Original Article

Manifestations of Developmental Dyslexia in Monolingual Persian Speaking Students

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Abstract

Background: Manifestations of dyslexia depend on language systems and scripts. This study explored the prevalence and clinical features of developmental dyslexia among monolingual Persian students and provided insights on mechanisms involved in reading Persian.

Methods: To measure reading ability we developed a new instrument, *Analysis of Persian Reading Ability*, which had acceptable validity and reliability. A total of 1562 children aged 6 ½ – 14 were randomly selected from a population of 109696 primary school students in the city of Qom, Iran.

Results: Using a variety of statistical and clinical criteria, 82 (5.2%) of the sample were classified as dyslexics. A detailed analysis of reading errors revealed eight types of errors related to three categories. The most frequent category in both dyslexic and the matched control group was phonological, followed by pragmatic and visual errors.

Conclusion: The observed prevalence rate of dyslexia and reading error categories would suggest that Persian in vowel-free format is an opaque language and predominant use of a sub-lexical strategy is involved when reading Persian.

Keywords: developmental dyslexia, Persian, prevalence, reading errors, sub-lexical

Introduction

Developmental dyslexia refers to a neurodevelopmental syndrome characterized by specific and significant impairments in reading despite conventional instruction, adequate intelligence, sensory acuity and socio-cultural opportunity.[1] It is one of the most frequently diagnosed conditions in childhood, found in most countries and languages, which if not treated leads to extensive educational and social problems.[2–5] The clinical features and prevalence estimates are thought to depend on two important factors: the chosen definition of dyslexia and the written language system.

Developmental dyslexia is operationally defined in a variety of ways. This has caused inconsistency in the estimation of the prevalence of dyslexia.[6] Nonetheless, "discrepancy" between expected reading (in relation to age and IQ) and actual reading ability is the central component in most definitions.[7,8] Some authors, however, have questioned the appropriateness of using IQ as an inclusion criterion for reading problems, objecting to the requirement for discrepancy between IQ and reading.[9] Others imply that IQ may not be necessary to predict reading ability[10, 11] and one could use arithmetic instead of IQ.[12,13]

Current research in the field no longer focuses on whether developmental dyslexia exists in a particular language system, but instead concentrates on the effect of the language system on reading acquisition, prevalence, reading errors, and other clinical manifestations of developmental dyslexia.[14,15] Languages and their written forms can be located along a transparency-opaqueness continuum. For example, Italian, Serbo-Croatian and Turkish have phonologically 'transparent' orthography; i.e., graphemes are always pronounced in the same way creating regular and consistent, transparent, grapheme -phoneme correspondences. In contrast, English and Hebrew (in vowel-free format) are relatively opaque, creating a considerable phonological ambiguity.[16] In transparent languages the regular grapheme-phoneme correspondence provides consistent feedback about the way words are structured,[17] which causes a problem of slow reading and low fluency rather than inaccurate reading in dyslexics.[18] In contrast, in opaque languages such as English and Hebrew,[19] dyslexics mainly present with reading errors.[18,20,21] In general, dyslexia is more common among people with opaque language than those with transparent language.[22,23]

Reading error analysis is particularly useful not only in classifying reading difficulties, but also in assisting understanding the basic mechanisms involved in the reading process suited to each script. For example, Castles and Coltheart[24] suggested that specific deficits in the lexical or sub-lexical routes lead to different patterns of reading disability in English. Siegel[25] observed semantic errors in a group of English children with reading disabilities because the majority of them had deficits in phonological (sub-lexical) skills and hence were forced to use the lexical route to read. In contrast, Fuk-Chuen[26] found that Chinese children with reading disability made more phonological errors, because they were forced to use sub-lexical procedures to compensate for their difficulties with the lexical route mainly required for reading Chinese characters. Similar findings reported in other studies compared reading acquisition in scripts that differ in orthographic transparency. Ellis and Hooper[27] showed that Welsh readers were more reliant on an alphabetic decoding strategy, as they made longer reading errors, which were more complete attempts to represent the sounds in the stimulus word rather than those made by English readers.

