



Relationships between handwriting performance and organizational abilities among children with and without dysgraphia: A preliminary study

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ABSTRACT

Organizational ability constitutes one executive function (EF) component essential for common everyday performance. The study aim was to explore the relationship between handwriting performance and organizational ability in school-aged children.

Participants were 58 males, aged 7–8 years, 30 with dysgraphia and 28 with proficient handwriting. Group allocation was based on children's scores in the Handwriting Proficiency Screening Questionnaire (HPSQ). They performed the Hebrew Handwriting Evaluation (HHE), and their parents completed the Questionnaire for Assessing Students' Organizational Abilities-for Parents (QASOA-P). Significant differences were found between the groups for handwriting performance (HHE) and organizational abilities (QASOA-P). Significant correlations were found in the dysgraphic group between handwriting spatial arrangement and the QASOA-P mean score. Linear regression indicated that the QASOA-P mean score explained 42% of variance of handwriting proficiency (HPSQ). Based on one discriminant function, 81% of all participants were correctly classified into groups. Study results strongly recommend assessing organizational difficulties in children referred for therapy due to handwriting deficiency.

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Extensive research has been conducted in recent years about executive functions (EF) and their relationship with learning and behavior (McCloskey, Perkins, & Van Divner, 2008; Riccio, Reynolds, & Love, 2001). Welsh and Pennington (1988) defined EF as the ability to adopt and maintain an appropriate problem-solving set to obtain a future goal. Other literature illustrates the importance of EF; naming it as “the orchestra conductor” (Brown, 2005) and as the Chief Executive Officer (CEO) of the brain (Saltus, 2003).

Executive functions are a set of multiple cognitive capacities that activate and govern our conscious perceptions, feelings, thoughts and actions, constituting a collection of “co-conductors” (McCloskey et al., 2008). EF leads the individual to act in a purposeful, *organized*, strategic, self-regulated goal-directed manner. EF is in fact, an umbrella term that encompasses high-level cognitive functions such as setting and managing goals, planning, inhibition and dealing with diverse elements, shifting among cognitive and affective sets, *organization*, working memory and metacognition (Ylvisaker & Feeney, 2002). In actual fact, varied components of EF capacities were mentioned in the literature (e.g., Barkley, 1997, 2005; Denckla, 1996; Stuss & Alexander, 2000). One of the components mentioned by most researchers and emphasized in the cognitive–metacognitive theoretical model is *organizational ability* (Godefroy, 2003; Godefroy et al., 2004). Arnadottir (1990) defined this as humans'

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ability to *organize* their thoughts in a way that will enable them to perform actions in the correct sequence, with appropriate phases and timing.

Zentall, Harper, and Stormont-Spurgin (1993) defined it as the ability to plan and execute an activity within a limited time, place objects where it will be easy to find them, and plan how to execute the activity. Blanche and Prahm (2001) indicated that organization of behavior requires people to receive, conceptualize and perform integration of varied dimensions of space and time. Other researchers emphasized the aspects of time and space in relation to organizational ability (Temple, 1997; Zentall et al., 1993). Temple (1997), for example, defined organizational ability as the ability to plan ahead and *organize* behavior across time and space in order to fulfill goals and intentions.

In fact, the process of organization in space and time requires organization for executing movements already at the *body* organization phase (Ayers, 1989; MacKay, 1985). Ayers suggested that the term 'praxis' manifests the body organization process. Such a process involves consolidating the idea ('what to do'), motor planning ('how to perform') and executing a purposed action or activity (Ayers, 1989). This process enables participation in meaningful occupations and compels a proper integration of sensory input received from the body and the external environment (Ayers, 1989; Blanche & Prahm, 2001).

Therefore, organizational ability has meaningful influence on the ability to complete a task in a useful manner, and therefore has an effect on daily functions: starting actions at the right time and performing them at the correct frequency, and completing them at the required time without disturbances of unwanted behaviors (Coster & Haley, 1992; Zentall et al., 1993).

Despite the importance of organizational abilities for daily living performance and their influence on successful academic performance (Levin, 1994), little evidence can be found in the literature regarding the relationships between children's organizational abilities and their actual performance.

One of the required academic tasks confronting children in school is handwriting. It was found that children categorize handwriting as the *ultimate* work activity (Wing, 1995). This is not surprising, since 30–60% of children's school day is spent performing fine motor tasks, consisting primarily of handwriting (McHale & Cermak, 1992).

