The Production of Laterals by English-Arabic Bilingual Children

Bilal Ibrahim Alsharif[1,] Razan Khasawneh[2]

[1] Assistant professor, Department of Applied linguistics, Al-Zaytoonah University of Jordan, Jordan

[2] A lecturer, Department of Translation, Al-Zaytoonah University of Jordan, Jordan

Correspondence: Bilal Ibrahim Alsharif, Assistant professor, Department of English Language, Al-Zaytoonah University of Jordan, Jordan.

Received: November 7, 2024 Accepted: February 4, 2025 Online Published: April 17, 2025

doi:10.5430/wjel.v15n5p301 URL: https://doi.org/10.5430/wjel.v15n5p301

Abstract

This study aims to measure the accentual feature of the acoustic properties of English and Arabic alveolar laterals produced by Arabic-English bilinguals. More precisely, it examines whether bilinguals develop or maintain separate spectral and temporal properties for the sounds of their community when these converge with the phonetic properties of their first language. Further, it investigates the effect of syllable position in the acoustic production of Arabic and English laterals. Finally, it explores if there is any phonetic convergence of the laterals in each language due to the elicitation of a bilingual language mode. The acoustic analysis of bilinguals' realizations of /l/ consists of the F1, F2, F2-F1, and F3-F2 differences values expressed in Hertz and Bark. These values are extracted from the midpoint of the laterals and realized in three contexts: word-initial, word-medial, and word-final positions. The results reveal that bilinguals exhibit language-specific phonetic distribution and relatively acoustic accommodation in realizing laterals when code-switching tokens.

Keywords: speech learning model, bilingual, dark lateral, clear lateral, acoustic analysis, cross-dialect

1. Introduction

1.1 Clear and Dark Laterals in Arabic and English

English laterals are commonly described as having allophonic patterning of /l/: dark /l/ occurs in the syllable rimes, and clear /l/ occurs in the syllable onsets (Carter & Local, 2007; Kirkham & McCarthy, 2021; Recasens, 2004; Sproat & Fujimura, 1993). The former is more back and vowel-like in quality, whereas the latter is more consonantal in quality (Abushihab, 2010; Abushihab et al., 2011; Recasens, 2004). In articulatory speaking, when producing the clear and dark allophones of /l/ in English, it is argued that two gestures are involved, namely apical and dorsal. More specifically, clear /l/ is produced when the apical gesture precedes the dorsal gesture, whereas the reversed gesture pattern is found when producing dark /l/ (Sproat & Fujimura, 1993). In terms of acoustic properties, previous studies have revealed that laterals have different resonant qualities that are sensitive to positional effects. By extension, clear /l/ has relatively low F1 and high F2, whereas dark /l/ has a more compact spectrum in which a lower F2 formant is combined with a higher F1 formant (Amengual,2018; Cater & Local, 2007; Ladefoged & Maddieson, 1996; Recasens, 2012). Conversely, Arabic has been described as having clear /l/s in all syllable positions, except in some limited environments. For instance, pharyngealized /l/s occur in words that include the name of God /ʔa**l**ɑh/, emphatic segments such as /ba**l**iiT/ ("tiler"), or in some loan words such as /**l**ɑmba/ ("lamp"). Generally, the precise site of the articulatory feature of emphatic sounds in Arabic is a disputed issue among Arab grammarians. Moreover, the presumably universal acoustic difference descriptive studies have advocated between the realization of /l/ in initial and final positions is relatively small. In terms of the gestures involved in the articulation, the Arabic laterals are characterized as apico-alveolar lateral (Al-Ani, 1970; Shaheen, 1979). However, Arabic varieties differ in terms of whether they have a clear/dark binary distinction. For example, Shaheen (1979) examined the acoustic and temporal properties of Egyptian /l/s across phonological words in the context of long vowels. He found Egyptian clear /l/s have high F2, whereas pharyngealized /l/s exhibit low F2. These findings were consistent with subsequent studies (e.g., Laufer & Baer, 1988). In a study conducted on laterals produced by Lebanese speakers, Haddad (1984) found that Lebanese Arabic does not involve emphatic /l/, but in a few cases, /l/ becomes velarized by a dental consonant or back vowel as triggers.

Phonetic codeswitching is a natural aspect of bilingual communication. It shows the ability of bilinguals to blend and alter two separate phonological systems within the same conversation. Several acoustic studies performed on the production of laterals by bilinguals have investigated the behavior of the code-switched tokens involving laterals. For example, Khattab (2011) examined the realizations of the allophonic variants of Arabic and English laterals by Arabic-English bilinguals and monolinguals. She measured the first three formants (F1, F2, and F3) for /l/s in different contextual positions. The findings of her study reveal that Arabic has clearer /l/s than English, and bilinguals maintain separate acoustic distribution for clear and dark /l/s in each language. Amengual (2018) conducted a study on the acquisition of laterals by Spanish-English bilinguals. He stated that bilinguals have acquired the allophonic variants characteristics of laterals in each language. Also, he argued that language dominance significantly affects the production of Spanish and English laterals. In light of this background, this study used different acoustic measurements (F2-F1 and F3-F2) and recruited cross-dialectal Arabic-English bilinguals. A linear mixed-effects regression model was used to quantify the differences between dark and clear /l/s in Arabic and English for statistical analysis.

