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Attention and written expression in school-age, high-functioning children with autism spectrum disorders

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Abstract

High-functioning children with autism spectrum disorders often find writing challenging. These writing difficulties may be specific to autism spectrum disorder or to a more general clinical effect of attention disturbance, as these children are often comorbid for attention-deficit/hyperactivity disorder (ADHD) symptomatology (and children with attention-deficit/hyperactivity disorder often also find writing challenging). To examine this issue, this study investigated the role of attention disturbance on writing in 155 school-age children across four diagnostic groups: high-functioning autism spectrum disorder (HFASD) with lower ADHD symptoms (HFASD-L), HFASD with higher ADHD symptoms (HFASD-H), ADHD symptoms but no autism spectrum disorder symptoms, and typical development. Both HFASD subgroups and the ADHD group displayed lower word production writing scores than the typical development group, but the clinical groups did not differ. The HFASD-H and ADHD groups had significantly lower theme development and text organization writing scores than the typical development group, but the HFASD-L and typical development groups were not significantly different. The findings support prior research reporting writing problems in children with autism spectrum disorder but also suggest that children with HFASD-H may be at greater risk for writing difficulties than children with HFASD-L. Better understanding the role of attention in writing development could advance methods for assessment and intervention for children with high-functioning autism spectrum disorder at risk for writing difficulties.

Keywords

academic achievement, attention-deficit/hyperactivity disorder, autism spectrum disorders, cognition (attention, learning, memory), school-age children, writing processes, written communication, written expression

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by social communication impairments and restricted or repetitive behavioral patterns (American Psychiatric Association, 2013). Current prevalence estimates indicate one in 68 children is affected by ASD (Centers for Disease Control and Prevention, 2014). In all, 44% of affected children have average intellectual abilities, 24% have intelligence quotients (IQs) in the borderline range, and 32% are comorbid for intellectual disabilities (Christensen et al., 2016). Those children without intellectual disabilities are often referred to as affected by high-functioning autism spectrum disorder (HFASD). Their profile of intellectual development, along with evidence of the benefits of inclusion, have led to increasing numbers of children with HFASD participating in regular education classes and curriculums in elementary and especially secondary school (Ferraioli and Harris, 2011; Wei et al., 2014).

With the entry of more children into regular education, research on ASD has begun to pivot to understand learning and academic development needs of children with HFASD (e.g. Machalicek et al., 2008; Mundy et al., 2009; Randi

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et al., 2010). Several studies, for example, have indicated that school-age children with HFASD are at significant risk for reading comprehension problems (Jones et al., 2009; Mayes and Calhoun, 2008; Nation et al., 2006; Ricketts et al., 2013). These problems may reflect a learning disability associated with the social, cognitive, and communication disturbances that are specific to ASD (Randi et al., 2010; Whitby et al., 2009).

While reading is a receptive form of academic and social communication development, writing is an expressive form of academic and social communication development that involves processes distinct from reading (Berninger and Richards, 2002; Read, 1981; Shanahan, 2015). While reading research is more prominent than writing research (Mo et al., 2014), some evidence also suggests that the development of age-appropriate expressive written communications skills is challenging for many students with HFASD (e.g. Griswold et al., 2002). Hence, interest is growing concerning developing writing interventions for these children (Asaro-Saddler, 2015; Pennington and Delano, 2012). However, too little is currently known about the writing problems of children with ASD to fully inform the development of effective writing interventions for school-age children with HFASD (Asaro-Saddler, 2015). For example, it is not clear whether the writing difficulties of HFASD children are specific to ASD or the consequence of difficulties held in common with other clinical conditions, such as attention-deficit/hyperactivity disorder (ADHD).

Children with HFASD are often comorbid for symptoms of ADHD (Gargaro et al., 2011), just as children with ADHD can be comorbid for symptoms of ASD (Reiersen et al., 2007; Reiersen and Todd, 2011). Children with ADHD also exhibit difficulty with age-appropriate writing (e.g. Graham et al., 2016). Furthermore, studies have shown that the presence of elevated ADHD symptoms in school-age children with HFASD moderates cognitive and social abilities that can directly impact their academic performance (Ashburner et al., 2010; Gadow et al., 2008; Mayes and Calhoun, 2007; Sinzig et al., 2009; Yerys et al., 2009) as well as social cognition and social interactive experience in school (Sinzig et al., 2008a). Thus, impaired attention regulation may disrupt the capacity for more complex writing-task-related cognition and give common cause to the writing problems of children with HFASD or ADHD (Mayes and Calhoun, 2007). Examining this hypothesis may inform the understanding of writing communication difficulties in children with HFASD. To test this hypothesis, this study examined the writing achievement of 8–16 year olds with HFASD with and without elevated ADHD symptoms, children with elevated ADHD symptoms and no ASD diagnosis, and children with typical development (TD).

