

Prosodic assessment in Egyptian children with specific language impairment

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Background

Prosody is the aspect of language that conveys emotion by changes in tone, rhythm, and emphasis during speech. Prosody includes aspects such as intonation and tone of voice. Specific language impairment (SLI) is a developmental disorder in which language development is below the chronological age despite normal nonverbal intelligence and no obvious neurological or physiological impairments or emotional and/or social difficulties that could impact language use. Most of these children experience considerable difficulty in language comprehension and/or production and experience specific problems in learning syntactic rules. In the speech stream, boundaries of major syntactic constituents are reliably marked by prosodic cues. Although deficits in related aspects of prosody have been hypothesized to underlie SLI, prosody has been little studied in Egyptian children having SLIs.

Objective

The objective of this work was to assess prosody in Egyptian children with an SLI in order to correlate the results with the clinical profile of the patients so as to choose the proper rehabilitation training program.

Participants and method

This study included 30 Egyptian children with SLIs and 30 normal children as a control group; their ages ranged between 4 and 6 years. Assessment included language assessment using the Arabic language test and prosodic assessment using the protocol of prosodic assessment, which was especially designed to assess prosodic abilities in Arabic-speaking children.

Results

Results revealed a significant difference in most of the individual and total subjective scores of prosodic skills between the control group and children with SLIs. Although the difference in the average of the total objective scores of prosodic assessment, which included pitch and energy, was highly significant, the average of total sentence duration was insignificant. There was significant correlation between the total language age and all subjective scores and an insignificant correlation with the total objective scores of prosodic assessment skills in SLI children.

Conclusion

SLI children have defective receptive, expressive, subjective, and objective scores of prosodic assessment skills that should be considered during the rehabilitation program for language stimulation for these children.

Keywords:

expressive language, intonation, prosody, receptive language, rhythm, specific language impairment, stress

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Introduction

Children with specific language impairment (SLI) experience considerable difficulty in language comprehension and/or production and experience specific problems in learning syntactic rules. In the speech stream, boundaries of major syntactic constituents are reliably marked by prosodic cues. Prosodic information provides an important cue for discovering the syntactic structure of a language.

Prosody is the aspect of language that conveys emotion by changes in tone, rhythm, and emphasis during speech. It is a neocortical function that allows graded and highly varied

vocal emotional expression [1]. Prosody is the suprasegmental aspect of speech, including variations in pitch/fundamental frequency, loudness/intensity, duration, pause/silence, intonation, rate, stress, and rhythm. A lot of information relevant for our understanding of spoken messages is carried through prosody. Prosody plays an important role in signaling attitudes and emotions. Prosodic features also constitute an important resource that participants use to achieve mutual understanding during interaction [2].

Prosodic information plays an important role during language acquisition while learning syntactic regularities. As language learners become more experienced and

proficient, prosodic information might be particularly relevant for language comprehension if there is a mismatch between different types of information such as prosody and syntax. Children with SLI may not be able to use prosodic information in the way unimpaired children do in order to learn new syntactic rules [3].

The difficulty that children with SLI have in successfully learning novel syntactic rules has been attributed to their inability to use prosodic information in the way normally developing children do [4]. Some authors have found that children with SLI might not benefit from prosodic information to the same degree as normal children [5]. Another study focused on the issue of prosodic impairment in children with developmental problems, including those with SLI. The study reviews the literature on prosody and discusses the issue of what may be considered a prosodic impairment as opposed to a delay in the acquisition of prosodic abilities in these children [6].

Despite the fact that prosodic information provides an important cue for discovering the syntactic structure of a language, to our knowledge, there are no detailed studies on prosodic characteristics in Egyptian SLI children.

The objective of this work was to assess prosody in Egyptian children having an SLI in order to correlate the results with the clinical profile of the patients to choose the proper rehabilitation training program.

Patients and methods

The study sample consisted of 60 Egyptian children from the same socioeconomic stratum. Their native language was Arabic. Their ages ranged from 4 to 6 years, with normal hearing, no apparent neurological or psychological disorders, and no mental retardation; their intelligence quotient was 90 or more. Children were selected from the outpatient clinic of the Phoniatic unit of Kasr El-Aini Hospital. Consent was taken from the parents of all children. The sample was as follows:

The patient group consisted of 30 children diagnosed with an SLI and included 22 boys and eight girls with a mean length of sentence in 3 words.