1.2 Speech Learning Model

According to Flege's (1995) speech learning model (SLM), categories that are similar in the L1 and L2 phonetic systems undergo either assimilation or dissimilation. In other words, similar phonetic categories will block the development of separate categories. This is presumably due to L2 sounds being perceptually identical to the native learners' language and a merged L1 + L2 category being created in their perceptual-acoustic space. However, dissimilation occurs when bilinguals develop separate phonetic categories for L1 and L2, assuming the coexistence of the L2 and L1 phonetic categories in the same perceptual-acoustic space. Following Flege’s (1995) SLM, this study makes the following predictions:

- If there are any significant differences, this means the bilinguals are adept at accommodating different phonetic categories for each language? But,
- However, if there is an overlap in the production of the code-switched token, bilinguals cannot separate the phonetic aspects of laterals in each language.
- The quality and the implementation of initials, intervocalic/medial, and final positions of /l/s in Arabic and English have language-specific and dialect-specific differences.

Based on these predictions, the main objective of this study is to investigate the acoustics of clear and dark /l/s in Arabic and English as produced by Arabic-English bilingual children. More specifically, it attempts to answer the following questions:

1. What is the essential acoustic correlate of clear-dark /l/s in Arabic and English as produced by bilingual children?
2. Are the F2, F2-F1, and F3-F2 values of laterals significantly different in Arabic-English bilinguals’ productions of code-switched tokens?
3. To what extent do the productions of clear-dark /l/s in both languages exhibit convergence?
4. Do bilingual children develop or maintain separate language-specific and dialect-specific variants of /l/s?

2. Methods

2.1 Participants

Nine Arabic-English bilingual children took part in this study. All of them were aged between 13 and 15. They were from the Levant, Iraq, and Egypt but were recruited in Newcastle, UK. The target accent for the clear-dark /l/s/ distinction in English was “Southern Standard British English” (SSBE). Generally, the salient accentual features of this area are described as showing a lack of clear-dark /l/ distinction (Wells, 1982). As for /l/s in Arabic varieties, clear /l/s appear in all word positions, while the dark/pharyngealized /l/s occur in limited positions. The participants were receiving education at English schools during the week and Quranic recitation lessons for 2 hours on the weekend. Prior to recording, a questionnaire was administered to examine their language background. The questions were as follows: (1) What language do you speak at home and with your friends?; (2) What language do you use more frequently in your daily life?; and (3) Out of ten, rate the use of Arabic/English in your daily life (a) family, (b) with friends, (c) at school, and (d) while shopping. Normal hearing and no history or language impairment were reported.

2.2 Data Collection

The aim of the study is to examine the realization of clear-dark /l/s in different vowel contexts and syllable positions in Arabic and English using acoustic analysis. The acoustic measures of Arabic and English tokens were recorded at the Muslim Welfare House using a TASCAM DA-P1 portable DAT recorder with an AKG C420 headset condenser microphone. Each participant was asked to read the sentences naturally at a normal speech rate and in a quiet room. The acoustic structure of the clear-dark /l/s and the preceding and following vowels in Arabic and English tokens were manually segmented on the basis of visual information in a broadband spectrogram and auditory assessment.

2.3 Material

The Arabic and English tokens were set in carrier sentences "?ukub/?ikitib…. martin" and "write….twice, respectively. The Arabic target dark/pharyngealized and clear /l/s are elicited in word-initial, medial, and final positions and coda clusters. In contrast, the English clear-dark /l/s were recorded in prevocalic, intervocalic, and coda positions. Tables 1 and 2 show the contexts used to analyze the /l/s.

Table 1. Summary of the /l/ English tokens analyzed in the study

Position	Example	Syllable affiliation	Number of tokens
V1#LV1	I leap	Onset	305 tokens
V1L#V1	Call it hea**l**-ing	Coda	495 tokens
V1L#	Foo**l**		
V1LV0	Taula	Intervocalic	243 tokens

Table 2. Summary of the /l/ Arabic tokens analyzed in the study

Position	Clear /l/ examples	Emphatic /l/ examples	Syllable affiliation	Number of tokens
#LV1	**L**ibis	**l**ibiT	Onset	54 tokens
	lasaʕ	**l**aTaʕ		
	Lugmih	**l**ugTa		
V1LV1	ɣi**l**is	ɣi**l**iT	Intervocalic	90 tokens
	Xa**l**af	xa**l**aT		
	Zu**l**um	Du**l**um		
V1L#	Tifi**l**	Tifi**l**	Coda	108 tokens
	Badal	baTal		
C1L#	sah**l**	saTl	Syllabic	54 tokens

2.4 Data Analysis

The acoustic analysis extracted the steady state of the midpoint of F2, F2-F1, F3-F2, and duration for /l/ using an automatic tracker in different context-specific allophonic patterning, as shown in Table 1 and Table 2, using Praat with the maximum formant of 5,500 Hz for children (Boersma & Weenink, 2008). The results of the formant frequencies were analyzed to explain the language-dependent differences. Acoustically speaking, it is documented that the F2 values are associated with the constriction of the back of the tongue, whereas the F2-F1 and F3-F2 values provide the degree of the lateral darkness because lower F2 and F2-F1 and higher F3-F2 values indicate darker /l/s than clearer /l/s (Recasens & Espinosa, 2005; Recasens et al., 1995). The means and standard deviations of F1, F2, and duration midpoints were calculated. As for statistical analyses, linear mixed-effect models (LMMs) were carried out using R software (Team, 2014) to provide statistical evidence for the differences between English and Arabic laterals (Bates et al., 2015).

