

## The Influence of Vowel Context on the Perception and Production of Emphatic Sounds Among L2 learners of Arabic

Hajar Binasfour & Jane Setter

In the field of phonetics and phonology, it has been argued that Arabic emphatic sounds /s<sup>ʕ</sup>/, /ð<sup>ʕ</sup>/, /d<sup>ʕ</sup>/, and /t<sup>ʕ</sup>/ are distinctive and unique to Arabic and they are considered the most difficult sounds for L2 learners of Arabic to acquire. This research included investigating the ability of a group of Arabic L2 learners to perceive and produce these sounds in different vowel contexts. The aim was to investigate which vowel context is the most difficult to perceive and produce and whether the difficulty of a certain context is related to learners' L1s or the amount of pharyngealisation spread. Audio samples and identification test results were collected from 38 participants and speakers of Mandarin, Urdu and English producing and perceiving the four emphatic sounds in the three vowel contexts. The results showed that the influence of the quality and realisation of pharyngealisation spread rather than L1 transfer could be a robust and plausible explanation for relative difficulty due to finding similar identification and production patterns in the three language groups that have different vowel inventories.

### 1. Introduction

This study is a preliminary work to examine the ability of a group of Arabic second language (L2) learners from different first language (L1) backgrounds to perceive and produce the Arabic emphatic sounds /s<sup>ʕ</sup>/, /ð<sup>ʕ</sup>/, /d<sup>ʕ</sup>/, /t<sup>ʕ</sup>/ in the three phonological environments [ \_a ], [ \_u ], and [ \_i ], found in Modern Standard Arabic. The investigation focuses on the acquisition of emphatic sounds because they are considered unique characteristics of Arabic (Embarki, et al., 2007; Jongman, Herd & Al-Masri, 2007; Newman, 2002). The absence of these sounds in most languages of the world may pose a difficulty in pronunciation for L2 learners of Arabic.

### 2. Background

Arabic emphatic sounds, also known as pharyngealised sounds, have a coronal constriction as a first articulation and a secondary constriction at the pharynx. The coronal constriction, which involves the tip or blade of the tongue, occurs at the alveolar ridge in the case of /t<sup>ʕ</sup>/, d<sup>ʕ</sup>/, s<sup>ʕ</sup>/, or at the teeth for /ð<sup>ʕ</sup>/ . There are four plain equivalent phonemes of Arabic pharyngealised phonemes, which are /t/, /d/, /s/ and /ð/. These plain counterparts are articulated only by coronal approximation. What distinguishes the emphatics from the non-emphatic sounds is the effect of emphatics on the following and preceding vowels, causing an 'emphasis or pharyngealisation spread' and altering these vowels to allophones (Al-Ani, 1970; Shar & Ingram, 2010; Watson, 1999).

#### 2.1 Acoustic Analysis of the Pharyngealised and Non-Pharyngealised Sounds

In exploring the differences visually through speech analysis technology, it can be seen that there are differences in shape between pharyngealised and non-pharyngealised consonants, which result in differences in the quality of the vowels surrounding these sounds. These differences are unnoticeable and indistinguishable in the natural speech of native speakers. Figures 1 and 2 show the differences between minimal pairs with pharyngealised versus non-pharyngealised sounds.

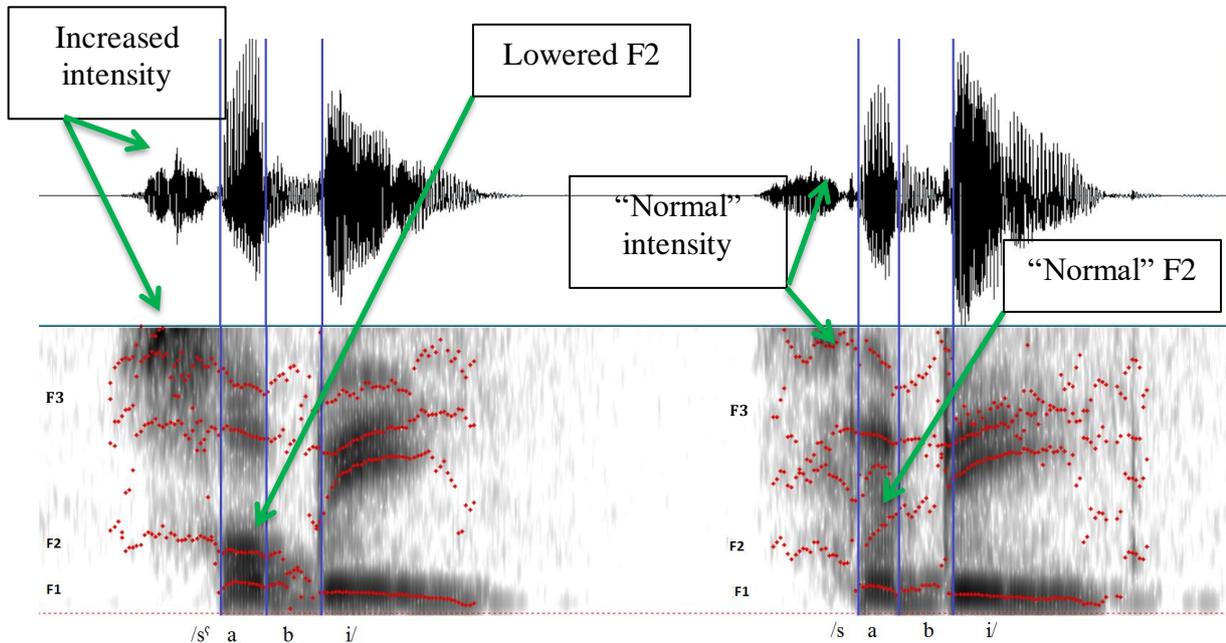


Figure 1: The acoustic shape of the words [sʰabi] ‘boy’ and /sabi/ ‘steal’

