The Egyptian Journal of Otolaryngology

ORIGINAL ARTICLE Open Access

Exploring phonological awareness skills in Arabic-speaking children with borderline intellectual functioning and poor reading

Sara Hesham[1], Omayma Afsah[2*] and Hemmat Baz[2]

Abstract

Background Phonological awareness (PA) is the awareness of speech sounds and the ability to reflect on and manipulate the phonemic segments of speech. Research on PA skills in children with borderline intellectual functioning (BIF) is scarce. The objective of this study was to explore PA skills in Arabic-speaking children with BIF and poor reading in comparison to dyslexic children using a modified version of the Arabic PA test.

Methods A sample of 98 Egyptian children in the age range 6 years and 6 months to 11 years and 5 months was subjected to assessment by the modified Arabic PA test. The sample included 50 typically developing children, 24 dyslexic children, and 24 children with BIF and poor reading.

Results and conclusion Children with BIF and poor reading demonstrated poor PA skills. Their performance on the modified Arabic PA test was significantly lower than the performance of normal as well as dyslexic children in younger age groups (6 years and 6 months to 8 years). However, in the older age group (8 years and 1 month to 11 years and 5 months), the performance of BIF and dyslexic children was comparable and significantly lower than normal children. The modified Arabic PA test shows evidence for its validity and reliability and can be used for the assessment of PA skills of children with average intelligence as well as children with intellectual dysfunction.

Keywords Reading development, Phonological awareness, Dyslexia, Borderline intellectual functioning

Background

Phonological awareness (PA) is defined as "the ability to identify, isolate, and manipulate speech sounds in a language" [1]. A child's phonological awareness develops during childhood, moving from syllable-level sensitivity through onset-rime sensitivity to phoneme sensitivity [2]. Early acquisition of this fundamental skill is important since it is a good predictor of future reading proficiency [3].

Dyslexia is a specific learning disability characterized by difficulties with accurate or fluent reading and spelling, despite adequate educational opportunities, and otherwise normal cognitive and intellectual abilities [4, 5]. Dyslexia is neurobiological in origin and is largely inherited and greatly modified by environmental variables [5, 6]. Phonological processing deficit is believed to have a causal role in the majority of individuals with dyslexia [4].

Borderline intellectual functioning (BIF) is a condition characterized by diverse cognitive impairments, with a borderline IQ (between 71 and 85), and impairment in personal functioning disturbing daily and social activities [7]. Its prevalence among the school-aged population is estimated to be around 7% [8]. Borderline intellectual functioning children frequently exhibit some degree of motor ability limitations in addition to intellectual (e.g., learning, reasoning, and problem-solving) and adaptive

*Correspondence:
Omayma Afsah
omafsah@yahoo.com
[1] Phoniatrics Unit, ORL Department, New Mansoura General Hospital, Mansoura, Egypt
[2] Phoniatrics Unit, ORL Department, Faculty of Medicine, Mansoura University, Mansoura 35516, Egypt

skill challenges (age-inappropriate social, communicative, and daily living behaviors) [9].

Learning issues are more common in individuals with BIF than in their contemporaries with typical intellectual functioning [8]. Such issues are due to their weak executive functions, and short-term and working memory, in both verbal and visuo-spatial components [10–12]. Additionally, the BIF group read real words and pseudo-words more slowly and with worse accuracy than the norm [11].

Research on phonological awareness skills in children with borderline intellectual functioning is scarce. Also, assessing phonological awareness in these children is considered challenging. The aim of this study is to explore the phonological awareness skills in Arabic-speaking Egyptian children with BIF and poor reading in comparison to dyslexic children using a modified version of the Arabic phonological awareness test. This would allow identifying the specific PA deficits that would be targeted in reading interventions.

Materials and methods

Subjects

This observational comparative cross-sectional study was carried out on 98 Egyptian children in the age range of 6 years and 6 months to 11 years and 5 months, during the period from October 2018 to October 2021. Participants were divided into three groups:

- Group I: Composed of 50 typically developing children (27 males and 23 females) with average intelligence and average reading development. These children were collected from primary schools in Dakahlia Governorate and from children attending the phoniatrics outpatient clinic at Mansoura University Hospital with complaints other than learning problems.
- Group II: Composed of 24 dyslexic children (19 males and 5 females) with average IQ (>85).
- Group III: Composed of 24 children (16 males and 8 females) with borderline intellectual functioning (IQ 70–85) and poor reading.
- Groups II and III children were selected from children attending the phoniatrics outpatient clinic at Mansoura University Hospital.

Each of the 3 studied groups was further divided into three age groups as follows:

- Group A: including children in the age range 6 years and 6 months to 8 years.
- Group B: including children in the age range 8 years and 1 month to 9 years and 5 months.
- Group C: including children in the age range 9 years and 6 months to 11 years and 5 months.

Inclusion criteria were children and parents were native Arabic speakers, normal hearing and visual abilities, and adequate language productivity. Children with attention deficit hyperactivity disorders were excluded.

The sample size was calculated online using www.dssresearch.com, provided the following:

1) From the previous study (Dessemontet et al. [13]), the mean score in children with intellectual disability was 10.26 ± 9.37, while the expected mean in this study is 9.1.
2) The alpha error level is 5%, and the confidence interval is 95%.
3) The beta error level is 20%, and the statistical power of the study is 80%.

So, the sample size would be 42 children at least. To compensate for non-responders and defaulters, the sample size was increased by 10%, reaching 48 children for groups II and III.