3. Results

3.1 Descriptive Results

Tables 3 and 4 below show the means and standard deviations for F1, F2, and F2-F1 values in Hertz for the bilinguals' productions of English and Arabic laterals. These are organized by language, context, and speaker. As shown by Sproat and Fujimura (1993), the range of F2-F1 values at the midpoint of the laterals is from 904.23 Hz to 1315.71 Hz for "clear" realization and from 515.34 Hz to 908.96 Hz for "dark" productions. These data show that bilinguals have a mean of 1166 Hz before back vowels and 1373 Hz before front vowels but a mean of 926 Hz after back vowels and 1228 Hz after front vowels. Accordingly, final /l/s have positional effects in which F2 is lower than in initial /l/s. This suggests a continuum rather than a binary classification between clear and dark /l/. The following section will show the phonetic results for both languages in different contexts to explicitly compare laterals' positional contrast between Arabic and English and the positional allophony of laterals in English.

3.2. Phonetic Results

Figures 1 and 2 show the acoustic properties of the bilinguals' production of laterals in three different contexts. Overall, as can be seen, the Arabic-English bilinguals produce Arabic laterals with relatively lower F2 and smaller F2-F1 distance in Bark compared to English laterals except in the coda position, where the English laterals have the lowest F2 and smallest F2-F1 distance. The small cut-off in the final position of the English production of tokens supports the idea of gradient orderliness. Also, this suggests that the bilinguals maintain distinct phonetic categories for English and Arabic. In addition, these findings reveal that English has lighter /l/s than Arabic /l/s, as shown in Figure 1, which contradicts Khattab's (2011) claim that Arabic has clearer /l/s than English. Presumably, bilinguals' realizations produce the Arabic tokens with an intermediate degree of darkness.

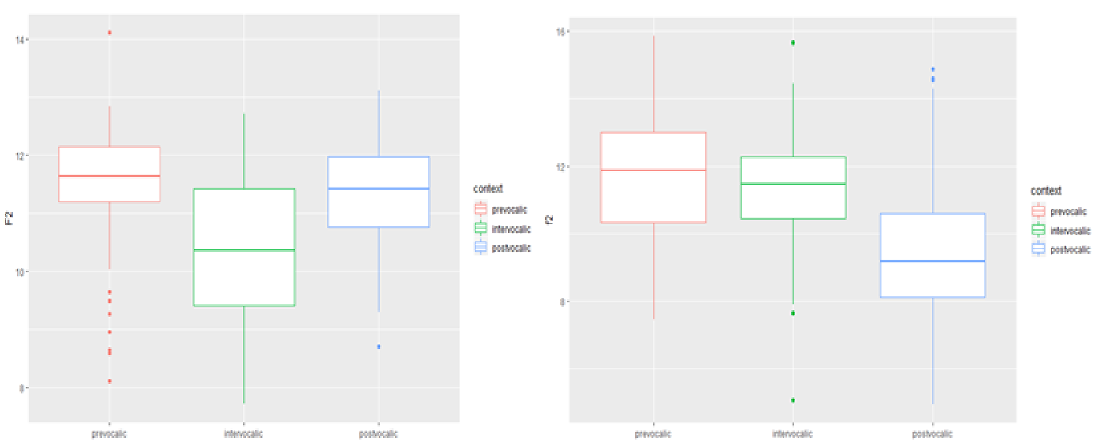

Figure 1. F2 results of bilinguals' productions of laterals in Arabic (leftward) and English (rightward)in three contexts (prevocalic, intervocalic, and postvocalic) in Barks. Circles represent outliers

Table 3. The frequency average in Hertz for F1, F2, and F2-F1 of English laterals in midpoint. Standard deviations added in brackets.

Language	English											
Context	Prevocalic						Postvocalic					
	Back vowel			Non-back vowel			Back vowel			Non-back vowel		
	F1	F2	**F2-F1**	F1	F2	**F2-F1**	F1	F2	**F2-F1**	F1	F2	**F2-F1**
Speaker 1	258(50.6)	1469(288)	**1144**	295(9.6)	1819(421)	**1524**	548(33.8)	1390(715)	**842**	434(92.5)	1483(255)	**1045**
Speaker 2	317(52)	1475(406)	**1158**	270(25.4)	2091(314)	**1821**	459(74.5)	997(193)	**538**	456(70.4)	1427(292)	**971**
Speaker 3	448(103)	1632(501)	**1184**	414(65.1)	1190(355)	**776**	317(41.2)	1714(180)	**1397**	316(45.7)	1985(265)	**669**
Overall mean	363(68.33)	1525(398)	**1162**	326(33.36)	1700(363)	**1373**	441(49.83)	1367(362)	**926**	402(69.53)	1632(271)	**1228**

Table 4. The frequency average in Hertz for F1, F2, and F2-F1 of Arabic laterals in midpoint. Standard deviations added in brackets.

Language	Arabic											
Context	Prevocalic						Postvocalic					
	Back vowel			Non-back vowel			Back vowel			Non-back vowel		
	F1	F2	**F2-F1**	F1	F2	**F2-F1**	F1	F2	**F2-F1**	F1	F2	**F2-F1**
Levantine	284(12.72)	1739(316)	**1455**	316(43.94)	1739(161)	**1423**	348(45.95)	1698(129)	**1350**	413(64.44)	1741(108)	**1328**
Iraqi	304	1626	**1322**	462(212)	1622(318)	**1160**	314(42.37)	1593(242)	**1279**	391(72.1)	1366(331)	**975**
Egyptian	312(28.7)	1610(104)	**1298**	333 (25.4)	1639(76.3)	**1306**	345(25.6)	1437(150)	**1092**	366(32.5)	1434(153)	**1068**
Overall mean	300(20.71)	1658(210)	**1358**	370(93.78)	1666(185)	**1296**	336(37.97)	1576(173)	**1240**	390(56.3)	1513(197)	**1124**