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Table 1. Prevalence of developmental dyslexia in 14 studies carried out in monolingual or bilingual Persian students.

Authors	Year	Sample size, educational grades and location	Prevalence (%)
Azad, H[55]	1972	10000, 1and 2, Tehran	10
Pouretemad, H.R.[4]	1992	1381,1 and 2, Qom	2.7
Flah-Chai, R[56]	1995	341, 2–5, Rasht	2.1
Arfani, N[38]	1997	3775, 1–5, Kurdistan Province [1]	1.4
Bazrafshan, A[57]	1997	3927, 2 and 3, Mashhad	3.1
Daneh-Kar, M[58]	1998	(not specified), 1–3, Tehran	5.5
Ghafeleh Bashi[59]	1999	(not specified), 1–5, Tehran	10
Pasha-Pour, N and Yavaran, R[28]	2000	2067, 3, Urmia [2]	3.2
Jalili, F[60]	2001	960, 1–5, Birjand	1.2
Mohammadi, SH[37]	2003	2919, 1–5, Robat-Karim	2.9
Khalgi, F[61]	2003	600, 1–5, Kashan	4.9
Rahimian-Boger, A and Sadegi, A[62]	2004	1200, 2–5, Shahreza	6.9
Hossini-Lar, F[34]	2005	3, Tehran–1500,1	3.3
Bonyadian, A[39]	2005	1364, 1–3, Tehran [3]	2.5

[1]Kurdish-Persian bilinguals, [2]Turkish-Persian bilinguals, [3]Armenian-Persian bilinguals

Additionally, Welsh reading errors tended to be non-word mispronunciations, whereas English children made more real word substitutions. This indicated that English children were apparently attempting to use direct access strategies (lexical) to read words, whereas Welsh children made greater use of grapheme to phoneme translation (sub-lexical) strategies. In a short report, Pasha-Pour and Yavaran[28] identified six types of errors among Turkish-Persian bilingual primary school students with dyslexia from the city of Urmia, Iran. The most frequent errors were additions, followed by substitutions, omissions, refusals, verbal inflections, and reversals. Although they did not classify these errors, orthographic errors (i.e., omissions, additions, and reversals) related to impairment of lexical processing and visual functioning appeared to be predominant in bilinguals with dyslexia. Reading errors have been categorized in different ways[26,29,30] but the core of these classifications includes semantic, phonologic, orthographic or visual, and mixed errors.

The Persian language, is a member of Indo-European family of languages,[31] with phonologically opaque orthography especially in vowel-free format. The prevalence of developmental dyslexia in Persian populations has been estimated in several previous studies, some of which summarized in Table 1. Since dyslexia seems to be under-represented in bilingual as compared with monolingual pupils,[32,33] the rates have been separately estimated for the two populations. Among bilingual Persian pupils, the prevalence of dyslexia falls between 1.4% to 3.2% (mean 2.3%); whereas it averages 4.8% (range 1.2% to 10%) among monolingual Persian pupils. However, no systematic study to date characterized the clinical presentation of dyslexia in Persian-speaking children.[34] For this reason we designed a prospective study using a combination of methods to detect dyslexia and to characterize its clinical manifestation.

Materials and Methods

Participants

A total of 1570 primary school students (grades 1 – 5) aged 6 ½ – 14 years (mean=9.3, SD=1.5) were chosen at random from the total population of primary school children in Qom (n=109696). Mean scores for mathematics, reading, spelling, science and art for the three trimesters (one academic year) were obtained for the sample. Excluded were eight bilingual children from further analyses.

Several statistical analyses, including regression models showed that math scores were the best independent predictor of reading scores for all grades. On this basis, predicted reading scores were established for the population sample (n=1562) and discrepancies between predicted and observed reading score were then calculated. It was found that a discrepancy of more than 1.5 standard error of estimate (SE) was the best threshold for identification of suspected cases with dyslexia.

