Phonological Processes in the Speech of Jordanian Arabic Children With Cleft Lip and/or Palate

Feda Y. Al-Tamimi¹, Arwa I. Owais¹, Omar F. Khabour¹, and Zaidan A. Khamaiseh²

Abstract
The controlled and free speech of 15 Jordanian male and female children with cleft lip and/or palate was analyzed to account for the different phonological processes exhibited. Study participants were divided into three main age groups, 4 years 2 months to 4 years 7 months, 5 years 3 months to 5 years 6 months, and 6 years 4 months to 6 years 6 months, with bilateral or unilateral cleft lip and/or palate. Based on a productivity scale of a 20% or higher occurrence, results indicated the use of five productive processes: consonants backing, lateralization, depharyngealization, stopping, and final consonant deletion. Other phonological processes—for example, strident deletion, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, and deaffrication—did not reach the 20% or higher productivity scale. Age correlated significantly with the phonological processes, with the youngest group exhibiting these processes more than the other two groups did. There was no significant correlation between gender and phonological processes usage.

Keywords
Cleft lip and palate, Jordanian Arabic, children, phonological processes

Researchers who have conducted studies of cleft lip and palate (CLP) have acknowledged the fact that CLP speech varies cross-linguistically both inter (i.e., in the speech of the same speaker) and intra (i.e., across different speakers). The source of heterogeneity, variation, or “tremendous range in articulation skills” (Morris, 1989, p. 185) could be due to the “nature of the original deformity, the outcome of treatment, presence and type of other congenital abnormalities, the degree to which hearing loss is controlled, intelligence, social experience both at and away from home, genetic characteristics, and family constellation” (McWilliams, Morris, & Shelton, 1984, p. 207). These factors might variably affect the intelligibility of the speech of persons with CLP or disturb the norms of “correct articulation” at the level of phonetics or phonology. Misarticulations could arise from the presurgical or immediate postsurgical articulatory maladaptations acquired by the individual. The phonetic misarticulations might be related to the aerodynamic requirements and articulatory configurations of certain sounds or sound categories, whereas the phonological deviations might result from the “simplifying processes that affect entire classes of sounds” (Ingram, 1976) and result in losing meaningful phonemic contrasts.

Despite the heterogeneity in the speech of individuals with CLP, it is important to study and characterize the common articulation patterns of these people that, generally speaking, arise from the inappropriate valving of air through the oral and nasal cavities. Two major classes of atypical articulatory features can be noted: active and passive cleft-type processes applied by speakers. The active processes establish meaningful contrasts between consonants, whereas the passive processes result from structural abnormalities or dysfunctions (Harding & Grunwell, 1996). Harding and Grunwell divided the active cleft-type processes into the following domains:

1. Active nasal fricatives: Speech contains nasopharyngeal misarticulation with sibilants articulated through complete closure across the hard palate, with nasal escape.

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2. Glottal articulation: Alveolar and velar stops are replaced by glottal stops.
3. Pharyngeal fricatives: Fricatives are produced with the tongue dorsum retracted to the pharyngeal wall, causing primary constriction in the lower larynx rather than in the area between the velum and lips.
4. Backing: Alveolar consonants are produced in the uvular and velar regions.
5. Double articulation: Bilabials are produced with glottal/pharyngeal constrictions, and alveolars are produced with alveolar/velar constrictions.
6. Palatal fricatives, lateral fricatives, and gliding of fricatives: Fricatives are produced with palatal contact, with lateralization, or as /w/.

The passive cleft-type processes are as follows:

1. Absence of pressure consonants: plosives, fricatives, and affricates are misarticulated due to the inability of the individual to maintain high oral air pressure.
2. Weak articulation: Although there is a reduction of intraoral pressure, some speakers continue to articulate some consonants weakly, albeit from the correct place of articulation.
3. Passive nasal fricative: The /s/ is produced with an unintended nasal airflow (surgical intervention can eliminate this cleft-type speech error).
4. Voiceless [h] for voiceless plosives: Reduced oral air pressure affects /p t k/ production and leaves aspiration as the only distinctive feature for these sounds.
5. Nasal realization of voiceless plosives: In the speech of some speakers with CLP, /b d g/ might be realized as [m n ŋ].
6. Nasal emission accompanying consonants: Velopharyngeal incompetence might lead to nasal emission accompanying some consonants with air escaping through the nasal route, causing reduction in the intraoral pressure.