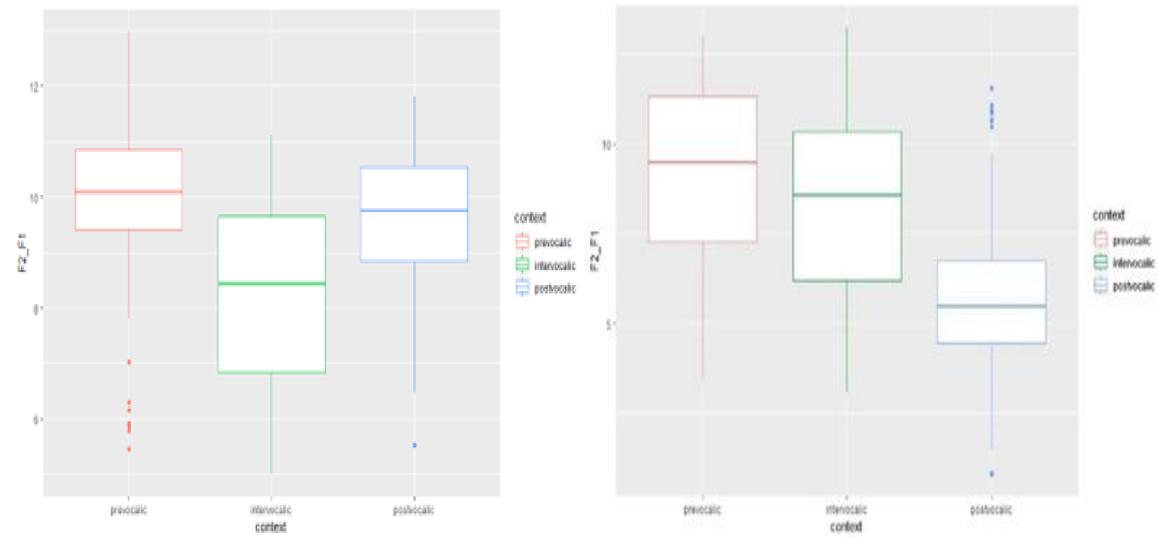

Figure 2. F2-F1 differences of bilinguals' productions of laterals in Arabic (leftward) and English (rightward)in three contexts (prevocalic, intervocalic, and postvocalic) in Barks. Circles represent outliers

3.3 Linear Mixed Model Results

Two linear mixed-effects regression models fitted by REML were run to the midpoint of F2, F2-F1, and F3-F1 in Barks as a varying intercept. Context (i.e., prevocalic, intervocalic, and postvocalic), duration, and vowel (front and back) were used as fixed effects separately per language in addition to the restricted maximum likelihood estimation. For English laterals, the analysis revealed that the effects on F2 values in the context of front vowels were found significant (βfrontvowel= -6.41, 95% CI -0.012 to -0.0001; t-test using Satterthwaite's method, t7= 3.523, p= <0.001). However, no significant interactions with context-prevocalic (βprevocalic=1.33, t4=1.82, p=1451) or duration (βduration=1.32, t3=1.32, p=1861) were found, as shown in Table 1. However, the mixed analysis indicated two fixed factors that demonstrated significant effects on the F2-F1 results, mainly; context-prevocalic (βprevocalic= -1.48, 95% CI -0.023 to -0.006; t-test using Satterthwaite's method, t 4= 2.270, p <0.001) and vowel: front (βvowel-front= -1.48, 95% CI -0.023 to -0.006; t-test using Satterthwaite's method, t8= 2.687, p <0.001). However, no significant interaction with duration was found (βduration=9.039, t3=0.768, p=0.4428). Interestingly, the F3-F2 results revealed significant effects with all fixed factors: vowel-front (βfront-vowel=1.039, t6=2.799, p=<0.001), context (βprevocalic=-2.856, t6=-6.556, p=<0.001) and duration (βduration=0.013, t6=2.461, p=<0.001), as shown in Table 3. However, the Arabic F2 and F2-F1 values had no significant interaction with the fixed factors- *vowel, context, and duration*. That is said, the Arabic F3-F2 results showed significant interaction with front vowels (βvowel-front=0.752, t116=3.383, p=<0.001), but no significant interaction was found with context and duration.

Another two linear mixed-effects models were fitted by RELM for both languages together, with Arabic as the default language. The results revealed that F2 values have a marginally significant effect interaction with the fixed factor vowel-front (βvowel-front=9.943, t5=2.226, p=<0.001), with English having more lower F2 values than Arabic. Moreover, F2 values have another marginal significant interaction with context-prevocalic (βprevocalic=1.634, t5=2.454, p=<0.001). However, the linear model test yielded no significant effects of the F2 values on the fixed effects duration (βduration=1.165, t5=1.286, p=0.1991), language (βduration=7.293, t5=-0.947, p=3840) and context-postvocalic (βduration=-1.563, t8=1.757, p=0.1168).

As for the F2-F1 results, the linear test model showed that F2-F1 values have no significant interaction with the fixed factors context (βprevoclaic=2.517, t5=1.633, p=0.0427; βpostvoclaic=2.050,t5=1.633,p=0.1408), duration(βduration=0.001,t483=0.992,p=0.321), language (βEnglish=-0.784, t6=-0.717, p=0.5022), or vowel-front(βvowel-front=0.977, t9=1.533, p=0.1600). Interestingly, the F3-F2 results yielded the main significant interaction with all fixed factors as follows: vowel-front (βfrontvowel=1.145,t497=10.659,p=<0.001), context postvocalic (βpostvocalic=-2.699, t497=-4.490, p=<0.001), context-prevocalic (βprevocalic=-2.950, t497=-8.008, p=<0.001), language-English (βEnglish=3.575, t497=6.946, p=<0.001) and duration (βduration=-0.007, t497=-4.651, p=<0.001).