Children were defined as dyslexic if they fulfilled the following criteria: i) monolingual Persian speakers, ii) mean standard score above 85 in the short form (similarities and block design) of Persian version of the Wechsler Intelligence Scale for Children-third edition (WISC-III),[35] iii) their reading scores in three trimesters of one academic year were more than 1.5 SE below that expected from their math scores, and iv) no history of brain damage, hearing or visual problems. By the above criteria, 82 children with developmental dyslexia were identified. A control group consisted of 82 students without scholastic or other documented psychological or physiological problems recruited from classmates of those with dyslexia. The groups were matched for sex, grade of education, intellectual ability, and socio-economic level. This study did not aim to actively identify co-morbidities (i.e., apraxia, attention deficit disorder) associated with dyslexia, but excluded any subjects who already had such diagnoses.

Analysis of Persian Reading Ability (APRA)

We designed a reading test for Persian speaking children based on the "Neale Analysis of Reading Ability".[36] This test consisted of 11 cards; each contained a short story graded in difficulty according to educational grade. Similar to Neale, the number of words and related comprehension questions used in each story increased linearly. Word frequency was calculated from Persian national curriculum text books (years 1 – 5). Classifications for words included highly frequent, moderately frequent or rare for each educational year. Two cards were allocated for each educational year; the first card was for practice only. Cards with even numbers were adopted from Neale[36] and odd numbered cards were based on word fre-

Table 2. Demographics: population sample, poor readers and identified dyslexics.

Grade	Gender	Population sample (n=1562)		Poor readers (n=107, 6.8%)		Dyslexic group (n=82, 5.2%)	
		N (%)	Age (months) Mean (SD)	N (%)	Age (months) Mean (SD)	N (%)	Age (months) Mean (SD)
1	F	138 (8.8)	87 (5.5)	5 (4.7)	90 (7.9)	3 (3.6)	88.7 (4.2)
	M	160 (10.2)	87 (5.4)	10 (9.3)	83.8 (4.4)	8 (9.7)	84.4 (5.4)
2	F	142 (9.1)	99 (5.2)	5 (4.7)	100.4 (7.9)	3 (3.6)	101.3 (8.5)
	M	129 (8.2)	99 (5.4)	9 (8.4)	101 (3.8)	6 (7s.3)	101.5 (2.9)
3	F	162 (10.4)	110 (6.9)	7 (6.5)	109.7 (6.7)	7 (8.5)	108.3 (5.9)
	M	147 (9.4)	112 (6.8)	18 (16.8)	111.07 (8.05)	15 (18.3)	108.9 (3.3)
4	F	169 (10.8)	124 (6.4)	6 (5.6)	128.7 (14.3)	4 (4.9)	129.7 (18.2)
	M	161 (10.3)	125 (7.9)	19 (17.7)	129.7 (13.1)	16 (19.5)	127.2 (9.4)
5	F	178 (11.4)	135 (6.8)	8 (7.5)	135.9 (10.4)	6 (7.3)	135.7 (11.4)
	M	176 (11.3)	134 (5.7)	20 (18.7)	135.2 (5.6)	14 (17.1)	135.5 (6.3)

quencies in Persian books for education years 1 – 5, as described above. Subjects were allowed to try all cards sequentially and stopped when s/he made 25 errors in a card. The scoring system allowed us to calculate percentage reading accuracy, comprehension, speed of reading, and analyze reading errors.

Procedures

After random selection of the population sample (n=1562), official annual school reports (certificates, which have an almost identical format throughout the country) of the population sample were collected from schools. Using the abovementioned statistical analyses, suspected cases with dyslexia (n=107) were identified in the population sample. Soon after the summer holiday, all suspected cases were sent consent forms. Parents of 86 children completed consent forms and returned them. These cases were then individually assessed with the short form WISC-III and APRA, with a short break after each subtest or reading passage during which subjects chatted with the examiner and were rewarded with chocolates. Although all previously passed psychological (including general intellectual ability) and physical examinations prior to primary school entry, 4 cases scored below 85 on the WISC. The APRA was not administered to this group of children and they were excluded from the analyses.

