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Research article

Dysgraphia in Egyptian dyslexic children: related abilities to writing performance in Arabic

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Key words: Dysgraphia, dyslexia, handwriting, related abilities, Arabic language.

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Abstract

Objectives: This study aims to find out the cognitive and linguistic abilities related to writing skills in a sample of Egyptian children with developmental dyslexia. The identification of such abilities will add to the understanding of the neurobiological basis of writing development and proper construction of rehabilitation programs for children manifesting both dyslexia and dysgraphia. **Material and Methods:** Fifty Egyptian native Arabic speaking children (age: 8.43±1.27; IQ:97.04±6.3) participated in this study. They were diagnosed to have a reading disorder (developmental dyslexia) according to the criteria of DSM-IV-TR. The Arabic dyslexia assessment test, the Illinois test of psycholinguistic abilities (Arabic version) and the phonological awareness test were among the tests used for their assessment. Correlation between the scores of their writing (copying) performance and the other cognitive, linguistic and motor abilities was performed. **Results:** The forms of handwriting difficulties among the participants were specified. The rapid naming semantic function, the motor control, the phonological awareness and the auditory and visual processing abilities were correlated with the writing performance of the participants. The syntactic and auditory memory skills along with some other abilities did not show associations with their writing scores. **Conclusion:** The correlation outputs emphasize the role of phonological awareness, visual and motor skills in Arabic writing performance. Special attention should be paid for enhancing the abilities related to writing performance in dyslexic children during the remediation plans designed for such individuals.

Introduction

Handwriting is a complex psychomotor skill. It requires a blend of adequate cognitive and perceptual skills together with proper visual-motor coordination, motor planning and proper kinesthetic and tactile sensitivities. About 50% of school time is spent in tasks that require writing. Therefore, writing development is essential in the process of learning[1]. Handwriting difficulty, or dysgraphia, is a specific learning disability (LD) that is characterized by disturbance in production of written language. About 30-40 % of children with specific LD manifest dysgraphia. Moreover, it was estimated that about 7-15% of school children experience difficulties in acquiring proper handwriting skills. This disorder affects boys 2–3 times more than girls [2-4]. In Egypt, the prevalence of LD varied among districts and time frames. It was estimated to be 28/1000 in 1995, 10.7% in 2003 and 12.6 % in 2014 [5-7]. It's worth noting that these studies, which targeted Egyptian children, did not target the writing disorders as a separate entity among LD types but rather focused on reading and spelling disorders. However, these studies could mirror the size of writing disorders because the associations between reading and writing disorders have been frequently reported [8]. The variations in the prevalence of learning disabilities could be attributed to

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the differences in definitions and criteria for diagnosis which are used in these studies [9].

Arabic language has its own characteristics and orthography. Arabic language used in learning to read and write is called Educated Spoken Arabic which is different from the spoken colloquial Arabic [10]. Therefore, the development of Arabic language reading and writing could have its own model. Additionally, the abilities related to learning development and the neurobiological basis for learning could vary between typically developing children and those who have a learning disability [11].

The role of phonological awareness and some linguistic skills in learning have been reported in typically developing and dyslexics school-aged Arabic children [6,12,13]. However, the influence of other cognitive, linguistic and motor abilities on the writing performance was not adequately investigated in native Arabic speaking children especially the Egyptian ones.

This study aims to find out the cognitive and linguistic abilities related to writing skills in a sample of Egyptian native Arabic speaking children with developmental dyslexia. The identification of such abilities will add to the understanding of the neurobiological basis of writing development and proper construction of rehabilitation programs for children manifesting both dyslexia and dysgraphia.

