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Observing visual attention and writing behaviors during a writing assessment: Comparing children with autism spectrum disorder to peers with attention-deficit/hyperactivity disorder and typically developing peers

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Lay Summary

Children with autism spectrum disorder (ASD) demonstrate variable writing skills. Here, we examine how children with ASD engage during a writing task by using video data to compare their engagement to peers with and without attention difficulties. Findings indicate a) lower draft engagement and similar task disengagement compared to their peers and b) moderate-to-strong relationships between engagement, writing scores, and ASD symptom severity (but not attention difficulties) in children with ASD and their peers with attention difficulties.

Abstract

Children with autism spectrum disorder (ASD) demonstrate heterogeneous writing skills that are generally lower than their typically developing (TD) peers and similar to peers with attention difficulties like attention-deficit/hyperactivity disorder (ADHD). Recent evidence suggests children with ASD spend less time engaging in writing tasks compared to their peers, but previous studies have not examined how children engage with the task environments of writing tasks. This study used video observation data collected from 121 school-age children (60 children with ASD, 32 children with ADHD, and 29 TD children) to compare differences in visual attention and writing task behaviors and relationships between behaviors and age, cognitive skills, and ASD and ADHD symptom severity. Findings indicated that groups mostly spent time looking at and writing on the draft, though this was lowest in the ASD group. No differences were found between the ASD and ADHD groups after accounting for duration as a percentage of total task time used. Groups spent little time looking at their outlines and looking away from the task, with all groups spending relatively more time looking at the task picture. Time spent engaged with the draft showed a positive relationship with writing performance across groups, but a negative relationship between time spent looking at the task picture and writing performance only appeared for the ADHD group. The ASD and ADHD groups showed negative associations between draft engagement and ASD symptom severity but not ADHD symptom severity. Implications are discussed for understanding writing task engagement in research and instructional contexts.

Keywords: Autism spectrum disorder; Attention-deficit/hyperactivity disorder; Education; Engagement; Writing.

Autism spectrum disorder (ASD) is a neurodevelopmental disability that predominantly affects social and behavioral development (American Psychiatric Association, 2013). Individuals with ASD demonstrate highly variable academic skills (Caterino, 2014; Ibrahim, 2019; Keen, Webster, & Ridley, 2016; Mundy, Mastergeorge, & McIntyre, 2012; Simpson & Myles, 2016), and recent studies have offered approaches that target general academic development (Bauminger-Zviely, 2013; Harris, Bruey, & Palmieri, 2018; LaCava, 2016). Fewer studies have offered insights into challenges with specific academic skills (Keen et al., 2016; Whitby & Mancil, 2009), like writing (Corbett & Iqbal, 2018; Ibrahim, 2019; Zajic & Wilson, 2020).

Creating written text requires the use of transcription (handwriting and spelling) and text generation (construction and translation of ideas into text) skills with additional support from linguistic, cognitive, and social cognitive processes (Berninger & Winn, 2006; Graham, 2018; Hayes & Berninger, 2014). Children with ASD demonstrate diverse transcription and text generation skills (Finnegan & Accardo, 2018; Kushki, Chau, & Anagnostou, 2011; Zajic & Wilson, 2020) with a relatively high rate of significant challenges (Mayes & Calhoun, 2006). Empirical studies examining associated processes remains limited (see Zajic & Wilson, 2020), but cognitive, attention and executive function, language, and social communication skills have been highlighted as potential factors influencing writing development heterogeneity (Brown, Johnson, Smyth, & Oram Cardy, 2014; Dockrell, Ricketts, Charman, & Lindsay, 2014; Hilvert, Davidson, & Gámez, 2020; Hilvert, Davidson, & Scott, 2019; Johnson et al., 2013; Mayes & Calhoun, 2006, 2008; Zajic et al., 2018; Zajic, Solari, Grimm, McIntyre, & Mundy, 2020).

One gap in the current literature is on understanding how children with ASD engage during writing. Existing empirical studies examining engagement during academic tasks suggest low rates of on-task classroom engagement (Bryan & Gast, 2000; Pelios, MacDuff, & Axelrod,

2003). Sparapani and colleagues (2016) used a multicomponent observational measure of active engagement to find that elementary school-age children with ASD in classroom settings demonstrated well-regulated, productive, and independent behaviors in less than half of their observations. However, studies focused on issues of writing development have offered at most preliminary insights into engagement, often via focusing on skills like attention and executive functions that support self-regulation during writing. In a review of the current literature, Zajic and Wilson (2020) found only 26% of existing studies examined relationships between writing skills and attention or executive function skills in children with ASD. Studies generally examined interventions that targeted self-regulating writing behaviors (see Asaro-Saddler, 2016) with few descriptive studies having examined broader relationships between attention and executive function skills with writing skills.

Both social and physical factors of a writing task environment may influence how individuals engage in their writing process (Graham, 2018; Hayes & Berninger, 2014). Social factors include inputs from the individuals involved in crafting the text and from an understanding of the writing space. Physical factors include the task materials, the transcribing technology (i.e., handwriting, typing, or speaking), and the text itself. Writing task physical environments may place constraints on the types of writing being done, such as the writing tools available, the form that writing takes, and how writers complete writing tasks (Graham, 2018).

While engagement and ASD research has taken place predominantly in classrooms, writing and ASD research has relied on data collected from standardized, curriculum-based, and experimenter-designed psychoeducational assessments (see Zajic & Wilson, 2020). While these assessment environments differ in their social and physical affordances, both are important to thinking about the writing skills of children with ASD, as psychoeducational assessments are

commonplace in school and research contexts (see Caterino, 2014; Iqbal & Corbett, 2018). Findings have suggested attention and executive function skills influence both transcription and text generation skills in children with ASD (Dirlikov et al., 2017; Hilvert et al., 2019; Zajic et al., 2018). However, studies have not often examined direct task engagement. Hilvert et al. (2020) found that children with ASD demonstrated greater difficulties with getting started and staying on task relative to their typically developing (TD) peers during a personal narrative writing assessment. Zajic et al. (2020b) examined task-level engagement during a fictional narrative writing task comparing children with ASD to TD peers and peers with attention-deficit/hyperactivity disorder (ADHD). Children with ADHD exhibit writing difficulties similar to those observed in children with ASD (DuPaul & Langberg, 2015; Graham, Fishman, Reid, & Hebert, 2016; Molitor, Langberg, & Evans, 2016). Findings indicated that the ASD group spent less overall time engaged with the task compared to their peers and that task-level engagement explained variance in word production for both ASD and ADHD groups but only in text quality for the ASD group (while controlling for associated variables including age, cognitive skills, and ASD and ADHD symptom severity).

