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Acquiring the Phonetics and Phonology of English Word Stress: Comparing Learners from Different L1 Backgrounds

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Abstract

This paper explores the acquisition of phonetic and phonological realisation of word stress, by Arabic speaking second language learners of English, in a small production study. Spoken Arabic dialects differ from each other in the phonology of stress, and the phonetic realisation of stress may also vary across dialects. In the present study the English speech productions of learners from two Arabic dialectal backgrounds (Cairo and Amman) is compared to permit disambiguation between L1 transfer and 'learner intonation' as the source of any non-native-like patterns in the phonological and/or phonetic realisation of stress. Phonetic realisation is investigated by means of quantitative acoustic analysis of read speech experimental data, with comparison to L1 Arabic and native English speaker control data. Phonological realisation is investigated by means of auditory qualitative analysis of read speech narrative data. No differences are found in the phonetic realisation of stress between the two Arabic dialects under consideration, however differences are found between the realisation of stress in Arabic as compared to English. In the L2 English production data, the results show a clear pattern of L1 transfer in the phonetic realisation of stress, in particular in lack of vowel reduction in unstressed syllables; this contrasts with

minimal errors in word-stress placement. The implications of the findings of the study for future research are briefly explored.

Keywords: stress, accent, Arabic, L2 English, acoustic cues, L1 transfer

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There is a sizeable body of work on second language acquisition of the phonology of word stress (Archibald, 1994; 1997; 1997; Ghazali & Bouchhioua, 2003) – that is, the task of learning which syllable in the word should be stressed – but comparatively few studies have explored acquisition of language-specific patterns in the phonetic realisation of stress.

We seek to fill this gap by exploring, in a small production study, the acquisition of both aspects of word stress, by second language learners of English whose first language is Arabic. It is well known that spoken Arabic dialects differ from each other in the phonology of stress (Watson, 2011), and there are suggestions in the literature that the phonetic realisation of stress may also vary across dialects. In the present study the English speech productions of learners from two different Arabic dialectal backgrounds is compared; this approach should allow disambiguation between L1 transfer and 'learner intonation' (Mennen, Chen, & Karlsson, 2010) as the source of any non-native-like patterns in the phonological and/or phonetic realisation of stress.

BACKGROUND

Stress and Accent

In the present study, we use the term 'stress' to denote word-level prominence, whereby one syllable within a word is picked out and assigned metrical prominence (sometimes called lexical stress), and the term 'accent' to denote a phrase-level prominence, whereby one or more words within an utterance are picked out and assigned intonational prominence in addition to metrical prominence (sometimes called sentence stress). The position of stress within the word is strictly rule-governed in Arabic and is known to vary across dialects (van der Hulst & Hellmuth, 2010; Watson, 2011). The mechanisms governing the distribution of accent within an utterance in Arabic are less well understood, but the actual distribution of accents is known to vary across dialects (Chahal & Hellmuth, 2014).

In experimental studies, a confound between stress and accent has often been inadvertently triggered through use of single word stimuli. A single word utterance will bear the phonetic and phonological properties of a single word, but also of a whole utterance (Beckman & Edwards, 1994), thus there is no way to know whether any phonetic features observed are the hallmarks of word-level or phrase-level prominence. It is important to disambiguate the phonetic correlates of stress and accent however, because there is an overlap across languages in which cues are used at different levels: in Japanese f0 is a cue to word-level prominence whereas in English f0 is a cue to phrase-level prominence (Beckman, 1986).

Cross-Linguistic Variation in the Correlates of Stress

The phonetic correlates employed in production and perception of stress in English have been investigated in a number of studies, some of which suffer from the stress/accent confound. A classic perception study is Fry (1955; 1958), which relied on pairs of single word utterances as stimuli, and found that a hierarchy of correlates were relied upon by listeners: f0 > duration > intensity. In contrast, in production, the most reliable cue to stress in English has been argued to be spectral balance (Sluijter, Shattuck-Hufnagel, Stevens, & van Heuven, 1995; van Heuven & Sluijter, 1996), as well as in a number of other languages (see Bouchhioua, 2008 for a review).