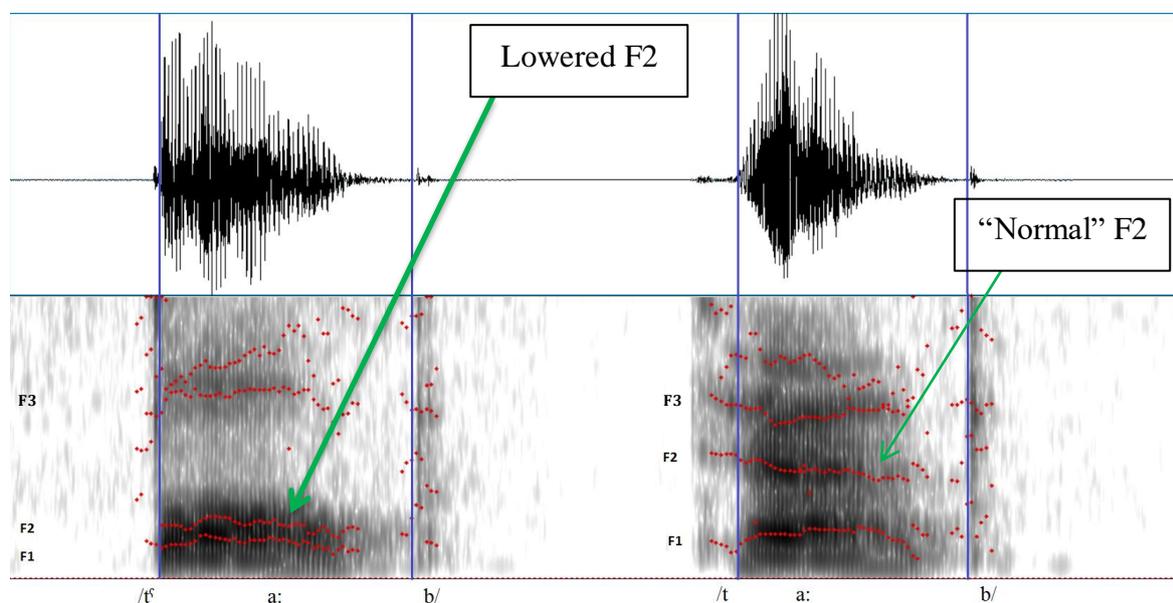


Figure 2: The acoustic shape of the words [tʰa:b] ‘recovered’ and /ta:b/ ‘repented’

These figures show acoustic differences between the pharyngealised and non-pharyngealised consonants and the adjacent vowels. Regarding intensity, the pharyngealised consonants, especially fricatives, appear to be more intense at higher frequencies than the non-pharyngealised sounds, because they require more pressure to produce them (Al-Halees, 2005). This is clearly observable in Figure 1 above.

The pharyngealised vowels which follow the pharyngealised consonants show a degree of lowering more than the non-pharyngealised vowels. This phenomenon is called ‘emphasis spread’ or ‘pharyngealisation spread’ (Al-Ani, 1970; Anyanwu, 2008; Shar & Ingram, 2010). The amount of spread is varied according to dialects and speakers (Davis, 1993; Huneety & Mashaqba, 2016; Israel, et al., 2012; Watson, 1999; Youssef, 2016).

## 2.2 The Effect of Emphatics on the Three Pharyngealised Vowels

The lowering of second formant (F2) varies, based on the quality of the vowel (Card, 1983; Zawaydeh, 1999). That is, the impact of the emphatic sounds on the adjacent vowels differs in the vowels [i], [u], and [a] (Card, 1983; Yeou, 1997). The greatest effect is on the low front vowel [a], while the vowel [u] has the least amount of lowering (Al-Ani, 1970; Jongman, et al., 2007). Figures 3, 4 and 5 are evidence taken from a native speaker of Arabic, which show the effect of the four emphatic sounds on the three adjacent vowel phonemes /a/, /u/ and /i/, which precede and follow the pharyngealised consonant in each case. The resulting effect on F2 of the allophone following the consonant is clearly observable.