The control group included 30 children with normal language development and consisted of 19 boys and 11 girls.

The differences between boys and girls were statistically nonsignificant (P -value: 0.405, >0.05).

All children were subjected to the language assessment protocol and to the prosodic assessment protocol applied at the Phoniatic Unit, Kasr El-Aini Hospital, which included:

Elementary diagnostic procedures

- (1) *History taking*: This included personal, prenatal, natal, postnatal and developmental history, history of childhood illness, and social behavior of the child.
- (2) *Examination*: This included general, neurological, and local ear, nose, and throat examination.

Clinical diagnostic aids

- (1) *Arabic language test* [7]: This test measures receptive, expressive, semantic, pragmatic age, prosodic, and total language age.
- (2) *Prosodic skill assessment protocol* [8]: This includes:

(a) *Subjective assessment of prosodic skills*: It is used as a quantitative and qualitative measure to standardize prosodic development in Arabic-speaking children in the age range of 2–6 years. The protocol of prosodic assessment is a 40-point scale. Each child has to perform appropriate sentence stress in order to be considered prosodically well developed. The protocol of assessment includes the following prosodic skills:

- (1) Emotional status – for example, expressions of resentment and anger ((مخضمك) (زعلان منك) = I am angry).
- (2) Verbal disapproval – for example, expressions of opposition to others' opinions/acts ((كده غلط) : (كده عيب)) = This is wrong).
- (3) Verbal exclamation – for example, expressions of puzzlement and surprise ((الله) = wow!!).
- (4) Wishful thinking indication – for example, reflecting wishful thinking and craving for something ((يا رب) = please God).
- (5) Interrogative forms – for example, rising tone of speech at the end of a sentence to indicate a question ((بابا فين؟) = Where is dad?).
- (6) Exception indicators ((الا) = except).
- (7) Demonstrative pronouns – for example, referring to a certain person, object, or place ((هـ) = this).
- (8) Embedded phrases ((اللى) = that).
- (9) Warning speech – for example, expressions of warning ((اوعى) (حاسب) = take care).
- (10) Negation phrases ((معملتش) = I did not do).

These parameters were designed in the form of 10 sets, each containing four pictures. Picture 1 was used as a demo to demonstrate to the child what was actually required of him/her. The second picture was used as a trial to make him/her familiar with the introduced stimulus. The other two pictures served as test stimuli to elicit an appropriate prosodic production from the child under study.

The results were numerically scored as follows:

- (1) 0 → incorrect or no response.
- (2) 1 → one correct response with help (imitation).
- (3) 2 → two correct responses with help (imitation).
- (4) 3 → one correct response spontaneously + another correct response with help (imitation).
- (5) 4 → two correct responses spontaneously with 100% accuracy.

The total score was calculated by adding all the subscores obtained for the various parameters.

(b) *Objective prosodic assessment*: The 10 prosodic skills that were assessed previously were captured as signals and

were analyzed by a spectrogram, a program of computerized speech lab (CSL), Kay Model 4300. Each utterance passed through a narrow band display of a 45 Hz filter emulated by processing the sound wave of the whole sentence (utterance). Spectrographic analysis of the sound wave of the whole sentence was performed to obtain the following data:

- (1) The whole pitch contour in Hertz, calculated from the beginning to the end of the utterance.
- (2) The whole energy contour representing the energy in decibels from the beginning to the end of the utterance.
- (3) Duration of the sound wave of the whole utterance, calculated in seconds.
- (3) Psychometric evaluation, using the Stanford Binnet test [9]: This test has two parameters (verbal and performance). Mental age is determined for each child. Intelligence quotient = (mental age/chronological age) × 100.
- (4) Audiological assessment, through pure tone audiometry, tympanometry, and the auditory brainstem response for cases with subjective impression of affected hearing and for high-risk cases to confirm normal peripheral hearing.

All results were statistically analyzed

The data were coded and entered using the statistical package SPSS version 15 (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA). The data were summarized using descriptive statistics: mean, SD, and minimal and maximum values for quantitative variables and number and percentage for qualitative values. Statistical differences between groups were tested using the χ^2 -test for qualitative variables, the independent-sample *t*-test for quantitative normally distributed variables, and the nonparametric Mann-Whitney test for quantitative variables that were not normally distributed. Correlations were assessed to test for linear relations between variables. *P*-values less than or equal to 0.05 were considered statistically significant.