Methods

The whole studied sample (n= 98) was subjected to phonological awareness assessment. In addition, children in groups II and III were subjected to the following assessment protocol:

1. Elementary diagnostic procedures: These included parents' interview and history taking, general examination, and subjective language and speech evaluation.
2. Clinical diagnostic aids
   - **Psychometric evaluation:** through Stanford Binet Intelligence Scale "4th Arabic version" [14] for determination of IQ and mental age and Vineland Social Maturity Scale [15] for determination of social age.
   - **Language assessment:** the preschool language scale-4 (Arabic Version) [16] was used for the determination of language age.
   - **Audiological assessment:** to exclude children with hearing loss.
   - **Modified Arabic dyslexia screening test** [17] for diagnosis of reading disability.
   - **The Arabic phonological awareness test:** The Arabic phonological awareness test [18, 19] was used for the assessment of phonological awareness skills in the studied groups. However, modification of the test was done to suit the purpose of the

present study. For testing blending tasks (including blending syllables, blending onsets and rimes, and blending phonemes), and substitution tasks (including substituting initial, middle, and final phonemes), pictures were presented as visual aids (prompts) to be used if the child found difficulty to respond to the task auditorily. The picture representing the true answer was presented together with three picture distractors. For example, when testing blending syllables into words using syllables /læ/ and /bæn/, pictures of a cup of milk, a door, an elephant, and a pencil were presented to the child and he/she was asked to choose the correct picture and say the answer.

Accordingly, for each of the 6 items presented with pictures, the child was given a score of 2 if the child gave a correct response auditorily (without a visual prompt), a score of 1 if the child responded correctly with the use of visual prompt, and a score of zero if the child gave an incorrect response. Regarding segmenting sentences into words and segmenting words into syllables, the child was given a score of 2 if the child could segment the task completely, a score of 1 if the child partly segmented the task, and a score of 0 if the child gave an incorrect response. For the rest of the items, the child was given a score of 2 for correct response, and a score of 0 for incorrect response. A composite raw score of PA ability with a maximum score of 185 points was created by adding the scores of all tasks.

Therefore, the original Arabic PA test was supplemented with a picture booklet containing 52 pictures. Pictures were carefully selected from Google images with great resolution, and representing real objects, to be easily recognized by the child.

Participants were assessed individually in a noiseless room in their schools or in the phoniatric outpatient clinic. The time of administration of the PA test was about 40–45 min. Responses to the whole test items were recorded on a score sheet to get a total raw score.

Statistical analysis

Data were analyzed using IBM SPSS (Statistical Package for Social Science) version 25 for Windows. Numbers and percentages were used to present qualitative data, whereas mean ± standard deviation or median (minimum–maximum) was used for quantitative variables.

The association between categorical variables was verified by chi-square test. However, Fisher's exact test and Monte Carlo test were used instead when appropriate. In order to compare continuous variables in two independent groups, independent sample t test was used for normally distributed variables and Mann-Whitney U test was used for non-normally distributed ones. In order to compare continuous variables in more than two independent groups, the one-way analysis of variance (ANOVA) followed by post hoc tests was utilized for normally distributed variables whereas Kruskal-Wallis H test was utilized for non-normally distributed ones.

In all statistical tests, results were considered significant when $P \leq 0.05$.

Results

Descriptive statistics

Demographic data

The present study was conducted on 98 children aged 6 years and 6 months to 11 years and 5 months. They included 62 males (63%) and 36 females (37%), organized into 3 groups:

- Group I: 50 typically developing children with average intelligence and average reading development. They included 27 males (54 %) and 23 females (46 %), with a mean age of 9.0 ± 1.4 years.
- Group II: 24 dyslexic children with average IQ (>85). They included 19 males (79.2 %) and 5 females (20.8%), with a mean age of 8.9 ± 1.4 years.
- Group III: 24 children with borderline intellectual functioning (BIF) (IQ 70–85) and poor reading. They included 16 males (66.7 %) and 8 females (33.3%), with a mean age of 8.7 ± 1.4 years.

Twenty-four percent of the studied children were in the 3rd grade. The 3 studied groups were matched for age, sex, and school grades (Table 1).

Validity and reliability of the modified Arabic PA test

Validity

The validity of the modified Arabic phonological awareness test was tested using content validity and contrasted group validity. Three experienced bilingual phoniatricians judged all items as being entirely relevant to the purpose of the PA assessment. The normal group showed significantly higher performance on the test when compared to the dyslexic and BIF groups.

Reliability

To verify the reliability of PA test, the Cronbach alpha (α) equation was used. The total Cronbach alpha (α) for the 18 questions was 0.79 which indicates that the test has an acceptable degree of reliability based on the Nunnally scale [20], which established 0.7 as the minimal stability degree.

Table 1 Demographic characteristics of the three studied groups (*n*=98)

Parameters	Group I (normal children) *n*= 50	Group II (dyslexic children) *n*= 24	Group III (BIF children) *n*= 24	Test of significance
Age in years				
mean ± SD (min–max)	9.0 ± 1.4 (6.5–11.3)	8.9 ± 1.4 (6.8–11)	8.7 ± 1.4 (6.6–11)	*F*= 0.27 *P*= 0.77
Gender				
➢ Male	27 (54%)	19 (79.2%)	16 (66.7%)	χ^2= 4.6
➢ Female	23 (46%)	5 (20.8%)	8 (33.3%)	*P*= 0.10
School grade				
➢ 1st	10 (20%)	4 (16.7%)	4 (16.7%)	
➢ 2nd	10 (20%)	6 (25%)	6 (25%)	
➢ 3rd	13 (26%)	5 (20.8%)	6 (25%)	MC= 4.2
➢ 4th	8 (16%)	5 (20.8%)	4 (16.7%)	*P*= 0.96
➢ 5th	9 (18%)	3 (12.5%)	4 (16.7%)	
➢ 6th	0	1 (4.2%)	0	