Current Study

The current study expands upon the task-level engagement findings (Zajic et al., 2020b) by examining visual attention and writing task behaviors during the Writing stage of the Test of Written Language, 4th Edition (TOWL-4; Hammill & Larsen, 2009). This study uses video observation data to examine engagement during the psychoeducational assessment, as video data allows for the development of systematic coding approaches to capture events during a wide array of contexts (Jewitt, 2012; Yoder, Lloyd, & Symons, 2018). A similar approach was described in a separate report that focused on overt planning task behaviors (see Zajic, Solari,

McIntyre, Lerro, & Mundy, 2020a). The current study addresses two primary research questions:

1. Do children with ASD, children with ADHD, and TD children differ in the time spent engaged in visual attention and writing task behaviors?
2. Do within-group relationships differ between task behaviors and narrative writing scores, age, cognitive skills, and ASD and ADHD symptom severity?

Methods

All data were collected from families participating in a longitudinal study on academic, cognitive, and social development that were recruited through a university-affiliated center's subject tracking system, by fliers through local school districts, and by word of mouth. Participants visited a university-based child assessment laboratory for data collection and completed neuropsychological and psychoeducational assessments. Trained research team members (i.e., undergraduate and graduate research assistants, and postdoctoral research associates) conducted all assessment visits with individual participants. This research was conducted in compliance with the Institutional Review Board Administration at the University of California, Davis. Parents/guardians completed parent-report measures in a room separate from where the research team worked with their child. Exclusionary criteria included an identified syndrome other than ASD or ADHD, significant sensory or motor impairment, a neurological disorder, psychotic symptoms, or any major medical disorder that could be associated with extended absences from school. This study included 121 children between 9-17 years old, including 60 children with ASD, 32 children with ADHD, and 29 TD children. Children with ASD and ADHD came into the study with community diagnoses that were confirmed via trained researcher assessment and parent report. Participants across groups were predominantly male and Caucasian and spent their time in general education settings in public schools (see Table 1).

Diagnostic and Symptom Severity Measures

The Autism Diagnostic Observation Schedule, 2nd Edition (ADOS-2; Lord et al., 2012) confirmed diagnosis (ASD group) and assessed ASD symptom severity (ASD and ADHD groups). The ADOS-2 is a semi-structured assessment of communication, social interaction, play, and restricted and repetitive behaviors and interests. A research-reliable team member administered Module 3 (Child/Adolescent) or Module 4 (Adolescent/Adult) to calculate algorithm-adjusted Total Scores. Modules demonstrate strong interrater reliability (αs = 0.82-0.94; Lord et al., 2012). All groups also completed the Social Responsiveness Scale (SRS; Constantino & Gruber, 2005), a 65-item parent-report rating scale of ASD symptom severity and general social responsivity in naturally occurring contexts. The SRS provides a Total Score (*M* = 50, *SD* = 10) as a composite of five subscales (Awareness, Cognition, Communication, Motivation, and Mannerisms) and has demonstrated strong internal consistency (αs = 0.93-0.97; Constantino & Gruber, 2005). A Total Score above 76 suggests severe difficulties in social responsivity.

The Conners 3 (Conners, 2008) confirmed ADHD diagnosis (ADHD group) and assessed ADHD symptom severity across groups. The Conners 3 is a comprehensive parent-report assessment for identifying the presence of ADHD symptomatology, and parents/guardians completed the DSM-IV Inattentive and DSM-IV Hyperactive/Impulsive subscales. A T-score (*M* = 50, *SD* = 10) above 70 suggests a very elevated score with many more concerns compared to same-age peers. Both subscales have strong demonstrated internal consistency (αs > 0.90; Conners, 2008).

Cognitive Measures

The Wechsler Abbreviated Scale of Intelligence, 2nd Edition (WASI-II; Wechsler, 2011)

assessed verbal (Vocabulary and Similarities) and nonverbal (Block Design and Matrix Reasoning) skills to provide estimates of verbal reasoning (Verbal Comprehension Index [VCI]), nonverbal reasoning (Perceptual Reasoning Index [PRI]), and overall cognitive skills (FIQ; *Ms* = 100, *SDs* = 15). Sample-specific internal consistency estimates were excellent across subtests (αs = 0.87-0.93) and were consistent with publisher-reported estimates (α = 0.96; Wechsler, 2011). All participants had an estimated FIQ of at least 73.

Narrative Writing Measure

The TOWL-4 (Hammill & Larsen, 2009) assessed handwritten, spontaneous writing skills. Participants completed three task stages where they a) listened to a sample story about an example picture read aloud by a research team member (Scripting), b) planned their story about a new picture (Planning), and c) drafted their story while having access to the task picture and their planning notes (Writing). All participants received the same task instructions and completed Form A, which depicts a scene showing the aftermath of a car crashing into a fire hydrant due to a dog being off its leash that includes numerous people (e.g., policewoman, the car driver, and the dog's owner). No graphic organizers were provided, but participants were allowed to use any notes created during the Planning stage during the Writing stage. For the Writing stage, all participants had 10 minutes to complete their stories (reduced from 15 minutes due to study visit time constraints). Participants were prompted about time remaining when 5 minutes and 1 minute remained, and participants were allowed to finish their final sentence when time was up. Participants were allowed to end the task early by telling a research team member they were done (see Zajic et al., 2020b for further details).

Writing samples were evaluated based on the Contextual Conventions (orthographic and grammatic writing features) and Story Composition (text quality) subtests. Scaled scores (*M* =

10, *SD* = 3) were used to calculate an overall Spontaneous Writing Index composite score (*M* = 100, *SD* = 15). The total number of words produced was counted for each sample. The first author trained two research assistants using the TOWL-4 scoring guidelines (Hammill & Larsen, 2009). Following training, interrater reliability was calculated on 34 randomly selected samples across groups and was great-to-excellent for Contextual Conventions (α = 0.94), Story Composition (α = 0.84), and word count (α = 1.00). See Zajic et al. (2020b) for further discussion of TOWL-4 writing performance.

Visual Attention and Writing Task Behaviors

A video camera placed on a tripod positioned diagonal to the assessment table captured behaviors during the TOWL-4 assessment (see Supplemental Figure 1). This captured the full view of participants' faces and upper bodies and the task materials on the table. Participants had been video recorded during multiple assessments prior to the TOWL-4. The research team member administering the task was present at the assessment table only when supplying instructions to the participant and left participants alone during designated task writing times.