Results

The age of the control group ranged from 4 years (48 months) to 5 years and 11 months (71 months), with a mean of 57.63 ± 7.06 SD. The age of the case group ranged from 4 years (48 months) to 5 years and 11 months (71 months), with a mean of 57.93 ± 8.58 SD. There was no significant difference in mean age between the case and control groups (*P*-value is >0.05).

The results of this study are as follows:

Table 1 shows the comparison of the mean of both individual and total subjective scores of prosodic skills between the control group and children with SLI. The results reveal a highly significant difference in terms of the following: emotional status, verbal disapproval, verbal exclamation, wishful thinking indication, interrogative forms, demonstrative pronouns, embedded phrases, negation phrases, and total subjective score (*P*-value < 0.01).

Table 1 Comparison of the mean of subjective prosodic skills between the control group and children with a specific language impairment

Item	Mean \pm SD		<i>P</i> -value
	Control group	Children with SLI	
Emotional status	4.00 \pm 0	2.47 \pm 0.57	0.000*
Verbal disapproval	3.27 \pm 0.74	2.33 \pm 0.61	0.000*
Verbal exclamation	4.00 \pm 0	1.93 \pm 0.69	0.000*
Wishful thinking indication	3.13 \pm 0.82	1.70 \pm 0.79	0.000*
Interrogative forms	4.00 \pm 0	1.77 \pm 0.86	0.000*
Exception indicators	2.37 \pm 1.38	1.63 \pm 0.85	0.061
Demonstrative pronouns	4.00 \pm 0	1.90 \pm 0.71	0.000*
Embedded phrases	3.03 \pm 0.61	1.30 \pm 0.88	0.000*
Warning speech	2.27 \pm 1.48	1.87 \pm 0.78	0.169
Negation phrases	3.30 \pm 0.47	1.20 \pm 0.81	0.000*
Total subjective score	33.37 \pm 4.61	18.10 \pm 5.40	0.000*

Data are presented as mean and SD.

SLI, specific language impairment.

*Highly significant (*P*-value < 0.01).

Table 2 Comparison of the mean of sentence duration between the control group and children with a specific language impairment

Items	Mean \pm SD		<i>P</i> -value
	Children with SLI	Control group	
Emotional status	1.97 \pm 0.37	1.36 \pm 0.48	0.000*
Verbal disapproval	1.16 \pm 0.13	1.04 \pm 0.45	0.000*
Verbal exclamation	2.27 \pm 0.14	1.33 \pm 0.43	0.000*
Wishful thinking indication	1.29 \pm 0.14	1.40 \pm 0.44	0.296
Interrogative forms	1.43 \pm 0.11	1.38 \pm 0.56	0.096
Exception indicators	2.30 \pm 0.14	1.87 \pm 0.14	0.000*
Demonstrative pronouns	1.70 \pm 0.11	1.67 \pm 0.95	0.060
Embedded phrases	1.92 \pm 0.21	3.71 \pm 1.62	0.000*
Warning speech	2.11 \pm 0.14	1.69 \pm 0.80	0.000*
Negation phrases	1.72 \pm 0.12	1.33 \pm 0.57	0.001*
Average of total sentence duration score	1.79 \pm 0.07	1.68 \pm 0.40	0.155

Data are presented as mean and SD values.

SLI, specific language impairment.

*Highly significant (*P*-value < 0.01).

The results also reveal no significant difference in the subjective score of exception indicators and warning speech between the case and control groups (*P*-value > 0.05).

Table 2 shows that there is a significant difference between the SLI group and control group with respect to the mean of sentence duration of emotional status, verbal disapproval, verbal exclamation, exception indicators, demonstrative pronouns, embedded phrases, warning speech, and negation (*P*-value < 0.01). With regard to wishful thinking, interrogative form, and the average of total sentence duration score, the difference was insignificant (*P*-value = 0.05).

Table 3 shows that there is a highly significant difference between the control group and children with SLI in terms of the mean of sentence pitch in all items of prosodic assessment (*P*-value < 0.01), except in case of embedded phrases, for which the difference is insignificant (*P*-value > 0.05). SLI children scored higher than those in the control group.