4. Discussion

4.1 Arabic Laterals

This section discusses the Arabic tokens' results of F2-F1 and F3-F2 values realized by bilinguals, as shown in Figures 3 and 4, respectively. The box plots in Figures 3 and 4 display the bilinguals' production of /l/ across phonological environments, showing a nice linear trend and no evidence of clear bimodal distribution. The acoustics data reveals that the Arabic /l/-type tokens are relatively tight and have to some extent stable lightness in all the phonological environments to some extent, with wider variation in the *?a**l**ab*-type tokens, *suhuu**l***-type tokens, and the syllabic "*sah**l***" –type tokens. As can be seen, the ***l**ibis*-type tokens are the lightest in the articulations. This suggests that initial~final contrast is not distinct, but the word-final /l/s are produced with slight pharyngealized articulations. This is potentially due to preservatory coarticulatory darkness in Arabic laterals. Moreover, although it is expected that the environment of *suhuu**l***-type tokens, where /l/ is preceded by a high back vowel, falls out of the line of lightness, it shows the opposite pattern. With respect to the existing literature, this plot provides further weight to the claim that Arabic exhibits "clear" /l/s in all contextual positions to some extent, whereby there are no two potential categories are seen, but a slight stepwise gradient pattern can be noticed.

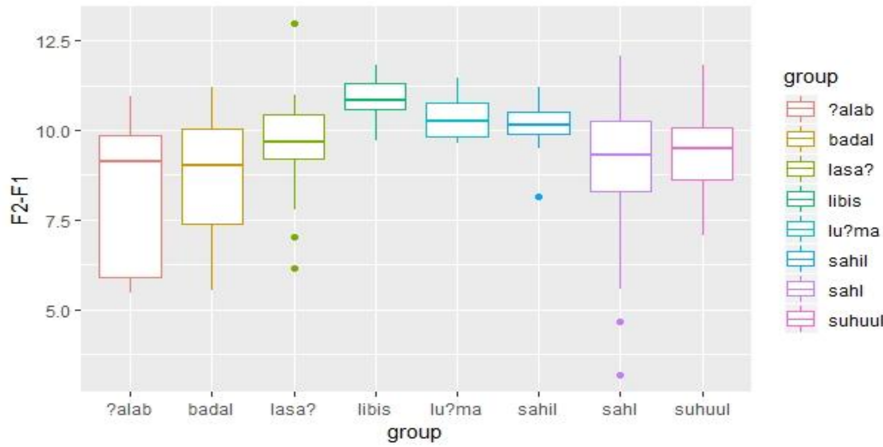

Figure 3. F2-F1 values for Arabic /l/

The boxplot of the F3-F2 values exhibits how light Arabic laterals compare to English laterals. It shows a relatively stable lightness in the last six contexts. Further, it can be seen that the laterals show higher values and wider distribution in the context of the /a/ vowel, while they are tight and clustered together in the vocalic context /u/ and /i/.

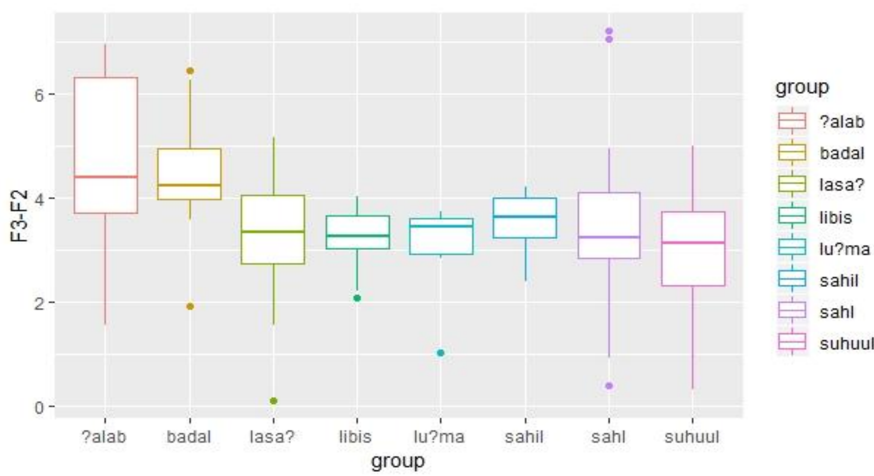

Figure 4. F3-F2 values for Arabic /l/

4.2 English Laterals

This section discusses the English tokens results of F2-F1 and F3-F2 as produced by bilinguals in three different vocalic contexts, high front, mid-high, and high back vowels, to examine the scale and degree of darkness and coarticulatory resistance. The box plot in Figure 5 shows the results of F2-F1 values across phonological environments, providing plausible evidence for the categorical allophonic patterning of /l/ in English as produced by bilinguals. The ***l**eap*-type, *hea**l**ing*-type, and *hea**l**#it*-type tokens have "clearer" /l/s compared with *hea**l***-type, *fe**l**ix*-type and *hea**l**#people*-type tokens, which they have a low F2 and high F1 values, resulting in smaller F2-F1 differences. As can also be seen, the *hea**l***-type, *fe**l**ix*-type and *hea**l**#people*-type tokens have tight, and more clustered, and relatively stable darkness. Moreover, a small cut-off is seen as a border between darkness and clearness. The acoustic analysis shows that the categorical allophonic distinction is not sensitive to the word-level onset and coda /l/s, as shown in the *hea**l**#it*-type tokens.