ASD and writing development, performance, and interventions

Writing has been observed to be particularly challenging for some children with HFASD. Previous research has shown that children with HFASD produce shorter, less complex texts compared to TD peers (Chavkin, 2008; Church et al., 2000; Griswold et al., 2002; Mayes and Calhoun, 2003a, 2003b, 2006, 2008; Myles et al., 2003). However, other research has shown that children with HFASD demonstrate a wide range of writing abilities (Foley-Nicpon et al., 2012). In a comparison study with children with language impairment, Dockrell et al. (2014) found that handwriting, oral language, and ASD symptomatology were predictors of written product quality in young writers with ASD. Brown et al. (2014) showed that children with HFASD not at risk for linguistic impairments scored lower on measures of productivity, grammatical complexity, lexical diversity, cohesiveness, writing conventions, and overall quality compared to TD peers. Previous research has suggested that children with HFASD are at risk and generally display writing difficulties, although research has not addressed the factors underlying these writing difficulties. Recent intervention research has shown a number of writing interventions may be helpful in addressing writing difficulties in children with HFASD (Asaro-Saddler, 2015; Pennington and Delano, 2012). One of these that has received empirical support is self-regulated strategy development (SRSD), an empirically validated model for teaching writing strategies through helping struggling writers learn higher-level cognitive processes and writing strategies (Graham and Harris, 1989; Harris and Graham, 1985; Santangelo et al., 2008). A small yet growing number of studies have demonstrated the use of SRSD with school-age children with ASD for story writing (Asaro-Saddler, 2014; Asaro-Saddler and Saddler, 2009, 2010; Mason et al., 2010), persuasive essay writing (Asaro-Saddler and Bak, 2012, 2013; Delano, 2007b), and vocabulary development (Delano, 2007a). However, more research is needed to more fully understand ASD-specific difficulties not addressed by non-ASD-specific writing practices, such as SRSD (Asaro-Saddler, 2015).

ADHD and writing development, performance, and interventions

ADHD is a neurodevelopmental disorder that entails impairments in self-regulation as well as executive functioning (American Psychiatric Association, 2013). Current prevalence rates estimate approximately 5%–7% of children have ADHD (American Psychiatric Association, 2013). ADHD can manifest as three separate subtypes: inattentive, hyperactive-impulsive, or combined type (consisting of both inattentive and hyperactive-impulsive symptoms); individuals with ADHD can often change subtype presentation over time (Barkley, 2015; Roberts et al., 2015).

School-age children with ADHD have also been shown to have numerous academic challenges (DuPaul and Langberg, 2015), with writing again highlighted as an area of concern (Re et al., 2007). Children with ADHD have shown difficulty with text production and often write less proficient texts, make more errors, and write shorter texts compared to TD peers (Re et al., 2007). Similar to children with HFASD, SRSD has been a useful writing intervention for children with ADHD (De La Paz, 2001; Reid et al., 2014). A recent meta-analysis of writing difficulties of children with ADHD highlighted (1) children with ADHD are at risk for writing difficulties but not all children struggle with writing and (2) prior research on the writing abilities of children with ADHD has not often compared the writing performance of these children to other clinical samples, including those with ASD (Graham et al., 2016).

Theory-based writing research

Previous research on school-age children with HFASD or ADHD has rarely examined the issue and implications of symptom comorbidity for understanding the common and unique features of writing difficulties for these two groups. Moreover, research on writing in clinical groups has rarely been guided by theoretical models of writing. Dockrell et al. (2014) suggested that this lack of attention to theory has led to speculative conclusions regarding writing ability in children with ASD. Writing is a core component of the school curriculum that draws on complex social and cognitive processes and requires an array of skills and knowledge (MacArthur et al., 2015). Recent research has emphasized the need for using sociocognitive writing model frameworks for understanding writing development in clinical populations, although this research has focused solely on developmental coordination disorder, language learning disabilities, and dyslexia (Connelly and Dockrell, 2015). Additional research is needed here, especially for children with developmental disabilities including HFASD or ADHD.

Models for understanding the cognitive and social processes in writing have existed and have continued to evolve over the last few decades (Berninger and Swanson, 1994; Flower and Hayes, 1981; Hayes, 1996, 2012; Hayes and Berninger, 2014; Hayes and Flower, 1980, 1986). A longstanding critique of these models is that they were first developed for skilled writers (Bereiter and Scardamalia, 1987); however, revised models have been explicitly adapted for developing writers (Hayes and Olinghouse, 2015). In the latest revision of these models, Hayes (2012) argued for an updated writing model that focuses on three cognitive levels (which refer to a hierarchy of cognitive and social processes involved in writing). The control level contains task initiation, planning and goal setting, and background knowledge processes in order to contextualize different writing tasks. The process level delineates four internal processes that specify how writers produce written text: the proposer, the translator, the transcriber, and the evaluator. The process level also includes four task environment factors that highlight social and physical writing processes: collaborators or critics, task materials, transcription technology, and text written thus far. The resource level incorporates general cognitive processes that influence writing, including attention, long-term memory, working memory, and reading. Of those components listed at the resource level (Hayes, 2012), attention has received the least rigorous empirical investigation (Olive, 2012), and its role in writing development in children with disabilities is poorly understood (Connelly and Dockrell, 2015).