Table 4 shows that there is a highly significant difference between SLI children and the control group with respect

Table 3 Comparison of the mean of sentence pitch between control group and children with a specific language impairment

Items	Mean ± SD		P-value
	Control group (n=30)	Children with SLI (n=30)	
Emotional status	306.42 ± 7.68	226.62 ± 16.67	0.000*
Verbal disapproval	303.94 ± 8.79	227.98 ± 26.53	0.000*
Verbal exclamation	296.30 ± 10.34	224.77 ± 19.23	0.000*
Wishful thinking indication	245.07 ± 36.54	225.15 ± 25.57	0.018*
Interrogative forms	286.54 ± 8.10	230.73 ± 25.99	0.000*
Exception indicators	245.72 ± 15.18	231.37 ± 21.87	0.005*
Demonstrative pronouns	282.66 ± 20.06	239.71 ± 18.63	0.000*
Embedded phrases	258.67 ± 19.39	248.54 ± 23.61	0.075
Warning speech	277.60 ± 9.27	240.39 ± 11.74	0.000*
Negation phrases	252.21 ± 48.44	221.86 ± 28.78	0.005*
Average of total sentence pitch score	275.51 ± 15.00	231.71 ± 10.12	0.000*

Data are presented as mean and SD values.
SLI, specific language impairment.
*Highly significant (P-value < 0.01).

Table 4 Comparison of the mean of sentence energy between the control group and children with a specific language impairment

Items	Mean ± SD		P-value
	Control group	Children with SLI	
Emotional status	50.30 ± 6.50	67.14 ± 2.24	0.000*
Verbal disapproval	51.95 ± 7.68	66.96 ± 3.34	0.000*
Verbal exclamation	51.44 ± 7.26	67.12 ± 2.52	0.000*
Wishful thinking indication	56.67 ± 8.22	62.24 ± 4.18	0.002*
Interrogative forms	48.68 ± 7.68	61.66 ± 3.75	0.000*
Exception indicators	47.36 ± 8.15	64.50 ± 3.22	0.000*
Demonstrative pronouns	53.09 ± 8.05	61.89 ± 4.95	0.000*
Embedded phrases	51.96 ± 6.90	60.03 ± 4.31	0.000*
Warning speech	53.95 ± 12.96	62.88 ± 4.95	0.001*
Negation phrases	102.46 ± 7.16	63.95 ± 4.98	0.000*
Average of total sentence energy score	56.79 ± 4.79	63.84 ± 1.84	0.000*

Data are presented as mean and SD values.
SLI, specific language impairment.
*Highly significant (P-value < 0.01).

to the mean of sentence energy for all parameters of prosodic assessment (P-value < 0.01). SLI children scored higher than the control group in the sentence energy category.

Table 5 shows that in SLI cases there is a highly significant correlation between total language age and all subjective scores (emotional status, verbal disapproval, verbal exclamation, wishful thinking, interrogative form, exception indicators, demonstrative pronouns, embedded phrases, warning speech, and negation) of prosodic assessment.

In the control group, there was a highly significant correlation between total language age and all subjective scores, except for the following: emotional status, verbal exclamation, wishful thinking, and exception indicators.

Table 6 shows that, although in SLI cases there was no linear correlation between total language age and the average of the total objective scores of the mean sentence

Table 5 Correlation between total language age and individual and total subjective score of prosodic assessment skills in specific language impairment children

Item	Total language age			
	SLI cases (n=30)		Controls (n=30)	
	r	P-value	r	P-value
Emotional status	0.606	0.000*	–	–
Verbal disapproval	0.797	0.000*	0.715	0.000*
Verbal exclamation	0.643	0.000*	–	–
Wishful thinking	0.663	0.000*	0.635	0.000*
Interrogative forms	0.769	0.000*	–	–
Exception indicators	0.715	0.000*	0.687	0.000*
Demonstrative pronouns	0.737	0.000*	–	–
Embedded phrases	0.619	0.000*	0.520	0.003*
Warning speech	0.631	0.000*	0.795	0.000*
Negation	0.787	0.000*	0.498	0.005*
Total subjective score	0.957	0.000*	0.827	0.000*

r is the correlation coefficient.
SLI, specific language impairment.
*Highly significant (P-value < 0.01).