Most of these processes are considered language-universal (Bronsted et al., 1994; Harris & Cottam, 1985). However, some features might be realized differently in different languages (Gibbon, Whitehill, Harcastle, Stokes, & Nairn, 1998). This difference might be related to whether a certain phonological process is realized in a certain language, how it is realized, and whether it is productive in this language. The influence of the speaker’s first language on cleft speech is worth investigating, as it could reflect some phonemic inventories and developmental phonological features unique to the language. For example, Jordanian Arabic has the glottal stop /ʔ/, voiceless and voiced pharyngeal fricatives /h/ and /ʕ/, the voiceless uvular stop /q/, and the voiceless velar fricative /x/ as phonemes in its consonantal inventory. In English, /ʔ, h, ʕ, q/ are used as compensatory articulations to substitute and compensate for the English phonemes that speakers with CLP find difficult to produce (Harding & Grunwell, 1996). Because these consonants are not part of the English consonantal inventory, phonemic neutralization is avoided, and therefore, different phonemes in the same language will be kept distinguishable. In Jordanian Arabic, however, all these consonants are phonemes. It is important to determine if Jordanian Arabic speakers with CLP preserve the phonemic contrast and avoid substituting these consonants for other consonants in their speech. The only previous study of Arabic speech involving CLP, a case study of three Palestinian children, was conducted by Shahin (2006). Shahin addressed this concern in her research and sought data from Arabic speech that might indicate some language-specific results. She observed no language-specific effects for Arabic cleft speech. In this regard, some explanation of the Jordanian Arabic phonemic and phonological structures might help to map the general phonetic and phonological features of the speech of our study participants with CLP.

Jordanian Arabic Phonetics and Phonology Overview

The Jordanian Arabic language has 28 consonants and 9 vowels: /i, ii, u, uu, a, aa, e, e, e:/ with two diphthongs /ou and ei/. A unique feature of Jordanian Arabic is that it has a number of (a) back consonants produced by the dorsum of the tongue and the velum or uvula: /q/ (a voiceless uvular stop), /x/ (a voiceless velar fricative), and /v/ (a voiced velar fricative) and (b) gutturals produced in the pharynx and glottis: /h/ (a voiceless pharyngeal fricative), /ʕ/ (a voiceless pharyngeal fricative), /ʔ/ (a voiceless glottal fricative), and /ʔ/ (a voiceless glottal stop). Added to these are the emphatic consonants that McCarthy (1991) grouped as gutturals because they are characterized by the feature [+pharyngeal]. Emphasis is a phonological feature whose domain spreads beyond a single segment. The whole syllable might be [+pharyngeal] because of the occurrence of an emphatic sound. From an articulatory perspective, emphasis results from the following, according to Lehn (1963):

...the co-occurrence of the first and one or more others of the following articulatory features: (1) slight retraction, lateral spreading, and concavity of the tongue and raising of its back (more or less similar to what has been called velarization), (2) faucal and pharyngeal constriction (pharyngealization), (3) slight lip protrusion or rounding (labialization), and (4) increased tension of the entire oral and pharyngeal musculature resulting in emphatics being noticeably more fortis than plain segments. (pp. 30-31)
Emphatic consonants in Arabic are /tˤ/ (a voiceless alveolar emphatic plosive), /dˤ/ (a voiced alveolar emphatic plosive), /sˤ/ (a voiceless alveolar emphatic fricative), and /Dˤ/ (a voiced interdental emphatic fricative). They exhibit a primary articulation of constriction and a secondary articulation of pharyngealization (Al-Tamimi, Alzoubi, & Tarawnah, in press). Arabic-speaking children usually master pharyngealized consonants and pharyngeals around the age of 6 years (Amayreh, 2003). However, they start as uvularized consonants around the age of 4 years (Al-Tamimi, 2006). These consonants are usually considered the most difficult sounds in Arabic (Amayreh & Dyson, 2000). As part of the normal consonantal development non-emphatic cognates of the Arabic phonemic inventory, children usually replace these “late” consonants with their nonemphatic cognates.

