Functional Handwriting Performance in School-Age Children With Fetal Alcohol Spectrum Disorders

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MeSH TERMS

- fetal alcohol syndrome
- handwriting
- prenatal exposure delayed effects
- psychomotor performance

Handwriting is a critical skill for school success. Children with fetal alcohol spectrum disorders (FASD) often present with fine motor and visual-motor impairments that can affect handwriting performance, yet handwriting skills have not been systematically investigated in this clinical group. This study aimed to comprehensively describe handwriting skills in 20 school-age children with FASD. Children were tested with the Process Assessment of the Learner, 2nd Edition (PAL-II), and the Visuomotor Precision subtest of NEPSY, a developmental neuropsychological assessment. Participants performed below average on PAL-II measures of handwriting legibility and speed and on NEPSY visual-motor precision tasks. In contrast, PAL-II measures of sensorimotor skills were broadly within the average range. Results provide evidence of functional handwriting challenges for children with FASD and suggest diminished visual-motor skills and increased difficulty as task complexity increases. Future research is needed to further describe the prevalence and nature of handwriting challenges in this population.

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Occupational therapists view the occupational performance of children within the context of age-appropriate self-care, play, and school tasks (American Occupational Therapy Association, 2008). The functional use of written communication is a critical component of participation in school-based activities. Handwriting is often the primary method that school-age children use to demonstrate knowledge, participate in learning tasks, and transcribe written narratives. Therefore, it is critical to understand the nature of handwriting difficulties for children who are at risk for handwriting dysfunction.

It has been estimated that elementary school-age students may spend up to one-quarter to one-half of their school day engaged in paper-and-pencil tasks, which include handwriting (McHale & Cermak, 1992). Difficulties with handwriting thus can adversely affect many aspects of a child's classroom participation. For example, poor handwriting can increase frustration with and avoidance of classroom tasks, thereby negatively influencing behavior (Kern & Bambara, 2002). Decreased legibility and quality of handwritten text can affect a teacher's perceptions of written content and of the student's academic knowledge, which may result in lower grades (Cahill, 2009). Also important is that the ability to use handwriting for composition in the early grades has been identified as a critical factor in solidifying skills such as symbol memory and retrieval, which are important to literacy development and composition proficiency (Berninger, 2009; Berninger, Abbott, Augsburger, & Garcia, 2009).

Children with fetal alcohol spectrum disorders (FASD) often exhibit fine motor and visual-motor difficulties that place them at risk for handwriting dysfunction (Adnams et al., 2001; Jirikowic, Olson, & Kartin, 2008). An estimated

0.2–1.5 in 1,000 newborns are diagnosed with the full fetal alcohol syndrome (FAS), and the prevalence of all diagnoses grouped under the umbrella term of FASD is as much as 5 times greater (May & Gossage, 2001). Sensorimotor impairments, including decreased visual–motor abilities and persistent fine motor delays, have been widely described in children and adults affected by prenatal alcohol exposure (Adnams et al., 2001; Connor, Sampson, Streissguth, Bookstein, & Barr, 2006; Jirikowic et al., 2008; Kalberg et al., 2006). For children with FASD, however, these impairments have not been examined in the context of functional handwriting. This absence is surprising, given clinical and anecdotal reports of handwriting dysfunction and the importance of these foundational sensorimotor skills for writing success (Benbow, 2006; Berninger & Rutberg, 1992; Weil & Amundson, 1994).

Poor handwriting and challenges with fine motor skills in the classroom are among the most common reasons children are referred to occupational therapists in school-based settings (Chandler, 1994). Information that identifies risk factors and describes the nature of handwriting dysfunction among children with neurodevelopmental disabilities serves as an important guide for assessment, therapeutic intervention, and classroom accommodations. To that end, the purpose of this study was to comprehensively describe the performance of children with FASD on measures of handwriting legibility, speed of written production, visual–motor control, and sensorimotor performance as related to functional handwriting skills. We addressed three research questions:

1. How do school-age children with FASD score on measures of handwriting legibility, specifically the Handwriting Total Automatic Letter Legibility Composite and the Handwriting Total Legibility Composite of the Process Assessment of the Learner, 2nd Edition (PAL–II; Berninger, 2007)?
2. How do school-age children with FASD score on a measure of speed of handwriting production, specifically the Handwriting Total Time Composite of the PAL–II (Berninger, 2007)?
3. How do school-age children with FASD score on measures of sensorimotor performance and motor control, specifically the Finger Sense subtests of the PAL–II (Berninger, 2007) and the NEPSY Visuomotor Precision subtest (Korkman, Kirk, & Kemp, 1998)?