Video observation data was human coded using the Observer XT 14.0 (Noldus Information Technology, 2016). This study focused only on the visual attention and writing task behaviors occurring during the Writing stage. Visual attention behaviors were coded for the total time spent engaged visually with various task components (i.e., picture, outline, and draft) and away from the task. Physical writing behaviors were coded for the total time participants spent engaged physically writing on the outline and the draft. All behaviors were coded exhaustively throughout the Writing stage at the millisecond level (with a change in behaviors coded at the point a participant's gaze shifted). Due to the use of human coders, this study focused on macro-level engagement (e.g., time spent looking at the overall picture or the overall draft) rather than

micro-level engagement (e.g., time spent attending to different parts of the task picture or time spent writing different sentences).

Two trained graduate student researchers (trained based on the above-mentioned criteria for start-stop specifications using five videos along with post-coding discussion until agreement) independently coded behaviors on a randomly selected 34 videos drawn across all groups. Reliability was calculated using generalizability theory (Briesch, Swaminathan, Welsh, & Chafouleas, 2014) to estimate variance sources (single-facet, person-by-rater analysis with all responses scored by both research assistants and treated as random) and to conduct a decision study examining projected change in generalizability (ρ^2) and dependability (ϕ) coefficients for using one rather than two raters. The generalizability study was done using SPSS version 25 (IBM Corp., 2018), and the follow-up decision study was done using Microsoft Excel. Most variance fell within participant behaviors (looking at picture: 93.71%; looking at outline: 95.69%; looking at the draft: 98.27%; looking away: 99.10%; writing on the draft: 98.62%) with minimal rater (0.00%-2.72%) and residual variance (0.84%-4.31%). Using one rater (ρ^2 and ϕ = 0.94-0.99) did not greatly differ from using two raters (ρ^2 and ϕ = 0.97-1.00). One rater coded all remaining participant videos.

Data Analysis

Analyses were done using IBM SPSS version 25 (IBM Corp., 2018). After examining group-level estimates for all behaviors using boxplots (Figure 1), writing on the outline was removed from further analysis as only five participants engaged in that behavior. A two-way mixed analysis of covariance (ANCOVA) controlling for FIQ (due to group differences; Table 1) was used to examine between-group differences (ASD, ADHD, and TD) in visual attention and writing task behaviors. Statistically significant ($p < 0.05$) two-way interactions were examined

using follow-up univariate ANCOVA to assess for simple main effects, with statistically significant simple main effects examined using pairwise comparisons with a Bonferroni correction. FIQ was grand mean centered based on the full sample (Schneider, Avivi-Reich, & Mozuraitis, 2015).

Given that the ASD group spent less time engaged in the Writing stage relative to the ADHD and TD groups (Zajic et al., 2020b), examining duration only in seconds would be biased against the ASD group. We conducted a second set of analyses that treated duration as a percentage of total task time. For example, if participant A wrote on the draft for 4 minutes and spent 5 minutes total completing the task and participant B wrote on the draft for 8 minutes and spent 10 minutes total completing the task, then these analyses treated both participants as having spent 80% of their task time engaged in writing.

Pearson product-moment correlations examined group-specific relationships between task behaviors (percentage of total task time) and TOWL-4 scores, age, cognitive skills (VCI, PRI, and FIQ), and ASD and ADHD symptom severity (ADOS-2, SRS, and Conners 3). Given the exploratory nature of this study, these analyses did not adjust for multiple comparisons (Althouse, 2016; Rothman, 1990).

Results

Demographic information and descriptive statistics are provided in Table 1. Groups were matched on gender and age, but the TD group had elevated IQ estimates compared to the ASD and ADHD groups. The ASD group showed elevated overall levels of ADHD symptom severity. In contrast to the ADHD group, the ASD group had fewer children showing very elevated inattentive symptoms (63% and 81%, respectively) and very elevated inattentive and hyperactive symptoms (43% and 53%, respectively) with similar percentages of individuals showing very

elevated hyperactive symptoms (52% and 56%, respectively). The ADHD group showed a slight elevation in ASD symptom severity, with 22% showing severe social responsivity difficulties (while 83% of the ASD group received similar ratings). Children across groups generally looked at the task picture and looked at or wrote on the draft at least once (97-100%). Relatively fewer children across groups looked at the outline at least once (ASD: 51%; ADHD: 38%; TD: 69%), and very few children wrote on the outline at least once (ASD: 3%; ADHD: 6%; TD: 3%).

Between-Group Comparisons for Task Behaviors

Between-group comparisons were first analyzed using duration in seconds followed by subsequent analyses using duration as task time percentage. Sphericity was violated for the two-way interaction between group and behavior for duration in seconds, $\chi^2(9) = 439.07$, $p < 0.001$, and duration as task time percentage, $\chi^2(9) = 400.12$, $p < 0.001$. A Greenhouse-Geisser correction was applied for both comparisons.

Task behaviors (duration in seconds). There was a statistically significant interaction between group and task behavior duration, $F(2.79, 163.10) = 8.26$, $p < 0.0001$, $\eta_p^2 = 0.12$. See Table 2 for group-level estimates. Significant main effects were found for looking at the draft, $F(2, 117) = 8.32$, $p < 0.001$, $\eta_p^2 = 0.12$, looking away from the task, $F(2, 117) = 3.49$, $p = 0.034$, $\eta_p^2 = 0.06$, and writing on the draft, $F(2, 117) = 11.21$, $p < 0.001$, $\eta_p^2 = 0.16$. The ASD group spent less time looking at the draft relative to the ADHD and TD groups (*ps* = 0.035 and 0.001), and the TD and ADHD groups did not differ ($p = 0.47$). The ASD group spent less time looking away relative to the TD group ($p = 0.041$), and no other comparisons differed (*ps* > 0.05). The ASD group spent less time writing relative to the TD group ($p < 0.001$), and no other comparisons differed (*ps* > 0.05). No main effect was observed for looking at the picture or looking at the outline (*ps* > 0.05).

Task behaviors (duration as task time percentage). There was a statistically significant interaction between group and task behavior duration, $F(2.99, 175.02) = 3.61$, $p = 0.015$, $\eta_p^2 = 0.06$. See Table 2 for group-level estimates. Significant main effects were found for looking at the draft, $F(2, 117) = 3.30$, $p = 0.04$, $\eta_p^2 = 0.05$, and writing on the draft, $F(2, 117) = 5.88$, $p = 0.004$, $\eta_p^2 = 0.09$. The ASD group spent less time looking at the draft relative to the TD group ($p = 0.034$), and no other comparisons were significant ($ps > 0.05$). The ASD and ADHD groups spent less time writing on the draft relative to the TD group ($ps = 0.003$ and 0.031) but did not differ from each other ($p = 1.00$). No main effects were observed for looking at the picture, looking at the outline, or looking away ($ps > 0.05$).