Data expressed as "mean ± SD" or "number (%)",χ^2 chi-square test, *MC* Monte Carlo test, *F* One-way ANOVA test. Not significant, $p > 0.05$. *BIF* Borderline intellectual functioning

Comparative statistics

Comparison between the three studied groups in each age group as regards performance in phonological awareness (PA) assessment:

- Comparison between groups IA, IIA, and IIIA as regards their performance in phonological awareness (PA) assessment:

  Significant differences were observed between the three groups in the total score and individual items of the phonological awareness assessment (except for multisyllabic word production). The scores were consistently highest in the normal group and lowest in the borderline intellectual functioning (BIF) group (Table 2). Post hoc analysis showed significant differences between each of the two groups, demonstrating that the performance of the BIF group differs significantly from that of the dyslexic group (Table 3).
- Comparison between groups IB, IIB, and IIIB children as regards their performance in phonological awareness (PA) assessment:
  Significant differences were found between the three groups in the total score and nearly all individual items of the phonological awareness assessment. The highest scores were observed in the normal group (Table 4). Post hoc analysis showed significant differences between the normal group and each of the dyslexic and BIF groups. However, the majority of items as well as the total score did not differ significantly between dyslexic and BIF groups, demonstrating that both groups were comparable as regards their performance on PA assessment (Table 5).
- Comparison between groups IC, IIC, and IIIC children as regards their performance in phonological awareness (PA) assessment:

Significant differences were observed between the three groups in the total score and nearly all individual items of the phonological awareness assessment. The highest scores were observed in the normal group (Table 6). Post hoc analysis showed significant differences between the normal groups and each of the dyslexic and BIF groups. However, the majority of items as well as the total score did not differ significantly between dyslexic and BIF groups, demonstrating that both groups were comparable as regards their performance on PA assessment (Table 7).

Scoring of the modified version of the Arabic phonological awareness test

Since the administration of the Arabic PA test in the present study involved the use of pictures as visual aids, a new scoring system was developed. Consequently, the calculation of the 5th percentile values of the PA subtests and total score was done for the 3 age groups of the normal children (Table 8).

This would allow for the use of this modified version of the Arabic PA test as a diagnostic tool especially for children with intellectual dysfunction. If a child's total score on the test was found to be lower than the 5th percentile

Table 2 Comparison between groups IA, IIA, and IIIA as regards their performance in phonological awareness (PA) assessment

Items	Group IA (6 years and 6 months to 8 years) *n*= 17	Group IIA (6 years and 6 months to 8 years) *n*= 10	Group IIIA (6 years and 6 months to 8 years) *n*= 10	Test of significance
1. Segmenting sentences into words	10 (9–10)	9 (0–10)	7 (1–9)	KW= 21.9 *P* ≤ 0.001*
2. Blending syllables into words	9.9 ± 0.2 (9–10)	9.5 ± 0.9 (7–10)	8 ± 2.4 (2–10)	*F*= 6.7 *P*= 0.003*
3. Segmenting words into syllables	9.1 ± 1.1 (6–10)	9.2 ± 0.9 (8–10)	7 ± 2.9 (0–10)	*F*= 5.5 *P*= 0.008*
4. Isolating initial phonemes	10 ± 0 (10–10)	10 ± 0 (10–10)	8.3 ± 2.5 (3–10)	*F*= 6.4 *P*= 0.004*
5. Isolating final phonemes	10 (10–10)	10 (6–10)	5 (0–10)	KW= 26.9 *P* ≤ 0.001*
6. Isolating middle phonemes	10 (8–10)	6 (2–10)	2 (0–6)	KW= 26.8 *P* ≤ 0.001*
7. Blending onsets and rimes into words	9.9 ± 0.2 (9–10)	9.6 ± 0.5 (9–10)	8.6 ± 1.4 (6–10)	*F*= 9.9 *P* ≤ 0.001*
8. Blending individual phonemes into words	9.4 ± 0.9 (8–10)	8.7 ± 1.6 (6–10)	5.4 ± 1.1 (3–9)	*F*= 26.9 *P* ≤ 0.001*
9. Segmenting words into individual phonemes	10 (6–10)	2 (0–10)	0 (0–10)	KW= 18.4 *P* ≤ 0.001*
10. Recognizing rhyming words	10 (8–10)	8 (4–10)	5 (0–10)	KW= 18.1 *P* ≤ 0.001*
11. Deleting initial phonemes	10 (4–10)	5 (0–10)	0 (0–6)	KW= 23.9 *P* ≤ 0.001*
12. Deleting final phonemes	10 (6–10)	9 (0–10)	0 (0–10)	KW= 21.4 *P* ≤ 0.001*
13. Deleting middle phonemes	10 (8–10)	6 (0–10)	0 (0–6)	KW= 25.3 *P* ≤ 0.001*
14. Substituting initial phonemes	10 (6–10)	7 (0–10)	0 (0–7)	KW= 23.9 *P* ≤ 0.001*
15. Substituting final phonemes	10 (6–10)	4.5 (0–9)	0 (0–7)	KW= 25.7 *P* ≤ 0.001*
16. Substituting middle phonemes	9 (6–10)	1 (0–10)	0 (0–7)	KW= 19.6 *P* ≤ 0.001*
17. Phoneme-grapheme correspondence	19.8 ± 0.6 (18–20)	16.4 ± 4.2 (6–20)	9 ± 2.6 (2–17)	*F*= 27.8 *P* ≤ 0.001*
18. Producing multisyllabic words	4.9 ± 0.1 (4.5–5)	4.9 ± 0.2 (4–5)	4.9 ± 0.3 (4–5)	*F*= 0.40 *P*= 0.68
Total PA score	175.7 ± 6.4 (163–185)	134.4 ± 31.2 (74–172)	75.6 ± 21.7 (49–154)	*F*= 58.3 *P* ≤ 0.001*

Data expressed as "mean ± SD" or "median (minimum–maximum)"

F One-way ANOVA test, *KW* Kruskal-Wallis test

* Significant, *P* ≤ 0.05

of his age group, this would indicate a PA deficit. By comparing the subtests' scores with their 5th percentile values, specific areas of deficit could be delineated and targeted in the intervention.