Table 6 Correlation between total language age and average of total objective scores of prosodic assessment skills in specific language impairment children

Item	SLI cases (n=30)		Controls (n=30)	
	r	P-value	r	P-value
Average of total sentence duration	0.111	0.559	0.472	0.008*
Average of total sentence pitch	–0.017	0.930	0.669	0.000*
Average of total sentence energy	–0.079	0.678	0.635	0.000*

r is the correlation coefficient.
SLI, specific language impairment.
*Highly significant (P-value < 0.01).

duration, mean sentence pitch, and energy, in the control group there was a highly significant correlation between total language age and the average of the total objective scores of mean sentence duration, pitch, and energy.

Discussion

In this study, assessment of prosody in Egyptian SLI children revealed a significant difference between the SLI group and the control group. The SLI children scored much lower than the control group in the subjective and objective measures, except in sentence energy, in which they scored higher than the control group. These results indicate the importance of considering the prosodic defect while planning the rehabilitation program for language stimulation in SLI children.

In this study, the significantly low subjective scores in SLI children compared with their control peers with respect to all parameters except exception indicators and warning speech can be explained by the defective receptive and expressive abilities in these children (Table 1). This explanation is supported by the fact that receptive and expressive language impairment is at the heart of SLI. Children with SLI experience disturbances while expressing themselves that are a manifestation of their decoding impairment [10]. They suffer from a

short-term memory disorder that causes imperfect fixation of speech patterns in speech development and especially complicates further education and speech rehabilitation [11,12].

In Arabic-speaking children, normal development of interrogative skills is expected to be fully developed by the age of 2 years, but the objective correlates become fully apparent at an older age (3–4 years). Normal development of emotional status is expected to be fully developed by the age of 4 years, verbal exclamation and demonstrative pronoun skills are normally fully developed by the age of 5 years, and exception indicators, warning speech, verbal disapproval, wishful thinking, embedded phrases, and negation skills are normally fully developed by the age of 6 years [8].

The results in Table 1 are in accordance with those of Leonard and colleagues [13,14], who found a significant defective grammatical pattern in SLI children, especially in long complex sentences, which is a linguistic criterion. The possibility that a prosodic processing deficit underlies SLI has been explored in a series of studies with German-learning children. These studies related prosodic input processing to children's ability to learn and produce grammatically accurate sentences [15]. Other results showed that children with SLI, unlike normally developing children, were not helped by prosodic information in learning a miniature language [4], nor in repeating sentences accurately in terms of grammar and lexis. The authors concluded that prosodic deficits may underlie SLI defects. These findings were further supported by the fact that deficits in the abilities of children in the SLI group to see prosodic features in the language-learning task varied with their rhythmic ability, as demonstrated by a rhythm discrimination task [16].

Defective imitation of subjective parameters in the SLI children may be explained by defective memory, perception, comprehension of the concept, and difficulty in imitating sentences because of their defective expressive ability. These results agree with other studies that have focused on looking for a link between defective speech production and abnormal speech perception. Identification of speech sounds appears to be a problem for all groups. For more typical SLI where language comprehension is impaired, the most obvious problems are with expressive syntax and phonology [17].

The prosodic processing of spoken language input is a key factor in enabling the child to identify grammatical structures in the input, thus providing a basis for acquiring those structures. This view is predicated on the assumption that there are robust and consistent phonetic cues to grammatical structure available to children through speech directed at them. The salient pitch, duration, and rhythmic features that have been identified in studies of child-directed speech are assumed to be particularly important in this respect [15].

The delayed language development and maturational lag theory in language processing in SLI children can explain the defective maturation of all the subjective parameters

mentioned above. The results of this study agree with other findings of studies documenting that the rising intonation contour required to signal questions in English is difficult for young children and does not seem to be mastered until the age of 7 or 8 years [18,19].

The impaired embedded phrases in SLI children in this study can be explained by the impaired processing of speech that affects the development of phonological representations. Phonological representations and a defective working memory can cause deviant acquisition of morphology and syntax learning. Children with SLI have difficulty producing and comprehending morphologically complex words (past tense and plural inflections) in English (e.g. baked books). Their ability to express concepts using grammatical morphemes is also impaired [20].