Correlations between Task Behaviors and Narrative Writing Skills, Age, Cognitive Skills, and ASD and ADHD Symptom Severity

Within-group relationships between task behavior durations (task time percentage) and TOWL-4 scores are shown in Table 3. The ADHD group showed negative, moderate-to-strong associations between time spent looking at the picture and TOWL-4 scores ($rs = -0.53$--0.66, $ps < 0.05$); similar associations were non-significant for the ASD and TD groups ($ps > 0.05$). All groups showed non-significant associations between time spent looking at the outline and TOWL-4 scores ($ps > 0.05$). The ASD group showed moderate ($rs = 0.36$-0.49, $ps < 0.05$) and the ADHD group showed moderate-to-strong associations ($rs = 0.65$-0.80, $ps < 0.05$) with time spent looking at and writing on the draft and TOWL-4 scores; the associations for the TD group were non-significant ($ps > 0.05$). The ADHD group showed moderate associations between looking away from the task and TOWL-4 scores ($rs = -0.44$--0.58, $ps < 0.05$) with similar but weaker associations for the ASD group ($rs = -0.33$--0.42, $ps < 0.05$). The TD group showed similar associations for all scores except for Contextual Conventions ($r = -0.33$, $p = 0.08$).

Within-group relationships between task behavior durations (task time percentage) and age, cognitive skills, and ASD and ADHD symptom severity are shown in Table 4. For the ASD group, looking at the picture was weakly associated with PRI ($r = 0.26$, $p < 0.05$), looking at the outline showed no significant associations ($ps > 0.05$), looking at and writing on the draft were weakly associated with age ($rs = 0.27$-0.28, $ps < 0.05$) and moderately associated with ADOS-2 Total Score ($rs = -0.28$--0.36, $ps < 0.05$), and looking away from the task was moderately associated with ADOS-2 Total Score ($r = 0.44$, $p < 0.05$). No significant associations were found between behavior durations and FIQ, SRS Total Score, and Conners 3 subscales ($ps > 0.05$). For the ADHD group, looking at the picture was moderately associated with ADOS-2 Total Score and SRS Total Score ($rs = 0.38$-0.40, $ps < 0.05$), looking at the outline showed no significant associations ($ps > 0.05$); looking at and writing on the draft were moderately associated with ADOS-2 Total Score and SRS Total Score ($rs = -0.41$--0.50, $ps < 0.05$), and looking away from the task was moderately associated with SRS Total Score ($r = 0.46$, $p < 0.05$). No significant associations were found between behavior durations and age, VCI, PRI, FIQ, and Conners 3 subscales ($ps > 0.05$). The TD group showed significant associations between age and looking at the picture ($r = -0.47$, $p < 0.05$) and looking at and writing on the draft ($rs = 0.49$-0.50, $ps < 0.05$). No other associations were significant ($ps > 0.05$).

Discussion

This study adopts an exploratory approach to examining differences in visual attention and writing task behaviors during a fictional narrative writing task in children with ASD compared to peers with ADHD and TD children. The largest between-group differences emerged for time spent looking at and writing on the draft, with the ASD group spending the least amount of overall time; in contrast, groups did not differ in time spent looking at the picture, at the

outline, or away from the task. However, the ASD group showed highly variable task behaviors, particularly with looking at and writing on the draft (Figure 1). While group-level estimates suggest limited fixations on particular task components, outliers do appear in the ASD and ADHD groups. Overall, these findings also suggest that the identified lower task engagement durations observed in the ASD group compared to their peers (Zajic et al., 2020b) manifest as differences in time spent engaged with the draft.

The overall low amount of time spent looking at the outline is surprising given the importance of planning (Hayes & Berninger, 2014) and the expectation to use planning during the TOWL-4 assessment. However, overt pre-planning behaviors based off classroom expectations show weaker associations with writing task quality compared to covert planning behaviors (Torrance, 2016). Findings from the Planning stage found that the ADHD group planned less than the ASD and TD groups, though relationships between planning behaviors and writing scores were strongest for the ADHD and TD groups (Zajic et al., 2020a). The low overall reliance on the outline during the Writing stage suggests that participants rely more on the picture than pre-written plans, though it cannot be determined if this is assessment specific. Additional research examining the function and the use of planning during writing assessments is needed, particularly for children with ASD where the existing evidence often comes from intervention rather than descriptive research (see Asaro-Saddler, 2016; Zajic & Wilson, 2020).

While time spent looking away initially appeared elevated in the ASD and ADHD groups, these groups did not appear increasingly disengaged compared to their TD peers after accounting for durations as task time percentage. As attention and broader executive function difficulties are potential factors contributing to writing difficulties in children with ASD and ADHD (Graham et al., 2016; Hilvert, Davidson, & Scott, 2019; Zajic et al., 2018), these findings

suggest that challenges may manifest more at the individual rather than the group level (see Figure 1). It is also important to consider that participants may have been less likely to spend time looking away during this task compared to other writing tasks because of the task picture. Visuals and graphic organizers are effective tools for helping children who struggle with writing difficulties (see Accardo, Finnegan, Kuder, & Bomgardner, 2019), and further research observing visual attention behaviors is needed in tasks with and without these visual components.

Relationships between Task Behaviors, Narrative Writing, and Other Variables of Interest

The ADHD group showed the strongest associations between task behaviors and narrative writing scores, followed by moderate associations in the ASD group. These relationships suggest that spending more time engaged with the draft and less time disengaged was associated with writing higher quality narratives. While this might be expected given the focus of the task is to produce written text, this finding also provides evidence that engaging more with other task components (such as the picture or away from the task altogether) is associated with lower quality writing samples, meaning that engagement difficulties may impact task performance.

An unexpected finding occurred for the ADHD group that showed a negative, moderate-to-strong association between looking at the picture and narrative writing performance. A similar relationship was not observed in the ASD group. One explanation for this finding might be that children in the ADHD group spent more time looking at the picture when they were done writing but before finishing the task (given that they spent more time completing the task compared to the ASD group; Zajic et al., 2020b). Examining this hypothesis found 33 participants fit this profile with a larger representation from the ADHD group but overall low time spent and highly

variable behaviors across groups (see Supplemental Figure 2).

A second explanation for this finding takes into consideration the stronger relationships between task behaviors and narrative writing scores for the ADHD group compared to the ASD group. Findings indicate that time not spent looking at the draft was time spent looking at the picture (which would be negatively related to writing scores given the strong positive relationship for draft engagement). These behaviors may be representative of challenges observed in children with ASD regarding sustained attention for nonpreferred activities as well as the level of attentional impairment varying based on the task (Garretson, Fein, & Waterhouse, 1990; Pascualvaca, Fantie, Papageorgiou, & Mirsky, 1998). Such attentional challenges may also be attributed to differences in attentional impairments seen in children with ASD and ADHD, with the former being more prone to internal distractibility while the latter more prone to external distractibility (see Deprey & Ozonoff, 2018). In this task, internal distractibility may have occurred at the text-production level as children synthesized and organized the visual elements from the picture into a written narrative. External distractibility may be more representative of fixation on less important but more stimulating task components, such as the task picture. Both types of challenges may also occur simultaneously, which also supports why interventions targeting writing self-regulation can be effective for some children with ASD and ADHD (Asaro-Saddler, 2016; Roitsch, Murphy, & Michalek, 2017).