The Current Study
Keeping these facts in mind, we created the study reported herein with the following goals:
1. to highlight the phonological processes common in the speech of Jordanian children with CLP;
2. to determine whether age, gender, and the phonological processes are correlated in Jordanian cleft speech; and
3. to determine whether these phonological processes are language-universal or language-specific, due to the difference in the phonemic inventories between Jordanian Arabic and other languages.

Method
Participants
Fifteen Jordanian children with CLP participated in this study. In Jordan, it is estimated that the overall prevalence rate for live births with CLP is 1.39 per 1,000, with 30% of these having cleft lip, 22% having cleft palate, and 48% having both. Higher prevalence rates are found in boys (55%) versus girls (45%; Al Omari & Al-Omari, 2004). The participants in our study were divided into three main age groups: Group 1 (4.5 years average age), Group 2 (5.5 years average age), and Group 3 (6.5 years average age). All participants underwent full extra and clinical oral examination by a pediatric dentist (A.I.O.). They had repaired unilateral/bilateral cleft lip and/or palate with no other congenital abnormalities, neurological impairments, intellectual deficits, or hearing problems (see Table 1 for age breakdown). All participants had attended speech therapy sessions after surgery.

Data Collection
Recorded data were elicited through the use of a picture-naming technique and through spontaneous speech. We employed a picture-naming test designed by Amayreh (1994) to elicit single-word consonants in different word positions. A group of 10 Jordanian monolingual researchers and university speech–language therapy students assessed the test’s reliability and familiarity. All found the test pictures familiar to the Jordanian community and representative of the community’s everyday language. In addition, spontaneous data were obtained by asking the participants to speak about a cartoon movie they liked to watch. All participants indicated that they liked to talk about Power Rangers.

Analysis
Data were transcribed narrowly. The different phonological processes found in the productions of the study participants were classified as productive and unproductive. We used McReynolds and Elbert’s (1981) definition that a productive phonological process had to “occur in at least 20% of the items that could be affected by the process” (p. 201). In other words, a productive phonological process had to occur 5 out of 20 times in the speech of a single speaker. To identify the frequency of occurrence of the phonological processes and differences between the groups in using them, we used a digitization process. Phonological processes were listed on an Excel sheet, and instances of production representing them were listed under each. The correct pronunciation of the word was transcribed in front of it, and the different pronunciations of this word affected by one, or more than one, phonological process were distributed under the process (or processes). These instances
were numbered out of the total correct productions and fed into the SPSS software program to determine the frequency of occurrence and the roles of age and gender in the use of the phonological processes. For example, the backing phonological process was assigned the number 1. The different instances of backing were also numbered per speaker. So, for example, when a certain speaker produced miter (meter), kur (donkey), djaras (bell), raas (head), james (sun), and ruzz (rice) as [miʔe], [.RelativeLayout], [Lu], [Laac], [camēc], and [Lu], respectively, each of these mispronunciations was given a number, for example, [miʔe] (1), [Lu] (2), [Laac] (3), [Laac] (4), [camēc] (5), and [Lu] (6), respectively. Accordingly, [ʔ] is a pharyngealized stop, [c] is voiceless palatal fricative, [b] is a voiced alveolar lateral fricative, and [g] is a voiced uvular stop.

Gender and age were also digitized, with (1, 2) for male and female, respectively, and (1, 2, 3) for young (Group 1), middle (Group 2), and older (Group 3) children. All these data were fed into the SPSS program to determine the frequency of occurrence of the phonological processes, their means, and their correlations with age and gender. To increase reliability, two of the authors acted as interraters and listened to the speech of each participant separately, noting his or her mispronunciations under the suitable phonological process. The percentage of agreement between the raters was 100%.