Handwriting is a sophisticated human skill used for the highest level of human communication. To create a written outcome, the writer is required to activate sensory-motor and cognitive skills simultaneously, in order to formulate an idea, plan the syntax and spelling of each sentence, make a motor-orthographic integration to produce the text, and evaluate the outcome. All these phases require intact organization in space and time (Jones & Christensen, 1999).

Previous studies indicated that 10–34% of school-aged children (Rubin & Henderson, 1982; Smits-Engelsman, Niemeijer, & Van Galen, 2001; Smits-Engelsman, Van Galen, & Michels, 1995) are failing to develop efficient handwriting performance required to cope at school. Those children who do not succeed in developing proficient handwriting are defined by some authors as "poor handwriters" and by others as "dysgraphic" (Marr & Cermak, 2001). Hamstra-Bletz and Blote (1993) defined 'dysgraphia' as a disturbance or difficulty in the production of written language that has to do with the mechanics of writing.

Children who cannot write properly may have difficulty keeping up with the required pace of writing in class, especially when copying from the blackboard. Furthermore, doing homework requires continuous long hours and results in frustration (Sovik, Arntzen, & Karlsdottir, 1993). These children's writing difficulties are evidenced in the fluency and quality of their compositions (Berninger & Graham, 1998), with illegible handwriting often leading to lower marks (Sweedler-Brown, 1992).

Taking into account the importance of organizational abilities for body organization, for everyday life activities and the need for spatial and temporal organization for accurate handwriting performance, clinicians and researchers may raise the question of whether children's organizational abilities are related to their actual handwriting performance.

Children with learning disabilities and clumsiness had significantly lower visuo-spatial organization abilities than controls, when evaluated by the Rey complex figure (Cermak & Murray, 1991; Hamlet-Mundlak, 1994). In the same vein, children with Developmental Coordination Disorders (DCD) constitute one of the groups of children with handwriting difficulties or dysgraphia.

There is evidence in the literature that children with DCD have difficulty not only with handwriting but also in domains such as self-care skills, activities and duties at home, sports activities and varied school tasks (Cermak, 1985; Gubbay, 1979; May-Benson, Ingolia, & Koomar, 2002). These deficits may stem from organizational ability deficits.

Indeed, McCloskey et al. (2008) claimed that difficulties in text formation, poor text production, speed and automaticity can result from disuse or ineffective or inconsistent use of EF. Furthermore, other researchers indicated that while children need to invest energy in orthographic motor processing, such as organization of letter forms as well as their location on the paper, they are not available to think and plan the writing content (Badian, 2000; Graham, Struck, Santoro, & Berninger, 2006).

However, as far as we know, no answer has yet been found to the question of whether *organizational ability is related to handwriting performance ability*.

Further research is required to gain insight regarding the relationships between children's organizational ability (EF) and their actual handwriting performance.

In the current study, children's organizational abilities were evaluated via a parents' questionnaire (Questionnaire for Assessing Students' Organizational Abilities-Parents—QASOA-P, Lifshitz & Josman, 2006) while their handwriting was evaluated both via the teachers' questionnaire (Handwriting Proficiency Screening Questionnaire—HPSQ, Rosenblum, 2008) and their actual performance (Hebrew Handwriting Evaluation—HHE, Erez & Parush, 1999). The research questions were as follows: Do children who were defined by their teachers as having handwriting difficulties also have organizational deficits? Might organizational deficits predict handwriting deficiency as observed by their teachers and by an objective measure of actual performance? What is the contribution of an organizational ability measure for discriminating between children with and without handwriting deficiency?

We hypothesized that significant differences will be found between children with and without dysgraphia in their actual handwriting performance as evaluated by the HHE and in their organizational abilities as reported by their parents (QASOA-P). Our second hypothesis was that the Children's organizational abilities as reported by their parents (QASOA-P) will predict their handwriting performance level, as evaluated by both their teachers' report via HPSQ and HHE results based on their actual handwriting performance. Finally, the last hypothesis was that the organizational ability score will best determine group membership (children with and without handwriting deficits).