Statistical analysis

Prior to analysis, all data were checked for unexpected outliers or any mistakes that might have occurred during data entry. Regression analysis identified suspected cases with dyslexia. Several statistical analyses, including t, χ^2, Mann-Whitney U, Friedman test, and correlations compared results between the two groups.

Results

Prevalence of dyslexia

Demographic data for the sample population, the suspected cases with dyslexia (i.e., poor readers) and those finally diagnosed as dyslexic as summarized in Table 2. Whereas in each educational year there were equal numbers of males and females in the population sample (male=773, 49.5%; female =789, 50.5%), there were more male than female suspected cases of dyslexia in the third ($\chi^2_{(1)} = 4.8$, $P<0.03$), fourth($\chi^2_{(1)} = 6.8$, $P<0.01$) and fifth ($\chi^2_{(1)} = 5.1$, $P<0.03$) grades. Overall, the proportion of males (n=76, 71.1%) was significantly higher than females (n= 31, 28.9%) among suspected cases with dyslexia ($\chi^2_{(1)} = 18.9$, $P<0.001$). A similar proportion was found in the dyslexic group, as the ratio of males (n=59, 71.9%) was significantly higher than females (n=23, 28.1%) in this group ($\chi^2_{(1)} = 15.8$, $P<0.001$). This suggests a higher incidence of dyslexia among males, as found in many different cultures.

Validity and reliability of the APRA

Construct validity of the reading accuracy scores was between r=0.3-0.9 for odd cards and r=0.7-0.9 for even cards. The construct validity of comprehension scores for even cards was r=0.3-0.6 and r=0.3-0.5 for odd cards, respectively. All values were significant at $P<0.001$. Convergent validity of reading accuracy for both even and odd cards was calculated using correlation between the scores in our test and mean reading scores over the academic year (r=0.5, $P<0.001$).

Reliability of the accuracy scores was tested in two ways: Cronbach's Alpha and the parallel test. Reading accuracy was 0.9 for even and 0.8 for odd cards, and comprehension scores were 0.8 (even cards) and 0.7 (odd cards). Parallel reliability of both even and odd cards for reading accuracy and comprehension was 0.9. These analyses demonstrated the acceptable reliability and validly of our reading test, particularly for even cards. Thus only even cards were used for further analysis.

Characteristics of the dyslexic group

Table 3 shows no significant differences between the groups in terms of age, gender, and WISC-III subtest. The proportion of males was significantly higher than females in both groups. The dyslexic group performed well below the control group in reading subject score at school as well as in all APRA measures, including percentage of reading accuracy, total time (seconds), and comprehension scores. Therefore, slow reading was associated with frequent reading mistakes and lack of comprehension in dyslexic children compared to the controls.

The association between reading comprehension and reading (decoding) skills was tested using Pearson correlation analysis on total comprehension scores and percentage of reading accuracy scores on the even cards. The correlation between the scores was r=0.63 ($P<0.001$) in the dyslexic group and r=0.62 ($P<0.001$) in the control group. Thus, as in other languages, there was a close relation between reading comprehension and decoding skills with the two abilities running in the same direction.

Reading errors

Reading errors were classified into eight categories, six of which

Table 3. Descriptive statistics of main demographic data, reading performance on school and in the Analysis of Persian Reading Ability of groups.