Method

Research Design

The study described in this article was a descriptive substudy of handwriting function in children with FASD

who were participants in a larger study that examined the efficacy of the Families Moving Forward (FMF) Program. The FMF Program is a tailored behavioral consultation intervention designed for families raising preschool- and school-age children with FASD who show high levels of externalizing behavior problems. The larger study had several aspects, including a small training study; a larger intervention study; and several descriptive substudies, including the present handwriting study. The institutional review boards of a children's research institute and a state department of social and health services (for foster children) approved and monitored all aspects of the study. All participating caregivers and caseworkers (when applicable) consented, and all children assented. Study researchers also met regulations required by the Health Insurance Portability and Accountability Act (45 C.F.R. § 164.102 *et seq.*, 2007).

Participants

Participants enrolled in the larger study were recruited from an FASD clinical database, and all had a diagnosis within the umbrella category of FASD. The database contains data on a clinical population of patients with confirmed prenatal alcohol exposure systematically diagnosed by an interdisciplinary team (Astley & Clarren, 2000; Clarren, Carmichael-Olson, Clarren, & Astley, 2000) using the *FASD Four-Digit Diagnostic Code*, which is a rigorously defined and validated diagnostic system (Astley, 2004; Astley et al., 2009a, 2009b). The four digits of the code reflect the magnitude of expression of the four key diagnostic features of FASD: (1) growth deficiency, (2) facial features, (3) central nervous system damage or dysfunction, and (4) maternal alcohol consumption during pregnancy. The magnitude of expression of each feature is ranked independently on a 4-point Likert scale ranging from 1 = *complete absence of the FAS feature* to 4 = *strong classic presence of the FAS feature*. Every four-digit diagnostic code is grouped into a set of distinct clinical diagnostic categories, including the following that fall under the designation of FASD:

- FAS/alcohol-exposed
- FAS/alcohol exposure unknown
- Partial FAS/alcohol-exposed
- Static encephalopathy/alcohol-exposed
- Neurobehavioral disorder/alcohol-exposed.

See Astley (2004) for a full explanation of the FASD Four-Digit Diagnostic Code, including diagnostic methods and categories, and Astley (2010) for a comprehensive profile of the clinical population.

In addition to presence of FASD, study inclusion criteria included clinically concerning behavior problems. Children were aged 4–12 yr at enrollment; spoke English; were of any gender, ethnicity, or socioeconomic status; and lived within a large geographic catchment area that allowed in-home intervention services. Children lived with their birth, adoptive, or foster family or with a legal guardian. Children had to have lived with their current family for at least 4 mo at enrollment, and the caregiver had to indicate willingness to continue caregiving for at least 18 mo after study enrollment. Children with diagnosed psychotic disorders, behavior problems (e.g., serious, repetitive fire setting) beyond the scope of the FMF intervention, other birth defects leading to cognitive impairment, or uncorrected significant hearing or vision problems were excluded. Families with a primary caregiver who reported current hazardous alcohol use were also excluded. Although all children initially recruited into the larger study had an FASD and met the inclusion and exclusion criteria, no parameter related to handwriting function or academic achievement was considered, and the intervention did not focus on any aspect of handwriting or sensorimotor function.

