of the ROCF.

Discrepancy: Controlled Oral Word Association (COWA) Versus WISC–III Vocabulary*

On the COWA, the participant is asked to orally produce as many words as possible beginning with a given letter (F, A, or S) in 1 min. It measures the efficiency of word retrieval when constrained by unusual categories and is sensitive to lexical organization. The Vocabulary subtest from the WISC–III provides an index of a participant's verbal lexicon and was used to control for the verbal knowledge component of the COWA task. To calculate this discrepancy, the Vocabulary scaled score was converted to a standard score.

RESULTS

HFA Versus AD Groups

T tests comparing the HFA and AD groups on measures of EF revealed few group differences. As shown in Table 2, there were no group differences on global measures of EF or on measures that assess EF within the nonverbal domain. Not surprisingly, the AD group achieved consistently higher scores (approximately 1 standard deviation higher) on tasks that rely on verbal ability, including auditory working memory. In addition, the HFA group was more impaired on a parent report measure of attention problems, but there were no significant group differences on other measures of attention, including omissions and reaction time variability on the Test of Variables of Attention (TOVA). To maximize the possibility of detecting group differences, no correction was made for multiple comparisons. Thus, the findings here may overstate actual group differences. For all EF tasks where group differences were found (e.g., verbal tasks), diagnostic group was included as an independent variable and all significant interactions were reported.

Executive Functioning in the Combined HFA and AD Group

Table 3 describes the results from the Behavior Rating Inventory of Executive Function (BRIEF), Behavior Assessment System for Children (BASC), and TOVA scores. Table 4 provides the results of all analyses that utilized the discrepancy-based approach. The combined ASD group was significantly worse on all measures of *global EF* and the scores of nearly two thirds of the sample fell in the clinically impaired range on all three BRIEF summary scores. Discrepancy analyses comparing the VABS Composite to WISC FSIQ and VABS Communication to WISC VCI indicated that VABS scores were 1.5 to 2 standard deviations lower than WISC scores (Table 4). As depicted in Figure 1, the AD group performed better than the HFA group overall (Fs > 9.8, ps < .05), but both groups displayed a similar decrement in performance on the VABS scores relative to the WISC scores.

On measures of *attention*, the ASD group scored significantly lower than the standardization samples (Table 3, TOVA Omissions and Reaction Rime Variability). Because the HFA group was significantly more impaired on BASC Attention than the AD group, the two groups were examined separately on this measure. Both groups were significantly more impaired than the standardization

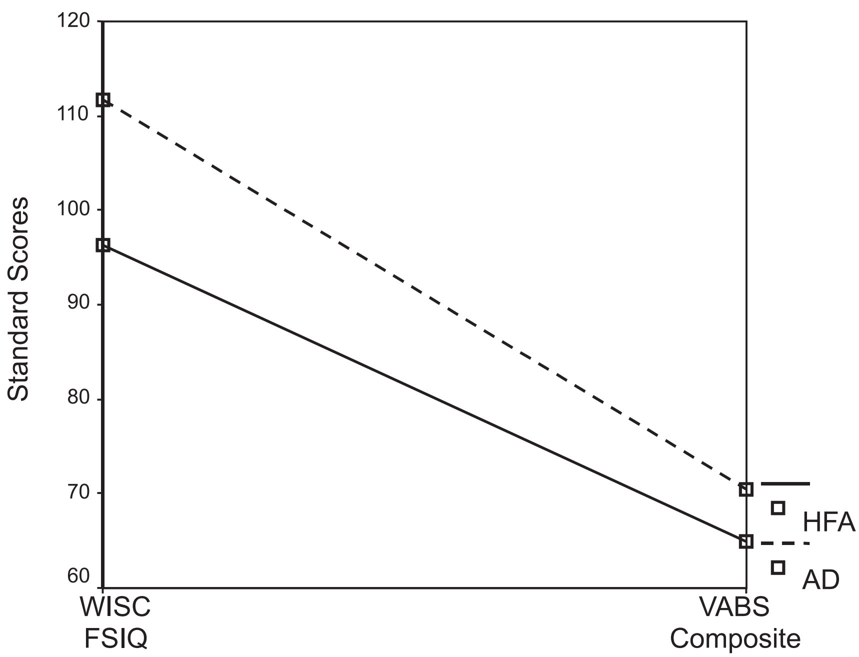

FIGURE 1 Wechsler Intelligence Scale for Children (WISC) Full Scale IQ (FSIQ) versus Vineland Adaptive Behavior Scales (VABS) composite.

sample and significant portions of both groups had scores in the at-risk or clinically impaired range ($t \geq 65$). With regard to *inhibition*, the ASD group was significantly more impaired than the standardization sample on the BRIEF Inhibit subscale and 49% of the sample had scores in the clinically impaired range. TOVA commission (impulsivity) scores were significantly lower than the standardization sample.