Discussion

Phonological awareness is one of the factors that most accurately predict a child's capacity to learn to read [21]. In all languages thus far studied (such as English, German, and Swedish), studies have provided conclusive evidence that individual differences in reading are predicted by individual differences in phonological awareness [22]. Additionally, numerous studies found that phonological awareness training assists in reading development [23, 24].

Much like other languages, the PA influence on reading proficiency was also acknowledged in Arabic [25–28].

Table 3 Post hoc test for groups IA, IIA, and IIIA as regards their performance in phonological awareness (PA) assessment

Items	P1 Group IA vs group IIA	P2 Group IA vs group IIIA	P3 Group IIA vs group IIIA
1. Segmenting sentences into words	0.01*	≤ 0.001*	0.07
2. Blending syllables into words	0.41	0.001*	0.02*
3. Segmenting words into syllables	0.84	0.005*	0.07*
4. Isolating initial phonemes	1.0	0.002*	0.006*
5. Isolating final phonemes	0.59	≤ 0.001*	≤ 0.001*
6. Isolating middle phonemes	≤ 0.001*	≤ 0.001*	≤ 0.001*
7. Blending onsets and rimes into words	0.27	≤ 0.001*	0.006*
8. Blending individual phonemes into words	0.21	≤ 0.001*	≤ 0.001*
9. Segmenting words into individual phonemes	≤ 0.001*	≤ 0.001*	0.03*
10. Recognizing rhyming words	0.04*	≤ 0.001*	0.002*
11. Deleting initial phonemes	≤ 0.001*	≤ 0.001*	0.001*
12. Deleting final phonemes	0.03*	≤ 0.001*	≤ 0.001*
13. Deleting middle phonemes	≤ 0.001*	≤ 0.001*	≤ 0.001*
14. Substituting initial phonemes	0.002*	≤ 0.001*	≤ 0.001*
15. Substituting final phonemes	≤ 0.001*	≤ 0.001*	0.001*
16. Substituting middle phonemes	≤ 0.001*	≤ 0.001*	0.04*
17. Phoneme-grapheme correspondence	0.03*	≤ 0.001*	≤ 0.001*
Total PA score	≤ 0.001*	≤ 0.001*	≤ 0.001*

* Significant $P \leq 0.05$

The current study aimed to explore the phonological awareness skills in Arabic-speaking Egyptian children with borderline intellectual functioning and poor reading in comparison to dyslexic children using a modified version of the Arabic phonological awareness test. This would allow identifying the specific PA deficits that would be targeted in reading interventions. Ninety-eight Egyptian children aged 6 years and 6 months to 11 years and 5 months were subjected to assessment by the Arabic phonological awareness test. The sample included 50 typically developing children, 24 dyslexic children, and 24 children with borderline intellectual functioning and poor reading.

The Arabic PA test [18, 19] was supplemented with a picture booklet as pictures were used as visual aids for testing blending and substitution tasks and scoring was modified accordingly. The use of visual aids helped children to respond to tasks more easily and minimized memory demands which are generally poor in BIF children. Many researchers believe that individuals with BIF experience learning problems due to their weak executive functions, and poor short-term and working memory, as compared to typically developing (TD) peers particularly in verbal and visuo-spatial constituents [11, 12].

Comparison between normal, BIF, and dyslexic children in the age range 6 years and 6 months to 8 years as regards their performance on the modified Arabic PA test revealed significant differences between the 3 groups with the highest scores in the normal group. The BIF group showed the lowest scores. The lower performance of the dyslexic group as compared to the normal group was in agreement with earlier studies (e.g., Thomas-Tate et al. [29] and Afsah [19]) which demonstrated that children in the dyslexic group scored worse than the non-dyslexic children on tests assessing PA. In contrast, Stanovich [30] proposed that individuals with dyslexia would have a more severe phonological core deficit when compared with garden-variety poor readers (i.e., poor readers with low cognitive performance).

On comparing the performance of normal, dyslexic, and BIF children at older ages (from 8 years and 1 month to 11 years and 5 months) on phonological awareness tests, significant differences were observed between the 3 groups where the highest scores were observed in the normal group. However, the majority of items as well as the total score did not differ significantly between dyslexic and BIF groups, demonstrating that both groups were comparable as regards their performance on PA assessment. Similar

Table 4 Comparison between groups IB, IIB, and IIIB as regards their performance in phonological awareness (PA) assessment