The role of attention on writing in children with HFASD and ADHD

Attention during writing, specifically supervisory attention, helps regulate higher-level executive functions during the writing process (Berninger et al., 2012; Levine et al., 1993) and children with writing difficulties have been shown to display difficulty with supervisory attention tasks (Altemeier et al., 2006; Hooper et al., 2002). However, research on the role of attention in the study of children with HFASD has rarely been presented. For example, Mayes and Calhoun (2007) observed evidence of significant writing difficulties in samples of children with HFASD or ADHD compared to TD controls but saw few differences between the clinical samples. It was not clear, though, if the commonality between the clinical groups was due to the presence of a subset of children with HFASD who were comorbid for ADHD symptoms or true for all children with HFASD. So the possible role of attention in the writing problems of children with HFASD was not clear in this study, or any other study to our knowledge.

This study

This study investigated the impact of attention on written expression performance in two groups of children with HFASD, an individual group of students with ADHD symptoms, and a control sample of children with TD. One group of children with HFASD was characterized by parent reports of clinical levels of ADHD symptoms, and one group of children with HFASD did not have parent reports indicative of clinical levels of ADHD. Thus, the study was designed to compare the writing of four diagnostic groups of school-age children who were positive for ADHD symptoms but not HFASD, positive for HFASD but not

ADHD, positive for HFASD and ADHD symptoms, and a TD comparison sample.

Methods

Participants

This research was conducted in compliance with the Institutional Review Board, and written consent and assent was obtained from parents and participants before data were collected. Children and families were recruited through a university research subject tracking system, through local school districts, and by word of mouth. Exclusionary criteria for this study included children with an identified syndrome other than ASD or ADHD (e.g. Fragile X), significant sensory or motor impairments, a neurological disorder (e.g. epilepsy or cerebral palsy), parent report of a history of or current psychotic symptoms (e.g. hallucinations or delusions), or extended absences from school due to medical or other problems according to parent report. The criterion for high-functioning status was a full-scale intelligence quotient (FIQ) estimate greater than 70 ascertained with the Wechsler Abbreviated Scales of Intelligence–Second Edition (WASI-II; Wechsler, 2011).

A total of 155 children (8- to 16-year-old children) enrolled in a longitudinal project on academic development participated in this study (sample demographics can be found in Table 1). The sample included 77 children affected by HFASD, 39 children with symptoms of ADHD, and 39 children with TD. The HFASD sample was split into subgroups based on ADHD symptoms assessed with the Conners-3 Parent Report scale (Conners, 2008). Children with an average Conners-3 parent report of total ADHD symptom *T*-scores greater than 69 were assigned to the HFASD with higher ADHD symptoms subgroup (HFASD-H, $n=52$) and those with ADHD *T*-scores less than 70 were assigned to the HFASD with lower ADHD symptoms subgroup (HFASD-L, $n=25$; see Table 2). One-way analyses of variance (ANOVAs) revealed no group differences in age or grade across the four diagnostic groups. The TD group was significantly different from the clinical samples on the IQ measures (Table 2); therefore, FIQ was used as a covariate in all applicable analyses.

Measures

Writing achievement. Writing achievement was measured with the Wechsler Individual Achievement Test-III (WIAT-III; Wechsler, 2009). Participants were given 10 min to handwrite an expository essay. Responses were scored for three subscales: overall, word count, and theme development and text organization. All subscales were standardized ($M=100$, standard deviation (SD) = 15) using age-based standards, and the overall subscale score was created by summing and standardizing the standardized word count and theme development and text organization scores. Age-based scores were deemed more appropriate due to children with disabilities sometimes being considered too old for their grade (Breaux, 2009: 48).

In line with the sociocognitive processes model discussed earlier, this study focused on examining attention differences at the resource level during this writing task; therefore, components related to the control and process levels were controlled. For the control level, all participants were administered the same task with the same prompt, ensuring that the task initiator did not differ between participants. For the process level, the task environment was controlled by requiring all participants to handwrite. Experimenter feedback during writing was limited to reduce collaborators or critic input. While not all components of the framework could be controlled, the design of this study is one of the first to explicitly control for factors guided by the sociocognitive processes writing model.

Five undergraduate research assistants were trained to score the WIAT-III writing samples following formal WIAT-III manual procedures. Intraclass correlation coefficients (ICCs) were computed to assess reliability across coders using Cronbach's alphas to measure the proportion of variance between coders to assess for how well coders scored samples in similar manners across both word count and thematic elements (McGraw and Wong, 1996; Shrout and Fleiss, 1979). Cronbach's alphas between coder pairings ranged from 0.87 to 1.00 for word count and theme development and text organization scores, showing evidence for acceptable inter-rater reliability levels (Kline, 1999).

Intellectual assessment. IQ was assessed with the WASI-II (Wechsler, 2011). IQ was assessed for age-standardized scaled scores ($M=100$, $SD=15$) of performance intelligence quotient (PIQ) and verbal intelligence quotient (VIQ), which were summed to calculate FIQ.

Diagnostic and symptom measures. All children with HFASD or ADHD had corresponding community diagnoses. HFASD symptomatology was confirmed using the Autism Diagnostic Observation Schedule–Second Edition (ADOS-2; Lord et al., 2012) administered by trained researchers and by parent report on the Social Communication Questionnaire (SCQ; Berument et al., 1999), the Autism Symptom Screening Questionnaire (ASSQ; Ehlers et al., 1999), and the Social Responsiveness Scales (SRS; Constantino et al., 2003). ADHD symptomatology was confirmed with parent report on the Conners-3 (Conners, 2008). All children received the SCQ, ASSQ, SRS, and Conners-3; all children with community diagnoses of ASD or ADHD received the ADOS-2.