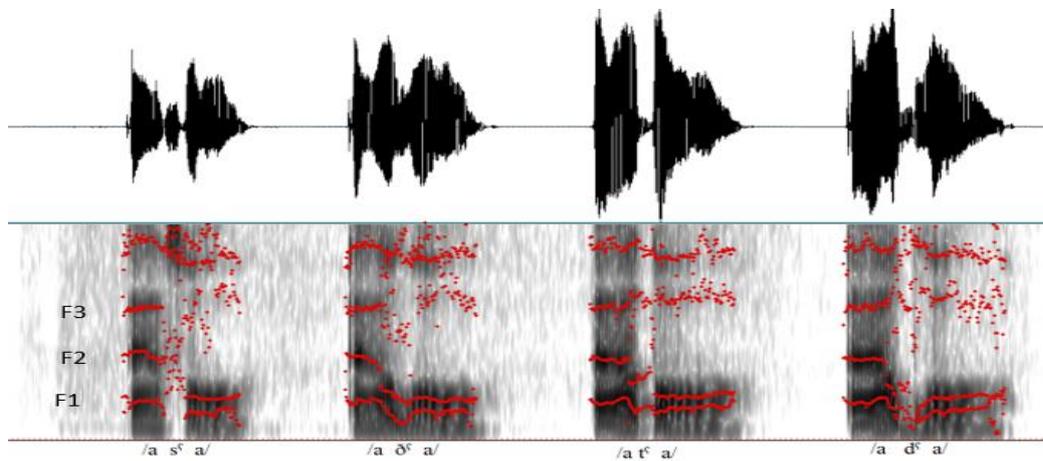


Figure 3: Spectrogram of the pharyngealised vowel /a/

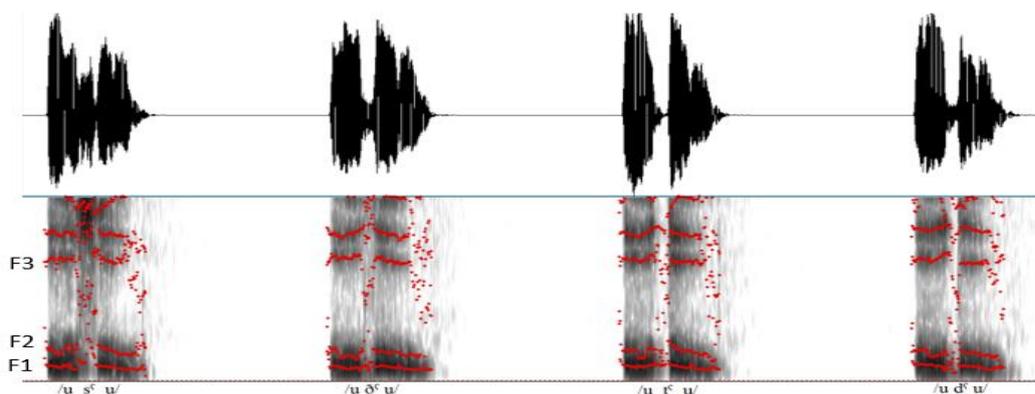


Figure 4: Spectrogram of the pharyngealised vowel /u/

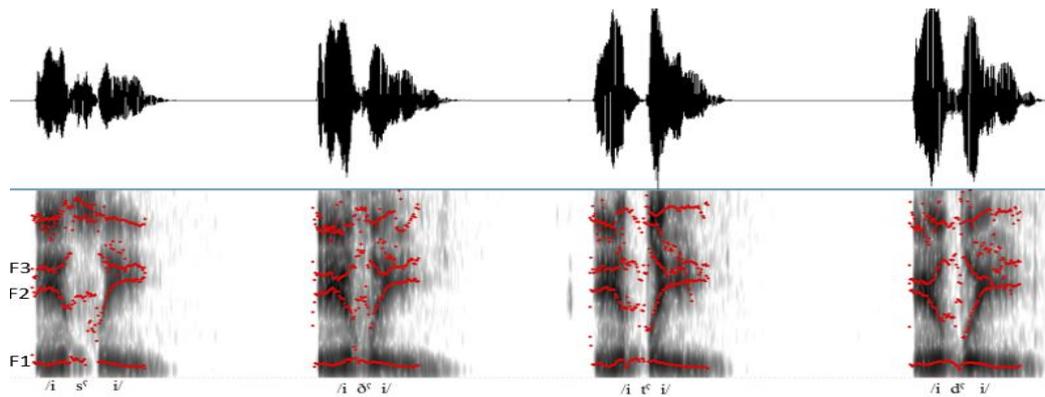


Figure 5: Spectrogram of the pharyngealised vowel /i/

In Figures 3, 4 and 5, the pharyngealised vowels [a], [ʊ] and [i], preceded by the four emphatic sounds /sʰ, ɖʰ, tʰ, dʰ/, show varying degrees of F2 lowering. As shown, the vowel [a] has a noticeable degree of lowering, more than the vowels [ʊ] and [i]. The F2 lowering of the vowel [i], on the other hand, was the least of all, which shows that the pharyngealisation spread from emphatics towards the vowel [i] is weaker than the vowels [ʊ] and [a].

This conclusion leads to the assumption that the pronunciation of the allophone [i], when neighbouring emphatics might be very similar to the phoneme /i/, could pose discrimination difficulties between emphatics and non-emphatics in this vowel context. Therefore, it is possible that L2 learners of Arabic are more likely to correctly perceive, identify and pronounce an Arabic word that has a pharyngealised consonant followed by the vowels [a] and [ʊ] than a pharyngealised consonant followed by the vowel [i].

One of the first studies that tested this assumption on L2 learners of Arabic was carried out by Zaba (2007). She investigated the relationship between Arabic and English vowel inventories and suggested a role for the adjacent vowels as cues for accurately perceiving emphatics. The researcher sought to find which vowels native English listeners perceive following pharyngealised and non-pharyngealised consonants /tʰ/ and /t/. To this end, 13 native English speakers underwent both identification and AXB discrimination tests. The identification test included 24 stimuli, and participants were asked to listen to each stimulus and choose which vowel each stimulus contained. The results for the identification task showed that participants did not accurately discriminate emphatics that came after the high front vowel /i/ but they had the ability to accurately identify the emphatics that came after the high back vowel /a/.