Items	Group IB (8 years and 1 month to 9 years and 5 months) *n*= 15	Group IIB (8 years and 1 month to 9 years and 5 months) *n*= 5	Group IIIB (8 years and 1 month to 9 years and 5 months) *n*= 5	Test of significance
1. Segmenting sentences into words	10 (9–10)	10 (9–10)	7 (0–10)	KW= 8.4 *P*= 0.02*
2. Blending syllables into words	9.9 ± 0.5 (8–10)	9.4 ± 0.5 (9–10)	9 ± 0.7 (8–10)	*F*= 4.9 *P*= 0.02*
3. Segmenting words into syllables	9.5 ± 0.7 (8–10)	8.6 ± 0.9 (8–10)	7.8 ± 1.3 (6–9)	*F*= 7.6 *P*= 0.003*
4. Isolating initial phonemes	10 ± 0 (10–10)	10 ± 0 (10–10)	9.6 ± 0.9 (8–10)	*F*= 2.2 *P*= 0.14
5. Isolating final phonemes	10 (10–10)	10 (8–10)	10 (4–10)	KW= 3.1 *P*= 0.21
6. Isolating middle phonemes	10 (8–10)	6 (2–10)	4 (2–6)	KW= 18.1 *P*= ≤ 0.001*
7. Blending onsets and rimes into words	10 ± 0 (10–10)	9.4 ± 0.9 (8–10)	9.2 ± 0.8 (8–10)	*F*= 5.6 *P*= 0.01*
8. Blending individual phonemes into words	9.7 ± 0.7 (8–10)	9 ± 0.7 (8–10)	7.4 ± 1.5 (5–9)	*F*= 11.5 *P* ≤ 0.001*
9. Segmenting words into individual phonemes	10 (8–10)	2 (0–10)	4 (0–6)	KW= 16.6 *P* ≤ 0.001*
10. Recognizing rhyming words	10 (10–10)	8 (4–10)	8 (6–10)	KW= 13.7 *P*= 0.001*
11. Deleting initial phonemes	10 (10–10)	4 (0–8)	2 (0–4)	KW= 22.3 *P* ≤ 0.001*
12. Deleting final phonemes	10 (8–10)	8 (6–10)	10 (4–10)	KW= 6.5 *P*= 0.04*
13. Deleting middle phonemes	10 (10–10)	0 (0–10)	8 (0–10)	KW= 14.3 *P*= 0.001*
14. Substituting initial phonemes	10 (9–10)	4 (0–10)	0 (0–7)	KW= 17.7 *P* ≤ 0.001*
15. Substituting final phonemes	10 (8–10)	4 (0–9)	3 (0–9)	KW= 19.9 *P* ≤ 0.001*
16. Substituting middle phonemes	10 (9–10)	0 (0 – 8)	1 (0–7)	KW= 20.3 *P* ≤ 0.001*
17. Phoneme-grapheme correspondence	20 ± 0 (20–20)	15.2 ± 3.6 (12–20)	15 ± 1.9 (12–17)	KW= 19.1 *P* ≤ 0.001*
18. Producing multisyllabic words	4.9 ± 0.3 (4–5)	5 ± 0 (5–5)	4.9 ± 0.2 (4.5–5)	*F*= 0.26 *P*= 0.77
Total PA score	182.9 ± 1.5 (180–185)	127.4 ±31.8 (95–175)	118.5 ± 24 (86–148)	*F*= 37.4 *P* ≤ 0.001*

Data expressed as "mean ± SD" or "median (minimum–maximum)"

F One-way ANOVA test, *KW* Kruskal-Wallis test

* Significant, *P* ≤ 0.05

results were obtained by Stanovich and Siegel [31] who did not discover any differences between poor readers with higher IQs and those with lower IQs in their phonological reading abilities. According to Kuppen et al. [32], the poor vocabulary abilities linked to having a lower IQ may be sufficient to account for the poor phonological development of low-IQ poor readers.

Many studies revealed a considerable and consistent gap in PA between typically developed readers and reading-disabled children across grades, signifying persistent phonological deficits in reading-disabled children across developmental stages [4, 33]. Dandache et al. [34] found that despite dyslexic children showing PA impairment across grades, they exhibited progress even on the more

Table 5 Post hoc test for groups IB, IIB, and IIIB as regards their performance in phonological awareness (PA) assessment

Items	P1 Group IB vs group IIB	P2 Group IB vs group IIIB	P3 Group IIB vs group IIIB
1- Segmenting sentences into words	0.90	**≤ 0.001***	**0.002***
2- Blending syllables into words	0.12	0.007*	0.27
3- Segmenting words into syllables	0.06	0.001*	0.17
6- Isolating middle phonemes	≤ 0.001*	≤ 0.001*	0.12
7- Blending onsets and rimes into words	0.04*	0.007*	0.55
8- Blending individual phonemes into words	0.17	≤ 0.001*	0.01*
9- Segmenting words into individual phonemes	≤ 0.001*	≤ 0.001*	0.57
10- Recognizing rhyming words	0.001*	0.005*	0.67
11- Deleting initial phonemes	≤ 0.001*	≤ 0.001*	0.07
12- Deleting final phonemes	0.09	0.01*	0.45
13- Deleting middle phonemes	≤ 0.001*	0.009*	0.21
14- Substituting initial phonemes	≤ 0.001*	0.001*	0.23
15- Substituting final phonemes	≤ 0.001*	≤ 0.001*	1.0
16- Substituting middle phonemes	≤ 0.001*	≤ 0.001*	0.55
17-Phoneme-grapheme correspondence	≤ 0.001*	≤ 0.001*	0.86
Total PA score	≤ 0.001*	≤ 0.001*	0.42

* Significant, $P \leq 0.05$

challenging PA abilities; however, typically developing children in their study already achieved ceiling at grade 3.

Since the administration of the Arabic PA test in the present study involved the use of pictures as visual aids, a new scoring system was developed. Consequently, calculation of the 5th percentile values of the PA subtests and total score was done for the 3 age groups of the normal children. This would allow for the use of this modified version of the Arabic PA test as a diagnostic tool especially for children with intellectual dysfunction.