A third explanation related to the second takes into consideration the elevated presence of ASD symptom severity in the ADHD group and elevated ADHD symptom severity in the ASD group. In the ASD and ADHD groups, ASD symptom severity appears moderately associated with looking at the picture, looking at the draft, looking away from the task, and writing on the draft. For the ADHD group (which appeared for both the SRS and ADOS-2), these findings

suggest increased ASD symptom severity to be associated with less engagement with key task components (i.e., draft engagement) and more engagement with less important task components (i.e., looking at the picture). However, this finding may not be due solely to the presence of elevated ASD symptoms given that elevated SRS ratings in children with ADHD may indicate increased oppositional behavior and more general behavior dysregulation (Grzadzinski et al., 2011). More research is needed to understand the comorbidity of ASD and ADHD symptoms (Deprey & Ozonoff, 2018; Pliszka, 2015) and their implications for written language development. This could be especially important given the non-significant relationships observed between ADHD symptom severity and task behaviors in the ASD group yet recent findings highlighting relationships between executive function skills and writing skills in children with ASD (Hilvert et al., 2019).

Other variables of interest showed weaker relationships across groups. IQ appeared predominantly unrelated to task behaviors with only a weak relationship between non-verbal IQ and looking at the picture in the ASD group. While IQ is a generally strong predictor of writing skills (see Keen et al., 2016), these findings suggest that IQ may not be as strongly related to writing task behaviors. Importantly, this suggests that it is not the duration of writing behaviors that may be important but the quality and specific intentions underlying these behaviors. The moderate relationships observed in the TD group and the weak associations in the ASD group for age and task behaviors offers preliminary evidence that observed behaviors may differ across development. Children become increasingly strategic in their writing behaviors as they get older (Graham, 2018; Hayes & Berninger, 2014), but these findings highlight that this relationship may be weaker in children with ASD and ADHD. However, these findings need to be replicated.

Implications

Children with ASD or ADHD who struggle with writing benefit from evidence-based writing practices that provide structure to the writing task environment, including visual organizers and self-management instruction (see Accardo et al., 2019; Asaro-Saddler, 2016; Graham et al., 2016; Pfiffner & DuPaul, 2015; Roitsch et al., 2017). Overall findings suggest that children with ASD and ADHD do not exhibit group-level challenges in engaging with all of the task materials but, instead, may show differences with specific task components.

For children with ASD, challenges focused around engaging strategically and efficiently during the allotted task time, as shown by the ASD group spending less time engaged with the draft compared to their peers with ADHD only when accounting for overall task durations. However, even though accounting for task time resulted in similar findings between the ASD and ADHD groups, the ASD group still showed comparatively weaker relationships between draft engagement and writing scores. This highlights the variability noted in the different task behaviors and suggests the need to attend to the potential quality of these different behaviors during the task. Findings for the ADHD group suggest that children with ADHD may appear more prone to fixating on specific task stimuli. Focusing on approaches that emphasize strategic focus within the task may be helpful, given that children showed less overall task-level engagement challenges. For example, in the context of the TOWL-4, this may involve teaching approaches to use the picture strategically in line with drafting to support the writing process.

In general, findings suggest that meaningful task engagement may be challenging for some children with either ASD or ADHD. For these children, instructional approaches focused on self-regulation during writing that emphasize structuring the writing process may be beneficial (Asaro-Saddler, 2016; Roitsch, Murphy, & Michalek, 2017).

Conclusions

Findings from this exploratory study focused on the task environment highlight important similarities and differences in between-group comparisons and within-group relationships that may help to understand more about the variability observed in the writing skills of children with ASD. Findings also highlight the ongoing need to adopt interdisciplinary perspectives from writing research to consider the underlying factors influencing the writing development of children with ASD as well as ADHD (Graham et al., 2016; Zajic & Wilson, 2020).

Limitations

Several limitations should be considered. First, additional research is needed with larger sample sizes that considers other important individual-level factors (e.g., gender) and adopts more advanced methodological approaches (e.g., eye-tracking). Second, current findings may not generalize to other writing assessments. The TOWL-4 provides a task environment that could be easily observed due to the reliance on a picture-based prompt. As the picture is a visual stimulus, other assessments with no visuals may result in different behavioral engagement (e.g., look away more often, look to the outline more often for planning and ideas, or choose to end the task sooner). Further, findings may differ by genre as narrative text demands differ from persuasive, personal and fictional narrative, and expository text demands (see Price, Martin, Chen, & Jones, 2020; Zajic, Dunn, & Berninger, 2019). These plus other social and physical task environment concerns may be influential contextual variables that affect the measurement of observed behaviors using video observation (Yoder et al., 2018). Third, while participants did not display significant motor impairments, the study did not measure handwriting skills. Children with ASD and ADHD demonstrate elevated risks for handwriting and graphomotor difficulties (e.g., Mayes, Breaux, Calhoun, & Frye, 2019), but few available studies assess transcription and text generation skills simultaneously (Zajic & Wilson, 2020). Poor handwriting skills may lead to

children ending the task sooner due to frustration or to engaging for the full task but composing less advanced text. Some research studies have collected typed rather than handwritten responses (e.g., Brown et al., 2014; Hilvert et al., 2019, 2020), and future research might consider collecting transcription and text generation skills across both modalities. Fourth, the current study did not exhaustively explore relationships between language skills and task behaviors. The VCI estimate for the ASD group was in the average range with only three participants having an estimate lower than 75 (60, 67, and 69), and FIQ and VCI were moderate predictors of narrative writing scores for the ASD and ADHD groups, respectively (see Zajic et al., 2020b). Future research should incorporate language measures into understanding relationships between writing task behaviors and writing skills.