Data analysis

All analyses were done using SPSS version 23 (IBM Corp., 2014). To investigate the research question, an analysis of

Table 1. Subgroup demographics.

	TD%	ADHD%	HFASD-L%	HFASD-H%
n	39	39	25	52
Gender				
Male	67	82	84	81
Female	33	18	16	19
Ethnicity				
African American	0	3	4	0
Asian	3	0	0	6
Caucasian	69	74	64	65
Caucasian plus other ethnicity	10	14	12	8
Hispanic/Latino/a	3	3	8	10
Native American	0	0	0	0
Native Hawaiian/Pacific Islander	3	3	0	0
Other	8	5	8	10
Decline to state	5	0	4	2
School type				
Private	21	8	12	14
Public	62	87	84	85
Homeschool	18	5	4	2
School placement				
General education	85	69	68	37
Mainstream with aide	0	13	8	25
Resource	0	10	12	10
Special day	0	3	0	17
Other	5	0	12	10
Decline to state	10	5	0	2
Percent time per day in general education				
81%–100%	90	80	76	56
61%–80%	3	10	4	10
41%–60%	3	5	4	8
1%–40%	3	5	8	12
0%	0	5	4	14
Decline to state	3	0	0	2
Has IEP/504 plan				
Yes	5	56	84	96
Current types of services[a]				
No services	97	54	20	6
1	3	26	24	17
2–3	0	10	48	42
4+	0	5	4	29
Decline to state	0	5	4	6
Mother's education				
Some/completed high school	3	8	4	2
Some/completed college	57	64	22	66
Some/completed graduate school	34	23	40	33
Decline to state	8	3	4	0
Father's education				
Some/completed high school	3	13	12	8
Some/completed college	51	69	56	66
Some/completed graduate school	36	15	32	25
Decline to state	10	3	0	0

TD: typical development; ADHD: attention-deficit/hyperactivity disorder; HFASD: high-functioning children with autism spectrum disorder; HFASD-L: HFASD with lower ADHD symptoms; HFASD-H: HFASD with higher ADHD symptoms.
Percentages may not sum to 100% due to rounding.
[a]Services include speech therapy, occupational therapy, applied behavioral analysis, resource, social skills, and personal aide.

Table 2. Subgroup comparisons for demographics, IQ, and diagnostic confirmation measures.

	TD		ADHD		HFASD		HFASD-L		HFASD-H		3DX ANOVA		4DX ANOVA	
n	39		39		77		25		52					
Measures	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*F*	*p*
Demographics														
Age	11.59	2.24	11.77	2.32	11.32	2.12	11.36	2.29	11.31	2.24	0.574	0.57	0.384	0.77
Grade	5.36	2.16	5.64	2.28	5.34	2.14	5.40	2.36	5.31	2.05	0.270	0.76	0.189	0.90
IQ														
FIQ	114.51	14.24	100.33	15.64	98.70	15.23	100.24	16.35	97.96	14.77	15.073	<0.001	10.136	<0.001
PIQ	116.44	15.83	101.38	16.90	102.77	17.12	104.84	18.69	101.77	16.40	10.480	<0.001	7.155	<0.001
VIQ	109.85	14.97	99.46	14.36	95.32	15.43	96.00	15.18	95.00	15.68	12.083	<0.001	8.031	<0.001
ASD diagnostics														
ADOS-2	[a]	[a]	2.37	1.94	6.56	1.76	6.13	1.36	6.76	1.89	11.260[a]	<0.001[a]	65.022	<0.001
SCQ	2.31	1.85	6.87	6.34	21.08	7.39	19.72	8.22	21.75	6.94	142.170	<0.001	95.899	<0.001
ASSQ	2.03	3.20	8.95	7.00	18.62	5.53	15.32	6.24	20.21	4.39	126.657	<0.001	96.888	<0.001
SRS	44.82	8.36	60.89	15.32	81.84	10.86	75.67	13.01	84.69	8.42	138.715	<0.001	101.904	<0.001
ADHD diagnostics														
Conners-3 Inatten.	48.62	10.55	76.85	11.11	75.53	11.14	65.00	9.36	80.60	7.95	90.689	<0.001	91.901	<0.001
Conners-3 Hyper/Imp.	48.28	8.71	72.95	16.61	72.22	15.18	55.00	8.17	80.50	9.84	42.054	<0.001	70.996	<0.001
Conners-3 Average	48.72	8.80	75.15	11.67	74.26	11.68	60.40	6.29	80.92	6.73	80.179	<0.001	117.708	<0.001

3/4DX: diagnostic group; IQ: intelligence quotient; TD: typical development; ADHD: attention-deficit/hyperactivity disorder; HFASD: high-functioning children with autism spectrum disorder; HFASD-H: HFASD with higher ADHD symptoms; HFASD-L: HFASD with lower ADHD symptoms; SD: standard deviation; ASD: autism spectrum disorder; VIQ: verbal intelligence quotient; PIQ: performance intelligence quotient; FIQ: full-scale intelligence quotient; ADOS-2: Autism Diagnostic Observation Schedule–Second Edition; SCQ: Social Communication Questionnaire; ASSQ: Autism Spectrum Screening Questionnaire; SRS: Social Responsiveness Scale; Conners-3 Inatten.: Conners-3 Inattention Symptoms Parent Report Scale; Conners-3 Hyper/Imp.: Conners-3 Hyperactive/Impulsive Symptoms Parent Report Scale.