The results of Zaba (2007) were confirmed by Hayes-Harb & Durham (2016) after applying similar experiment on a similar sample in the production of the pharyngealised and non-pharyngealised consonants /dʰ/ and /d/. The idea in Hayes-Harb & Durham's (2016) study was taken from Walley & Carrell (1983), who found that adult and child L1 listeners may rely on the acoustic information of adjacent vowels to identify consonants. The subjects in Walley and Carrell's (1983) study were native speakers of English and they were tested on perceiving English synthetic speech. Hayes-Harb & Durham (2016), on the other hand, sought to test this hypothesis on English L1 learners of Arabic as L2 from a pedagogical perspective, especially with emphatics, because the pronunciation of these sounds is largely based on acoustically raising F1 and lowering F2 of the adjacent vowels (Card, 1983; Jongman, et al., 2007).

Hayes-Harb & Durham's (2016) study was on the possibility of moderating native English speakers' ability to discriminate Arabic emphatic and non-emphatic contrasts in different vowel contexts, based on understanding the relationship between Arabic and English vowel inventories. The authors proposed that the allophonic variation of the Arabic pharyngealised vowel [a], which follows or precedes the emphatics, overlaps with the two English vowels /æ/

and [ɑ]. The overlap between the English vowels /æ/ and [ɑ] and the Arabic allophone [ɑ] makes the latter detectable by English listeners. In contrast, the allophonic variation of Arabic pharyngealised vowels [i] and [u] do not indicate this differential mapping to English vowels (see Figure 6 below). In this case, Arabic /i/ and /u/ would be identified as mostly /i/ and /u/ in both plain and emphatic contexts by English listeners. Hence, it was predicted that English L2 learners of Arabic would find it easier to perceive the emphatics surrounded by the vowel [ɑ] than the emphatics with the vowels [i] or [u]. These predictions were based only on the theory of language transfer and not on the realisation of the degrees of emphasis spread.

To test their predictions, Hayes-Harb & Durham (2016) recruited 40 English native speakers who had not learned Arabic or any language that has emphatics. They were given a vowel identification task which consisted of three tokens for each of the six Arabic vowels, and they were asked to listen to each token and choose which English vowel sound each word contained by using DMDX experiment presentation software (Forster & Forster, 2003). In addition, an AXB discrimination task was also conducted in this study by using the same DMDX software. In this AXB task, listeners were asked to compare which stimulus (A or B) is the same or closely similar to the stimulus X. The stimuli in the discrimination task were three pairs of Arabic nonwords with a CVC syllable structure. The onset consonant was either emphatic /d<sup>s</sup>/ or plain /d/ and the vowel was /a/, /u/, or /i/.

The results revealed there was a high sensitivity in the identification of the emphatics with the vowel [ɑ] more than with the vowels [i] and [u], because – as the authors argued – of the overlap between the Arabic allophone [ɑ] with the English vowels /æ/ and [ɑ]. The percentage of identification overlap for [ɑ] was only 3.7% in emphatic and non-emphatic contexts, i.e., the listeners were mostly able to hear the difference between emphatic and non-emphatic sounds in contexts where the /a/ phoneme was present. On the other hand, the percentage of identification overlap for the vowel [i] was 71.3% (p=.0005), and for the vowel [u] was 69.2% (p=.0005), and they were significantly higher than the vowel [ɑ]. At the end, the authors suggested that the vowel mapping between Arabic and English influenced the performance of English native speakers in identifying and discriminating the emphatic consonants.

The researchers in both studies attributed these findings to the relationship between Arabic and English vowel inventories, as explained earlier. However, there might be another explanation that has not been discussed, regarding the differences in the realisation of emphasis spread between the three vowel contexts. It could be that English native speakers identified emphatics preceded by the vowel [ɑ] because the pharyngealisation was stronger and clearer to the listeners than the vowels [i] and [u]. The differences between the pharyngealised vowels in Figures 3, 4 and 5 above support this claim.

There is no doubt that the studies of Zaba (2007) and Hayes-Harb & Durham (2016) were the first to provide significant and valuable results, which shed light on understanding the role of surrounding vowels in the accurate perception and production of Arabic emphatics by L2 learners. However, testing speakers of a language other than English, which has no (or different) overlaps with the vowel inventory of Arabic, is necessary to test this claim and in order to establish whether it is the realisation of emphasis spread that affects the acquisition of emphatics or it is rather the effect of language transfer. The results of these studies were the starting point of this research and were considered when testing the role of vowel contexts in accurately perceiving and producing emphatics by L2 learners of Arabic.

### **3. Contrastive Analysis of Arabic with Mandarin, Urdu and English**

This section explores briefly the similarities and differences between the vowel systems of speakers of Mandarin, Urdu and English as L1 and Arabic as L2. The comparison aims at

identifying vowels that overlap with the vowels in Arabic. The choice of these three languages in this study was based on two reasons. First, speakers of Mandarin, Urdu and English are the majority L2 learners of Arabic in the Arabic language institutes in Saudi Arabia. Second, and most importantly, these three languages lack emphatic sounds in their phonemic systems. Figure 6 below shows the vowel systems of Arabic, Mandarin, Urdu and English:

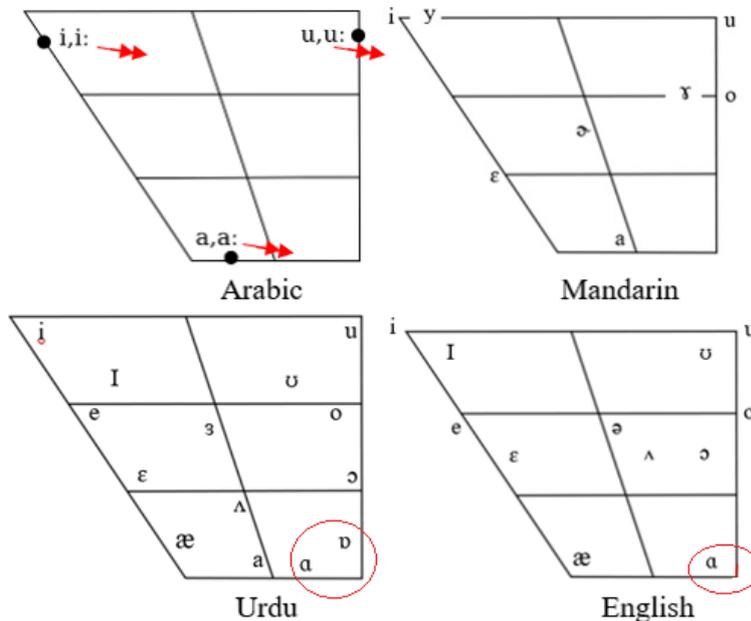


Figure 6: Vowel systems of Arabic (Abushihab, 2010), Mandarin (Cai and Lee, 2015), Urdu (Saleem, et al., 2002) and American English (Roach, 2010).

In Figure 6, the red arrows in the Arabic vowel inventory show the direction of these three vowels if they are pronounced after the emphatics, in which they change from vowel phonemes to allophones. Based on the results of Hayes-Harb & Durham (2016) and Zaba (2007), Urdu and English speakers are expected to be more efficient in perceiving and producing emphatics that are followed by the pharyngealised vowel [ʌ] than Mandarin speakers, due to the existence of the low back vowel [ʌ] in Urdu and English. Mandarin speakers, on the other hand, would find it equally difficult to perceive or produce emphatics in the three vowel contexts. To investigate these predictions, a vowels identification experiment involving the three language groups was conducted.

#### 4. Method

The main purpose of this study was to investigate the influence of the vowel context on learners' ability to perceive and produce the emphatic sounds accurately.

##### 4.1 Participants

The participants were 38 female students of Arabic who were all enrolled in the Arabic linguistic institute at Princess Nourah University in Saudi Arabia. Their ages ranged from 20 to 26 years old and they were from elementary (n= 13), intermediate (n= 14) and advanced (n= 11) levels of Arabic proficiency. The participants were from China, India, the United Kingdom and the United States. 14 Urdu speakers, 13 Mandarin speakers, and 11 English speakers were selected to participate in the study. Participants were mainly chosen based on their language

backgrounds and not proficiency levels. The spread of participants in the three proficiency levels were not taken into consideration in this study.

#### *4.2 Procedure and data collection*

This experiment was submitted to the University of Reading's research ethics committee and the approval to collect data was obtained. First the participants were introduced to the study. The procedure of the study was explained and it was clarified that the purpose of the tests was to examine the perception and production of Arabic sounds. Participants were reassured that their grades would not be affected.

On the first day, questionnaires were administered which contained questions about participants' proficiency level, nationality, age, language group and whether they spoke any language other than their L1 and Arabic. They were then asked to take the perception test. On the following day, the participants took the production test.

The perception and production tests were administered by means of the DMDX display software, which employed specific scripts and codes designed carefully to fit into the program (Forster and Forster, 2003). The perception and production tests each included 30 Arabic words placed in a carrier phrase. The carrier phrase was (... الكلمة هي) 'This word is...'. The reason for placing the words in a carrier phrase was for the purpose of eliciting speech similar to that produced in normal conversation.

The words included either emphatic (e.g. /s<sup>ʕ</sup>/ in /s<sup>ʕ</sup>ar/ 'became'), non-emphatic (e.g. /s/ in /sar/ 'walk') or unrelated sounds for distraction (e.g. /χ/ in /χabi:r/) (see Appendix 1). Three phrases for each of the eight emphatics and non-emphatics and six phrases which served as distracters were included in the tests. The emphatic and non-emphatic words in the tests were minimal pairs in order to test participants' ability to discriminate between sound contrasts. The stimuli for the perception and production tests were similar but they were in different and random order.

All the 30 phrases were presented to the participants using DMDX software on a laptop. For the perception test, two buttons were labelled on the keyboard by red and yellow stickers. During the test, one audio file was played, producing a phrase, and at the same time, two words appeared on the screen. Participants had unlimited time to think and decide which word they thought they had heard: the left or the right one. After they chose one of the words, they pressed the space bar to move to and listen to the next phrase.

In the production test, the phrases appeared on the screen in a random order for each participant whenever the participant pressed the button SPACE. They were asked to read each phrase and their voices were recorded. The recorder used was an Edirol R-09HR, and the recordings were at a sampling rate of 44100 Hz, 16-bit.

#### *4.3 Inter-rater Reliability*

The perception test results were extracted directly from the DMDX software. The recordings for the production test were rated by 11 raters. All raters were adult native speakers of Arabic who hold bachelor's or master's degrees in the Arabic language. The ratings included circling the incorrect sounds and writing the sounds they thought they heard. In order to calculate the inter-rater reliability of the 11 raters, an intra-class correlation coefficient (ICC) was chosen because it provides a measurement of consistency between multiple raters, while Cohen's kappa calculates agreement between only two raters (McGraw and Wong, 1996). The results of the ICC showed a high degree of reliability between raters' measurements. The average measure of ICC was  $r_{ICC} = .981$ , with a 95% confidence interval ( $\alpha = 0.05$ ) from .971 to .989,  $F(570.1) = 37$ .

## 5. Results and Discussion

The perception and production data included testing four emphatics in three different vowel contexts (i.e., [\_ɑ], [\_ʊ], [\_i]). The errors were calculated for each vowel and for all the four emphatics. Each vowel was perceived and produced four times by each participant and 152 times in total by all participants.