As noted from the 5th percentile values of PA test in the normal group, isolation of initial and final phonemes was the easiest task, a finding that was in line with Stahl and Murray [35] who found that isolation of phonemes was the easiest PA tasks and seem essential to reading, because almost all children who could not successfully accomplish this task also did not have pre-primer academic proficiency. Tibi [36] examined some PA tasks in the Arabic language and found that identifying the word's initial sound and rhyme oddity was considerably easier for children to perform than syllable omission and phoneme segmentation.

The current findings are consistent with those by Vloedgraven and Verhoeven [37], who showed that children appear to acquire rhyming, phoneme isolation, and phoneme blending abilities as PA begins to develop; children appear to acquire phoneme segmentation and phoneme deletion abilities as PA continues to develop. When Anthony et al. [2] looked into the development of PA, they found evidence for a quasi-parallel development of PA abilities in overlapping phases. Accordingly, the cognitive process required to accomplish tasks like phoneme segmentation and phoneme deletion is far more complex than the cognitive process required to perform rhyming, phoneme isolation, and phoneme blending [38].

In all age groups, the normal children in the current study got higher scores in isolation of initial and final phonemes than scores on tasks assessing word and syllable awareness. This finding could be attributed to the teaching method that is currently implemented in Egyptian schools which relies on teaching KG children the isolation of initial and final phonemes besides teaching the alphabet and early reading skills. According to McCormack and Pasquarelli's [39] research, sounds or phonemes must be specifically taught in order to be recognized in speech. If students are unable to deconstruct words verbally, they will not be able to distinguish between sounds and relate them to letters. They fail to decipher words when they are written down and will have a hard time learning to read. In agreement with the present results, Bdeir et al. [40] found that for the isolation of final phonemes, blending phonemes, and segmenting phonemes, students who received PA instructions significantly outperformed students who did not receive any

Table 6 PA in group IC of normal children, group IIC of dyslexic children, and group IIIC of below-average children

Items	Group IC (9 years and 6 months to 11 years and 5 months) *n*= 18	Group IIC (9 years and 6 months to 11 years and 5 months) *n*= 9	Group IIIC (9 years and 6 months to 11 years and 5 months) *n*= 9	Test of significance
1. Segmenting sentences into words	10 (9–10)	10 (8–10)	10 (5–10)	KW= 3.5 *P*= 0.17
2. Blending syllables into words	10 ± 0 (10–10)	9.7 ± 0.5 (9–10)	9.4 ± 0.7 (8–10)	*F*= 5.3 *P*= 0.01*
3. Segmenting words into syllables	9.7 ± 0.6 (8–10)	9.2 ± 0.8 (8–10)	9.3 ± 0.9 (8–10)	*F*= 1.7 *P*= 0.19
4. Isolating initial phonemes	10 ± 0 (10–10)	10 ± 0 (10–10)	10 ± 0 (10–10)	———
5. Isolating final phonemes	10 (10–10)	10 (8–10)	10 (8–10)	KW= 3.9 *P*= 0.14
6. Isolating middle phonemes	10 (10–10)	8 (4–10)	6 (0–10)	KW= 23.4 *P* ≤ 0.001*
7. Blending onsets and rimes into words	10 ± 0 (10–10)	8.8 ± 0.9 (8–10)	9.3 ± 0.7 (8–10)	*F*= 13.4 *P* ≤ 0.001*
8. Blending individual phonemes into words	9.9 ± 0.3 (9–10)	9.3 ± 1.1 (7–10)	8.1 ± 1.1 (7–10)	*F*= 15.1 *P* ≤ 0.001*
9. Segmenting words into individual phonemes	10 (8–10)	6 (0–10)	6 (0–10)	KW= 17.0 *P* ≤ 0.001*
10. Recognizing rhyming words	10 (8–10)	8 (4–10)	6 (4–8)	KW= 21.7 *P* ≤ 0.001*
11. Deleting initial phonemes	10 (10–10)	10 (0–10)	4 (0–10)	KW= 14.9 *P*= 0.001*
12. Deleting final phonemes	10 (10–10)	10 (8–10)	8 (2–10)	KW= 12.0 *P*= 0.002*
13. Deleting middle phonemes	10 (10–10)	4 (0–10)	6 (0–10)	KW= 18.7 *P* ≤ 0.001*
14. Substituting initial phonemes	10 (9–10)	8 (0–10)	6 (0–10)	KW= 20.6 *P* ≤ 0.001*
15. Substituting final phonemes	10 (8–10)	8 (2–10)	8 (0–10)	KW= 20.8 *P* ≤ 0.001*
16. Substituting middle phonemes	10 (8–10)	2 (0–10)	5 (0–8)	KW= 23.1 *P* ≤ 0.001*
17. Phoneme-grapheme correspondence	20 ± 0 (20–20)	17.3 ± 2.3 (13–20)	16.7 ± 3.8 (8–20)	*F*= 8.6 *P*= 0.001*
18. Producing multisyllabic words	5 ± 0 (5–5)	5 ± 0 (5–5)	4.9 ± 0.2 (4.5–5)	*F*= 1.5 *P*= 0.23
Total PA score	183.4 ± 1.7 (180–185)	149.4 ± 22.4 (110–178)	136.9 ± 30.1 (94–165)	*F*= 22.2 *P* ≤ 0.001*

Data expressed as "mean ± SD" or "median (minimum–maximum)"

F One-way ANOVA test, *KW* Kruskal-Wallis test

* Significant, $P \leq 0.05$

instructions. Students who received direct training could also identify the initial phoneme of any word irrespective of their letter knowledge and whether they are familiar with that word or not.

The modified Arabic PA test showed evidence for its validity and reliability as a diagnostic tool for PA deficit. If a child's total PA score was found to be lower than the 5th percentile of his age group, this would indicate PA deficit. By comparing the subtests' scores with their 5th percentile values, specific areas of deficit could be delineated and targeted in the intervention.