Subjects and methods

Participants

The participants included 50 Egyptian native Arabic speakers who are enrolled in the national education system. They were recruited from the Learning Disability Research Clinic, Medical Research Centre of Excellence, National Research Centre, Cairo, Egypt. They were diagnosed to have a reading disorder according to the criteria of Diagnostic and Statistical Manual of Mental Disorders-4th edition-Text Revised (DSM-IV-TR)[14]. These criteria included that the reading performance of the participants was less than what was expected from them considering their individual chronological age and school grade based on data from standardized testing. Furthermore, the reading disorder manifested by the participants hindered their academic achievements. As the intelligence quotients of the participants were within average range, they were considered to have developmental dyslexia [4,9]. They were 37 males and 13 females (age range: 6.5–11 years; age mean 8.43±1.27; Intelligence quotient (IQ) range: 89-115; IQ mean: 97.04±6.3). Children who manifested sensory deficits, major neurological abnormalities, MRI abnormalities, EEG abnormalities and co-morbid neuropsychiatric disorders were excluded from the study.

The scales and tests used for assessment:

1. The Arabic version of Stanford-Binet Intelligence Scale, 4th Edition (SB-IV). It was used for IQ assessment [15,16].
2. Mini International Neuropsychiatric Interview for Children (M.I.N.I. Kid). It is a short structured diagnostic interview for DSM-IV and ICD-10 psychiatric disorders. It was used for psychiatric examination to exclude psychiatric co-morbidities with the reading disorder [17,18].
3. The Arabic Dyslexia Assessment Test. It was used for evaluating the reading, writing and some other abilities of the participants. The starting age at which the test could be applied is 6.5 years. It has the following subtests: rapid naming, bead threading, one minute reading, postural stability, phonemic segmentation, two minute spelling, backward digit span, nonsense passage reading, one minute writing, verbal fluency and semantic fluency [19,20]. The one minute reading, nonsense passage reading, and two minute spelling subtests investigate the reading (decoding) and spelling abilities of the child. The rapid naming, verbal fluency and semantic fluency investigate the semantics ability of the child at word level which is a verbal linguistic function. The one minute writing is used for assessment of the speed and quality of writing by copying certain texts that are specific for each age group [20]. This subtest was used for the correlation with other aptitudes of the participants. The phonemic segmentation is concerned with deleting syllables or phonemes and it is a phonological awareness function. The following subtests reflect some cognitive abilities and some related motor functions: backward digit span (verbal working memory), bead threading (fine motor coordination), postural stability (gross motor control).
4. The Arabic version of the Illinois test of psycholinguistic abilities. It has the following sub tests: auditory reception, visual reception, auditory association, visual association, verbal expression, manual expression, grammatic closure, visual closure, auditory sequential memory and visual sequential memory [21,22]. The test is applied for obtaining raw scores for each child in each subtest. The raw scores of each subtest are converted to scaled scores according to the child's mental age. However, the raw scores are the ones which are used for correlation in this study. The auditory reception, visual reception, auditory association, visual association, visual closure, auditory sequential memory, and visual sequential memory are considered cognitive abilities. The verbal expression and grammatic closure are considered linguistic functions. Manual expression could be considered a cognitive function and/or a non-verbal linguistic function.
5. The Phonological Awareness test. It was performed to assess the word awareness, syllable awareness, rhyme awareness, phoneme awareness (isolation-deletion and

substitution: at the beginning, the end and the middle of the word; blending and segmenting phonemes), grapheme-phoneme correspondence and sound production ability in Arabic. The total score of the test was used for correlation. The phonological awareness is a linguistic function [23].

6. The Semantics test. It was used for assessment of semantics at word and sentence levels. The synonym, antonym and hyponym reflected the at-word level part. The at-sentence level was assessed by testing the ability to arrange 3-step or 4-step sequencing picture cards [24]. Semantic abilities are among the linguistic functions.

Analysis of data

Data were analyzed using SPSS computer package version 17 (SPSS, Chicago, IL, USA). Spearman's correlation coefficient was used to correlate various variables. The raw scores of one minute writing were tested for correlation with the raw scores of rapid naming, bead threading, one minute reading, postural stability, phonemic segmentation, two minute spelling, backward digit span, nonsense passage reading, verbal fluency, semantic fluency, auditory reception, visual reception, auditory association, visual association, verbal expression, manual expression, grammatic closure, visual closure, auditory sequential memory and visual sequential memory, the phonological awareness test, synonym, antonym, hyponym, sequencing, test of semantics (total scores). When (p) for any item is less than 0.05, it is considered to be statistically significant.