Of the 36 participants in various aspects of the larger study, 22 met one additional inclusion criterion for this substudy of handwriting function: entering or being enrolled in Grades 1–6. Grade placement was defined as the child's grade at the time of follow-up testing, when the data for the current substudy were collected. For children tested in the summer, grades were determined using a July 1 cutoff; if a child was tested on or after July 1, the child was considered to be in the next grade. Of the 22 children enrolled in the handwriting substudy, 1 was unable to meaningfully participate in the study measures because of significant cognitive delays and was dropped. Another child was dropped because the child's diagnosis (i.e., four-digit diagnostic code) did not fall in a category that met substudy inclusion criteria.

Procedures

As part of the larger study, participants and their caregivers were administered a comprehensive battery of standardized assessments at baseline and follow-up. Data for the current substudy were collected by adding two handwriting and sensorimotor assessments to the follow-up test battery. Three examiners administered the follow-up test battery, including the handwriting substudy assessments. The examiners were enrolled in graduate study programs in school psychology or clinical psychology. They had extensive child assessment experience and were trained and supervised in the larger study assessment battery and the

handwriting substudy tests by a licensed school psychologist and a licensed clinical psychologist. The examiners were trained by reading the study protocol and test manuals, observing test administrations, and completing the full battery on three or more prestudy pilot test participants.

Instruments

Process Assessment of the Learner, Second Edition. The PAL–II measures a variety of reading, writing, and math processes for children in kindergarten to Grade 6 (K–6). The PAL–II handwriting tasks include Alphabet Writing, in which the child is asked to print the alphabet in lowercase in alphabetic order as quickly and accurately as possible; Copying Task A, in which the child is asked to copy a sentence in manuscript as quickly and accurately as possible; and Copying Task B, in which the child is asked to copy a short paragraph as quickly and accurately as possible. Subtest scaled scores measuring speed of production and legibility are derived independently for each task. Three summary scores—Handwriting Total Automatic Letter Legibility Composite, Handwriting Total Letter Legibility Composite, and Handwriting Total Time Composite—are generated from the subtest scaled scores. PAL–II subtest and composite scaled scores are derived from normative data and have a mean of 10 and a standard deviation of 3.

The PAL–II also includes subtests that assess sensorimotor skills involving the coordination of finger movements and tactile perception, which are important sensorimotor foundations for handwriting performance. These Finger Sense subtests include Finger Repetition, in which the child touches the index finger rapidly to the thumb 20 times; Finger Succession, in which the child touches each of the four fingers in succession to the thumb for five repetitions; and Fingertip Writing, in which the examiner traces letters onto the child's fingertips with a blunt stylus while the child's vision is occluded. All Finger Sense subtests are performed on both hands.

Test–retest stability coefficients for PAL–II norms for Grades K–3 derived using the Pearson product-moment correlation were .54 for the Handwriting Total Automatic Letter Legibility Composite, .78 for the Handwriting Total Letter Legibility Composite, and .75 for the Handwriting Total Time Composite. For Grades 4–6, test–retest stability coefficients were .62 for the Handwriting Total Automatic Letter Legibility Composite, .54 for the Handwriting Total Letter Legibility Composite, and .64 for the Handwriting Total Time Composite. Test–retest reliabilities for the Finger Sense subtests

ranged from .67 to .78. For Grades K–6, average internal consistency reliability coefficients, calculated with a Fisher's z transformation, ranged from .72 to .81 for the handwriting composite scores and .69 to .74 for the Finger Sense subtests.

NEPSY. The NEPSY developmental neuropsychological assessment is a comprehensive assessment that evaluates children aged 3–12 yr in the areas of attention and executive function, language, memory and learning, social perception, sensorimotor processing, and visual–spatial processing. The Visuomotor Precision subtest from the NEPSY was included in this test battery to measure the child's visual–motor coordination and ability to use a pencil with speed and precision in a nonwriting task. For the Visuomotor Precision subtest, the child uses his or her preferred hand to draw a line between two outlines through a series of shaped, narrow pencil paths. The child's product is scored for accuracy on the basis of number of errors observed (e.g., child's line crossing over the parallel line for every marked interval on the record form). NEPSY scaled scores are derived from normative data and have a mean of 10 and a standard deviation of 3.