The results in Table 1 prove the enormous retardation in prosodic development in SLI children compared with their control peers. This can also be explained by defective processing of information, especially in more complex grammatical structures, which take longer to process than simpler structures. With increasing sentence complexity, structures that place greater demands on processing resources (such as grammatical inflections) may be omitted. Other factors that increase processing demands, such as phonologic complexity and even prosodic difficulty, can also impair comprehension and speech production in children with an SLI. Limitations in the amount of information that can be stored in verbal working memory may further constrain prosodic development [21].

The defect in children with respect to the interrogative form may also be explained by a defective intonation contour. The nuclear tone generally coincides with the most important informational item, irrespective of its position in the sentence. Thus, children's deficits in intonation production have consequences on their ability to realize the pragmatic function of information focus [22].

As regards the objective acoustic assessment parameters of the studied prosodic skills, the highly significant shorter mean duration of sentences in SLI cases compared with controls in Table 2, except with regard to wishful thinking, interrogative form, and demonstrative pronoun skills, can be explained by the fact that cases of impaired language are accompanied by a weakness in prosodic processing. Poor recognition of prosodic cues to sentence structure may contribute to a delay in recognizing and replicating combinations of phrasal units and sentence clauses [23]. Omission of pronouns in children with SLI subsequently leads to the characteristically shortened mean length of utterance for preschool children. This finding agrees with that of McGregor *et al.* [24], who reported that children with SLI were particularly likely to omit pronouns and articles that occur in the utterance-initial position, where the weak syllable is omitted. This can also be explained by the weak syllabic stress observed in such children; weak syllables are composed of significantly smaller and shorter duration movements compared with strong syllables.

Weak syllabic stress in children with SLI can be explained by a motor defect in such children [25].

Table 3 shows that the mean sentence pitch of prosodic assessment skills is highly significantly lower than in the control group. This finding is augmented by the presence of the defective emotional state expression in children with SLI, as pitch is an important variable in the communication of emotions in speech. In the study by Snow [26], it was found that 4-year-old children could not imitate rising contours with the same precision as falling contours. He noted that children used a narrower F0 range than adults and tended to have longer word durations when imitating rising contours. Similarly, Wells *et al.* [19] found that functional intonation was largely established by age 5 but not mastered until approximately 8 years of age. The defective emotion expression in children with SLI in the form of mono-pitch results in decreased mean pitch, which is an indication of a small pitch variation in most SLI children. This can be explained by the defective pitch variation due to defective motor abilities in these children and by the defective rhythmic aspects of movement that can provide an insight into links between motor and language processes, specifically that the prosodic distinctions are instantiated in rhythmic movement output by these children.

In this study, the mean energy of a sentence was found to be higher in SLI cases than in controls, with the difference being highly significant (Table 4). This can be explained by the compensation of the poor ability of children with SLI to express proper melodic changes along the sentence and their inability to process the target intonation. Thus, they speak with a loud intensity to induce a change in sentence intonation.

Another explanation for the decreased pitch and increased energy is the presence of a motoric impairment in SLI. There is increasing evidence that motor impairment is a common comorbidity in children with SLI [27]. Motor impairment is less likely to be secondary to a communication disorder than the impairments in other developmental domains. Among children with SLI, motor impairment has been found to correlate most strongly with the observed severity of the child's language disorder [28]. However, it is still unclear whether motor impairment in children with SLI is the result of a more global developmental impairment or reflects a biological function that has greater effects on language and motor function than nonverbal cognition [29].

In this study, the highly significant correlation between language age and emotional status agreed with the results of Van Der Meulen *et al.* [23], who investigated the ability of children with SLI to understand the emotional significance of prosody and found that children with language impairments were not as proficient as controls at identifying vocal cues of emotion (Table 5). They also found that older children were significantly better than younger children at identifying emotion.

The highly significant correlation between total language age and both individual and total subjective scores among

SLI children in Table 5 indicates that, with improvement in language ability, there will be improvement in the prosodic skill but still less than in the control group. This can be explained by the presence of communication breakdown, which results from mismatches in productive abilities and listener expectations. This may impact the child's ability to grasp linguistic distinctions as well as the listener's perception of the child's communicative and cognitive competence. It is important to note that an assumption of an adult underlying form may lead us to erroneously underestimate a young child's prosodic phonology or to overlook ways in which they are signaling differences within the constraints of their maturing speech production system. Elucidating the various ways in which prosodic contrasts can be signaled across the age span is essential for designing interventions that focus on improving speaker abilities and in tuning listener expectations. Unlike the findings of this study, the results of some other studies indicate that the ability to interpret affect from prosodic cues is independent of language impairment, suggesting that some aspects of intonation may be dissociated from other aspects of language [23].