Results

The deficits in the writing performance (copying a text from a paper) among the participants were mostly in the form of deficits in the duration of performing the task. Some participant further manifested deficits in the accuracy and or the quality of the handwriting. The deficits in accuracy were in the form of missed dots, extra dots, missed letters, extra letters, missed words, extra words, malalignment and connecting graphemes that should be written separately. Children from 8.5 to 11 years displayed speed problems while younger children manifested the other forms of deficits noticed in this study. Examples of the handwriting difficulties are presented in figures 1 and 2.

The abilities that showed significant correlation with the one minute writing subtest are presented in table 1. The bead threading, semantic fluency, phonological awareness, auditory reception, visual reception, visual association, visual closure and visual sequential memory showed positive correlation with the one minute writing subtest while the rapid naming and posture stability showed negative correlation.

The abilities that did not show significant correlation with the one-minute writing subtest are presented in table 2. It's noteworthy that the p value of correlations of the one minute writing with phonemic segmentation and manual expression was 0.06.

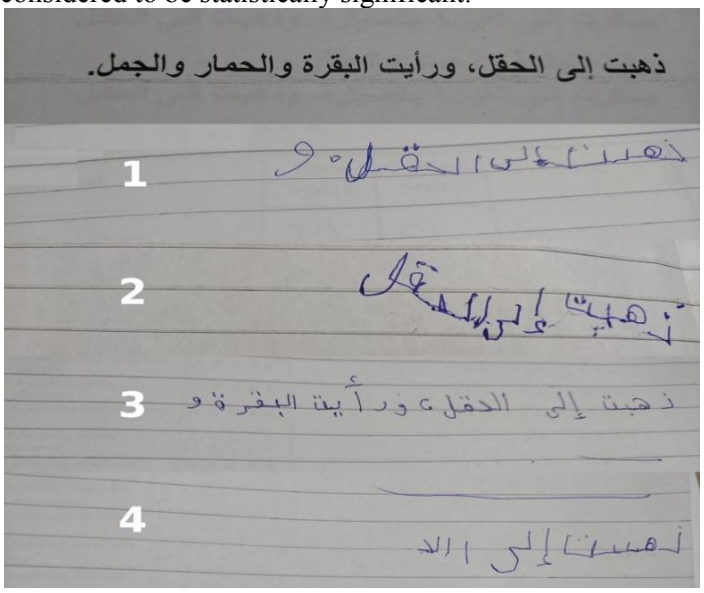


Figure 1. Some samples of the handwriting of participants (age: less than 8.5 years).Notice the connected grapheme while it should be separate in sample 1, the malalignment in sample 2, the extra letter in sample 4. None of the participants completed the task in time.

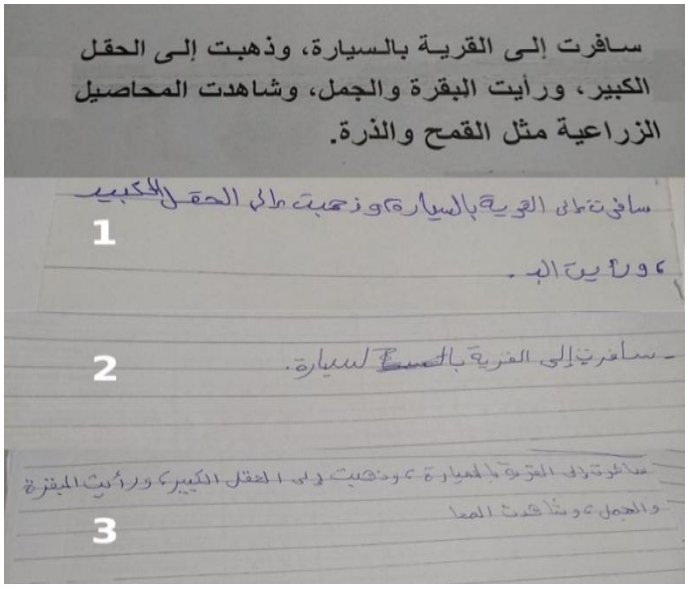


Figure 2. Some samples of the handwriting of participants (age: 8.5 years or more). Notice the hesitancy in sample 2 yet the legibility of the text. None of the participants completed the task in time.