1. Methods

1.1. Participants

Two groups of children with dysgraphia and proficient handwriting were recruited from first and second grades (aged 7–8 years) in regular public schools located in northern Israel. The group of children with dysgraphia consisted of 30 males and the proficient group consisted of 28 males. They were all born in Israel and used Hebrew as their primary verbal and written communication language.

The children in both groups were chosen based on the results of the Handwriting Proficiency Screening Questionnaire (Rosenblum, 2008) filled in by their teachers.

Based on a previous study, children who received a final score of 14 and above were included in the dysgraphic group, while proficient handwriters were those who received a final score of up to 13 (see Rosenblum, 2008 for more details).

The proficient handwriters were matched by gender, age, school and grade to the participants in the dysgraphic handwriting group. There were no significant differences between the two groups with respect to their age (7.50 ± 6.59 years for the proficient handwriters and 7.50 ± 7.78 years for the dysgraphic handwriters) and hand dominance (85% right-handed and 15% left-handed in each group).

Children with known psychiatric or emotional disorders, autistic tendencies, physical disabilities or neurological or systemic disease were excluded from the study.

1.2. Instruments

1.2.1. Handwriting Proficiency Screening Questionnaire (Rosenblum, 2008)

The HPSQ is a 10-item questionnaire that was developed to identify school-aged children with handwriting difficulties.

The 10 items cover the most important indicators of handwriting deficiencies in the following three domains: (1) legibility (items 1, 2, 10); (2) performance time (items 3, 4, 9); and (3) physical and emotional well-being (items 5–8) (Cornhill & Case-Smith, 1996; Rubin & Henderson, 1982). The items are worded to enable the teachers to respond while performing their observations of children as they are writing in the classroom. For example, "Does the child often erase while writing?". The items are scored on a five-point Likert scale, ranging from 0 = 'never' to 4 = 'always,' with higher scores indicating poorer performance. The final score is computed by summing the scores of all the 10 test items. The questionnaire's content validity, internal consistency, inter-rater and test–retest reliability have been established (see Rosenblum, 2008 for more details).

Based on the analysis of the HPSQ scores of 230 school-aged children (between 7 and 14 years old) a cut-off score of 14 (mean + SD) was established for the identification of handwriting deficiency (Rosenblum, 2008).

In the current study, the internal variability for the whole scale was found to be $\alpha = .92$.

1.2.2. The Hebrew Handwriting Evaluation (Erez & Parush, 1999)

The HHE was used in this study to collect data about the actual handwriting performance of the dysgraphic and proficient handwriters. The children were asked to copy a paragraph that included 15 words/56 letters (see Fig. 1). The HHE outcome measures are as follows:

Measures of handwriting product quality:

1. Global legibility—scored on a 4-point Likert scale, from the most legible [1] to the least legible [4], which refers to the overall clarity of the handwriting product.

In addition, the analytic measurement of legibility used in the HHE examined the following three component variables:

- a. Letters erased and/or overwritten—the number of letters that were erased and/or written over.
- b. Unrecognizable letters—the total number of letters that could not be recognized due to the quality of letter closure, rounding of letters, or letter reversals.
- c. Spatial arrangement of the written text, as determined according to detailed and precise criteria, utilizing a caliper that is calibrated to the millimeter. Specifically, these criteria included vertical alignment of letters (including the extensions of letters above and below the lines), the spacing of words and letters (whether too wide or overlapping), and letter size. The minimum score for spatial arrangement is 6, and the maximum is 24.

צירן הולך כל יום עם אסר לאל
 המחקים. ישם נדנדנות מצפ ומס
 סספים לויבה.

Fig. 1. The paragraph writing task.

For each HHE measure described above, a low score indicates better performance and a high score indicates poorer performance.

Furthermore, writing fluency is measured by the number of letters produced during the first minute.

Normative data for second and third graders are provided in the test manual.

During test development, reliability and validity were established and reported in the test manual (Erez & Parush, 1999). Internal consistency was high ($\alpha = .81$), and inter-rater reliability ranged from $r = .75$ to $.79$.

Construct validity of the HHE has been established by demonstrating significant statistical differences between the performance of children with proficient and poor handwriting ($t = 2.34$; $p = .027$) (Devash et al., 1995) and across school grades (second and third) ($p < .013$ to $p < .001$) (Erez & Parush, 1999).