In the control group, the highly significant correlation between total language age and subjective prosodic scores (individual and total) shows that prosodic development is related to the development of other linguistic aspects – namely, semantics, syntax, and pragmatic, which play an important role in prosodic function and competence. Similar results were obtained by McCann *et al.* [30], who reported that prosodic test scores increase with age in typical developing English-speaking children and that there are statistically significant differences in the appropriateness of responses among different age groups in the use of prosodic function [8].

The presence of a nonsignificant correlation between language age and total sentence duration, pitch, and energy of SLI children (Table 6) indicates the absence of a linear improvement in objective prosodic abilities with improvement in language age. This can be explained by the presence of a major link among language defect, motoric deficits, and prosodic defect. This agrees with a study in which there was evidence that physiological and linguistic parameters interact [31]. This explanation also agrees with the highly significant correlation between language age and total sentence duration, pitch, and energy of the control group.

Although there was significant correlation between subjective prosodic scores and language abilities in the case group, there was a nonsignificant correlation between total language age and total objective prosodic scores [32]. It has been reported that, although subjective perceptual assessment is important and can be used in detecting many – if not all – prosodic skills and in the diagnosis of many prosodic disorders (dysprosody), objective measures such as spectrographic analysis are essential to differentiate between minor changes or differences that may be overlooked by the listener.

In the study by Goffman [25], it was concluded that intonation difficulties may be present in children with

SLI who present with different speech and language profiles (including children with and without accompanying speech output difficulties and pragmatic problems) in the form of defective identification of specific areas of intonational strength and weakness.

A poor grasp of prosodic cues by children with SLI could undermine comprehension, particularly when syntax is complex. Even if they later outgrow the prosodic deficit, the early weakness in prosodic processing may have a lasting impact. Locke [33] suggested, for example, that children need the right processing resources at the right time as they pass through what was termed critical periods for language acquisition. If children with SLI did not acquire the processing prosodic cues to sentence structure at the time that they were learning to parse that structure, the latter skill may remain weak even after prosodic processing improves [34].

The interaction output function task is closely linked to the corresponding interaction input function task, and the relatively weak performance here may similarly reflect a particular difficulty with pragmatic uses of intonation. As in the input task, the child has to understand that, following another's turn, a speaker has options of confirming, understanding, or checking that understanding and thereby eliciting a repetition of the item by the original speaker. Incorrect responses on the task could thus result from not understanding these options (pragmatic problem) [35].

Although children with SLI in this study showed a low subjective score because of using imitation in almost all situations of assessment like some normal speaking children, their objective results were different with regard to many items. These results agree with studies of prosodic skills in children with impaired language that have used production tasks [23]. When children with SLI and normally developing 4-, 5-, and 6-year-old children were asked to imitate the intonation of other speakers, the children with SLI had more difficulty than normal children with normal language on this task. Similarly, Wells *et al.* [35] reported that children with SLI had difficulty imitating the types of prosodic cues that differentiate clause boundaries, sentence types, and emphatic stress patterns. There have been mixed results on the ability of young children with communication impairments to use prosodic cues in spontaneous speech [36]. Children with speech disorders were reported to have a tendency to not use falling intonation patterns in statements. Rather, they used final syllable lengthening to mark the end of syntactic units.

Studies of prosodic processing, rather than production, have largely concentrated on emotional prosody. Evidence suggests that children with SLI, from ages 3 to 11 years, make fewer correct judgments of vocal affect than do their peers without SLI. However, it has been suggested that these results might be attributed to an interaction between emotional processing and the relative difficulty of the linguistic load for children with SLI [37], a factor that might also explain the poor prosodic production abilities of SLI children in [35] studies that used an imitation format.

Despite the fact that prosodic studies have been published worldwide and in many cases applied in different languages, it would be rather impractical to try to apply any of these studies in the form of prosodic tests or programs of therapy in Arabic-speaking children without major changes to both testing and therapeutic systems. Despite the large number of Arabic speakers, this unique language has not received the same interest in its prosodic system as have most other languages. Neither the Arabic language nor Arabic-speaking children have been properly investigated for prosodic development [8].

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Conflicts of interest

There are no conflicts of interest.

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