Conclusion

Children with borderline intellectual functioning (BIF) and poor reading demonstrated poor phonological awareness (PA) skills. Their performance on the modified

Table 7 Post hoc test for groups IC, IIC, and IIIC as regards their performance in phonological awareness (PA) assessment

Items	P1 Group IC vs group IIC	P2 Group IC vs group IIIC	P3 Group IIC vs group IIIC
2- Blending syllables into words	0.07	0.004*	0.29
6- Isolating middle phonemes	≤ 0.001*	≤ 0.001*	0.23
7- Blending onsets and rimes into words	≤ 0.001*	0.009*	0.06
8- Blending individual phonemes into words	0.09	≤ 0.001*	0.002*
9- Segmenting words into individual phonemes	0.001*	≤ 0.001*	0.64
10- Recognizing rhyming words	0.01*	≤ 0.001*	0.002*
11- Deleting initial phonemes	0.07	≤ 0.001*	0.03*
12- Deleting final phonemes	0.33	≤ 0.001*	0.007*
13- Deleting middle phonemes	≤ 0.001*	0.001*	0.76
14- Substituting initial phonemes	0.005*	≤ 0.001*	0.10
15- Substituting final phonemes	0.002*	≤ 0.001*	0.41
16- Substituting middle phonemes	≤ 0.001*	≤ 0.001*	0.64
17- Phoneme-grapheme correspondence	0.006*	0.001*	0.53
Total PA score	≤ 0.001*	≤ 0.001*	0.16

* Significant, $P \leq 0.05$

Table 8 Fifth percentile values of the PA test in group I (normal children), *n*= 50

Items	Group IA (6 years and 6 months to 8 years) *n*= 17	Group IB (8 years and 1 month to 9 years and 5 months) *n*= 15	Group IC (9 years and 6 months to 11 years and 5 months) *n*= 18
1. Segmenting sentences into words	9	9	9
2. Blending syllables into words	8	8	10
3. Segmenting words into syllables	6	8	8
4. Isolating initial phonemes	10	10	10
5. Isolating final phonemes	10	10	10
6. Isolating middle phonemes	8	8	10
7. Blending onsets and rimes into words	9	10	10
8. Blending individual phonemes into words	8	8	9
9. Segmenting words into individual phonemes	6	8	8
10. Recognizing rhyming words	8	10	10
11. Deleting initial phonemes	4	10	10
12. Deleting final phonemes	6	8	10
13. Deleting middle phonemes	8	10	10
14. Substituting initial phonemes	6	9	9
15. Substituting final phonemes	6	8	8
16. Substituting middle phonemes	6	9	9
17. Phoneme-grapheme correspondence	18	20	20
18. Producing multisyllabic words	4	4	5
Total PA score	140	167	175

Arabic PA test was significantly lower than the performance of normal as well as dyslexic children in younger age groups (6 years and 6 months to 8 years). However, in the older age group (8 years and 1 month to 11 years and 5 months), the performance of BIF and dyslexic children was comparable and significantly lower than normal children.

The modified Arabic PA test shows evidence for its validity and reliability. The supplementation of the Arabic PA test with pictures as visual aids for 6 of its tasks allows for the use of this modified version of the test for the assessment of PA skills of children with average intelligence as well as children with intellectual dysfunction.

Abbreviations

PA Phonological awareness
BIF Borderline intellectual functioning
IQ Intelligence quotient

Acknowledgements
All the authors wish to thank all children and their parents who participated in this research.

Authors' contributions
All authors contributed to the study conception and design, and data interpretation. Subjects' recruitment, data collection, and writing the draft of the manuscript were done by SH. OA was responsible for the main revision and editing of the manuscript and its submission for publication. HB shared in revising the manuscript. The authors read and approved the final manuscript.

Funding
No funding was received to assist with the preparation of this manuscript.

Availability of data and materials
All data generated or analyzed during this study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
A formal written consent from parents was taken. The study protocol was approved by the institutional research board (IRB), Faculty of Medicine, Mansoura University (MS.18.07.206 – 15/8/2018).

Consent for publication
It was included in the written consent to participate in the study by the participants.

Competing interests
The authors declare that they have no competing interests.