HFASD constitutes both HFASD-L and HFASD-H diagnostic groups.

[a]ADOS-2 was not administered to children with TD; an independent samples *t*-test between HFASD and ADHD was conducted with *t* and *p* values reported.

Table 3. WIAT-III written expression task descriptive statistics for age-based scores before and after accounting for FIQ covariate.

	TD		ADHD		HFASD		HFASD-L		HFASD-H	
n	39		39		77		25		52	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Overall writing score	97.87	13.56	85.31	14.61	82.88	17.15	87.88	18.52	80.48	16.10
Word count score	102.15	13.33	90.26	13.71	87.26	16.56	90.16	18.07	85.87	15.78
Theme development and text organization score	93.31	15.61	82.77	15.00	81.83	15.77	87.60	15.35	79.06	15.34
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Overall writing score	95.98	2.67	85.77	2.50	83.61	1.81	88.33	3.09	81.29	2.18
Word count score	100.79	2.58	90.59	2.42	87.79	1.75	90.49	3.02	86.46	2.13
Theme development and text organization score	91.57	2.64	83.19	2.48	82.50	1.79	88.01	3.05	79.79	2.15

WIAT-III: Wechsler Individual Achievement Test-III; FIQ: full-scale intelligence quotient; TD: typical development; ADHD: attention-deficit/hyperactivity disorder; HFASD: high-functioning children with autism spectrum disorder; HFASD-H: HFASD with higher ADHD symptoms; HFASD-L: HFASD with lower ADHD symptoms.
Mean (M) and standard deviations (SD) in top half of table refer to observed, non-adjusted scores. M and standard error (SE) in bottom half refer to adjusted marginal means accounting for FIQ = 103.09.

covariance (ANCOVA) was conducted to assess the main effects of diagnostic group on each dependent variable (overall writing subscale, word count subscale, and theme development and text organization subscale) after controlling for the effects of the IQ covariate (FIQ). FIQ was chosen due to the significant difference between clinical (HFASD-L, HFASD-H, and ADHD) and TD groups (Table 2). Overall writing ability was examined first, followed by analyses of the two more specific measures—the word count subscale and the theme development text organization subscale. Effect sizes were reported as partial eta squared (η_p^2). Planned Tukey post hoc analyses were run to examine pairwise diagnostic group differences.

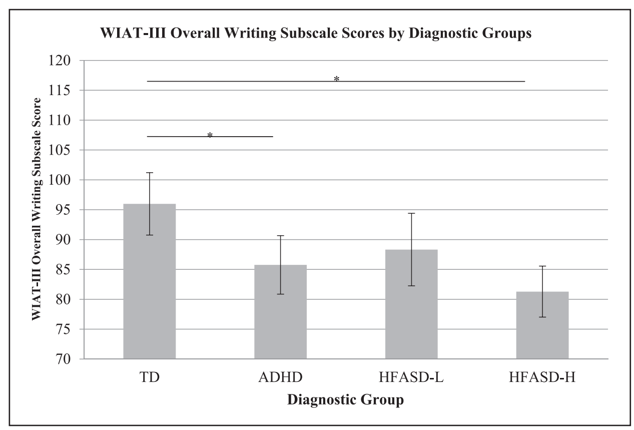

Figure 1. Estimated marginal means with 95% confidence intervals for the overall writing scores (age-based standardized scores) from the WIAT-III written expression task split by the four groups. Estimated marginal means shown above covary for FIQ = 103.09. *p<0.05.

Results

WIAT-III overall writing subscale, word count subscale, and theme development and text organization subscale performance scores across diagnostic groups can be found in Table 3. The following sections compare subgroup performances across the WIAT-III written expression subscales.

WIAT-III overall writing subscale scores

A one-way (diagnostic group) ANCOVA conducted for WIAT-III overall writing scores yielded a main effect for diagnostic group, $F(3, 150)=5.942$, $p=0.001$, $\eta_p^2=0.11$ (Figure 1). The overall writing scores of children with HFASD-H ($M=81.29$, $SE=2.18$) were significantly lower than were those for children with TD ($M=96.07$, standard error (SE)$=2.65$; $p<0.001$); however, the scores for children with HFASD-L ($M=88.33$, $SE=3.09$) were only marginally lower than children with TD ($p=0.063$). Children with ADHD ($M=85.74$, $SE=2.48$) also performed significantly lower than the children with TD ($p<0.007$). The clinical groups did not significantly differ from one another. Additional analyses were conducted to examine diagnostic group differences on the word count and theme development and text organization subscale scores.