Results

We found different phonological processes in the speech of study participants: backing to velar or uvular consonants, stridency deletion, lateralization, depharyngealization, final consonant deletion, stopping, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, and deaffrication. The results of the multivariate tests (see Tables 2 and 3) show the means, standard deviations, and correlations of the phonological variables across the different age and gender groups.

Based on the productivity scale of a minimum 20% of occurrence in the items that could be affected by the process, the study participants backed the front consonants most of the time. Age correlated significantly with this phonological process. The speech of the boys (71.3%) and girls (70.8%) in Group 1 exhibited backing more than that of Group 2 (52.0% and 37.6%, respectively) and Group 3 (24.0% and 16.0%, respectively). Final consonant deletion was the second most productive phonological process in the participants' speech. It correlated with age in the speech of the boys in Groups 1 and 2. Group 1 boys (67.0%) and girls (66.8%) deleted final consonants more than Group 2 boys (55.2%) and girls (48.0%) did; however, this process remained productive and even more frequent in the speech of the Group 3 boys (50.4%) and girls (52.0%). Lateralization remained productive in the speech of the Group 1 boys and girls (60.0% vs. 59.0%), Group 2 boys and girls (43.2% vs. 34.4%), and Group 3 boys and girls (28.0% vs. 22.4%), respectively. Depharyngealization was mainly productive in the speech of the Group 1 boys and girls (51.3% vs. 51.2%), and stopping was mainly productive in the speech of the Group 1 girls and girls (23.7% vs. 22.4%).

The other phonological processes (strident deletion, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, and deaffrication) did not appear productive, and their occurrence decreased significantly with age. In some cases (devoicing, liquid gliding, deaffrication), they disappeared completely in the speech of Groups 2 and 3.

Gender did not correlate significantly with all phonological processes. Nevertheless, there was a general trend for these phonological processes to be exhibited more in the boys' speech.

Discussion

Results of the current study suggest that the speech of Jordanian children with CLP exhibits phonological processes similar to those reported in the literature for other languages (e.g., Chapman, 1993; Shahin, 2006). As noted previously, the productive phonological processes were consonant backing, final consonant deletion, lateralization, depharyngealization, and stopping. The nonproductive phonological processes were strident deletion, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, and deaffrication.