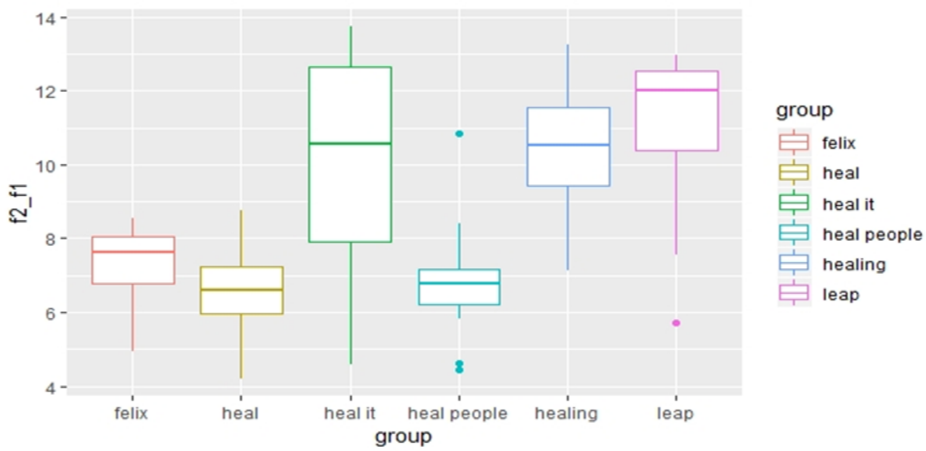

Figure 5. F2-F1 values for English /l/ before and after the front vowel

Figure 6 shows that word-final /l/s have relatively higher values than non-final tokens. More precisely, the productions of the ***heal#it***-type tokens appear to have a wider variation compared to the tight and more clustered productions of ***heal***-type and ***heal#people***-type tokens, which have the highest F3-F2 differences. The word-initial ***leap***-type, the word-medial ***felix***-type, and the word-medial morpheme boundary ***healing***-type tokens stay relatively stable, with lower F3-F2 differences compared to other word-type tokens. Confusingly, it can be noticed that the ***felix***-type tokens exhibit relatively lower F2-F1 values in line with ***heal***-type and ***heal#people***-type tokens in Figure 5 but exhibit lower F3-F2 values in Figure 6 compared to Figure 5.

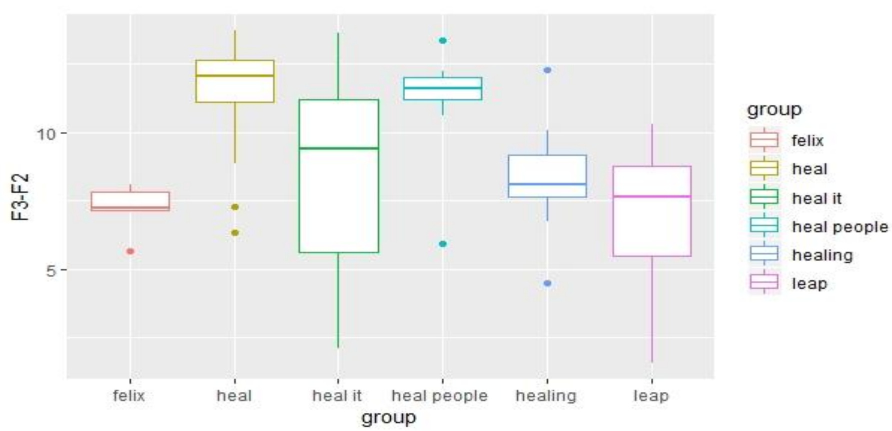

Figure 6. F3-F2 values for English /l/ before and after the front vowel

Regarding laterals in the context of mid-back vowels, the boxplot in Figure 7 shows a small but not definite cut-off in the realization of /l/ in the context of the back vowels /ɔ/. Generally, the bilinguals produce initial~final contrast /l/s in the context of mid-back vowels, producing where they produce higher F2-F1 values in non-final contexts and lower F2-F1 values in final contexts. Moreover, as can be seen, the ***call***-type and ***fall#badly***-type tokens are clustered together and have the darkest /l/s, whereas the word-medial and word-initial /l/s have wide variations.

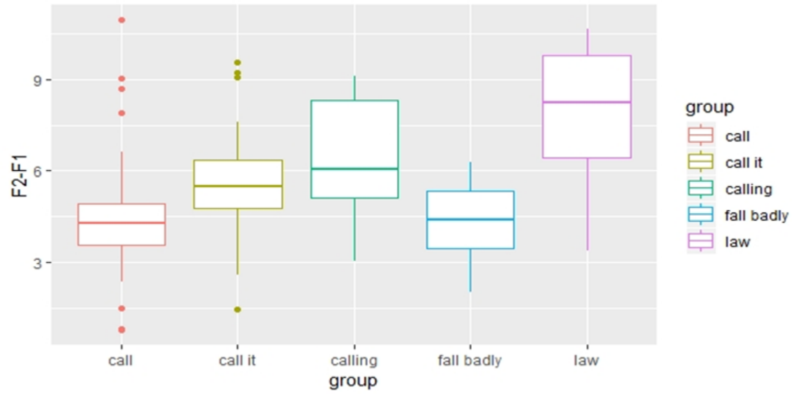

Figure 7. F2-F1 values for English /l/ before and after the mid-back vowel

Interestingly, as can be observed in Figure 8, the bilinguals have higher F3-F2 values for /l/s' produced across phonological environments. This suggests that the realizations of /l/ in the context of mid-back vowels lie in the middle of the continuum between clear and dark. However, while all the tokens have wide variations, the *fall#badly*-type tokens exhibit a clustered production.