Variables	Dyslexic group (*n*=82)	Control group (*n*=82)	t/χ^2	*P*-value (<)
Age (months)	115.49 (18.73)*	114.38 (17.74)	0.36	0.71
Gender (male/ female)	M=59 F=23	M=59 F=23	31.6	0.01
Mean of block design and similarity standard scores	9.86 (2.65)	10.12 (2.1)	1.02	0.33
Reading performance scores				
School reading scores	13.84 (3.17)	17.72 (1.94)	9.41	0.01
Analysis of Persian Reading Ability				
Percentage of reading accuracy of odd carts**	87.91 (14.62)	93.81 (5.89)	3.37	0.01
Percentage of reading accuracy of even carts	84.85 (17.42)	92.49 (6.88)	3.69	0.01
Comprehension score of odd cards	19.26 (6.58)	21.30 (5.99)	2.06	0.04
Comprehension score of even cards	12.01 (5.96)	14.46 (6.15)	2.57	0.01
Total time (seconds) of odd cards	497.42 (248.9)	414.73 (267.51)	2.04	0.04
Total time (seconds) of even cards	595.08 (319.2)	475.63 (331.55)	2.35	0.02

*Mean (SD); **Percentage of reading accuracy was calculated for each card by subtracting the number of errors from total number of words in the card subdivided by the total of errors multiplied by 100 [(total words-total error/total words)*100].

were suggested by Neale[36]: 1) mispronunciations: words that are wrongly pronounced or distorted and only partially decoded [i.e., in English, "bruvver" for "brother"; in Persian, رفد /Rafd/ for رفت /Raft/ (meaning gone)]. 2) Substitutions: real words used instead of the target words, but preserving the initial phoneme [e.g., in English "realized", "released"; e.g. in Persian "سخت" (meaning difficult) for "سخن" (meaning talk)]. 3) Refusals: pause for 5 – 7 seconds, with no attempt to say the word. 4) Additions: partial or whole words inserted into the text. 5) Omissions: words omitted. 6) Reversals: i.e., in English "on", "no"; i.e., in Persian "در" (meaning door) for "رد" (meaning rejection)]. Two further errors identified in our work were: 7) repetitions: rereading the whole word, and 8) fragmentation: word broken into components and then joined to read.

Mann-Whitney U compared error types between the groups. All eight types of error were significantly more frequent in the dyslexic than control group (Table 4). Mispronunciations were the most common type of error made by the dyslexic group followed by (in order of frequency) fragmentations, additions, substitutions, omissions, refusals, repetitions, and reversals. The most frequent errors in the control group were mispronunciations followed by fragmentations, repetitions, additions, omissions, substitutions, refusals, and reversals. The Friedman test showed that observed differences in the frequency of errors were significant in dyslexics ($\chi^2_{(7)}$=132.38, *P*<0.001) and controls ($\chi^2_{(7)}$=165.83, *P*<0.001).

According to correlation analysis, mispronunciations correlated with fragmentations (r=0.44) and additions (r=0.33); omissions were associated with additions (r=0.50), substitutions (r=0.64) and refusals (r=0.50); and substitutions correlated with additions (r=0.55), and refusals (r=0.43). All were significant at *P*<0.001.

These results were grouped into three types of errors: phonological (mispronunciations, substitutions, and fragmentations), visual (omissions, additions, and reversals) and pragmatic (refusals and repetitions). A Mann-Whitney U analysis revealed that the three categories of error were significantly more frequent in the dyslexic group. According to the Friedman test, phonological errors were the most frequent in both dyslexics ($\chi^2_{(2)}$=31.35, *P*<0.001) and controls ($\chi^2_{(2)}$=17.36, *P*<0.001), followed by the pragmatic visual errors. Thus, the phonological errors were the most important in both dyslexics and controls.

Discussion

This study examined the manifestations of dyslexia in monolin-

Table 4. Friedman mean rank and Mann-Whitney U results for the error types and error categories in children with dyslexia compared with controls.