No perception studies of the correlates of stress or accent have been carried out in Arabic, to our knowledge. Some early production studies acknowledged the stress-accent confound (Chahal, 2001; de Jong & Zawaydeh, 2002). Recent work suggests however that there may be cross-dialectal variation in the phonetic correlates of stress. In Ammani Arabic f0, duration and intensity have been shown all to be correlates of stress (Zuraiq, 2005). In contrast, in Tunisian Arabic, f0, spectral balance and F1 lowering were found to be correlates of both stress and accent, whereas duration and intensity were correlates of accent only (Bouchhioua, 2008). The present study adopts the methodology of Bouchhioua (2008), which is designed to avoid the stress-accent confound by elicitation of target stimuli in carrier phrase contexts.

Second Language Acquisition of Stress and Accent

There is more prior work on the acquisition of the phonology of stress than on the acquisition of the phonetic realisation of stress. A number of studies report evidence of L1 transfer effects, in the form of placement of stress in the L2 according to the stress assignment rules of the L1 (Archibald, 1994; 1997). Other studies report that another source of non-native-like stress patterns is placement of stress on function words, which ordinarily in English would not receive stress (Ghazali & Bouchhioua, 2003). A study which did explore acquisition of the phonetic realisation of stress is Flege and Bohn (1989). Based on auditory assessment of stress placement and degree of vowel reduction, in the production by Swedish L2 learners of stress near-minimal-pairs in English, they argue that acquisition of phonological stress placement was less problematic than acquisition of phonetic realisation.

Turning to accent, some studies have found evidence of L1 transfer effects in the positioning of accents (Nava & Zubizaretta, 2008; Hellmuth, 2010), whilst others attribute similar patterns not to L1 transfer but to general properties of learner intonation (Mennen et al., 2010). There is also evidence of L1 transfer effects in the fine-grained phonetic realisation of accent (Mennen, 2004; Atterer & Ladd, 2004).

RESEARCH QUESTIONS

The aim of this study is to determine whether L1 Arabic learners of L2 English realise stress in a native-like way, a) phonologically (in terms of position of stress in the word, and appropriate treatment of lexical vs. function words) and/or b) phonetically (do the acoustic correlates of stress match those of native speakers). Our research questions are thus: (1a) what are the L1 correlates of stress in Jordanian Arabic (JA) and Cairene Arabic (CA)? and (1b) how do these compare to those observed in English?; (2a) do JA/CA learners of English realise stress in a native-like or non-native-like way? and (2b) how does this compare to their phonological accuracy (putting stress on the right syllable)?

Based on the results of prior studies, we expect to find that L1 Arabic speakers use f0 to mark stress and accent, whereas L1 English speakers use f0 to mark accent only. We expect to find vowel reduction in unstressed syllables in English but not in Arabic. In their L2 English, we expect our learners to display a greater degree of L1 transfer with respect

to phonetic realisation of native-like properties of stress, than with respect to phonological properties.

METHODS

Data Collection

We collected L1 Arabic and L2 English production data with four male intermediate or post-intermediate level L2 learners of English, two from Cairo, Egypt (CA) and two from Amman, Jordan (JA), as well as with two male native speakers of British English to serve as controls (NE). The Arabic participants were aged between 18-26 years; they had all learned English at school for 12 or more years, but none had resided in an English-speaking country for longer than one month. Recordings were made in Cairo, Amman and York, in quiet classrooms or offices, directly to.wav format at 44.1KHz 16bit, using a Marantz PMD660 and head-mounted Shure SM10 microphones. Use of head-mounted microphones permits investigation of comparative intensity across different tokens within the recording made by each speaker.

Materials

Disyllabic near minimal pairs, 12 in English and 12 in Arabic, were used to examine the effect of ±stress in similar consonantal environments, following Bouchhioua (2008). Measurements are taken in the first syllable of the word, which is segmentally parallel in each pair, but differs in being either stressed or unstressed, as shown in Table 1.