The most productive phonological process appears to be consonant backing. Obstruents were backed toward a region farther back in the vocal tract. Miter (meter), kur (donkey), djaras (bell), raas (head), james (sun), and ruzz (rice) were produced as [miʔe], [RelativeLayout], [Laac], [Laac], [camēc], and [Lu], respectively. The most frequently backed stops were /t/ and /k/. They were realized as /t/ → [ʔ] and /k/ → [ʔ]. The most frequently backed fricatives were /s/ and /z/, and they were realized as [c] and [i], respectively. The only affricate sound in standard Arabic /ds/ was backed to /ca/. Fricatives, plosives, and affricates have been found to be backed more than other consonants in the speech of individuals with CLP. These high-pressure consonants require velic closure and buildup of oral pressure behind the constriction to be produced. The sibilant fricatives are distorted more than the nonsibilants. This might be due to the fact that the former have a more strident quality and longer duration than other consonants do. In addition, the production of these consonants requires a precise articulatory configuration. According to Fletcher (1978), they require precise placement and control of the tongue as it is positioned in contact with the alveolar margins laterally and at a specified distance from the incisor.
<table>
<thead>
<tr>
<th>Phonological variable</th>
<th>Group 1</th>
<th></th>
<th>Group 2</th>
<th></th>
<th>Group 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
<td>Boys</td>
<td>Girls</td>
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<tr>
<td>Backing</td>
<td>71.3</td>
<td>1.15</td>
<td>70.8</td>
<td>1.78</td>
<td>52.0</td>
<td>14.69</td>
</tr>
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<td>Stridency deletion</td>
<td>17.7</td>
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<td>15.4</td>
<td>1.14</td>
<td>13.6</td>
<td>3.28</td>
</tr>
<tr>
<td>Lateralization</td>
<td>60.0</td>
<td>2.00</td>
<td>59.0</td>
<td>1.73</td>
<td>43.2</td>
<td>11.79</td>
</tr>
<tr>
<td>Depharyngealization</td>
<td>51.3</td>
<td>1.15</td>
<td>51.2</td>
<td>1.09</td>
<td>31.0</td>
<td>16.97</td>
</tr>
<tr>
<td>Final consonant deletion</td>
<td>67.0</td>
<td>1.00</td>
<td>66.8</td>
<td>2.16</td>
<td>55.2</td>
<td>11.79</td>
</tr>
<tr>
<td>Stopping</td>
<td>23.7</td>
<td>0.57</td>
<td>22.4</td>
<td>1.51</td>
<td>16.8</td>
<td>6.57</td>
</tr>
<tr>
<td>Consonant harmony</td>
<td>15.3</td>
<td>0.57</td>
<td>14.4</td>
<td>1.51</td>
<td>8.0</td>
<td>7.48</td>
</tr>
<tr>
<td>Fronting</td>
<td>7.3</td>
<td>0.57</td>
<td>7.2</td>
<td>1.92</td>
<td>4.8</td>
<td>3.34</td>
</tr>
<tr>
<td>Syllable reduction</td>
<td>16.66</td>
<td>1.52</td>
<td>15.2</td>
<td>1.09</td>
<td>13.6</td>
<td>2.60</td>
</tr>
<tr>
<td>Devoicing</td>
<td>3.33</td>
<td>0.57</td>
<td>0.8</td>
<td>1.78</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Liquid gliding</td>
<td>1.66</td>
<td>1.52</td>
<td>1.0</td>
<td>1.73</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Deaffrication</td>
<td>1.66</td>
<td>2.08</td>
<td>1.0</td>
<td>1.73</td>
<td>0</td>
<td>0</td>
</tr>
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</table>
teeth anteriorly. The sibilants also require formation of a medial groove anteriorly between the blade of the tongue and the alveolar ridge. The airstream is then diverted at the velopharyngeal valve from whence it flows under pressure through the groove and turbulence space between the tongue and the teeth. (p. 64)

Stops also require high intraoral pressure buildup behind the closure. With this retracted articulation, the speaker “aims to avoid or camouflage the inappropriate escape of air into or through the nasal cavity” (Howard, 2004, p. 314). It is important to note that consonants are backed to be substituted by sounds that, generally speaking, are not part of the phonemic inventory of Jordanian Arabic. Substituting pharyngealized stops (e.g., [Ɂ]) for stop consonants (e.g., /k/), palatal fricatives (e.g., [ç] and [ʃ]), and dental fricatives (/s/ and /s/), and a uvular stop (e.g., [G]) for the postalveolar affricate /dʒ/ does not result in disturbance of the phonemic system of Jordanian Arabic or neutralization of the phonemic contrasts because these substitutes are not Jordanian Arabic consonants. This matches Shahin’s (2006) observation of there being no language-specific effects in the speech of Arabic individuals with CLP.

However, the glottal stop is part of the Jordanian Arabic phonemic system. Its usage in word initial and medial positions, for example, [mith] for mitér (meter) and [talafson] for talafson (telephone), might result in loss of meaningful contrast between this compensatory articulation of /t/, that is, [ʔ], and the etymological glottal stop /ʔ/, that is, words used with the Jordanian Arabic phoneme /ʔ/. What seems to happen is that the speaker uses a creaky glottal stop in word initial and medial positions to avoid phonemic neutralization. In other words, in this study, participants used complete glottal stops for words with etymological glottal stops (e.g., /ʔaxdár/ [green] → [ʔaxdā]) and glottal stops with creak phonation—or laryngealization (e.g., talafson [telephone] → [ʔalafson])—to substitute etymological /t/ in word initial and medial positions (see Figure 1). Word finally, /t/ is deleted.