Error types/ categories	Friedman mean rank (Dyslexic group)	Friedman mean rank (Control group)	Z scores	*P*-values (<)
Error types				
Mispronunciations	5.96	5.87	-4.5	0.01
Omissions	4.68	4.59	-6.8	0.01
Additions	5.36	5.19	-7.2	0.01
Substitutions	4.75	4.11	-7.3	0.01
Reversals	1.24	1.65	-2.5	0.01
Refusals	4.38	3.23	-5.5	0.01
Fragmentations	5.42	5.73	-3.2	0.01
Repetitions	4.22	5.64	-2.6	0.01
Error categories				
Phonological	2.57	2.38	-5.2	0.01
Pragmatic	1.94	1.98	-4.5	0.01
Visual	1.49	1.64	-6.5	0.01

gual Persian primary school students. The incidence of dyslexia increased from 3.7% and 3.3%, respectively in the first two grades to 7.1% in grade three and declined in grades 4 and 5 (6.1% and 5.6%, respectively). Although this pattern was similar to that reported in previous studies,[34,37] it was not statistically significant. The overall rate of dyslexia in the current study was about 5.2%, higher than the average prevalence (4.8) from previous studies (Table 1). This difference, however, is unlikely to be significant even though there are differences in sampling, operational definitions, and tests used in our study.[10] Methodologically speaking, the rate difference is unlikely to be due to a lax inclusion criteria (1.5 SE) because when we used a more stringent criterion (2 SEs) to identify children suspected dyslexia (Table 2) this only decreased the poor reader rate from 6.8% to 6.4%, with no impact on dyslexia rate (5.2%). This rate is higher than reported in more transparent languages such as Arabic (1%)[23] and Italian (3.6%),[3] but is comparable to the prevalence in non-transparent languages like English (4.6 – 7.3%).[3]

However, the average rate of dyslexia among bilingual Persian students (2.3%)[28,38,39] is significantly lower than in monolingual students (5%). This is consistent with Deponio et al.,[40] who carried out two studies on identifying bilingual students suspected of dyslexia in Scotland. The incidence of dyslexia, in the first study with 243 bilingual students from 26 primary schools was only 1.2%; the second study it was about 1.8% of 1023 bilingual students from 66 primary schools. Other studies have shown that familiarity with two different phonological systems enhances phonological skills, thus explaining why bilingual students are better at decoding phoneme-grapheme correspondence.[41,42] Therefore, we would expect less phonological difficulties in bilingual dyslexics in opaque languages, but no difference in their visual processing deficits. This notion requires additional study.

The enhanced incidence of dyslexia in opaque languages has more relation to linguistic characteristics of the scripts, such as grapheme-phoneme irregularity, than to cultural environment of the language. This hypothesis has been tested in different language systems in the same cultural context. In Japanese both phonographic (alphabetic) "Kana" and logographic "Kanji" scripts are used concurrently and the prevalence of reading difficulties is only 1.4% in Kana whereas it is 6.9% in Kanji.[5] Referring to the regularity concept, Gleitman and Rozin[43] have suggested that a greater degree of word lexical information is required to generate correct pronunciations of irregular words, whereas transparent words can be read non-lexically. Their correct pronunciation can be generated by translation of spelling to sound without needing to use any information from the mental lexicon. Therefore, acquiring reading ability in transparent languages is relatively easier for children[14] and results in a lower incidence of dyslexia.

This report provides the first classification of reading errors in the Persian language. Mispronunciation errors indicate inadequate grapheme to phoneme translation,[42] as do substitutions, where the initial phoneme of the target word is preserved. Both errors sound at least partially like the target words. Fragmentation errors represent the reader's efforts to match phoneme-grapheme components of the word. All these error types share phonological properties; as such, they are seen in all languages.[29,30] The dual-route model[24,45] explains phonological errors as due to impairment in the sub-lexical route that allows readers to derive the sounds of written words by converting letters or letter clusters into their corresponding sounds.