The NEPSY has evidence of content validity and sound test structure. For the Visuomotor Precision subtest for children aged 5–12 yr, internal consistency has been reported at .68, average test–retest stability coefficient at $r = .56$, and interrater reliability at $r = .99$.

Observation of Grasp and Hand Function

The examiner observed and recorded each child's hand preference during the performance of writing tasks. The examiner also recorded the child's grasp pattern with a standard Number 2 pencil using visual diagrams for scoring and descriptions of the following grasp patterns: palmar supinated grasp, digital pronated grasp, static tripod grasp, and dynamic tripod grasp.

Interrater Agreement

The written portions of the PAL–II were scored by the first author (Duval-White), who has 10 yr of experience with handwriting assessment and intervention. Interrater agreement for scoring the PAL–II handwriting samples was completed in two stages. First, to establish interrater agreement before scoring protocols from the study sample, the PAL–II handwriting tasks were administered to a convenience sample of six children with typical development in Grades K–6. These training sample protocols were scored by the first author and a second independent rater who was an experienced pediatric occupational therapist enrolled in a doctoral training pro-

gram. The interrater agreement for the training sample was 80% for the Handwriting Total Automatic Letter Legibility composite and 58% for the Handwriting Total Legibility Composite.

After the two raters further discussed the rating guidelines and specific situations that occurred when rating protocols for the training sample, data collection began for the study sample. To check interrater agreement for the study sample, the first author and the second rater independently scored six protocols from the study sample chosen using a stratified random approach. Interrater agreement for the study sample was 77% for the Automatic Letter Legibility composite and 78% for the Total Letter Legibility composite.

Results

The final handwriting substudy sample consisted of 20 children aged 7.1–13.0 yr (mean [M] = 9.5 yr, standard deviation [SD] = 1.8). The average full-scale IQ of the participants, determined with the Differential Ability Scales—2nd Edition (Elliot, 2007), assessed at baseline approximately 18 mo before this assessment, ranged from 65 to 107 ($M = 88.2$, $SD = 12.2$). The mean IQ of this sample was in the low average range, but the sample included children with IQ scores that reflected well below average to average cognitive abilities. Scores from all measures were reported as valid. Additional participant characteristics are outlined in Table 1.

Descriptive statistics for the PAL–II handwriting legibility and speed composite scores and task scaled scores are presented in Table 2. The mean scores for this sample of children with FASD were well below average on both Handwriting Automatic Letter Legibility and Handwriting Total Letter Legibility Composite scores and below average for the Handwriting Total Time Composite. This group of children had poorer performance than the PAL–II normative sample across all three writing tasks, which included Alphabet Writing (single letter production from memory), Copying Task A (copying a sentence), and Copying Task B (copying a short paragraph). Handwriting speed and accuracy also decreased with task complexity, with the highest mean score seen on Alphabet Writing total time and the lowest mean score seen on Copying Task B legibility at 90 s. Figure 1 illustrates the distribution of the PAL–II handwriting legibility and speed outcomes for the sample.

Descriptive statistics for PAL–II motor control and sensorimotor subtests and the NEPSY Visuomotor Precision subtest are reported in Table 3. The mean score for the Finger Sense subtests was well within the normal

Table 1. Participant Characteristics (*N* = 20)

Characteristic	<i>n</i> (%)
Sex	
Female	6 (30)
Male	14 (70)
Race	
White	14 (70)
African American	1 (5)
Mixed race or ethnicity	5 (25)
Grade in school	
1	3 (15)
2	7 (35)
3	2 (10)
4	3 (15)
5	3 (15)
6	2 (10)
Educational program	
General education with special education services	11 (55)
Special needs classroom	5 (25)
General education (no special education services)	4 (20)
Four-digit diagnostic code	
Fetal alcohol syndrome (alcohol-exposed)	1 (5)
Partial fetal alcohol syndrome (alcohol-exposed)	2 (10)
Static encephalopathy (alcohol-exposed)	4 (20)
Neurobehavioral disorder (alcohol-exposed)	13 (65)
Additional diagnoses ^a	
Attention deficit hyperactivity disorder	16 (80)
Intellectual disability	6 (30)
Speech or language delay	8 (40)

^a*n* = 19; children could have more than one additional diagnosis.

range compared with test norms for the PAL–II Finger Sense subtests of Finger Repetition and Finger Succession on both dominant and nondominant hands, and it was within the average range for the Fingertip Writing subtest. In contrast, the mean score for the NEPSY Visuo-motor Precision subtest was well below average compared with test norms. Figure 1 illustrates the distribution of the sensorimotor scores on the PAL–II and NEPSY.