In perception, the results revealed that participants misperceived the emphatic that preceded the vowel [i] (43.1%) more than the vowels [ɑ] (21.8%) and [ʊ] (35.1%). Table 1, below, provides descriptive statistical results in the perception of the three vowel contexts:

Vowel contexts	No. of errors	Mean	Std. deviation	95% confidence interval for mean	
				Lower bound	Upper bound
[_ɑ]	47	1.24	1.23	.87	1.61
[_ʊ]	76	2.00	1.09	1.64	2.36
[_i]	93	2.45	1.17	2.06	2.83

Table 1: The perception of the four pharyngealised sounds in the three vowel contexts

In production, the results showed that learners produced errors with the emphatic that preceded the vowel [i] (43.4%) more than the vowels [ɑ] (22.4%) and [ʊ] (34.2%). The statistical analysis of the pharyngealised vowels pronounced by all participants are summarised in Table 2, below:

Vowel contexts	No. of Errors	Mean	Std. deviation	95% confidence interval for mean	
				Lower bound	Upper bound
[_ɑ]	46	1.21	1.1	.88	1.55
[_ʊ]	70	1.84	1.19	1.45	2.24
[_i]	89	2.34	1.32	1.91	2.78

Table 2: The production of the four pharyngealised sounds in the three vowel contexts

In Table 1 and 2, the number of errors perceived and produced for the pharyngealised vowel [i] was more than for [ʊ] and [ɑ]. Furthermore, the vowel [ɑ] received fewer errors in both perception and production from all participants. The results suggested that the quality of the adjacent vowels may have affected the level of difficulty in perception and production of the pharyngealised consonants. To clarify, the emphatics that precede the vowel [ɑ] might be easier to be perceived and produced than the emphatics that precede the vowels [ʊ] and [i].

By looking at the differences between the three language groups, it was found that the perception and production of the emphatics in the three vowel contexts and from the three language groups were not significantly different except in the perception of the pharyngealised vowel /u/ (see Table 3). English speakers produced significantly fewer errors in the perception of emphatics preceding the vowel [ʊ] ( $p = .002$ ). It should be noted that the majority of the English speakers were in the intermediate and advanced level of proficiency, which explains the high accuracy in perception and production comparing to Urdu and Mandarin speakers. It should be noted that the unequal distribution of L1 speakers in each proficiency level may have affected the accuracy of these results. Distributing language groups equally in each proficiency level could lead to different outcomes.

Vowel contexts	Mandarin speakers (N=13)		Urdu speakers (N=14)		English speakers (N=11)		Kruskal Wallis test			
	M	Std. deviation	M	Std. deviation	M	Std. deviation	df	Chi-square	p-value	
Perception	[_ɑ]	1.77	1.092	1.07	1.269	.82	.571	2	5.226	.093
	[_ʊ]	2.46	7.66	2.14	1.292	1.27	.786	2	7.996	.018
	[_i]	2.54	1.198	2.64	1.216	2.09	1.136	2	1.476	.478
Production	[_ɑ]	1.54	1.127	1.07	.829	1.00	1.059	2	1.880	.391
	[_ʊ]	2.31	1.109	1.64	1.277	1.55	1.128	2	2.936	.230
	[_i]	2.31	1.377	2.43	1.342	2.27	1.348	2	.172	.918

Table 3: Descriptive analysis and Kruskal Wallis test from different L1 backgrounds.

Overall, the results of the current study indicated that learners of Arabic face a considerable problem when it comes to dealing with Arabic emphatics in certain vowel contexts. It was evident from the analysis of the results that the degree of difficulty and inaccuracy in the perception and production of emphatics by all learners was indeed high, ranging between 36% to 63% for perception and between 35% to 58.7% for production. The results for emphatic sounds are broadly consistent with previous findings about the difficulty of these sounds encountered by L2 learners of Arabic in perception and production (Abdul-Kadir & Sudirman, 2011; Hayes-Harb & Durham, 2016; Shehata, 2015).

It appears from the results in the current study that the difficulty that L2 learners experienced in perceiving and producing Arabic emphatics may relate to the effect of emphasis on the quality of following vowels. Due to the greatest effect of emphasis on the low front vowel [ɑ], which caused a stronger amount of F2 lowering than [ʊ] and [i], emphatics that precede the vowel [ɑ] were perceived and produced more accurately than those coming before [ʊ] and [i]. The findings of the current study supported the findings of Hayes-Harb & Durham (2016) and Zaba (2007) in general, although their interpretations of the difficulty between vowel contexts might contradict what has been found in the current study.

Hayes-Harb & Durham (2016) and Zaba (2007) explained the easiness of perceiving the pharyngealised vowel [ɑ] by English learners of Arabic as a result of the mapping of Arabic vowel allophones to English vowel phonemes. They mainly attributed the findings of their studies to the role of language transfer. Arguably, the interpretation of Hayes-Harb & Durham (2016) and Zaba (2007) is reasonable, given the fact that learners' L1s have a great effect on their acquisition of L2 speech sounds (Benson, 2002; Major, 2008). This case can also be seen in the current study with Urdu speakers, who, similar to English speakers, found consonants in the context of the vowel [ɑ] easier than [ʊ] and [i]. The vowel inventory of Urdu shows a low back vowel phoneme /ɑ/ that has similar quality to the pharyngealised allophone [ɑ]. Hence, it can be said that these results concur with the explanation of Hayes-Harb & Durham (2016) and Zaba (2007). However, the further investigation with Arabic learners other than English and Urdu speakers offered another interpretation.