Received: 20 December 2023 Accepted: 2 April 2024
Published online: 28 May 2024

References

1. Wagner RK, Torgesen JK, Rashotte CA, Pearson NA (1990) Comprehensive test of phonological processing: CTOPP. Pro-ed, Austin, p 112–132
2. Anthony JL, Lonigan CJ, Driscoll K, Phillips B (2003) Phonological sensitivity: a quasi-parallel progression of word structure units and cognitive operations. Read Res Q 38(4):470–487
3. Lesaux NK, Siegel LS (2003) The development of reading in children who speak English as a second language. Dev Psychol 39(6):1005
4. Vellutino FR, Fletcher JM, Snowling MJ, Scanlon DM (2004) Specific reading disability (dyslexia): what have we learned in the past four decades? J Child Psychol Psychiatry 45(1):2–40
5. Fletcher JM, Lyon GR, Fuchs LS, Barnes MA (2018) Learning disabilities: from identification to intervention. New York: Guilford Publications.
6. Grigorenko EL, Compton D, Fuchs L, Wagner R, Willcutt E, Fletcher JM (2020) Understanding, educating, and supporting children with specific learning disabilities: 50 years of science and practice. Am Psychol 75(1):37
7. Salvador-Carulla L, García-Gutiérrez JC, Gutiérrez-Colosía MR et al (2013) Borderline intellectual functioning: consensus and good practice guidelines. Rev Psiquiatr Salud Ment (English Edition) 6(3):109–120
8. Karande S, Kanchan S, Kulkarni M (2008) Clinical and psychoeducational profile of children with borderline intellectual functioning. Indian J Pediatr 75(8):795–800
9. Vuijk Pieter J, Hartman E, Scherder E (2010) Motor performance of children with mild intellectual disability and borderline intellectual functioning. J Intellect Disabil Res 54(11):955–965
10. Alloway TP (2010) Working memory and executive function profiles of individuals with borderline intellectual functioning. J Intellect Disabil Res 54(5):448–456
11. Bonifacci P, Snowling MJ (2008) Speed of processing and reading disability: a cross-linguistic investigation of dyslexia and borderline intellectual functioning. Cognition 107(3):999–1017
12. Schuchardt K, Gebhardt M, Mäehler C (2010) Working memory functions in children with different degrees of intellectual disability. J Intellect Disabil Res 54(4):346–353
13. Dessemontet R, de Chambrier A-F, Martinet C, Moser U, Bayer N (2017) Exploring phonological awareness skills in children with intellectual disability. Am J Intellect Dev Disabil 122(6):476–491. https://doi.org/10.1352/1944-7558-122.6.476
14. Melika L (1998) Stanford Binet intelligence scale (4th Arabic version). Victor Kiorlos Publishing, Cairo
15. Doll EA (1965) Manual of the Vineland Social Maturity Scale. American Guidance Service, Circle Pines
16. Abu-Hasseba A (2011) Standardization, translation and modification of the preschool language scale-4. Unpublished MD thesis of Phoniatrics. Faculty of medicine, Ain Shams University, Cairo
17. El-Fiky YH, El-Sady S, Hegazi M (2016) Modification and standardization of Egyptian dyslexia screening test for children. Ain Shams Med J 67(1,2,3):127–134
18. El-Sady S, El-Shoubary A, El-Assal N, Abou-Elsaad T, Afsah O (2011) Development of a screening test battery for assessing phonological awareness in Arabic-speaking children in the early elementary grades. Ain Shams Med J 62(1):95–103
19. Afsah O (2014) The usefulness of an Arabic phonological awareness test: validation in Egyptian dyslexic children. Benha Med J 31(3):205–235
20. Nunnally JC, Bernstein IH et al (1994) The assessment of reliability. Psychometric Theory 3(248):292
21. Stanovich KE (1986) Matthew effects in reading: some consequences of individual differences in the acquisition of literacy. Read Res Q 21(4):360–407
22. Goswami U (2008) The development of reading across languages. Ann N Y Acad Sci 1145(1):1–12
23. Brennan F, Ireson J (1997) Training phonological awareness: a study to evaluate the effects of a program of metalinguistic games in kindergarten. Read Writing 9(4):241–263
24. Lundberg I (2009) Early precursors and enabling skills of reading acquisition. Scand J Psychol 50(6):611–616
25. Asaad H, Eviatar Z (2014) Learning to read in Arabic: the long and winding road. Read Writing 27(4):649–664
26. Saiegh-Haddad E, Spolsky B (2014) Acquiring literacy in a diglossic context: problems and prospects. Literacy Studies. Dordrecht: Springer, p 225-240
27. Abou-Elsaad T, Ali R, Abd El-Hamid H (2016) Assessment of Arabic phonological awareness and its relation to word reading ability. Logoped Phoniatr Vocol 41(4):174–180
28. Afsah O (2019) The relationship between phonological processing and emergent literacy skills in Arabic-speaking kindergarten children. Folia Phoniatr Logop 73(1):22–33
29. Thomas-Tate S, Washington J, Edwards J (2004) Standardized assessment of phonological awareness skills in low-income African American First Graders. Am J Speech Lang Pathol 13(2):182–190
30. Stanovich KE (1988) Explaining the differences between the dyslexic and the garden-variety poor reader: the phonological-core variable-difference model. J Learn Disabil 21(10):590–604
31. Stanovich KE, Siegel LS (1994) Phenotypic performance profile of children with reading disabilities: a regression-based test of the phonological-core variable-difference model. J Educ Psychol 86(1):24–53

32. Kuppen S, Huss M, Fosker T, Fegan N, Goswami U (2011) Basic auditory processing skills and phonological awareness in low-IQ readers and typically developing controls. Sci Stud Read 15(3):211–243
33. Saiegh-Haddad E, Taha H (2017) The role of morphological and phonological awareness in the early development of word spelling and reading in typically developing and disabled Arabic readers. Dyslexia 23(4):345–371
34. Dandache S, Wouters J, Ghesquière P (2014) Development of reading and phonological skills of children at family risk for dyslexia: a longitudinal analysis from kindergarten to sixth grade. Dyslexia 20(4):305–329
35. Stahl SA, Murray BA (1994) Defining phonological awareness and its relationship to early reading. J Educ Psychol 86(2):221–234
36. Tibi S (2010) Developmental hierarchy of Arabic phonological awareness skills. Int J Spec Educ 25(1):27–33
37. Vloedgraven J, Verhoeven L (2009) The nature of phonological awareness throughout the elementary grades: an item response theory perspective. Learn Individ Differ 19(2):161–169
38. Adams MJ (1990) Beginning to read thinking and learning about print. MIT Press, Cambridge
39. McCormack RL, Pasquarelli SL (2009) Teaching reading: strategies and resources for grades K-6. New York: Guilford Publications
40. Bdeir M, Bahous R, Nabhani M (2020) Improving reading readiness in kindergarten children through early phonological awareness interventions. Education 3–13:1–13

Publisher's Note