In Arabic, the target vowel is varied systematically, with two near minimal pairs each to represent each of the main Arabic vowels /i iː a aː u uː/. The English stimuli mostly exploit the well-known stress distinction in noun-verb pairs. Note that these are not full minimal pairs, since the unstressed initial vowel is generally reduced to schwa in the verb. The English data are taken directly from Bouchhioua (2008); the Arabic stimuli follow the same pattern as used by Bouchhioua (2008) but using different lexical items, chosen because they are parallel across a range of spoken Arabic dialects.

Table 1. English and Arabic near minimal pairs, with stressed vs. unstressed first syllable.[1]

English				*Arabic*			
+stress		*-stress*		*+stress*		*-stress*	
ˈsʌbdʒɛkt	subject (n.)	səbˈdʒɛkt	subject (v.)	ˈbiːra	beer	biːˈreːn	two beers
ˈɹɛkɔːd	record (n.)	ɹɪˈkɔːd	record (v.)	ˈbaːshar	he preached	baːˈshart	I preached
ˈkɒntɹæst	contrast (n.)	kənˈtɹæst	contrast (v.)	ˈbuːme	owl	buːˈmaːt	owls
ˈkɒmbaɪn	combine(n.)	kəmˈbaɪn	combine (v.)	ˈsiːre	path	siːˈnaːt	sixes
ˈdaɪdʒɛst	digest (n.)	dɪˈdʒɛst	digest (v.)	ˈsaːda	plain	saːˈdaːt	gentlemen
ˈkɒntɹækt	contract (n.)	kənˈtɹækt	contract (v.)	ˈsuːra	verse	suːˈdaːn	Sudan
ˈpɜːmɪt	permit (n.)	pəˈmɪt	permit (v.)	ˈsitte	six	sitˈtaːt	ladies
ˈpɜːvɜːt	pervert (n.)	pəˈvɜːt	pervert (v.)	ˈsattar	he covered	satˈtart	I covered
ˈɒbdʒɛkt	object (n.)	əbˈdʒɛkt	object (v.)	ˈsukkar	sugar	sukˈkaːn	inhabitants
ˈkɒntɛnt	content (n.)	kənˈtɛnt	content(adj.)	ˈkisbit	she earned	kisˈbuːh	they earned it
ˈkɒndʌkt	conduct (n.)	kənˈdʌkt	conduct (v.)	ˈmarra	(one) time	marˈrart	I passed
ˈpɹɒdʒɛkt	project (n.)	pɹəˈdʒɛkt	project (v.)	ˈmurra	bitter	murˈriːn	passers-by

[1] In Arabic [-stress] targets (last column of the table), the initial unstressed long syllable will undergo phonological vowel shortening in CA but not in JA (Watson, 2002), yielding e.g. CA: [biˈreːn]; JA [biːˈreːn]. This may affect the contribution of duration to the marking of stress.

In order to systematically vary accent status of the target word, we used carrier phrases designed to place the target in either a focussed [+accent] or post-focal [-accent] context, following Bouchhioua (2008). The basic carrier phrase for English was "say ____ again", and for Arabic was /ʔuktub ____ kamaːn marra/ 'write ____ one more time'. To attract (focal) accent to the target word, a sentence containing a semantically related word preceded the carrier phrase with the target word. In order to deflect accent away from the target word, a sequence of preceding sentences is used so that the target word is given in context (repeated from earlier in the discourse) and highly likely to be deaccented (Cruttenden, 2006; Ladd, 2008).

Table 2. Target words (in bold) placed in carrier phrases to vary ±accent status.[2]

+accent	Say TOPIC again. Say **SUBJECT** again.
-accent	The subject is a grammatical category. WRITE subject again. SAY **subject** again.
+ accent	ʔuktub xamsa kamaːn marra ʔuktub ˈ**sitta/sit**ˈ**taat** kamaːn marra
	*'Write five another time, write **six/sixes** another time'*
-accent	sitta kalima sahla ʔuktub sitta kamaːn marra ʕiːd ˈ**sitta/sit**ˈ**taat** kamaːn marra
	*'Six is an easy word. Write six another time, REPEAT **six/sixes** another time.'*

This yields a 2x2 study in which both ±stress and ±accent are systematically varied, as in 1).