1.2.3. Questionnaire for Assessing Students' Organizational Abilities-Parents (Lifshitz & Josman, 2006)

The QASOA-P includes 14 statements, describing the child's organizational abilities in space and time, as reflected in the home environment (e.g., "Child is ready for the school day with homework prepared"). The statements are rated on a four-point Likert scale (0, *always*; 1, *usually*; 2, *not often*; 3, *never*). A higher score indicates a more severe level of organizational difficulties. The total score range is from 0 (*no difficulty*) to 42 (*maximum difficulty*). In a previous study (Lifshitz & Josman, 2006), Cronbach's alpha that was used to establish internal consistency yielded $\alpha = .81$ ($n = 82$). The cut-off point score for disorganization was found to be 10 and above (one SD = 4.2 from $M = 5.7$). Concurrent validity was established with the QASOA-T questionnaire and was found to be $r = .50$, $p < .001$.

Furthermore, discriminant validity was established while comparing organizational abilities of children with DCD to those of controls (see Lifshitz & Josman, 2006 for more details).

In the current study, Cronbach's alpha values were found to be sufficient for the QASOA-P ($\alpha = .88$).

1.3. Procedure

Ethical approval for the study was warranted by the Israeli Ministry of Education. Participants were identified as having dysgraphia using the cut-off scores of the HPSQ completed by their teachers. Parents whose children were found to be suitable for participation in the study were requested by the teacher to sign an informed consent form. Following receipt of the form, children who met the inclusion criteria were invited to a quiet room in their school and completed the copying task from the HHE. The handwriting products were subsequently evaluated according to the HHE criteria. Subsequently, their parents were requested to fill in the QASOA-P.

1.4. Data analysis

Descriptive statistics (means, standard deviation, percentages) were used to describe the study participants' main variables. Internal reliability of the Handwriting Proficiency Screening Questionnaire items, as well as parent organization questionnaire items, was analyzed using Cronbach's alpha.

To examine whether the groups of children with dysgraphia and proficient handwriting differed with respect to the HHE handwriting product measures (i.e., global legibility, number of erased letters, unrecognizable letters and spatial arrangement and number of letters in the first minute), MANOVA test was applied.

To examine the differences between groups in the parent organization questionnaire scores, *t*-tests were applied. To examine correlation among the QASOA-P, HPSQ and HHE measures, a Spearman correlation was applied. Following the correlation results, a linear regression analysis was applied to test whether the QASOA-P would be able to predict the *spatial arrangement* (HHE) and the HPSQ scores.

Finally, discriminant analysis was conducted to determine whether the organizational score or the handwriting measures are the best predictors of group membership. The mean score of the organization questionnaire and those of the HHE scale (global legibility, number of erased letters, unrecognizable letters and spatial arrangement, number of letters in the first minute) were included in the discriminant function.

2. Results

As expected, significant differences were found between children with dysgraphia and proficient writers. Teachers' scores on the HPSQ revealed the dysgraphic group to have a mean score of 24.50 and standard deviation of 4.88, while the mean score for the proficient group was 8.92 and standard deviation of 4.57 ($t(52) = 12.06$, $p < .001$).

Table 1

Mean (SD) of the handwriting product measures (HHE)—a comparison between the groups (children with dysgraphia versus proficient handwriters).

Number of letters in the first minute	Dysgraphic (<i>n</i> = 30) (mean ± SD)	Proficient (<i>n</i> = 28) (mean ± SD)	<i>F</i> (5,52)	<i>p</i>	ES- ² η
Global legibility (range: 1–4)	22.23 ± 8.47	24.71 ± 8.89	1.18	N.S.	.02
Number of letters erased and/or overwritten	1.94 ± 0.70	1.19 ± 0.40	17.93	<.001	.24
Number of unrecognizable letters	2.80 ± 2.47	1.24 ± 1.30	5.43	.023	.09
Spatial arrangement (range: 6–24)	6.50 ± 3.87	3.24 ± 3.73	14.61	<.001	.20
Number of letters in the first minute	9.40 ± 2.18	7.76 ± 1.85	13.23	.001	.19

The MANOVA applied to the HHE handwriting performance measures (i.e., number of letters produced in the first minute; global legibility; number of letters erased and/or overwritten; number of unrecognizable letters and spatial arrangement) to test for group differences (children with dysgraphia versus children with proficient handwriting) yielded a significant result across the five measures ($F(5,52) = 6.60, p < .001$ ES- $\eta^2 = .34$).