Table 1. The abilities that showed significant correlation with the one minute writing subtest

The ability	r value	p value	The category
Rapid naming	-0.44	0.02	Semantics
Semantic fluency	0.64	0.001	
Bead threading	0.68	0.000	Motor
Posture stability	-0.78	0.000	
Auditory reception	0.48	0.017	Auditory processing
Visual reception	0.52	0.009	Visual processing
Visual association	0.4	0.04	
Visual closure	0.65	0.000	
Visual sequential memory	0.42	0.03	
Phonological awareness	0.48	0.014	Phonological awareness

Table 2: The abilities that showed non-significant correlation with the one minute writing subtest

The ability	r value	P value
One minute reading	0.29	0.1
Phonemic segmentation	0.3	0.06
Two-minute spelling	0.2	0.2
Backward digit span	0.2	0.21
Non-sense passage reading	0.3	0.1
Auditory association	0.3	0.07
Verbal expression	0.1	0.3
Manual expression	0.3	0.06
Grammatic closure	0.1	0.3
Auditory sequential memory	0.22	0.2
Synonym	-0.2	0.3
Antonym	0.1	0.6
Hyponym	-0.11	0.5
Sequencing	-0.12	0.5
Total score of semantics test	-0.13	0.5

Discussion

Developmental dysgraphia is a disorder characterized by difficulties in the writing skills acquisition. The writing performance of such individuals is below what is expected from them based on their class and intellectual levels [4]. Handwriting difficulties have an impact on social and emotional well-being of the children[25]. Furthermore, dysgraphia was related to poor composition abilities. It even influences the judgment of teachers on the child's written performance in exams which adds more problems to the already manifested academic difficulties [26]. Whereas the spelling performance with dyslexia has gained the major interest, the associated developmental dysgraphia or writing difficulties has not attracted such attention. This is the first study, to our knowledge, that investigated the relation between the writing performance of Egyptian native Arabic dyslexic children and their different aptitudes.

Despite the high association reported between dyslexia including spelling disorders and dysgraphia, there are some areas of singularities. This was reflected by different areas stimulated during tasks related to spelling and writing [27]. The abnormalities in writing performance in the present study were related to speed, quality and accuracy of writing. These abnormalities could be attributed to the characteristics of Arabic language. Arabic language has a complex morphology with frequent adding of prefixes and suffixes to the Arabic roots [28]. Furthermore, Arabic is written with joined letters from right to left. The directionally confusing graphemes do not exist in Arabic [13]. However, the confusion between Arabic graphemes could stem from the position and number of dots. Some examples for that are the graphemes (ب،ت،ث) which has the following phonemes /b ب/, /t ت/ and /θ ث/. Moreover, the shape of the grapheme differs according to its position in the word (بـ ، ـبـ ، ـب) (جـ ، ـجـ ، ـج). These criteria could have led to confusion while copying the text which could result in errors and/or elongation of time consumed for performing the demanded task. These factors could have contributed to the writing disorders noticed in the present study.

According to the present study, the main abilitiesthat were associated to writing performance were semantics (rapid naming abilities), motor (fine and gross), auditory and visual information processing, and phonological awareness.

The semantics

According to this study, the semantic functions related to the writing performance were found to be the semantic fluency and rapid naming. The other semantic functions did not influence their writing performance. The rapid naming task in the present study required accurate and fast naming of pictures printed on the same paper [20]. The more time consumed for naming and/or the more mistakes will lead to the more scores of rapid naming. Hence, a negative correlation was detected. Nevertheless, semantic fluency task required rapid recall of constituents of a semantic group. Thus, semantic fluency scores increase by increasing the efficiency of recall which led to the current positive correlation output. The role of semantics related to writing and reading for both lexical and non-lexical models has been investigated. The proper writing process involves the lexical domain and this process is dependent on integration of semantic, orthographical and phonological features [29]. Disorders in this lexicon could explain the Arabic language writing deficits in the dyslexic children who participated in this study. They were asked to copy a text from a paper in front of them. They performed the required task but the majority of them consumed long time which means that they did not depend on their orthographical-phonological lexicon. Rather, they mostly depended on their visual abilities. However, this did not apply to all of them, as

some of them failed to copy the text correctly which suggests a contribution of a visual processing disorder.