When completing testing tasks, 18 of the children held the pencil in their right hand and 2 held the pencil in their left hand. Eighteen children used a dynamic tripod grasp (three digits in contact with the pencil, with movement at the distal fingertips while writing), and 2 used a static tripod grasp (three digits in contact with the pencil, with no movement at the distal fingertips while writing).

Discussion

This study is the first to comprehensively describe functional handwriting skills in school-age children with FASD. The children with FASD in this sample demonstrated clear challenges with handwriting legibility across

Table 2. Results for Handwriting Legibility and Speed Composite Scores and Scaled Scores

PAL–II Scores	<i>n</i> ^a	<i>M</i>	<i>Mdn</i>	Min	Max	<i>SD</i>
Composite scores						
Automatic Letter Legibility	18	5.06	4.00	1	11	2.99
Total Letter Legibility	20	4.90	5.50	1	9	2.75
Handwriting Total Time	20	7.95	7.00	1	15	3.80
Task scaled scores						
Alphabet Writing						
Automatic Legible Letter Writing	17	7.06	7.00	3	13	2.86
Legible Letter Writing	20	5.95	6.00	1	11	2.67
Total Time	20	8.20	7.50	1	16	4.66
Copying Task A						
Automatic Legible Letter Writing	19	5.53	5.00	1	11	2.43
Legible Letter Writing	19	6.05	6.00	1	12	3.74
Total Time	19	7.26	7.00	1	13	3.33
Copying Task B						
Legible Letter Writing at 30 s	20	6.30	6.00	1	13	2.56
Legible Letter Writing at 60 s	20	6.10	6.50	1	14	3.08
Legible Letter Writing at 90 s	20	5.20	6.00	1	12	3.07
Copy Accuracy	20	5.70	6.50	1	14	3.29

Note. *M* = 10, *SD* = 3 for scaled scores on the PAL–II. *M* = mean; max = maximum score; *Mdn* = median; min = minimum score; PAL–II = Process Assessment of the Learner, 2nd Edition; *SD* = standard deviation.

^aSample size varies because of missing data.

alphabet, sentence, and paragraph writing tasks and during performance of visual–motor tasks requiring motor accuracy and precision. Handwriting speed also was below average, with both speed and accuracy decreasing as tasks progressed in difficulty from simple alphabet writing to paragraph copying. In contrast, basic sensorimotor functioning as measured by the PAL–II Finger Sense subtests (i.e., finger tapping and thumb–finger touching speed) was generally within age expectations. Results indicate that children with FASD are at risk for handwriting dysfunction and that the nature of their handwriting performance difficulties may not be fully explained by impairments in foundational sensorimotor components.

In this study, only about one-third of the children with FASD demonstrated letter writing legibility within the average range compared with PAL–II test norms. Although legibility challenges were seen across different writing tasks, in general the participants performed best on the task requiring single-letter alphabet writing from memory. Poorer performance was seen on tasks involving near-point copying of a sentence and near-point copying of a short paragraph of text. Among children with FASD, as among children with typical development, difficulties with legible letter writing can compromise the ability of educators and peers to accurately assess the content and quality of written work. This difficulty, in turn, may negatively influence others' perceptions of the child's effort

Figure 1. Distribution of scores of children with FASD on the PAL-II and NEPSY.

Note. Average = scores ± 1 *SD* from the mean; below average = scores between 1 *SD* and 2 *SD* below the mean; substantially below average = scores ≥ 2 *SD* below the mean. D = dominant hand; FASD = fetal alcohol spectrum disorders; ND = nondominant hand; NEPSY = developmental neuropsychological assessment; PAL-II = Process Assessment of the Learner, 2nd Edition; *SD* = standard deviation.

and actual content knowledge as well as grades earned (Cahill, 2009).