WIAT-III word count subscale scores

A one-way (diagnostic group) ANCOVA of the WIAT-III word count scores revealed a significant main effect for diagnostic group, $F(3, 150)=5.880$, $p=0.001$, $\eta_p^2=0.10$

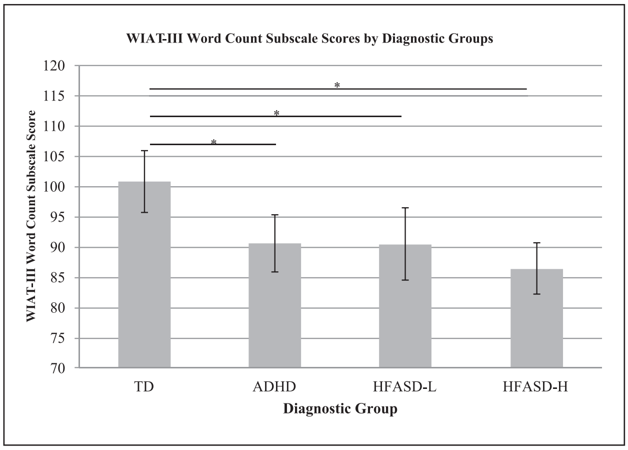

Figure 2. Estimated marginal means with 95% confidence intervals for the word count scores (age-based standardized scores) from the WIAT-III written expression task split by the four groups. Estimated marginal means shown above covary for FIQ = 103.09. *p<0.05.

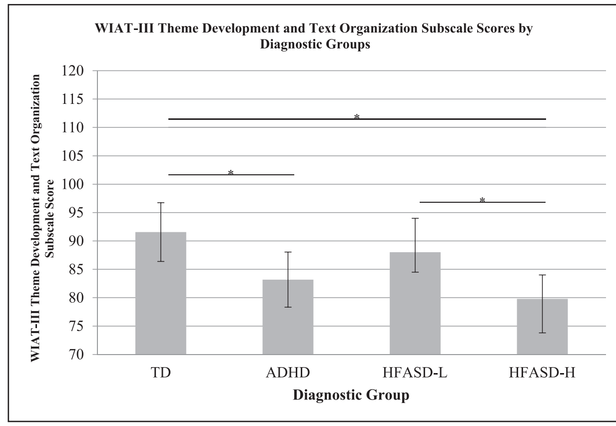

Figure 3. Estimated marginal means with 95% confidence intervals for the theme development and text organization subscale scores (age-based standardized scores) from the WIAT-III written expression task split by the four groups. Estimated marginal means shown above covary for FIQ = 103.09. *p<0.05.

(Figure 2). Children with HFASD-L (M=90.49, SE=3.02), with HFASD-H (M=86.46, SE=2.13), and with ADHD (M=90.57, SE=2.42) performed significantly lower than children with TD (M=100.84, SE=2.58; p=0.01, p < 0.001, p=0.005, respectively). Children in all three clinical groups did not significantly differ from one another.

WIAT-III theme development and text organization subscale scores

A one-way (diagnostic group) ANCOVA of the WIAT-III theme development and text organization scores revealed a significant main effect for diagnostic group, F (3, 150) = 4.384, p = 0.005, $\eta_p^2 = 0.10$ (Figure 3). Children with HFASD-L (M=88.01, SE=3.05) performed significantly higher than children with HFASD-H (M=79.79, SE=2.15, p=0.028). Children with HFASD-H performed significantly lower than children with TD (M=91.67, SE=2.61; p=0.001). Children with ADHD (M=83.16, SE=3.05) performed significantly lower than children with TD (p=0.021). Children with HFASD-L did not significantly differ from children with ADHD (p=0.22) or TD (p=0.37). Children with HFASD-H did not significantly differ from children with ADHD (p=0.30).

Discussion

In a recent paper, Dockrell et al. (2014) suggested that theory-based research was needed to develop a more precise understanding of writing ability in school-age children with ASD. Guided by the most recent cognitive process writing model of Hayes (2012), this study of writing in a large sample of school-age children with HFASD specifically addressed the hypothesis that attention regulation, a primary cognitive writing resource identified in Hayes (2012), could help explain the difficulty with writing that is often displayed by children with ASD. To examine this hypothesis, the study employed control groups of children with elevated ADHD symptoms but without an ASD diagnosis and children with TD. The study also included the novel design of two subgroups of children with ASD with one group characterized by higher levels of ADHD symptoms and the other by lower levels of symptoms. These elements of the research design allowed the study to address issues of the specificity of writing problems in school-age children with HFASD relative to a clinical comparison group and to examine the role of attention problems on heterogeneity in writing ability.

The results suggested that attention regulation difficulty, as measured by parent report of comorbid ADHD symptoms, may have influenced writing performance in children with HFASD. Overall writing performance was significantly worse in children with HFASD-H than children with TD. The children with HFASD-L did not display significantly worse overall writing scores when compared to children with TD, although they did display a lower pattern of scores that approached a conventional level of difference from the children with TD. The data presented in Figure 1 also indicated that there was a monotonic difference between the children with TD, the children with HFASD-L, and the children with HFASD-H on overall writing performance (Ms=97.87, 87.88, and 80.48, respectively; see Table 3).