Measures of cognitive *flexibility* revealed that the ASD group was significantly more impaired than the standardization samples and more than half of the sample had scores in the clinically impaired range (Table 3). Because the AD group showed less impairment than the HFA group on both indicators of *auditory working memory*, the two groups were analyzed separately on these measures. Both groups scored significantly worse than the standardization sample on the BRIEF Working Memory Scale; 64% of the HFA group and 38% of the AD group had scores in the clinically impaired range. The AD group performed significantly better than the HFA group on digits backward and digits forward, $F(1, 37) = 8.6$, partial $\eta^2 = .19$, $p = 006$. However, for within-group comparisons, there were no significant discrepancies in performance between the digits forward and digits backward tasks for either group.

Across all within-subject discrepancy analyses, the ASD group performance was significantly worse for tasks that required *organizational* ability for successful performance. With regard to nonverbal organization tasks, there were no differences between the HFA and AD groups (all Fs < 2.2, all ps = *ns*) Although the AD group generally performed better than the HFA group on verbal tasks (Table 2), main effects for task (EF task vs. comparison task) indicated that both groups performed significantly worse on verbal tasks that also included an organizational component.

DISCUSSION

This article investigates EF in a clinically referred sample of school-age children with HFA and AD. It addressed two questions: (a) Do children with HFA have different executive profiles than those with AD? and (b) Does a combined group of HFA and AD participants demonstrate executive deficits?

In light of the difficulty capturing EF with standard laboratory measures (Bernstein & Waber, 1990), this investigation incorporates a three-pronged assessment strategy. It describes: (a) ecologically valid parent ratings of EF (Gioia & Isquith, 2004); (b) performance on standard EF tasks that are relatively free of "contaminating" nonexecutive ability demands; and (c) within-subject discrepancy analyses that pair EF tasks with non-EF comparison tasks (e.g., compared vocabulary and verbal fluency scores) to control for the contribution of visual, verbal, motor, and other "core" abilities to EF scores (Denckla, 1996, 2002).

Where possible, confirmatory findings across the different assessment methods are reported. To acknowledge the complexity of EF, a wide range of EF subdomains was sampled.

In this investigation, HFA and AD were not differentiated by distinct patterns of executive abilities. Both groups showed executive deficits to an equal degree on tasks that were not verbally mediated. This is consistent with several previous investigations that have identified similar neuropsychological and EF profiles in HFA and AD (e.g., Manjiviona & Prior, 1999; Miller & Ozonoff, 2000; Ozonoff et al., 1991). The HFA and AD groups were differentiated by verbal abilities, however, as is reflected in the over 20-point difference in their verbal IQ scores. The superior verbal knowledge of the AD group improved its overall performance on a variety of verbal measures of EF when compared to the HFA group. Again, this finding is consistent with reports in the literature of higher verbal IQ scores (Eisenmajer et al., 1996) and better command of verbal facts (Ozonoff et al., 2000) in AD than HFA groups. The greater verbal knowledge of the AD group did not, however, eliminate verbal executive deficits. In fact, the HFA and AD groups showed equivalent within-subject decrements, or discrepancy scores, between tasks of verbal knowledge/memory and verbal executive tasks, as is demonstrated in Figure 1. Thus, the discrepancy score method reveals EF deficits in AD even on tasks demanding verbal knowledge.

The AD group's greater facility on verbal tasks may also explain why the HFA group was reported to have greater attention/working memory weaknesses than the AD group on behavior rating scales. A total of 64% and 59% of the HFA group were clinically elevated on the working memory and attention scales respectively, whereas 38% and 37% of the AD group were clinically elevated on the same measures. The overlap between the questions on these two scales is significant. Both scales probe response to directions, distractibility, forgetfulness, and attention (Gioia, Isquith, Guy, & Kenworthy, 2000). Because so much of the everyday environment is verbally mediated, it is likely that parent responses to these scales largely reflect attention and memory for spoken information. Thus, differences between the HFA and AD groups may not indicate different attention and working memory capacities, but rather the differences in language abilities.