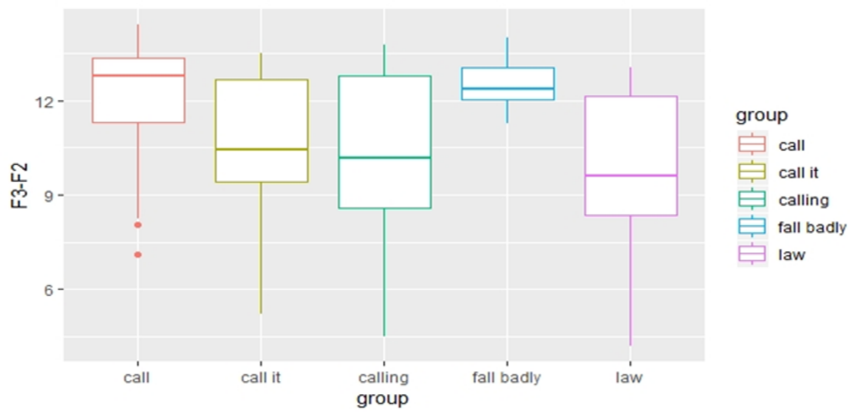

Figure 8. F3-F2 values for English /l/ before and after the mid-back vowel

In the context of the high back vowel /u/, there is a small but clear cut-off between tokens in the postvocalic context, where the *foo**l**#people*-type tokens have the darkest /l/, and tokens in the pre- and intervocalic as shown in figure 9. Compared with the F2-F1 differences in the context of mid-back vowel, the *foo**l***, *foo**l**#it*, and *foo**l**#people*-type tokens have smaller F2-F1 distance values than the ***l**oo*, *tu**l**a*, and *foo**l**ing*.

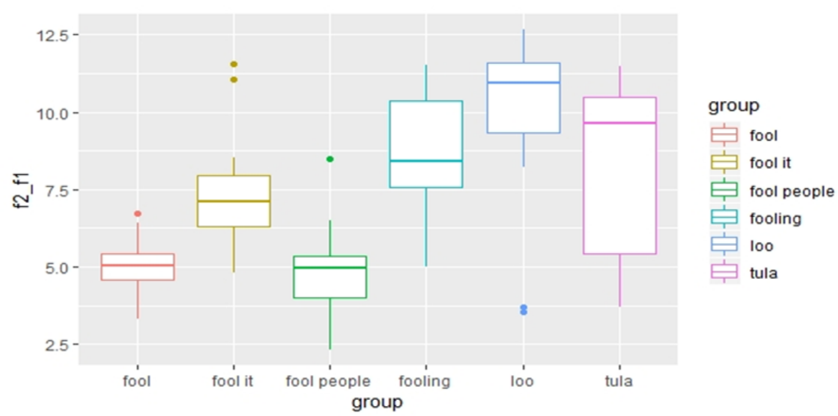

Figure 9. F2-F1 values for English /l/ before and after the high-back vowel

The F3-F2 values in Figure 10 are largely the mirror of the F2-F1 values, whereby the *fool*, *fool#it*, and *fool#people*-type tokens have high F3-F2 and low F2-F1 values, whereas *loo*-type, *tule*-type, and *fooling*-type tokens show the opposite patterns. When comparing the results of F3-F2 values of laterals in the context of the prevocalic high-back vowel /u/ with the mid-back vowel /ɔ/, laterals have lower F3-F2 values when followed by high-back vowels. These findings show that laterals followed by the high-back vowel /u/ are highly resistant to vowel coarticulation, and laterals preceded or followed by the mid-back vowel /ɔ/ have preservatory coarticulatory darkness.

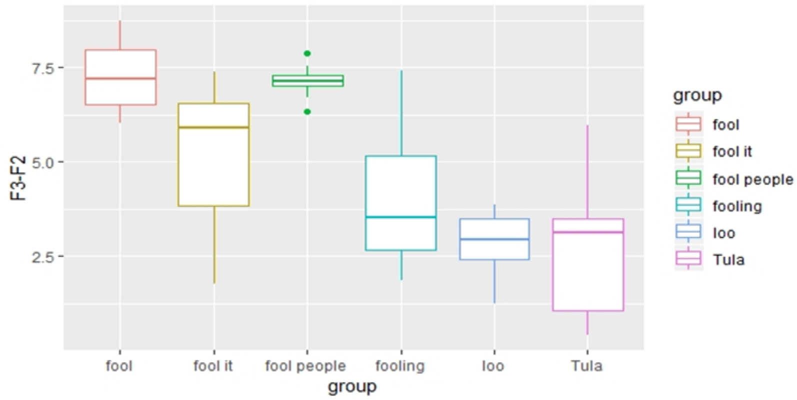

Figure 10. F3-F2 values for English /l/ before and after the high-back vowel

In summary, the results show that bilingual children produce clear realizations of laterals in Arabic, and the positional contrast does not affect the degree of laterality. In contrast, they adapt a positional contrast in English in front, mid-back, and high-back vowels but with varying degrees. This suggests that the bilingual children did not transfer their Arabic system to English as expected. More interestingly, Arabic-English bilingual children employ different articulatory gestures in producing laterals in Arabic and English, though this needs to be proved using articulatory data. This contradicts previous findings that claim that bilingual children employ articulatory strategies closer to English than Arabic (Khattab, 2011).