Table 3. Correlations Among Age, Gender, and Phonological Variables

<table>
<thead>
<tr>
<th>Phonological variable</th>
<th>Age</th>
<th></th>
<th>Gender</th>
<th></th>
<th></th>
</tr>
</thead>
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<td></td>
<td>F test</td>
<td>p</td>
<td>F test</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Backing</td>
<td>63.49304</td>
<td>&lt; .005</td>
<td>0.235203</td>
<td>.631754</td>
<td></td>
</tr>
<tr>
<td>Stridency deletion</td>
<td>40.71592</td>
<td>&lt; .005</td>
<td>0.964206</td>
<td>.335179</td>
<td></td>
</tr>
<tr>
<td>Lateralization</td>
<td>58.47576</td>
<td>&lt; .005</td>
<td>0.199809</td>
<td>.658576</td>
<td></td>
</tr>
<tr>
<td>Depharyngealization</td>
<td>53.83806</td>
<td>&lt; .005</td>
<td>0.153282</td>
<td>.698609</td>
<td></td>
</tr>
<tr>
<td>Final consonant deletion</td>
<td>19.8814</td>
<td>&lt; .005</td>
<td>0.018481</td>
<td>.892912</td>
<td></td>
</tr>
<tr>
<td>Stopping</td>
<td>33.4236</td>
<td>&lt; .005</td>
<td>0.276968</td>
<td>.603156</td>
<td></td>
</tr>
<tr>
<td>Consonant harmony</td>
<td>32.72991</td>
<td>&lt; .005</td>
<td>0.257167</td>
<td>.616348</td>
<td></td>
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<tr>
<td>Fronting</td>
<td>16.0014</td>
<td>&lt; .005</td>
<td>0.297485</td>
<td>.590113</td>
<td></td>
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<tr>
<td>Syllable reduction</td>
<td>34.20937</td>
<td>&lt; .005</td>
<td>1.568309</td>
<td>.221601</td>
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<tr>
<td>Devoicing</td>
<td>8.578431</td>
<td>.0014</td>
<td>1.108928</td>
<td>.302004</td>
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<tr>
<td>Liquid gliding</td>
<td>6.377551</td>
<td>.0057</td>
<td>0.018031</td>
<td>.894217</td>
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<tr>
<td>Deaffrication</td>
<td>5.19103</td>
<td>.0130</td>
<td>0.015659</td>
<td>.901379</td>
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</tbody>
</table>

Figure 1. Spectrogram of the words [ʔaxdár] green (left) and [ʔalafson] telephone (right) produced by a male speaker, 4 years 6 months.
The complete or full glottal stop was produced with full glottal adduction. There was a clear pulse in the first word [ʔaxda], with glottal pulses in the following vowels higher in amplitude than the ones in the vowel following [ʔ] in [ʔaʃfaʃ]. This indicates that [ʔ] was produced with tension in the larynx greater than that for [ʔ]. Although the current research did not cover the acoustic characteristics of cleft speech, it is worth mentioning that speakers with CLP seem to differentiate in their speech between complete glottals and creak glottals. According to Esling and Harris (2005), glottal stops and creak are produced via similar physiological mechanisms by adducting the arytenoid cartilages with the epiglottis. This aryepiglottal constriction might producing creak glottals.

With regard to lateralization, /r/ → [l] in word initial and final positions. Amayreh (1994) listed /r/ as a sound mastered between the ages of 4 years and 6 years. In a previous study, Al-Tamimi (2006) found that children mastered the trill /r/ around the age of 5 years 6 months. This sound starts as a tap /r/ (e.g., raas [head]) word initially and medially around the age of 4 years. The trill is mastered a year and a half later, with its singleton, warde (flower), or geminate, barraad (refrigerator), forms. Geminates are extra-long consonants produced at least twice as long as their singleton counterparts (Al-Tamimi, 2004).