Support for this interpretation is provided by the fact that there were no attention differences between the groups on a visual continuous performance task. This explanation is also supported by the discrepancy analysis on a verbal working memory task in this study. The AD group demonstrated a significant advantage on an orally administered task requiring them to repeat digits in reverse order, but there were no differences between HFA and AD performance, and no working memory-specific deficit in either group, when a discrepancy analysis (digits backward vs. digits forward) was used to isolate the working memory component of this task. Overall, these data suggest that the generally superior verbal abilities of individuals with AD play a role in their stronger auditory attention/working memory. Conversely, previous findings of verbal working memory deficits in individuals with HFA (Bennetto et al., 1996) may in fact reflect core language deficits in the group.

Although EF differences between the HFA and AD groups were sparse, there were pervasive deficits in the combined group of school age children with HFA and AD on measures of global EF, organization, and flexibility. These findings were consistent across laboratory measures and behavioral rating scales, with moderate to large effect sizes. Mean parent ratings of global EFs are in the clinically significant range. Over two thirds of the group scored in the clinically significant range for global deficits on the BRIEF. In addition, there were major discrepancies between IQ scores and adaptive skills, as others have also reported (Liss et al., 2001; Volkmar, Carter, Sparrow, & Cicchetti, 1993). Although these cannot be fully explained by dysexecutive processes, a gap between knowledge and the ability to act effectively with that knowledge is related to deficits in efficient goal-directed behavior, which is governed by the executive. In a related finding, Gilotty et al. (2002) reported that social and other adaptive skills were correlated with EF abilities in a high-functioning ASD group.

Consistent with our earlier report (Gioia et al., 2002), and the extensive literature documenting perseveration in ASDs (e.g., Sergeant et al., 2002), flexibility was the most commonly identified specific executive deficit in our group. Seventy three percent of the group was reported to have clinically elevated flexibility problems. This finding on the BRIEF was supported by evidence of significant deficits on the Adaptability scale of the BASC. The HFA and AD groups both showed equally severe deficits in this domain. This finding may reflect the marked rigidity and subservience to restricted routines and behaviors that is required for diagnosis of ASD.

Pervasive deficits in organization/integration that equally affected the HFA and AD groups were also found. Indeed, findings of organizational deficits are the most compelling from this study because they were consistently documented across multiple verbal and visual tasks. Data from parental ratings and discrepancy analyses on verbal and nonverbal tasks identify poor ability to integrate/organize complex information, despite strong abilities to interpret discrete data. Thus, study participants had inefficient access to verbal lexicons on a fluency task and limited ability to organize words into semantic categories when learning a word list. Poor organization/integration is costly when managing complex data. Although both the HFA and AD groups demonstrated good ability to learn and remember small units of information, they struggled as the amount of information and the organizational load increased. Thus, although they could repeat sentences in an age-appropriate fashion, they had much poorer abilities to repeat paragraph-length stories.

Organization deficits pervaded visual problem solving as well, producing relative decrements in the combined HFA/AD group's ability to organize and copy complex, as opposed to simple, geometric designs. Disorganization is also hypothesized to explain the difficulty they had translating their excellent ability to copy abstract visual information from a model (i.e., Block Design) into the capacity to organize puzzle pieces and perceive a visual gestalt when working without a model (i.e., Object Assembly).

This study also documents deficits in attention/working memory and impulse control in the combined ASD group when compared to normative samples. These difficulties were relatively milder and less pervasive than the flexibility and organization deficits described earlier. The evidence from this study is conflicting in the case of working memory. Deficits in these domains of EF are most consistently associated with ADHD in the research literature (Gioia et al., 2002; Sergeant et al., 2002). The majority of previous investigations of attention/working memory and inhibition in ASD groups have not found deficits. It is possible that our findings reflect the presence of comorbid attention disorders in a subset of our study group. Because ours is a clinically referred sample, it may overrepresent children with comorbid disorders. Nevertheless, attention, inhibition, and working memory deserve further scrutiny in ASD populations.