Our results clearly indicate that heterogeneity in written expression development in children with HFASD is associated with the presence of ADHD symptoms. Children with HFASD-H were at greater risk for writing difficulties, relative to children with TD, than were children with HFASD-L. The writing risk associated with the latter group, however, was not so clear. Recall that there were fewer children with HFASD-L ($n = 25$) than with HFASD-H ($n = 52$). Thus, there was less power in this study to observe significant effects associated with this diagnostic subgroup, making the marginal effects observed for this group more difficult to interpret. Larger samples in future research are necessary not only to determine if a significant level of risk relative to children with TD exists for this group but also if significantly less risk occurs for this group than is experienced by peers with HFASD-H.

These results also must be considered in terms of what they say about the syndrome-specific nature of writing difficulties in children with HFASD. The children with ADHD displayed the same lower levels of performance on the overall writing subscale as the children with HFASD-H. The most parsimonious interpretation of these data is that attention regulation problems play a similar role in hindering writing development in school-age children with ASD and ADHD of comparable IQs. This observation is consistent with the Hayes (2012) cognitive process writing model emphasis on attention regulation as a resource that is central to age-appropriate writing development (Hayes and Olinghouse, 2015). Data from other studies also suggest that school-age children with ASD and ADHD display comparable levels of difficulties with writing (Mayes and Calhoun, 2006).

However, the same symptoms of attention dysregulation from the Conners-3 ADHD parent report measures used in this study may be positive for children with ASD and ADHD for very different reasons. Take for example the Conners-3 items "Does not seem to listen to what is being said to him or her" and "Has trouble concentrating." These may reflect vulnerability to distraction in children with ADHD or a failure to attend to what other people attend to in children with ASD. These two distinct processes may lead to comparable attention problems in both groups of children, but for very different reasons. Consistent with this notion, recent research has indicated that sustained attention may be regulated by different functional cortical systems in children with ASD compared to children with ADHD (Christakou et al., 2013). Several other studies have also indicated that children with ADHD and ASD display both common and distinct patterns of executive function disturbance, which could be involved in the relation between attention and writing difficulties. With regard to distinct patterns, prior research has shown that children with ADHD may show more problems with working memory and response inhibition than children with ASD, but the latter display more evidence of problems with response selection/monitoring, cognitive flexibility, switching, and planning (Corbett et al., 2009; Happé et al., 2006; Sinzig et al., 2008b). It is not clear whether these executive functions would be classified within the resource level (within working memory or attention) or dispersed across levels (such as within goal setting at the control level or within the writing processes or task environment at the process level) within the Hayes (2012) model. Nevertheless, our results indicate disturbance of the superordinate resource category of attention in the Hayes (2012) model influences writing development in children with ASD and ADHD. However, it remains to be seen whether the same executive components of attention equally relate to the writing difficulties in school-age children with ASD or ADHD.

A third element of the results also has implications for understanding the context of the effects of attention regulation on writing in ASD. All of the clinical groups displayed similar low word production scores compared to children with TD. Hence, there did not appear to be attention-specific effects on factors associated with writing volubility. However, the children with HFASD-H and ADHD displayed significantly poorer performance compared to the children with TD on the theme development and text organization subscale; this was not the case for the children with HFASD-L. Therefore, the presence of elevated ADHD symptoms appeared to impact the performance on this subscale across the clinical samples.

The writing difficulties observed on the theme development and text organization subscale may be comparable to the problems with generating or recalling thematic elements on verbal narrative tasks that have long been recognized as characteristics of HFASD (Capps et al., 2000; Losh and Capps, 2003; Losh and Gordon, 2014). These studies have not typically involved written narrative tasks. Nevertheless, it is useful to note that attention problems have not often been considered as contributors to the problems in thematic narrative expression and comprehension in these children. Rather, research has suggested that these problems are associated with social cognitive difficulties; episodic memory; or understanding gist, ambiguous pronominal referents, and idiosyncratic language (Lind et al., 2014; Mason et al., 2008; Rumpf et al., 2012; Siller et al., 2014; Suh et al., 2014). It is not necessarily the case though that there is no connection between attention problems and these influences on narrative abilities in ASD. For example, social cognition appears to be significantly influenced by differences in attention and executive functions such as planning and set shifting in children without ASD (e.g. Fahie and Symons, 2003) and children with ASD (Pellicano, 2007). Fewer related studies have been conducted with children with ADHD, but at least one study suggests that there is an association between working memory and narrative task performance in children with ADHD (Papaeliou et al., 2015).

While this study provided evidence of associations between ADHD symptoms and thematic elements of written expression in ASD and other clinical groups, more research will be needed on the nature of the processes that lead to this association across groups. Our interpretation here is that previous research on narrative tasks may offer, although not specific to writing, useful clues to the nature of the causal paths from attention to problems in writing development for children with ASD and ADHD. One possibility here is that the causal paths are different with the attention problems affecting thematic writing elements through associations with social cognition and executive functions involved in planning and set shifting in children with ASD, but executive functions associated with working memory in children with ADHD.