Reversal errors are incorrect responses that share more visual/orthographic than phonological features with the target words; these have been reported in both logographic[26] and alphabetic language systems.[29,30] Such errors along with omissions and additions may be related to deficits in the visual perceptual mechanisms important for word decoding. Cornelissen et al.[46] found a close relationship between orthographic errors and subject performance in visual coherent motion detection; the latter was also related to ability in letter position encoding.[47] Thus impairment in such abilities can lead to specific errors such as omissions and additions. An increasing number of studies[48–50] have shown that this kind of impaired visual processing is associated with impaired function of the visual magnocellular stream.[51] The extent of subtle visual deficits among Persian dyslexics is not clear. However, these errors usually occur in the course of reading via the lexical route is implicated in the retrieval of stored information related to orthography and semantics of familiar words.[24,46]

Repetitions and refusals are not classified as phonologic or visual errors but represent the reader's attempt to achieve comprehension. These complex reading errors have rarely been reported,[26] probably because the majority of researchers used procedures (i.e., single word/non-word reading, naming speed) suitable for elucidating theories about reading English, such as the dual-route model.[24,45,52] They mainly focus on decoding words.[45,52] However, our procedures for assessing reading allowed us to examine reading at all levels, from grapheme-phone decoding at the sub-lexical level, through reading words, reading fluency and sentence comprehension. The complex errors are likely to be more frequent than other error types in more skilled readers as shown for repetitions in the control group.

Generally, there were three categories of errors identified in the present study: phonological, visual/orthographic and pragmatic. The frequency of phonological errors was greater than visual and pragmatic errors in both the dyslexic and control groups, which suggested that the main problem during reading was grapheme to phoneme conversion. These types of errors have been reported in other studies. Gupta and Jamal[30] categorized reading errors in Hindi-English bilingual dyslexics who undertook reading tasks in both languages. They found 60% and 57% of phonological errors in Hindi and English, respectively; 15% and 35% of orthographic errors; 25% and 7% of mixed errors; and 0.38% and 0.94% were unrelated errors. Thus, phonological errors were the most frequent in both Hindi (a transparent language) and English. In Hindi, however, they found a far greater percentage of non-word (89%) than word (11%) errors, whereas in English both non-word (54%) and real word (46%) errors were frequent. The greater proportion of non-word errors in Hindi implies that assembling pronunciations from grapheme-phoneme correspondences is important for reading words in Hindi. Nevertheless, in English, children apparently attempt to use direct access strategies to read words, resulting in real word rather than non-word errors. Similar findings have been reported in other studies comparing reading acquisition in languages differing in orthographic transparency.[27,53,54] The former authors, for instance, found that the majority of errors made by children who were learning to read German were non-words, in marked contrast to children learning to read English whose errors were largely (the wrong) real words. What is confusing in the case of English is that children apparently make more use of lexical strategies to read, yet the majority of their errors are phonological, suggesting involvement of the sub-lexical route. Likewise, Siegel[25]

found more semantic errors in a group of English poor readers, yet the majority of them showed deficits in phonological skill; she therefore suggested that these children are forced to use the lexical route to read to compensate for their basic phonological deficits.

Thus, it could be argued that the elevated rate of phonological errors made by our dyslexic group was due to their problems in using the sub-lexical procedure to decode words. Accordingly, a phonological deficit associated with damage to sub-lexical route is perhaps common to children with dyslexia in both Persian and English, as two non-transparent alphabetic language systems. English difficulties are primarily with phone-grapheme inconsistencies, whereas in Persian they seem to be caused by the limited phonemic representation of vowels (i.e., diacritics) as well as letter-sound inconsistencies. When the diacriticals are inserted into the text, Persian becomes a transparent language to a great extent. Thus, phonological errors simply represent deficiencies in the decoding system that give rise reading problems. Linguistic based therapeutic interventions should be introduced as the primary therapeutic intervention for Persian children with dyslexia.

We conclude that Persian language, in vowel-free format, can be considered an opaque language. It follows that the prevalence of developmental dyslexia in Persian speaking children is close to that of English speaking children. Persian dyslexics mainly use sub-lexical reading strategy. This study has implications for screening schoolchildren for dyslexia in Iran as well as introducing effective therapeutic interventions for them.

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