To examine the source of the significance, the data was subjected to univariate ANOVAs. The results, shown in Table 1, indicated that in four out of five outcome measures, the scores of children with dysgraphic handwriting were significantly higher (indicating lower performance) than those of the proficient handwriters.

Significant differences were found between children with dysgraphia and proficient writers: dysgraphic (mean = 1.08; SD = .34) proficient (mean = .48; SD = .33, $t(52) = 6.39, p < .001$) using the parents' organization ability questionnaire (QASOA-P).

Significant correlations were found among the group of children with dysgraphia between the global legibility score (HHE) and the mean score of the teacher evaluation (HPSQ) ($r = .46, p < .05$) and between the spatial arrangement score (HHE) and the mean score of the parent organization questionnaire (QASOA-P) ($r = .42, p < .05$). No significant correlations were found among the group of proficient handwriters between the HHE measures, the HPSQ and the QASOA-P.

Linear regression indicated that the QASOA-P predicted 27% of the variance of the mean spatial arrangement measure of the handwriting product as evaluated by the HHE ($F(1,53) = 19.86, p < .001, \beta = 3.02$).

Furthermore, the QASOA-P mean score explained 42% of the variance of the mean score of the teacher handwriting questionnaire for handwriting proficiency (HPSQ) ($F(1,50) = 36.14, p < .001, \beta = 1.31$).

In order to assess the relative importance of the different variables in differentiating between children with dysgraphia and proficient writers, a discriminant analysis was performed. The independent variables included were the QASOA-P mean score and the HHE scores (global legibility, number of erased letters, unrecognizable letters and spatial arrangement, number of letters in the first minute).

One discriminant function was found for group classification of all participants (Wilks' Lambda = .49, $p < .001$). As shown in Table 2, the variable that made the greatest contribution to group membership was the QASOA-P mean score (loading = .89). The values of the other measures are presented in Table 2. Based on this function, 81% of the participants overall, 80.8% of the dysgraphic, and 81.5% of the proficient writers were correctly classified. A Kappa value of .62 ($p < .001$) was calculated, demonstrating that the group classification did not occur by chance.

3. Discussion

Executive functions have become a major topic of discussion in theory and research in recent years. The relationships between EF and learning and behavior have also been studied (McCloskey et al., 2008; Riccio et al., 2001). However, no study focusing on EF in children with dysgraphia was found.

The objectives of the present study were to investigate the differences between children with dysgraphia and proficient writers in both their handwriting abilities and organizational skills, as reflected by their handwriting performance and reported by their parents.

Organizational ability is a major component of EF. It is argued in recent literature that the method of evaluating EF is insufficient. Most neuropsychology researchers use a collection of tests, which represent components of EF. However, since EF integrates and regulates other cognitive functions, it is recommended to evaluate it through daily or performance-based activities. Moreover, Burgess et al. (2006) stated the importance of using ecologically valid assessments for evaluating EF. In our study, we used a handwriting test, which constitutes a performance-based assessment and two questionnaires, both

Table 2

Discriminant analysis structure matrix predictors' loading values.

Variables	Function
QASOA-P mean score	.891
Global legibility	.567
Number of unrecognizable letters	.565
Spatial arrangement	.494
Number of letters erased and/or overwritten	.353
Number of letters in the first minute	-.207

based on questions regarding the child's daily activity throughout the day. In addition, the QASOA-P explores organizational abilities that are assumed to be underlying mechanisms of the child's adequate everyday function and constitute a major component of EF (Lifshitz & Josman, 2006).

3.1. Differences between groups in their handwriting abilities and organizational skills

Significant differences were found between children with dysgraphia and proficient handwriters in most parameters of handwriting performance. In the HHE, a paragraph that includes two meaningful sentences is used to evaluate handwriting. Other handwriting tests use either lists of individual words or parts of words; the use of sentences in the HHE increases its ecological validity by testing handwriting in a very similar way to the actual performance of handwriting in the classroom (Rosenblum, Goldstand, & Parush, 2006; Rosenblum, Weiss, & Parush, 2003; Rosenblum, Weiss, & Parush, 2004). The small to medium size effect that was revealed in this study emphasizes that although the HHE differentiated between the two groups, the groups overlap.