Unlike English and Urdu, the vowel inventory of Mandarin shows no similarities between the Mandarin vowel phonemes and Arabic pharyngealised allophones. However, the results of the current study showed that Mandarin speakers' responses were similar to Urdu and English speakers. Specifically, Mandarin speakers were able to more accurately perceive and produce emphatics that preceded the vowel [ɑ] than [ʊ] or [i].

If the explanation provided by Hayes-Harb & Durham (2016) and Zaba (2007) was accurate, Mandarin speakers would find the pharyngealised vowel [ɑ] in the same level of difficulty as [i] and [ʊ] due to the absence of any back and low vowel in Mandarin phonemic system. On the contrary, the current study showed that Mandarin speakers also found the pharyngealised vowel [ɑ] easier than [i] and [ʊ]. Therefore, beside the influence of language transfer, the

quality and realisation of pharyngealisation spread determines the quality of L2 perception and production.

It can be said that Hayes-Harb & Durham (2016) and Zaba (2007) may have failed to present identification patterns that L2 learners of Arabic would follow in identifying emphatic sounds. Learners' L1s could affect learners' decisions in identifying the emphatic sounds. However, the influence of the quality and realisation of pharyngealisation spread could be a robust and plausible explanation due to finding similar identification patterns between the three language groups who have different vowel inventories. These results regarding the acquisition of Arabic pharyngealised vowels from different language groups have never been demonstrated and discussed by previous research. Further studies must be undertaken on different language groups that do not share the same vowel system to confirm the influence of pharyngealisation spread on learners' perceptive and productive skills.

## 6. Conclusions

This study aimed at investigating the ability of L2 learners of Arabic to perceive and produce emphatic sounds in different vowel contexts accurately. The data provided sturdy support for the notion that L2 learners of Arabic find emphatic phonemes difficult to perceive and produce.

There was no variation of perception and production abilities between learners from different language backgrounds, which suggested that the major influence that determines the difficulty level of emphatic sounds is the quality of the adjacent vowels surrounding the emphatics. This study has shed light on specific areas of difficulty learners of Arabic may encounter during the process of learning Arabic. These findings could help Arabic teachers to focus on the adjacent vowels when teaching emphatics and show how relying on the quality of the vowels to produce emphatics can help raise learners' awareness of these acoustic cues. It is hoped that this research will benefit Arabic language instructors and researchers in embedding new techniques or creating teaching materials that focus on these vowel contexts in order to enhance learners' understanding.

## References

- Abdul-Kadir, N.-A. & Sudirman, R. (2011). Difficulties of standard arabic phonemes spoken by non-arab primary school children based on formant frequencies. *Journal of Computer Science* 7(7): 1003-1010.
- Abushihab, I. (2010). Phonological contrastive analysis of Arabic, Turkish and English. *Journal of Language and Literature* 1(4): 16-24.
- Al-Ani, S. H. (1970). *Arabic Phonology: An Acoustical and Physiological Investigation*. Berlin: De Gruyter Mouton.
- Al-Halees, Y. (2005). A xeroradiographic, ultrasonic, laryngoscopic, and acoustic study of pharyngeals and emphatics in Arabic. In: Proceedings 15th ICPHS, 2005. pp. 1747-1750.
- Anyanwu, R.-J. (2008). *Fundamentals of phonetics, phonology and tonology: with specific African sound patterns*. Frankfurt am Main: Peter Lang.
- Benson, C. (2002). Transfer/Cross-linguistic influence. *ELT journal* 56(1): 68-70.
- Cai, Y.-W. & Lee, H. Y.-H. (2015). A contrastive analysis of Mandarin Chinese and Thai: Suggestions for second language pronunciation. *Theory and Practice in Language Studies* 5(4): 719.
- Card, E. A. (1983). *A phonetic and phonological study of Arabic emphasis*. PhD Thesis, Cornell University.
- Davis, S. (1993). Arabic pharyngealization and phonological. In: Perspectives on Arabic Linguistics V: Papers from the Fifth Annual Symposium on Arabic Linguistics. Amsterdam: John Benjamins. pp. 149-162.
- Embarki, M., Yeou, M., Guillemint, C. & Al Maqtari, S. (2007). An acoustic study of coarticulation in modern standard Arabic and dialectal Arabic: pharyngealized vs non-pharyngealized articulation. *ICPhS XVI*: 141-146.
- Forster, K. I. & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior research methods, instruments, & computers* 35(1): 116-124.