1)		**+accent**	**-accent**
	+stress	ˈsitta 'SIX (not five)…'	REPEAT ˈsitta…
	-stress	sitˈtaat 'LADIES (not men]…	REPEAT sitˈtaat…

To assess phonological acquisition, each learner was asked to read aloud a 300-400 word excerpt from the Cinderella story, taken from the IViE corpus (www.phon.ox.ac.uk/IViE/).

[2] Capitalisation was used in the English written prompts to attract focus. There is no directly parallel typographical equivalent for use in Arabic.

Analysis

The experimental data comprise 12 lexical sets x 2 stress conditions x 2 accent conditions x 2 speakers, potentially yielding a total of 96 tokens per speaker/language dataset. There were no recordings errors or disfluencies in the Arabic speech recordings (N=192). In the English data, 45 tokens had to be excluded from analysis (N=288): 6 due to devoicing of the unstressed syllable; 39 due to realisation of stress on the wrong syllable (JA=5; CA=33; NE= 1).

The target vowels were labelled manually in Praat by the first author. The target vowels are preceded and followed by a stop, a fricative, a nasal, or /r/. Most vowels can reliably be segmented in these consonantal contexts (Turk, Nakai, & Sugahara, 2006). The primary cue used during segmentation was the appearance of a complete set of dark bands (formants) in the spectrogram, indicating the onset/offset of the vowel (Di Paolo, Yaeger-Dror, & Wassink, 2010, p. 91). The release burst of post-vocalic voiced stops was taken as the onset of the stop and thus the end of the preceding vowel, but aspiration following voiceless stops was not measured as part of the vowel. For fricatives, the onset and offset of frication energy was used to identify the beginning and end of the vowel, and nasals are also identified via abrupt spectral changes (Turk et al., 2006). Lowering of F3 and amplitude drop off were used to identify the onset of /r/ (Lawson, Stuart-Smith, Scobbie, Yaeger-Dror, & Maclagan, 2010, p. 79). The duration of the whole target word was also labelled, to provide a domain against which to normalise vowel duration and thus control for speech rate variation.

A sample labelled file is provided in Figure 1. A Praat script written by the third author was used to extract the following measurements: target vowel duration (divided by target word duration to normalise for speech rate), overall intensity (measured at the intensity peak [IP] within the target vowel, identified and labelled automatically), f0, F1, F2 and spectral balance measured at the midpoint [MP] of the target vowel (also labelled automatically). A manual check of pitch and formant tracking in all tokens was performed prior to running the measurement script. Two measures of spectral balance (H1-H2 and H1-A3) were measured using a script made available by Bert Remijsen (van Heuven & Sluijter, 1996).