Fine and gross motor functions

The current study revealed a highly significant correlation between writing performance and motor functions. The scores of stability of posture increases with less control of motor stability and consequently, it was negatively correlated with the writing performance. The motor control in individuals manifesting dysgraphia has been studied and was linked to the cerebellum. The role of the cerebellum in writing was not merely a motor control but rather it was reported to extend to the cortico-cerebellar circuits which are involved in procedural and declarative memory [30]. Furthermore, the left frontal cortex and the superior parietal region were reported to be activated during writing tasks. The superior parietal region is involved in the peripheral motor control during writing tasks [31].

Visual processing

The visual processing of visual stimuli that did not involve graphemes was related to the middle occipital gyrus in dyslexic children [32]. The relation between visual processing and writing performance in dyslexic children could stem from visual attention span deficits. Alteration of the visual attention span has been reported in dyslexic children and was related to reduced activation of the right superior parietal lobule and the ventral occipito-temporal cortices bilaterally [33].

Auditory processing

The auditory reception abilities were correlated to the writing performance in the present study. Auditory reception is related to the central auditory processing functions. The central auditory processing disorders were reported in some Egyptian dyslexic children. In addition, the phonological awareness performance of those dyslexic children was related to their scores in the test of speech perception in noise [34]. These findings emphasize the influential role of verbal phonological awareness tasks in learning to read and write.

Phonological awareness

To date, the best understood mechanism underlying dyslexia is weakness of phonological awareness (PA). It was found to be the best determinant of developing dyslexia. Learning a spoken language is almost a passive process. Notwithstanding, learning to read and write requires explicit practice and knowledge. The rapid automatic recognition of grapheme to phoneme matching is interrupted in dyslexia according to the phonological theory of dyslexia. The process of PA which is involved in writing is rather complex as it necessitates the conversion of phonemes to graphemes. Furthermore, the writing process involves splitting the words into syllables which confirms the role of PA [35]. Backes *et al.* [36] stated that children with dyslexia manifested impaired prefrontal and temporal activation on phonological processing tasks. However, the precuneus and inferior frontal gyrus areas were the areas that are involved in the phonological processing in normal readers [37]. Moreover, the visual word form area (left lateral occipitotemporal sulcus) which is concerned with printed PA (grapheme to phoneme correspondence) activities was reported to be aberrant in dyslexic children [32].

The phonemic segmentation is a phonological awareness function. It is concerned with deleting word, syllables and phonemes. Thus, it was about to show significant relation with the copying abilities. Moreover, the manual expression abilities which require integration between semantic, memory and motor function were close to be significantly correlated to writing. These factors highlight the role of PA and semantic-motor organization in writing. Other abilities were less likely to influence their writing performance such as auditory memory (sequential or working short term memory) and syntactic abilities. The writing scores of the participants in the present study were not related to their reading or spelling performance. Hence, the abilities related to writing tasks could differ between dyslexia and dysgraphia despite the presence of common mechanisms such as phonological awareness deficits. The functional alterations in the neurobiological systems of dyslexic individuals highlight the need for proper interventional plans to overcome such changes that obviously influence both reading and writing. The health professionals should not rely on spontaneous recovery of writing deficits during the remediation of abilities related to reading and spelling. Enhancing the writing performance of dyslexic children and the abilities related to writing is as mandatory as the remediation of reading and spelling performance of such children.

Conclusion

Disorders in the speed of writing were the most common deficit noticed in the participants. The correlation outputs emphasize the role of phonological awareness, visual and motor skills in Arabic writing performance. Some specifications for certain abilities were detected such as rapid naming function of semantics and auditory reception. Special attention should be paid to the abilities related to writing performance in dyslexic children during the design of remediation programs for such children.

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