The children in this sample also demonstrated functional impairments in the speed of written production across handwriting tasks, but to a lesser degree than in

legibility. The poorest performance was seen on paragraph copying over time, which suggests difficulty with sustained legible letter production and a trade-off prioritizing speed over accuracy. Children who consistently show impairments in speed of written production are likely to have

Table 3. Results for Measures of Motor Control and Sensorimotor Processing

Measure	<i>n</i> ^a	<i>M</i>	<i>Mdn</i>	Min	Max	<i>SD</i>
PAL-II						
Finger Repetition, Dominant Hand, Total Time	19	11.58	12.00	7	15	2.50
Finger Repetition, Nondominant Hand, Total Time	19	11.37	11.00	7	17	2.39
Finger Succession, Dominant Hand, Total Time	19	10.95	11.00	7	14	2.22
Finger Succession, Nondominant Hand, Total Time	19	10.95	11.00	8	14	1.93
Fingertip Writing	20	8.30	9.00	5	11	1.95
NEPSY						
Visuomotor Precision	20	6.45	6.50	2	11	2.82

Note. *M* = 10, *SD* = 3, for scaled scores on the PAL-II and NEPSY. *M* = mean; max = maximum score; *Mdn* = median; min = minimum score; NEPSY = developmental neuropsychological assessment; PAL-II = Process Assessment of the Learner, 2nd Edition; *SD* = standard deviation.

^aSample size varies because of missing data.

difficulties with classroom tasks that involve taking dictation, keeping pace during timed tests or quizzes, and producing longer written compositions (Weil & Amundson, 1994; Ziviani & Wallen, 2006).

In contrast to handwriting performance, the majority of children with FASD demonstrated performance within the average range on PAL–II sensorimotor tasks. This finding was unexpected given previous reports of fine motor and visual–motor difficulties in this population (Adnams et al., 2001; Jirikowic et al., 2008). The assessment of sensorimotor function in this study included finger tapping speed, speed of sequential thumb–finger movements, and mental mapping of tactile input. The ability to accurately perform these basic hand and finger movements has been identified as an important motor foundation for handwriting (Berninger & Rutberg, 1992). However, in combination with clinical observations of the participants’ grasp patterns and hand dominance that were relatively typical for age, these results suggest that foundational sensorimotor impairments may not be a primary barrier to efficient and fluent handwriting performance for many children with FASD.

Relative to performance on the PAL–II Finger Sense subtests, the children’s performance on the NEPSY Visuomotor Precision subtest (Korkman et al., 1998) was much poorer. The mean scaled scores for the PAL–II Finger Succession and Finger Repetition subtests were 11.5 and 10.9, respectively, compared with a mean scaled score of 6.2 for the NEPSY Visuomotor Precision subtest. This finding shows that the performance of the children with FASD declined as the complexity of the task increased from speed of simple finger movements to the coordination of hand function, tool use, attention, and visual–motor abilities. Findings suggest that compromised visual–motor integration may be a contributing factor to the handwriting difficulties of children with FASD.

Visual–motor impairments and greater difficulty performing complex tasks are challenges that have also been found in other studies of children with FASD (Kodituwakku, 2007, 2009; Mattson, Crocker, & Nguyen, 2011). Additionally, our findings are congruent with results from a study that examined the relationship between sensorimotor skills, visual–motor integration, and handwriting in a diverse sample of children with learning or behavioral disabilities or both (Klein, Guiltner, Sollereder, & Cui, 2011). The researchers found that although sensorimotor skills explained little of the variance in handwriting proficiency, visual–motor integration was a significant predictor in classifying children as either “skilled” or “unskilled” handwriters.