- Hayes-Harb, R. & Durham, K. (2016). Native English speakers' perception of Arabic emphatic consonants and the influence of vowel context. *Foreign Language Annals* 49(3): 557-572.
- Huneety, A. & Mashaqba, B. (2016). Emphatic segments and emphasis spread in rural Jordanian Arabic. *Mediterranean Journal of Social Sciences* 7(5): 294.
- Israel, A., Proctor, M. I., Goldstein, L., Iskarous, K. & Narayanan, S. (2012). Emphatic segments and emphasis spread in Lebanese Arabic: a Real-time Magnetic Resonance Imaging Study. *In: INTERSPEECH*. pp. 2178-2181.
- Jongman, A., Herd, W. & Al-Masri, M. (2007). Acoustic correlates of emphasis in Arabic. *In: Proceedings of the 16th International Congress of Phonetic Sciences*. pp. 913-316.
- Major, R. C. (2008). Transfer in second language phonology. *Phonology and second language acquisition* 36: 63-94.
- McGraw, K. O. & Wong, S. P. (1996). Forming inferences about some intraclass correlation coefficients. *Psychological methods* 1(1): 30.
- Newman, D. (2002). The phonetic status of Arabic within the world's languages: the uniqueness of the lughat al-daad. *Antwerp papers in linguistics* 100: 65-75.
- Roach, P. (2010). *English Phonetics and Phonology: A Practical Course*. 3rd ed. Cambridge, UK: Cambridge University Press.
- Saleem, A. M., Kabir, H., Riaz, M. K., Rafique, M. M., Khalid, N. & Shahid, S. R. (2002). Urdu consonantal and vocalic sounds. *CRULP Annual Student Report*.
- Shar, S. & Ingram, J. (Year). Pharyngealization in Assiri Arabic: an acoustic analysis. *In: 13th Australasian International Conference on Speech Science and Technology, 2010 Melbourne, Australia*. Causal Productions. pp. 1-8.
- Shehata, A. (2015). Problematic Arabic consonants for native English speakers: learners' perspectives. *International Journal of Educational Investigations* 2(9): 24-47.
- Walley, A. C. & Carrell, T. D. (1983). Onset spectra and formant transitions in the adult's and child's perception of place of articulation in stop consonants. *The Journal of the Acoustical Society of America* 73(3): 1011-1022.
- Watson, J. C. (1999). The directionality of emphasis spread in Arabic. *Linguistic Inquiry* 30(2): 289-300.
- Yeou, M. (1997). Locus equations and the degree of coarticulation of Arabic consonants. *Phonetica* 54(3-4): 187-202.
- Youssef, I. (2016). Palatalization in educated Cairene Arabic. *Nordlyd* 42(1): 21-31.
- Zaba, A. M. (2007). Native English speakers and Arabic pharyngealization contrasts: Perceptual and acoustic data. *The Journal of the Acoustical Society of America* 121(5): 3071-3071.
- Zawaydeh, B. (1999). *The phonetics and phonology of gutturals in Arabic*. PhD Thesis, Indiana University.

## Appendix 1: Words Used in Perception and Production Tests

Sounds	Words in Arabic	English translation and transcription
/s <sup>ʕ</sup> a/ and /sa/	صار - سار	/s <sup>ʕ</sup> a:r/ 'became' - /sa:r/ 'walk'
/s <sup>ʕ</sup> u/ and /su/	صورة - سورة	/s <sup>ʕ</sup> u:rah/ 'picture' - su:rah 'verse from Quran'
/s <sup>ʕ</sup> i/ and /si/	مصير - مسير	/mas <sup>ʕ</sup> i:r/ 'fate' - /masi:r/ 'walk'
/ð <sup>ʕ</sup> a/ and /ðā/	حظر - حذر	/hað <sup>ʕ</sup> ara/ 'forbid' - /haðara/ 'cautious'
/ð <sup>ʕ</sup> u/ and /ðu/	منظور - منذور	/manð <sup>ʕ</sup> u:r/ 'perspective' - /manðu:r/ 'promised'
/ð <sup>ʕ</sup> i/ and /ði/	نظير - نذير	/nað <sup>ʕ</sup> i:r/ 'counterpart' - /naði:r/ 'harbinger'
/d <sup>ʕ</sup> a/ and /da/	ضال - دال	/d <sup>ʕ</sup> a:l/ 'lost' - /da:l/ 'guided'
/d <sup>ʕ</sup> u/ and /du/	موضوع - مودوع	/maud <sup>ʕ</sup> u:ʕ/ 'subject' - /maudu:ʕ/ 'deposited'
/d <sup>ʕ</sup> i/ and /di/	ناضل - نادل	/na:d <sup>ʕ</sup> il/ 'struggle' - /na:dil/ 'waiter'
/t <sup>ʕ</sup> a/ and /ta/	طاب - تاب	/t <sup>ʕ</sup> a:b/ 'recovered' - /ta:b/ 'repented'
/t <sup>ʕ</sup> u/ and /tu/	طَب - تُب	/t <sup>ʕ</sup> ub/ 'heal' - /tub/ 'repent'
/t <sup>ʕ</sup> i/ and /ti/	طين - تين	/t <sup>ʕ</sup> i:n/ 'mud' - /ti:n/ 'figs'
Distractors	نحب - نهب عين - أين خبير - كبير	/naħaba/ 'cry' - /nahaba/ 'steal' /ħain/ 'eye' - /ʔain/ 'where' /ħabi:r/ 'expert' - /kabi:r/ 'big'

## **Author Bios**

Hajar Binasfour is a lecturer of Arabic Language and culture in the Arabic linguistics institute at King Saud University. She holds an MA in Applied Linguistics from Southern Illinois University in the United States and is currently doing a PhD in English Language and Applied Linguistics at the University of Reading under the supervision of Professor Jane Setter. Hajar's main areas of interest are Arabic phonetics and phonology, teaching and learning Arabic as a second language and computer assisted language learning. Contact: [hbinasfour@ksu.edu.sa](mailto:hbinasfour@ksu.edu.sa).

Jane Setter is Professor of Phonetics in the Department of English Language and Applied Linguistics. She is a Senior Fellow of the Higher Education Academy and Chair of the University of Reading Teaching Fellows' Community of Practice. Her research interests centre around phonological aspects of second language acquisition, and prosodic features in global Englishes and in children with speech and language deficits. She is probably best known as co-editor of the Cambridge English Pronouncing Dictionary (Jones, 2011). Contact: [j.e.setter@reading.ac.uk](mailto:j.e.setter@reading.ac.uk).