The differences between groups in handwriting performance were supported in several previous studies. O'Hare and Brown (1989) found that children without handwriting difficulties were able to organize their writing better on the sheet of paper than children with dysgraphia and explained their results in terms of spatial relationships, where children are able to organize the spaces between letters and words adequately in their written material. The only component that did not reveal a significant difference is the "number of letters in the first minute." Although a difference in the mean score was found, the SD were large (8.47 and 8.89), which might explain the reason for not revealing significant differences. In fact, the two main components in handwriting deficiency may be the lack of legibility and/or inappropriate speed (Rosenblum et al., 2003). It seems that the children in the current study manifested clear legibility deficits, but not deficits in handwriting speed or performance time.

The QASOA-P significantly differentiated between groups in their organizational abilities. Children with dysgraphia have difficulty organizing their time and space, as well as the items needed for learning. For example, parents were asked whether their children are ready on time to go to school, whether they organize their learning equipment for the following school day, etc. The parent is asked to respond to this questionnaire that focuses mainly on the child's functioning within the home, but on activities related to the child's schooling. Results of this study support previous studies where children with DCD had difficulty completing their school tasks and needed more time than children without DCD (May-Benson et al., 2002). Levin (1994) found that children with learning disabilities have more difficulty with their daily activities, specifically; it takes them more time to complete their homework and organize their time adequately.

3.2. Relationships between organizational skills and handwriting

Medium correlations were found between organizational skills and handwriting performance, except for writing speed. A high correlation between the parent organizational questionnaire and the teacher's questionnaire on children's handwriting was revealed. These correlations indicate the relationships between organizational abilities and handwriting performance. To the best of our knowledge, no other studies have indicated these relationships. However, May-Benson et al. (2002) noted that children's organizational difficulties also included difficulties with learning skills, specifically with handwriting. Most researchers claim that the underlying mechanism of both daily organization and handwriting are motor and motor planning, and that deficiencies in these mechanisms will affect daily performance. We suggest that organizational ability, which is a component of executive functions, constitutes a major underlying mechanism for the child's daily functioning, including handwriting performance. Kohli, Malhotra, Mohanty, Khehra, and Kaur (2005) found that children with learning disabilities had difficulties in their perceptual motor performance, as well as in EF, and that these difficulties were prominent in language and handwriting abilities (Kohli et al., 2005).

3.3. Assessing the relative importance of QASOA-P and HHE measures for the differentiation of the groups

The results of the present study showed that the QASOA-P score together with HHE measures provide an efficient way of predicting group allocation. Based on discriminant analysis, we found that QASOA-P and HHE enabled us to classify correctly 81% of the participants, 81.5% of the proficient writers and 80.8% of the dysgraphic group. These findings, although encouraging, point to the complexity of dysgraphia: it is not only about handwriting difficulties or organizational skills, but involves other executive functions and visuospatial skills (Tseng & Cermak, 1993) and a single domain can not classify and explain the full picture.

Although use of the HHE provides a good picture of children's handwriting, we consider the addition of an organizational questionnaire to be very important, as it can provide a richer picture of the child's functioning. Adding a parent questionnaire not only provides the therapist with more information about the child, but helps the parents to look at important daily activities in their child's functioning.

In sum, our findings provide preliminary evidence that the QASOA-P is sensitive to detecting organizational deficits in children with dysgraphia, and together with a performance-based assessment (HHE) is able to classify the children into their group.

However, some limitations must be acknowledged. First, the study sample was relatively small. Second, our participants are unlikely to be representative of the entire population with dysgraphia, since they were recruited in a convenience sample from one region in Israel. Third, the results regarding children's organizational skills were collected only from their parents; a similar questionnaire should be filled out by their teacher.

Despite these shortcomings, our study has significant implications for the evaluation of children with dysgraphia. First, it proved that the use of QASOA-P provides a sensitive tool based on the parent's answer regarding the child's performance of everyday functions. Second, it provides information about the child's organizational skills, which are part of EF.

In conclusion, the results of the present study strongly reinforce the presence of organizational difficulties in children with dysgraphia and the feasibility of assessing these limitations using a parent questionnaire. Future studies, using larger and representative samples, should be performed to expand and strengthen our preliminary findings.

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