5. Conclusion

The present study examined the phonetic realization of laterals in Arabic and English produced by bilingual children. The results of the acoustic analysis indicate that there is a language-specific phonetic distribution and relatively acoustic accommodation when bilinguals code-switched tokens. The descriptive results show that Arabic and English differed in their place and degree of velarization, as evidenced by their lower F2, smaller F2-F1, and higher F3-F2. However, Arabic laterals showed the opposite pattern to some extent. As has been echoed in many studies, F2 and F2-F1 were strong predictors of darkness. Moreover, the results indicate that the bilinguals produced more pharyngealized English /l/s in the code position, meaning that bilinguals have a merged phonetic category prevocalic but have two separate acoustic properties postvocalic, as predicted by SLM (Flege, 1995) and proved by Khattab (2011). Also, this assumes that bilingual children have developed different articulatory strategies involving pharyngeal constriction in producing English laterals. This is evidenced in the statistical analysis, which shows that the F2 values and duration were significantly higher for English than for Arabic. Finally, the findings of this study are consistent with the existing literature, which shows that English laterals are darker than Arabic laterals. Future follow-up studies should involve articulatory work to quantify the degree of tongue-dorsum involvement by bilinguals in producing Arabic and English laterals.

Acknowledgments

Not applicable

Authors' contributions

Bilal Alsharif was responsible for study design, revising, data collection, and drafting the manuscript. Razan khasawneh proofread and revised the work. The authors read and approved the final manuscript.

Funding

Not applicable

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

Open access

Copyrights

References

Abushihab, I. (2010). Phonological contrastive analysis of Arabic, Turkish and English. *Journal of Language and Literature*, *4*, 16-24.

Abushihab, I., El-Omari, A. H., & Tobat, M. (2011). An analysis of written grammatical errors of Arab learners of English as a foreign language at Alzaytoonah Private University of Jordan. *European Journal of Social Sciences*, *20*(4), 543-552.

Al-Ani, S. (1970). *Arabic Phonology*. The Hague: Mouton. https://doi.org/10.1515/9783110878769

Amengual, M. (2018). Asymmetrical interlingual influence in the production of Spanish and English laterals as a result of competing activation in bilingual language processing. *Journal of Phonetics*, *69*, 12-28. https://doi.org/10.1016/j.wocn.2018.04.002

Bates, D., Maechler, M., Bolker, B., Walker, S., Christensen, R. H. B., Singmann, H., ... Bolker, M. B. (2015). Package 'lme4'. *convergence*, *12*(1), 2.

Boersma, P., & Weenink, D. (2008). Praat: Doing phonetics by computer (Version 6.0. 37)[Computer program]. *Retrieved August*, *12*, 2008.

Carter, P., & Local, J. (2007). F2 variation in Newcastle and Leeds English liquid systems. *Journal of the International Phonetic Association*, *37*(2), 183-199. https://doi.org/10.1017/S0025100307002939

Flege, J. E., Munro, M. J., & MacKay, I. R. (1995). Factors affecting the strength of perceived foreign accent in a second language. *The Journal of the Acoustical Society of America*, *97*(5), 3125-3134. https://doi.org/10.1121/1.413041

Haddad, G. F. (1984). Epenthesis and sonority in Lebanese Arabic. *Studies in the Linguistic Sciences*, *14*(1), 57-88.

Khattab, G. (2011). Acquisition of Lebanese Arabic and Yorkshire English/l/by bilingual and monolingual children. *Instrumental studies in Arabic phonetics*, *325*. https://doi.org/10.1075/cilt.319.15kha

Kirkham, S., & McCarthy, K. M. (2021). Acquiring allophonic structure and phonetic detail in a bilingual community: The production of laterals by Sylheti-English bilingual children. *International Journal of Bilingualism*, *25*(3), 531-547. https://doi.org/10.1177/1367006920947180

Ladefoged, P., & Maddieson, I. (1996). *The sounds of the world's languages* (Vol. 1012). Oxford: Blackwell.

Laufer, A., & Baer, T. (1988). The emphatic and pharyngeal sounds are in Hebrew and Arabic. *Language and speech*, *31*(2), 181-205. https://doi.org/10.1177/002383098803100205

Recasens, D. (2004). Darkness in [l] as a scalar phonetic property: implications for phonology and articulatory control. *Clinical Linguistics & Phonetics*, *18*(6-8), 593-603. https://doi.org/10.1080/02699200410001703556

Recasens, D. (2012). A cross-language acoustic study of initial and final allophones of/l. *Speech Communication*, *54*(3), 368-383. https://doi.org/10.1016/j.specom.2011.10.001

Recasens, D., & Espinosa, A. (2005). Articulatory, positional, and coarticulatory characteristics for clear/l/and dark/l: evidence from two Catalan dialects. *Journal of the International Phonetic Association*, *35*(1), 1-25. https://doi.org/10.1017/S0025100305001878

Recasens, D., Fontdevila, J., & Pallarès, M. D. (1995). Velarization degree and coarticulatory resistance for/I/in Catalan and German. *Journal of Phonetics*, *23*(1-2), 37-52. https://doi.org/10.1016/S0095-4470(95)80031-X

Shaheen, K. S. K. (1979). *The acoustic analysis of Arabic speech* (Doctoral dissertation, University of Wales, Bangor).

Sproat, R., & Fujimura, O. (1993). Allophonic variation in English/l/and its implications for phonetic implementation. *Journal of phonetics*, *21*(3), 291-311. https://doi.org/10.1016/S0095-4470(19)31340-3

Team, R. C. (2014). R: a language and environment for statistical computing. *MSOR Connections, 1*(1). Retrieved from https://www.r-project.org/

Wells, J. C. (1982). *Accents of English: Volume 1* (Vol. 1). Cambridge University Press. https://doi.org/10.1017/CBO9780511611759