This investigation provides the greatest support for findings of executive deficits in flexibility and organization in high-functioning ASD groups, whereas reviews of previous findings on EF in autism have emphasized inflexibility and planning deficits (e.g., Pennington & Ozonoff, 1996; Sergeant et al., 2002). A relative emphasis on planning versus organizational deficits may simply reflect which tasks are administered in which studies. The two subdomains of EF also appear to be closely related. During construction of the Behavior Rating Inventory of Executive Function, for example, the planning and organization scales were collapsed into one scale after they were found to be highly correlated ($r = .94$; Gioia et al., 2000). Further investigation of the relation between planning and organization, as well as of their relation to working memory (Pennington, Bennetto, McAleer, & Roberts, 1996) and inhibition (Bishop, Aamodt-Leeper, Creswell, McGurk, & Skuse, 2001), is warranted.

In any case, an emphasis on executive deficits in organization/integration is congruent with other theories of cognition in autism. Frith and Happé (1994) argued that some aspects of autism stem from "weak central coherence," or a piecemeal processing style that emphasizes detail and interferes with integration, generalization, and appreciation of the gestalt or context of data. Baron-Cohen's (2002) "extreme male brain" theory of autism also describes "an exact eye for detail" (p. 248) and sequential logical processing of one unit of information at a time. Minshew et al. (1997) described weakness in "complex information processing" in a large, well-controlled study of HFA. They reported deficits in memory, language, and visuospatial domains when complex information is involved. In contrast, study participants performed well on a variety of tasks that involved simpler units of information. Each of these important theories of autism makes a unique contribution to the field and should not be reduced to a demonstration of the cost of disorganized management of information alone. However, the discrepancy between strengths in processing small units of information and weaknesses in learning and integrating complex data is related to executive skills such as organization.

Organization/integration deficits, combined with inflexibility, appear to contribute to core social deficits in autism. As Rumsey (1985) noted, successful social functioning, and similarly, EF, involves the “integration and weighing of multiple contextual variables” (p. 34). A typical social exchange involves the fluid evaluation of subtle and multifaceted information and the subsequent selection of appropriate responses. Thus, deficits in executive processes may contribute to the problems with reciprocity in social interactions that characterize children with autism. For example, joint attention is frequently labeled a “core” weakness in autism (e.g., Charman, 2003). Joint attention encompasses behaviors such as gaze and point following, showing, and pointing. It relies on the ability to flexibly shift attention and integrate several pieces of information simultaneously. Indeed, Dawson et al. (2002) found a relation between joint attention and performance on a ventromedial prefrontal task.

On a related topic, Klin, Jones, Schultz, and Volkmar (2003) argued that autism entails deficits in the “enactive mind,” in which “cognition is embedded in experiences resulting from a body’s actions upon salient aspects of its surrounding environment” (p. 357). The enactive mind as they describe it relies on many executive organizational abilities, such as identifying what is salient in a complex array of information and decoding complex, multistep interactions. Individuals with ASD struggle with these abilities and are described as focusing on inanimate details (e.g., a light switch) in a social setting instead of on human interactions, which require greater levels of integration to decode. Thus, integration/organization deficits in young children with autism may contribute to their failure to learn about people from the social information that surrounds them. Disentangling the complex relation between social and EF deficits in ASD is an important task for future research.

In summary, these findings are consistent with earlier reports of general equivalence of EF abilities in HFA and AD groups. Furthermore, these data document executive dysfunction in both groups of children at school age. Like many previous investigations, this study describes pervasive deficits in flexibility. It complements earlier findings of planning deficits with consistent evidence across several assessment modalities of organization/integration deficits. The redundancy of our findings on clinically relevant EF-organizational tasks is encouraging, but must be confirmed by others, particularly in light of our lack of a typically developing control group and our use of discrepancy analysis. Although we believe discrepancy analysis offers an essential tool for exploring EF in children, it is not yet a research-validated technique. Some discrepancy analyses in this study relied on comparing tasks that had been developed and standardized on different groups of children. Further investigation of school-age children is needed to confirm the importance of deficits in the organization subdomain of EF in autism.

This article does not address the question of causality in autism. It describes executive abilities in a subset of the larger ASD population: school-age children of borderline intelligence or better. These findings may differ from other reports (e.g., Dawson et al., 2002; Liss et al., 2001) because they pertain to older, clinically referred children on a broader range of tasks. This study does add to the growing body of evidence that a fundamental aspect of problem solving in HFA and AD at school age is captured, and can be addressed, with an EF perspective.

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