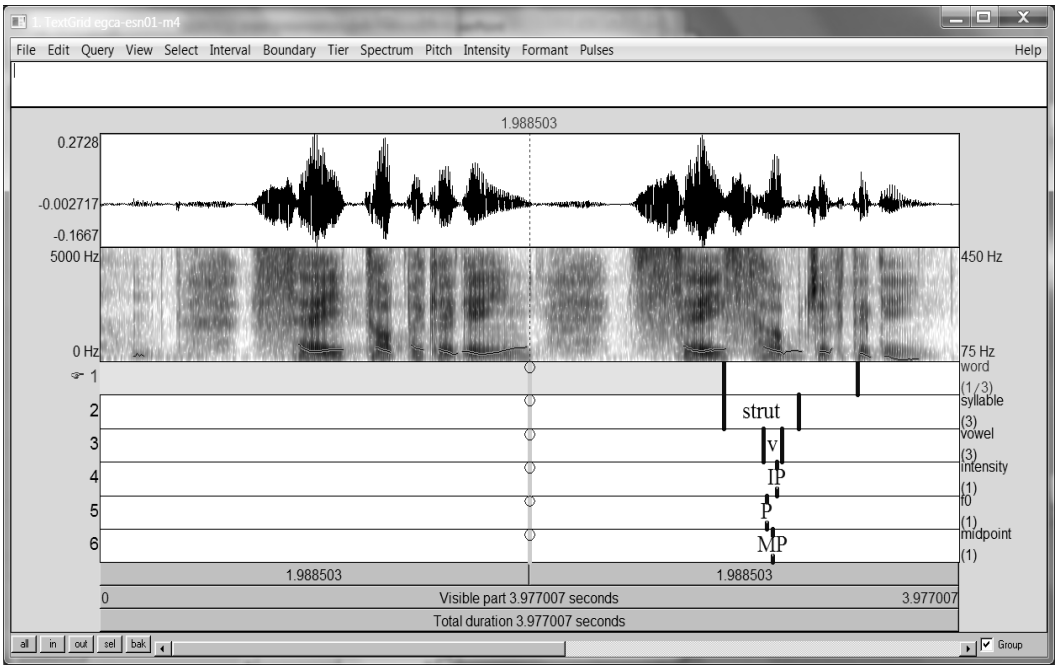


Figure 1. Sample labelled textgrid indicating measurement points of dependent variables.

The quantitative data were submitted to statistical analysis in a series of linear mixed models for each dependent variable, with *subject* and *item* as random factors, and *stress*, *accent* and *speaker language* as independent variables. Dependent variables were: duration, intensity, f0, two measures of spectral balance (H1-H2 and H1-A3), F1 and F2.

The narrative data were subjected to double blind error analysis by the second and third authors, based on auditory impression. Errors were classified into categories, according to type, such as stress placement on the wrong syllable or erroneous stress placement on a non-contrastive function word. Inter-transcriber agreement was 99.77%. No statistical tests were performed on the narrative data due to the relatively small sample size (1228 words in total).

RESULTS

We present results for each of our research questions in turn. To recap, our research questions are: (1a) what are the L1 correlates of stress in Jordanian Arabic (JA) and Cairene Arabic (CA)? and (1b) how do these compare to those observed in English?; (2a) do JA/CA learners of English realise stress in a native-like or non-native-like way? and (2b) how does

this compare to their phonological accuracy (putting stress on the right syllable)?

L1 Arabic correlates of stress in JA and CA, with comparison to L1 English

The results suggest that there is only a marginal difference between the two dialects, JA and CA. We found a main effect ($p<.05$) of *stress* on duration, intensity and f0, but not on F1, F2 or spectral balance (this latter result differs from that observed for Tunisian Arabic by Bouchhioua 2008). There was a main effect ($p<.05$) of *accent* on duration and intensity only, and none on f0, F1, F2 or spectral balance. This indicates that in both dialects stressed vowels are longer, louder and realised at a higher pitch than unstressed vowels; neither dialect uses f0 as a cue to differentiate accented/unaccented vowels. There is a near significant interaction between *speaker_language* and *stress* for duration and f0 [duration: $F(1,171)=2.975$; $p=.086$; f0:$(1,167)=3.196$;$p=.076$]. Stressed vowels are somewhat more lengthened with respect to unstressed vowels in EA than in JA (Fig. 2a) ; in contrast, stressed vowels are realised with somewhat greater f0 than unstressed vowels in JA than in EA (Fig. 2b).