Educational and clinical implications

Woodman et al. (2016) recently reported observations from 406 adolescents and adults with ASD that indicate that the K-12 educational context (above demographic and individual differences) is a significant predictor of more positive ASD outcomes. Their data, as well as other observations (see Mundy and Mastergeorge, 2012, for a review), have argued for more research to advance the effective implementation of evidence-based interventions in school for children with ASD; this has been a growing concern as well pertaining to effective implementation of writing interventions for children with ASD (Asaro-Saddler, 2015). One area of concern for school-age children with HFASD is that many of these children display significant delays in developmental academic skills such as reading (Jones et al., 2009; Nation et al., 2006; Randi et al., 2010) and writing (Asaro-Saddler, 2015; Pennington and Delano, 2012). One novel perspective is that these academic problems actually reflect their ongoing phenotypic disturbance of social communication development (Randi et al., 2010). For example, several studies indicate that reading comprehension deficits in children with HFASD are associated with individual differences in their ASD presentation, and this association has been observed to be mediated by individual differences in higher-order inferential language skills (Ricketts et al., 2013).

From these observations comes another novel idea: if reading and possibly writing problems in school-age children with ASD reflect ongoing problems of their social cognitive phenotype, then the development of effective school-based interventions for these problems may have positive impacts on core components of ASD during their years in school (Randi et al., 2010). However, to develop effective interventions and to test this important possibility, a deeper understanding of the nature of the academic learning problems of children with HFASD is needed. In a review of evidence-based practices for writing interventions for children with HFASD, Asaro-Saddler (2015) highlighted four general practices that practitioners need to be aware of: technology-aided instruction and intervention, self-management, visual supports, and peer-mediated instruction or training. She also highlighted that ASD-specific writing intervention practices have not yet been identified. To further address the development of such practices, researchers need to further study these practices with school-age children with HFASD to address adaptations needed regarding possible mediating factors, including attention (as addressed in this study), social communication development, and executive functions.

In addition, since some evidence-based writing interventions (such as SRSD) have shown to positively impact the writing performance of school-age children with HFASD, one possible intervention path is to further explore how writing interventions affect child attention during writing task performance. This is an important hypothesis to pursue in future research, and task attention may be an important outcome measure for future intervention research. For example, past research implementing SRSD with children affected by HFASD has focused on writing outcomes and not attention outcomes; if SRSD instruction positively impacts task attention, then exploring how children with HFASD with and without increased attention disturbance learn during and generalize beyond SRSD implementation may help researchers and educators understand how beneficial SRSD (and other writing interventions) are for particular subgroups of children with HFASD. Exploring these other writing-related sociocognitive processes within SRSD implementation may help researchers adapt SRSD and contribute to identifying evidence-based writing practices for school-age children with HFASD.

Our study contributes to the understanding of the nature of the ASD-related learning problems that affect their development of written expressive communication abilities. It is only a beginning, though. We hope that our group, as well as others, can expand on this study to inform educators and schools in how the use of specific writing interventions and curriculums can be a pivotal part of the comprehensive intervention for the social communication development of school-age children with HFASD.

Limitations

No study is without limitations. First, by splitting our HFASD group into HFASD-L and HFASD-H, we had two unequal groups with a relatively small sample of children in the former. Clearly, robust subgroup analyses require a larger sample.

Second, and perhaps most importantly, the findings were limited to analyzing the written products from one writing task. Mayes et al. (2005) demonstrated that different writing assessments can provide different findings when studying children with writing difficulties. A challenging facet of writing research entails capturing the complex writing process (Rijlaarsdam et al., 2012). Past research on children with HFASD has often used a single writing assessment, and multiple assessments are needed to better capture writing ability across contexts and assessments. In addition, past research involving children with HFASD or ADHD has focused on written products, often ignoring how writing processes unfold while writing (Fayol et al., 2012). Methodology for studying online writing processes have received increased attention over the last two decades (see Berninger et al., 2012, for a review), and making use of these methods can help better understand struggling writers with HFASD or ADHD (Dockrell et al., 2014; Graham et al., 2016).

Third, the administration of the WIAT-III involved handwritten texts only. With writing becoming increasingly multimodal and digital (Hayes, 2012; Rijlaarsdam et al., 2012), the composition medium can affect both writing fluency and content. Future research needs to consider the effect that typing may have on the ability to respond to written assessments, both for assessment and in-classroom practices. Limited research has looked at the effect of the composition medium on writing involving children with HFASD (Schneider et al., 2013), though a breadth of research exists on word processing for handwriting difficulties (see MacArthur et al., 2015). Some research has studied the use of technology-aided instruction and intervention with struggling writers with ASD, though not without issues that need to be further addressed (Asaro-Saddler, 2015). Further exploring the text production mediums allows for better understanding writing with children with HFASD or ADHD within the framework of cognitive process models (Hayes, 2012).

Fourth, the focus on attention with this study relied on parent-report measures of ADHD symptomatology; this research design used a global, objective measure of attention difficulties (parent report on the Conners-3), but we did not specifically assess how children deployed their attention during the writing task. Using objective attention measures and in-task attention assessment can help understand how differences in attention allocation may manifest during writing tasks themselves and influence written products.

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