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Table 1

Demographic and Descriptive Information by Group

	ASD (*n* = 60)		ADHD (*n* = 32)		TD (*n* = 29)	
	n	*%*	*n*	*%*	*n*	*%*
Gender[†] (Male, Female)	50, 10	83.3%, 16.7%	25, 7	78.1%, 21.9%	19, 10	65.5%
Race						
Caucasian	38	63.3%	24	75.0%	21	72.4%
Latinx	6	10.0%	1	3.1%	0	0.0%
Asian American	2	3.3%	0	0.0%	1	3.4%
Black/African American	1	1.7%	1	3.1%	0	0.0%
Native Hawaiian/Pacific Islander	0	0.0%	1	3.1%	0	0.0%
Mixed[‡]	8	13.3%	4	12.5%	5	17.2%
Decline to State	2	3.3%	0	0.0%	2	6.8%
Not Specified	3	5.0%	1	3.1%	0	0.0%
Parent Education (Mother, Father)						
Highschool	3, 5	5.1%, 8.3%	3, 5	9.7%, 16.1%	0, 1	0.0%, 3.6%
College	31, 37	52.5%, 61.7%	20, 20	64.5%, 64.5%	19, 15	67.9%, 53.6%
Post-College	25, 18	42.4%, 30.0%	8, 6	25.8%, 19.4%	9, 12	32.1%, 42.9%
School Type						
Private	5	8.3%	3	9.4%	7	24.1%
Public	54	90.0%	27	84.4%	17	58.6%
Homeschool	1	1.7%	2	6.3%	5	17.2%
Percent Time in General Education						
81-100%	40	67.8%	26	81.3%	25	89.3%
61-80%	6	10.2%	2	6.3%	1	3.6%
0-60%	13	22.0%	4	12.5%	2	7.1%
IEP/504 Plan	57	95.0%	19	61.3%	2	6.9%
Other Services[§]	53	93.0%	14	46.7%	1	3.4%

	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*F*	*p*
Age	12.63	2.11	9.33-17.17	13.13	2.30	9.64-17.31	12.74	2.29	9.35-17.02	0.55	0.58
WASI-II VCI	95.92	15.48	60-136	98.84	14.33	72-128	111.24	13.79	81-138	10.72	< 0.01
WASI-II PRI	102.25	16.86	70-150	99.94	15.81	74-126	116.83	14.14	91-160	10.44	< 0.01
WASI-II FIQ	98.73	15.13	73-132	99.31	15.00	74-131	115.62	12.82	90-150	14.46	< 0.01
ADOS-2	10.75	3.61	7-24	4.14	3.81	0-13	-[¶]	-[¶]	-[¶]	62.80	< 0.01
SRS	82.49	10.24	52-91	61.29	14.66	42-91	43.69	7.5	34-66	127.01	< 0.01
Conners 3 Inatten	73.97	11.19	50-90	77.63	10.57	54-90	46.9	10.67	35-90	75.60	< 0.01
Conners 3 Hyper	71.40	15.52	39-90	71.13	17.27	40-90	47.14	8.93	38-73	29.58	< 0.01

Note. ASD = autism spectrum disorder. ADHD = attention-deficit/hyperactivity disorder. TD = typically developing. IEP = Individualized Education Program. WASI-II = Wechsler Abbreviated Scale of Intelligence, 2nd Edition. VCI = Verbal Comprehension Index. PRI = Perceptual Reasoning Index. FIQ = Full-Scale IQ. ADOS-2 = Autism Diagnostic Observation Schedule, 2nd Edition. SRS = Social Responsiveness Scale. Inatten = Conners 3 Inattentive Symptoms Parent-Report Subscale. Hyper = Conners 3 Hyperactivity/Impulsivity Symptoms Parent-Report Subscale. Descriptive information reprinted with permission from Zajic et al. (2020a).

[†]$\chi^2(2) = 3.59$, $p = 0.17$.

[‡]Mixed includes the following groups: Caucasian and Latinx (ASD: 3, 5%; ADHD: 2, 6.3%; TD: 2, 7.4%), Caucasian and Asian American (ASD: 2, 3.3%; ADHD: 0, 0%; TD: 2, 7.4%), Caucasian and Black/African American (ASD: 2, 3.3%; ADHD: 1, 3.1%; TD: 0, 0%), Caucasian and Native Hawaiian/Pacific Islander (ASD: 1, 1.7%; ADHD: 0, 0%; TD: 0, 0%), Caucasian and Native American (ASD: 0, 0%; ADHD: 1, 3.1%; TD: 0, 0%), and Latinx and Asian American (ASD: 0, 0%; ADHD: 0, 0%; TD: 1, 3.7%).

[§]Other services includes speech (ASD: 43, 75.4%; ADHD: 2, 6.7%; TD: 0, 0%), occupational therapy (ASD: 19, 33.3%; ADHD: 4, 13.3%; TD: 0, 0%), applied behavior analysis (ASD: 6, 10.5%; ADHD: 0, 0%; TD: 0, 0%), resource room (ASD: 25, 43.9%; ADHD: 12, 40%; TD: 1, 3.4%), social skills (ASD: 25, 43.9%; ADHD: 3, 10.0%; TD: 0, 0%), and personal aide (ASD: 21, 36.8%; ADHD: 2, 6.7%; TD: 0, 0%).

[¶]The TD group did not receive the ADOS-2.

Table 2

Means, Standard Deviations, Adjusted Means, and Standard Errors for Mixed ANCOVA Results for Visual Attention and Writing Task Behaviors by Group

	ASD	ADHD	TD			
Duration (s)	*M (SD)*	*M (SD)*	*M (SD)*			
Looking at the Picture	85.86 (69.94)	96.64 (64.12)	87.42 (41.67)			
Looking at the Outline	6.15 (11.97)	4.49 (14.34)	6.65 (11.00)			
Looking at the Draft	328.49 (149.37)	400.93 (134.33)	487.06 (69.37)			
Looking Away	36.57 (37.83)	36.75 (44.16)	11.48 (15.26)			
Writing on the Draft	274.31 (136.95)	339.14 (127.83)	443.85 (77.92)			
	M_{adj} *(SE)*	M_{adj} *(SE)*	M_{adj} *(SE)*	*F*	*p*	η_p^2
Looking at the Picture	89.65 (8.12)	99.90 (10.98)	76.00 (12.46)	0.99	0.38	0.02
Looking at the Outline	5.59 (1.62)	4.00 (2.20)	8.36 (2.49)	0.82	0.44	0.01
Looking at the Draft	337.79 (16.74)	408.96 (22.64)	458.95 (25.69)	8.32	< 0.001	0.12
Looking Away	35.91 (4.73)	36.18 (6.40)	13.47 (7.26)	3.49	0.03	0.06
Writing on the Draft	281.80 (15.90)	345.60 (21.51)	421.23 (24.40)	11.21	< 0.001	0.16
Duration (Task Time %)	*M (SD)*	*M (SD)*	*M (SD)*			
Looking at the Picture	17.69 (11.93)	18.13 (11.27)	14.73 (6.51)			
Looking at the Outline	1.83 (5.43)	0.79 (2.51)	1.07 (1.76)			
Looking at the Draft	69.31 (18.88)	72.36 (19.12)	82.04 (8.25)			
Looking Away	9.62 (14.01)	7.47 (11.01)	2.01 (2.76)			
Writing on the Draft	58.63 (20.04)	60.93 (18.63)	74.78 (10.68)			
	M_{adj} *(SE)*	M_{adj} *(SE)*	M_{adj} *(SE)*	*F*	*p*	η_p^2
Looking at the Picture	18.09 (1.41)	18.47 (1.90)	13.52 (2.16)	1.74	0.18	0.03
Looking at the Outline	1.60 (0.54)	0.59 (0.73)	1.77 (0.82)	0.79	0.46	0.01
Looking at the Draft	69.75 (2.25)	72.74 (3.04)	80.71 (3.45)	3.30	0.04	0.05
Looking Away	9.12 (1.50)	7.04 (2.03)	3.51 (2.31)	1.96	0.15	0.03
Writing on the Draft	58.86 (2.36)	61.14 (3.19)	74.07 (3.62)	5.88	0.004	0.09