The current research indicates that the distortion in the production of /r/ as /l/ was not developmental. Although /r/ was mastered at the age of 5 years 6 months, it appeared as a tap earlier. Study participants substituted even the tap /r/ with /l/ (e.g., raas → [laaʃ]). Moreover, lateralization was still productive (≥ 20%) in the speech of Group 3. There was a decrease in its usage across age, but this decrease kept it within the productivity level.

Depharyngealization was productive in the speech of the study participants, but it disappeared by about the age of 5 years 6 months or soon afterward. In Jordanian Arabic, there are four emphatic sounds /t′, d′, s′, θ′/ that are usually mastered around the age of 6 years. However, they appear earlier as uvular around the age of 4 years. In an acoustic analysis of the acquisition of sounds by native speakers of Jordanian Arabic, Al-Tamimi (2006) noted that “the developmental process for the acquisition of the emphatics starts around the age of four when they are realized as uvulars. They then develop into pharyngeals around the age of 6:0” (p. 40).

In our study, the alveodental /d′/ and interdental /θ′/ were produced correctly by the different age groups, with Group 1 producing them as uvularized and Group 3 producing them as pharyngealized. Also, /t′/ and /s′/ appeared as [ʔʔ] /ʔˈaaba → [ʔʔaaba] (football) and [c] s′mrə → [cmmla] (picture), respectively. The emphatic /t′/ was produced as a preglottalized pharyngeal stop [ʔ]. The pharyngeal stop is a sound produced with strong retraction of the root of the tongue into the pharynx. Possibly the sound starts with a stricture of the vocal folds and ventricular folds followed by constriction on the aryepiglottic fold to get full supraglottal closure. This mechanism with the retraction of the tongue is an important feature for pharyngealized sounds. It means that speakers are aware that the emphatic stop /t′/ contains a front alveolar constriction as a primary articulatory feature of the sound and a retraction of the root of the tongue to get the secondary feature of articulation. This secondary feature is produced through the pharyngeal constriction. The difference between [ʔ] and the Arabic uvular /q/ is in the place of constriction. The lowered second formant transition and raised first formant transition indicate that the constriction that speakers have for [ʔ] is in the pharynx. A uvular constriction would cause a lowering of F1. This lowering is clear in the speakers’ phonemic /q/.

The claim that speakers are aware of emphasis as an extraphonological feature in Arabic can be corroborated when we examine the sibilants /s and s′/ in the words raas (head) and s′mra (picture), /s/ and /s′/ were produced as [ɕ] and [ɕ], that is, [la:ɕ] and [cmmla], respectively. Speakers used a palatal fricative sound for the plain sibilant but a more retracted one for the emphatic cognate. The friction of [ɕ] was released laterally through the two edges of the groove formed in the middle of the alveopalatal and palato-velar contact. Study participants also produced back vowels in the vicinity of [ɕ], as well as [ʔʔ], but not [ɕ].

Final consonant deletion was noted as an active phonological process in the speech of all participants. Amayreh and Dyson (2000) stated that typically developing Arabic-speaking children significantly eliminate this phonological process before the age of 4 years. Its occurrence in their speech does not exceed 10% of the total possible instances. However, for speakers with CLP, this process remains productive even in older children (6 years 5 months average age). Sibilants were more likely to be finally deleted than nonsibilant fricatives, followed by plosives, nasals, and glides, respectively.

As for stopping, Group 1 noticeably substituted the fricatives /ɬ/ by a labiodental [p] /filim [film] → [piʃ]) and /θ/ by an interdental [d] (θanab (tail)→[dänã]). The affricate /ds/ was sometimes produced as postalveolar [d].