The handwriting challenges demonstrated by the children with FASD in this study are similar to those described among children with attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD; Racine, Majnemer, Shevell, & Snider, 2008). Racine et al. (2008) reported that children with ADD or ADHD showed decreased legibility or inappropriate speed of execution, or both, when compared with the performance of children without ADD or ADHD. Although it is not known whether Racine et al.’s sample included children with prenatal alcohol exposure, the majority (80%) of children with FASD in the current study also met criteria for ADD or ADHD by caregiver report, consistent with other clinical samples of children affected by prenatal alcohol exposure (Mattson et al., 2011). This finding suggests that attention problems, as in children with ADD or ADHD, may significantly affect handwriting performance in children with FASD, even though the type of attention deficit in the two clinical populations differs (Vaurio, Riley, & Mattson, 2008).

Further, in this sample 40% of the children had a reported speech or language impairment. Thus, the challenges seen in functional handwriting performance among these children could also be attributable, in part, to language problems, which commonly occur among children with FASD (Coggins, Timler, & Olswang, 2007). Berninger (2009) correlated the broader context of writing performance, including both handwriting and composition, with the ability to use symbols, letters, and words to represent and convey thoughts. These skills appear to be linked to phonemic (sound) skills, word skills, sentence skills, and text skills, all of which are language-based processes (Berninger, 2009). Given the important link between language and written communication, future studies examining handwriting as a means of written communication among children with FASD should account for language function, ideally assessed from a process perspective.

Strengths and Limitations

This descriptive study had several strengths. The study focused on a systematically diagnosed sample of children with FASD ranging across the elementary school grades. A standardized test battery was used to assess foundational sensorimotor skills and multiple aspects of handwriting performance. Study results are limited by a relatively small sample size and lack of a comparison group, although psychometric norms were available for comparison purposes.

Although the PAL–II was chosen as the primary assessment tool for its relative ease of administration, recent

normative data for children in Grades 1–6, and strong theoretical and empirical development, one disadvantage of this instrument became evident during the study. The interrater agreements for the handwriting subtests of the PAL–II were relatively weak despite careful examiner training on administration and scoring. In addition to more specific descriptive criteria, more visual scoring models of both lowercase and uppercase letters likely would improve the scoring reliability of the PAL–II.

The scope of sensorimotor performance examined in this study was also limited. Graded motor control (Nguyen, Levy, Riley, Thomas, & Simmons, 2013) and visual–spatial processing (Mattson et al., 2011) are other relevant sensorimotor performance areas reported as diminished among children affected by prenatal alcohol exposure that warrant more research in terms of potential impact on handwriting function.

Finally, handwriting is a complex task that requires integration of sensorimotor, cognitive, and executive function and linguistic processes (Berninger, 2009). Contextual factors such as the classroom environment, grade-level writing expectations, and handwriting curriculum standards also affect handwriting function and competence. Therefore, future studies of children with FASD should investigate handwriting performance in the broader context of these other important child characteristics and contextual demands.

Implications for Practice

Clinically, these findings demonstrate that children with FASD are at high risk for handwriting dysfunction. Handwriting difficulties were seen across multiple handwriting tasks that included alphabet writing and near-point sentence and paragraph copying. Although findings from this study preliminarily suggest that foundational sensorimotor performance components are not a primary barrier to handwriting fluency and success, results do suggest that visual–motor integration is an area of clear need for children with FASD. Moreover, a notable decline in the quality of the children’s performance was seen as task demands increased from those requiring simple sensorimotor responses, to nonwriting tasks requiring visual–motor speed and precision, and finally to the more complex functional handwriting tasks requiring the integration of motor, language, and cognitive processes as well as speed and accuracy demands.

The results of this study have the following implications for occupational therapy practice:

- Occupational therapists should consider evaluating the handwriting performance of children with FASD both when they start school and later during key academic

transitions as grade-level expectations and writing demands change and increase.

- Even for children who do not show early handwriting or sensorimotor problems, the pattern of difficulties noted in this study suggests that periodic monitoring and screening of children with FASD across the elementary grades could help identify emerging problems and ensure timely evaluation and intervention.
- Timely evaluation and intervention, in turn, could better support these children’s ability to successfully participate in the many important school-based activities that require written communication. ▲

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