Note. ASD = autism spectrum disorder. ADHD = attention-deficit/hyperactivity disorder. TD = typically developing. Uncentered FIQ covariate = 102.93.

Table 3

Within-Group Correlation Coefficients Between Visual Attention and Writing Task Behaviors (Task Time Percentage) and TOWL-4 Writing Scores

	Spontaneous Writing Index	Contextual Conventions	Story Composition	Word Count
ASD				
Looking at Picture	-0.18	-0.14	-0.20	-0.18
Looking at Outline	-0.07	-0.01	-0.10	-0.07
Looking at Draft	0.45**	0.36**	0.47**	0.49**
Looking Away	-0.40**	-0.33**	-0.41**	-0.42**
Writing on Draft	0.48**	0.42**	0.47**	0.49**
ADHD				
Looking at Picture	-0.66**	-0.53**	-0.62**	-0.60**
Looking at Outline	-0.19	-0.15	-0.19	-0.10
Looking at Draft	0.77**	0.65**	0.71**	0.67**
Looking Away	-0.58**	-0.48**	-0.55**	-0.44*
Writing on Draft	0.80**	0.68**	0.74**	0.74**
TD				
Looking at Picture	-0.17	-0.07	-0.22	-0.28
Looking at Outline	0.33	0.31	0.28	0.24
Looking at Draft	0.22	0.10	0.28	0.32
Looking Away	-0.45*	-0.33	-0.46*	-0.38*
Writing on Draft	0.16	0.04	0.24	0.35

*$p < 0.05$, **$p < 0.01$.

Note. ASD = autism spectrum disorder. ADHD = attention-deficit/hyperactivity disorder. TD = typically developing. TOWL-4 = Test of Written Language, 4th Edition.

Table 4

Within-Group Correlation Coefficients Between Visual Attention and Writing Task Behaviors (Task Time Percentage) and Age, Cognitive Skills, and Symptom Severity

	Age	VCI	PRI	FIQ	ADOS-2	SRS	Hyper	Inatten
ASD								
Looking at Picture	-0.17	0.04	0.26*	0.17	0.01	-0.06	0.13	0.02
Looking at Outline	-0.07	-0.19	-0.23	-0.25	0.00	0.05	-0.02	-0.04
Looking at Draft	0.28*	0.23	-0.05	0.10	-0.36**	-0.08	-0.11	-0.04
Looking Away	-0.16	-0.24	0.00	-0.13	0.44**	0.12	0.04	0.05
Writing on Draft	0.27*	0.11	-0.15	-0.03	-0.28*	0.00	-0.08	-0.03
ADHD								
Looking at Picture	-0.22	-0.11	0.30	0.12	0.40*	0.38*	0.27	-0.05
Looking at Outline	0.21	-0.24	-0.04	-0.15	0.09	-0.06	0.15	-0.01
Looking at Draft	0.33	0.29	-0.16	0.07	-0.43*	-0.50**	-0.26	0.07
Looking Away	-0.27	-0.33	-0.07	-0.22	0.32	0.46**	0.15	-0.04
Writing on Draft	0.30	0.33	-0.08	0.13	-0.41*	-0.47**	-0.28	0.04
TD								
Looking at Picture	-0.47*	-0.18	0.15	-0.03	-†	-0.21	-0.26	-0.26
Looking at Outline	-0.21	-0.05	0.10	0.04	-†	0.01	-0.24	-0.06
Looking at Draft	0.50**	0.24	-0.09	0.10	-†	0.16	0.28	0.23
Looking Away	-0.21	-0.25	-0.10	-0.21	-†	0.00	-0.10	-0.03
Writing on Draft	0.49**	0.20	0.12	0.20	-†	0.12	0.19	0.09

*$p < 0.05$, **$p < 0.01$.

Note. VCI = Verbal Comprehension Index. PRI = Perceptual Reasoning Index. FIQ = Full-Scale IQ. ADOS = Autism Diagnostic Observation Schedule, 2nd Edition. SRS = Social Responsiveness Scale. Inatten = Conners 3 Inattentive Symptoms. Hyper = Conners 3 Hyperactivity/Impulsivity Symptoms.

†The ADOS-2 was not administered to the TD group.