Also traced in the speech of the study participants were nonproductive phonological processes: strident deletion, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, and deaffrication. According to Amayreh and Dyson (2000), strident deletion as a developmental phonological process is significantly eliminated in the speech of typically developing Arabic-speaking children before the age of 4 years 6 months, with a 12.5% frequency of occurrence. In our study, Group 1 children displayed a 17% occurrence of strident deletion in words such as daftar
Fronting of back consonants was restricted mainly to the velar stop /k/ and the uvular stop /q/. Both kaleb (dog) and qaleb (heart) were realized in few cases by Group 1 as [tajeb] and [dajej], respectively. Syllables appeared in words such as ma.fa.tiih (keys) → [mã.ﬁi] and bɔ.ə.kiir (towels) → [bɔ.kiil]. The devoicing process appeared rarely in the /b/ and /d/ sounds in the speech of Group 1 only. The Jordanian Arabic liquid /l/ was sometimes substituted by the glide [j] (e.g., kaleb [dog] → [tajeb] and qaleb [heart] → [dajej], in a liquid gliding phonological process. This appeared in the speech of the youngest children (Group 1), who should have mastered /l/ at the age of 3 years 6 months (Amayreh & Dyson, 1998). Deaffrication of the only affricate Arabic sound /d/ occurred in few instances with words such as d[ʒ]amal (camel) and dʃaras (bell), where /d/ is pronounced as [ʒ], that is, [ʒamã] and [ʒalaç].

All these phonological processes that mark child speech decrease with age. For English, for example, Morley (1966) reported that the misarticulations of the preschool children with CLP in his study decreased with age. Only 25% of the 5- and 6-year-old children with clefts had misarticulations, compared with 60% of the 3- and 4-year-old children. In addition, Philips and Harrison (1969) reported that the overall number of misarticulations in the speech of 2- to 6-year-old children with CLP decreased with age. Chapman (1993) also found that “children with cleft palate employ phonological processes more frequently in their speech at 3 and 4 years of age, but by 5 years of age they are similar to nonleft children in phonologic process usage” (p. 68). Although a longitudinal study of the same children with CLP would verify this claim more accurately, modern surgical techniques and early surgical and speech therapy interventions might justify this finding. Other results have shown that some misarticulations remain persistent in the speech of English-speaking persons with CLP for a longer period of time. Van Demark, Morris, and Vandehaar (1979) and Karnell and Van Demark (1986) noted that some of these phonological processes continued to improve after 10 years of age and even 12 years of age.

The phonological processes cited in the current study are commonly observed in European languages, for example, English (Howard, 2004), Danish (Hutters, Bau, & Brondsted, 2001), and Swedish (Karling, Larson, & Henningson, 1993). What might differ across these languages is the productivity level of the phonological processes. Based on 20% or higher frequency of occurrence (McReynolds & Elbert, 1981), the results of two English studies (Chapman, 1993; Chapman and Hardin, 1992) might be compared with those of our current study. It was difficult to find other studies for a comparison, due to a lack of clearly presented percentages of occurrence for the phonological processes. In the two Chapman studies, the phonological processes exhibited in the speech of the children with CLP were similar to the ones exhibited in the speech of the Jordanian children with CLP in our study. These were backing, stridency deletion, lateralization, depharyngealization, final consonant deletion, stopping, consonant harmony, fronting, syllable reduction, devoicing, liquid gliding, deaffrication, and cluster simplification. However, what appears to differ was the productivity level. In the Chapman studies, the only phonological processes that had a 20% or higher frequency of occurrence were backing, final consonant deletion, and syllable reduction. In the current study, backing, final consonant deletion, stopping, lateralization, and pharyngealization were the productive phonological processes. There were similarities with regard to the type of processes exhibited in the speech of the Jordanian and English study participants, but their productivity levels were different. The universality of the processes exhibited in the speech of children with CLP should not ignore the language-specific features that affect the productivity scale of every language. This finding is important for the therapy plans that speech-language pathologists design to assess and treat patients with CLP across different languages.

**Conclusion**

The major findings of this research are that Arabic-speaking children with CLP display speech phonological processes similar to those found for children with CLP who speak other languages. Their degree of occurrence decreases significantly across age. Some phonological processes are more active than others, and their usage is not affected significantly by gender. The productivity level of Arabic CLP phonological processes differs from that found in English. Future research is warranted to examine the role of early surgical and speech therapy interventions in the progression of the speech of children with CLP. The phonemic inventory of these children and the correlation between speech disorders and language delays are worth investigating.

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