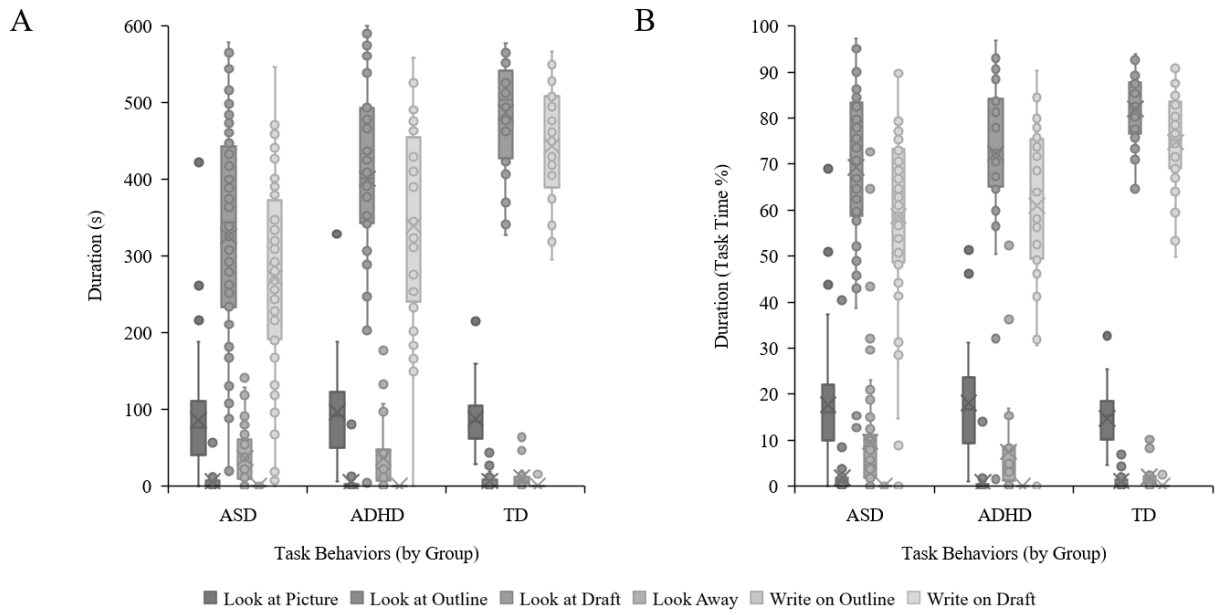
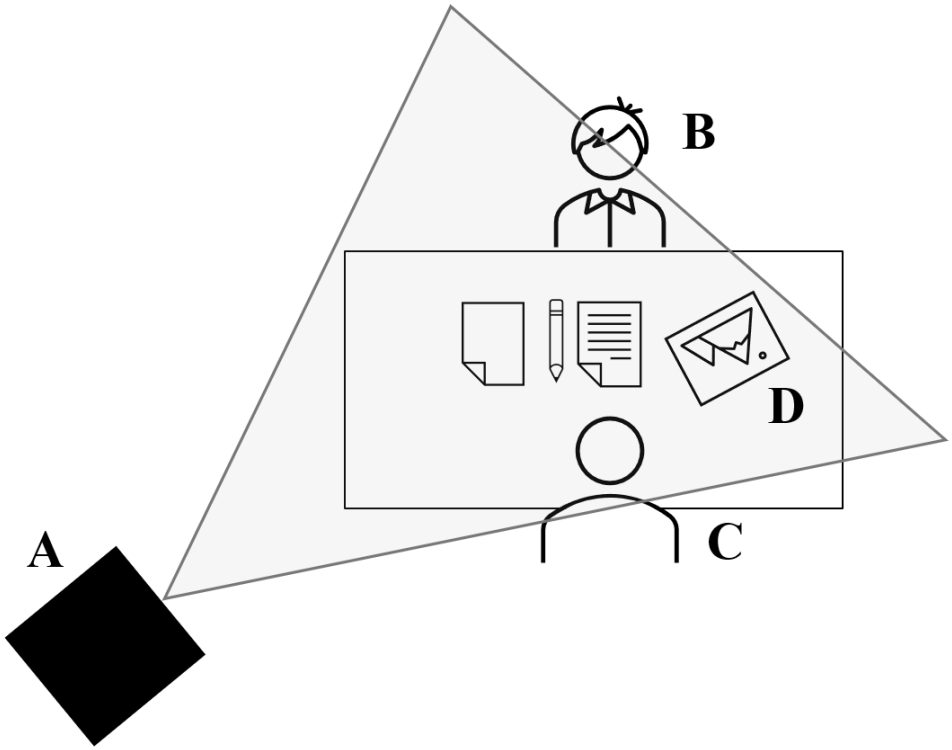
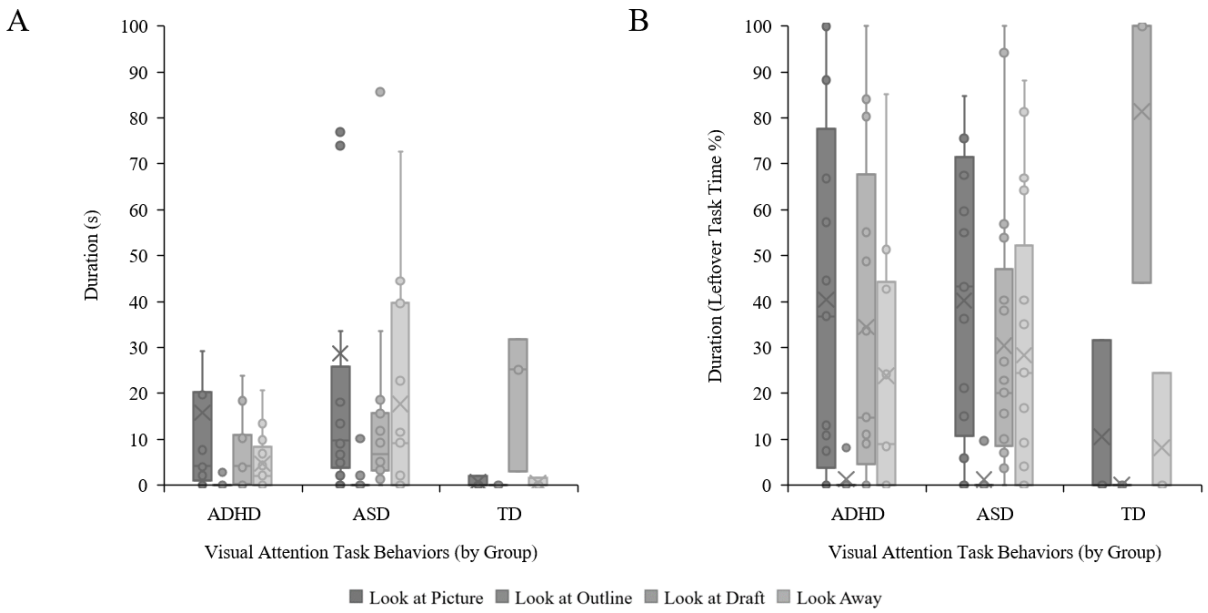


Figure 1. Boxplots showing visual attention and physical writing behavior durations for each group calculated as duration in seconds (A) and as a percentage of task time (B). Individual data points are represented by a circle, means are represented by a cross, and medians are represented by a horizontal line.



Supplemental Figure 1. A visual representation of the assessment space showing the camera and its viewing range (A) in relation to the participant (B), the research team member (C), and the task materials (D). While reading the task instructions, the research team member was present at the table. While the participant completed their writing after listening to the task instructions, the research team member removed themselves from the table and the immediate area. Figure made using icons from Microsoft PowerPoint.



Supplemental Figure 2. Boxplots showing visual attention task behavior durations for participants who continued to engage visually with the task after finishing their last instance of writing on the draft but before having completed the task. Individual data points are represented by a circle, means are represented by a cross, and medians are represented by a horizontal line. These figures contain 33 participants with a higher proportional representation from the ADHD group (n = 13, 41%) compared to the ASD (n = 17; 28%) and TD groups (n = 3, 10%; $\chi^2(2) = 7.10$, $p = 0.03$). Task behavior durations are calculated in seconds (A) and as a percentage of leftover task time (B).