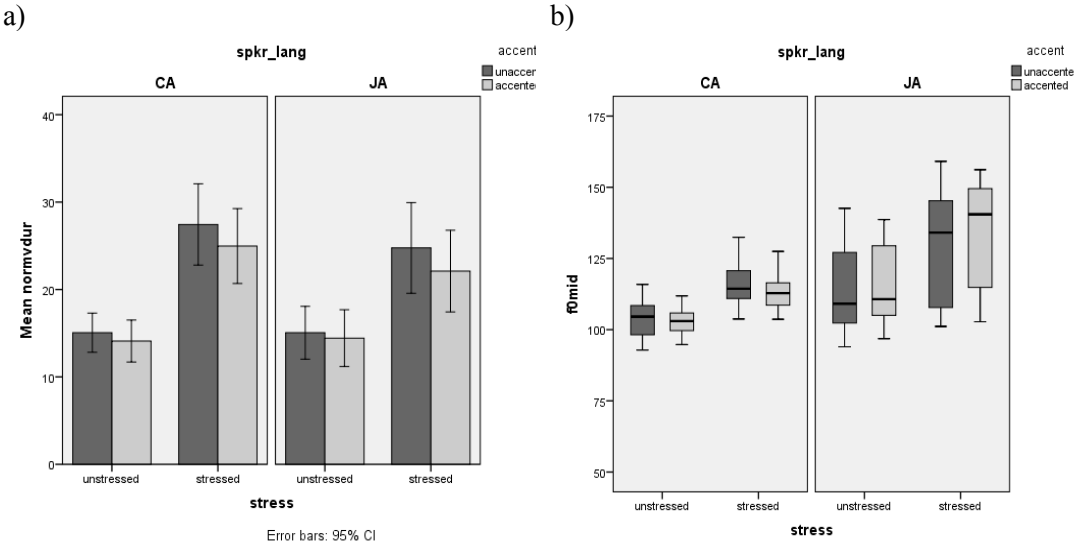


Figure 2. a) 95% confidence intervals around mean normalised target vowel durations in L1 Arabic, by dialect, stress and accent, and b) median and interquartile ranges of f0 at midpoint of the target vowel in L1 Arabic, by dialect, stress and accent.

The key differences between Arabic and English in the phonetic realisation of stress are thus that, in Arabic, f0 is used to mark (word-level) stress, not (phrase-level) accent, and F1/F2 are not used at all to mark stress. In contrast, in English, f0 is primarily a cue to (phrase-level) accent in English, and vowel reduction, reflected in F1/F2, is a strong cue to (word-level) stress. Both patterns are observed in our own NE control data (see Fig. 3 and Fig. 5c below).

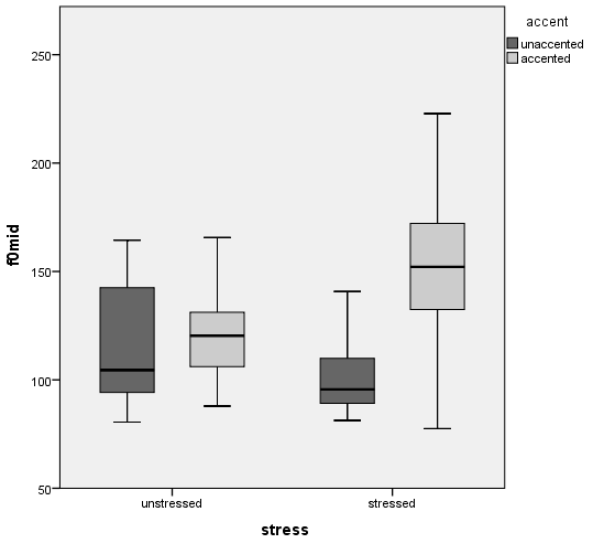


Figure 3. Median and interquartile ranges of f0 at midpoint of the target vowel in L1 English, by stress and accent.

Phonetic Realisation of Stress in L2 English with Comparison to Phonological Error Rates

In light of the above result, an eventual L1 transfer effect in the phonetic realisation of stress in our participants' L2 English is expected to be manifested in use of f0 to mark stress instead of accent, and in a lack of use of F1/F2 to mark stress, and this is indeed what we find.

We found an interaction of *speaker_language* and *accent* on f0 [F(2,240)=4.559, p=.011], together with an interaction of *speaker_language***stress***accent* on f0 [F(3,240)=5.010, p=.002]. The L2 learners use f0 mostly to differentiate stressed/unstressed vowels whereas the NE speakers use f0 mostly to differentiate accented/unaccented vowels (Fig. 4).

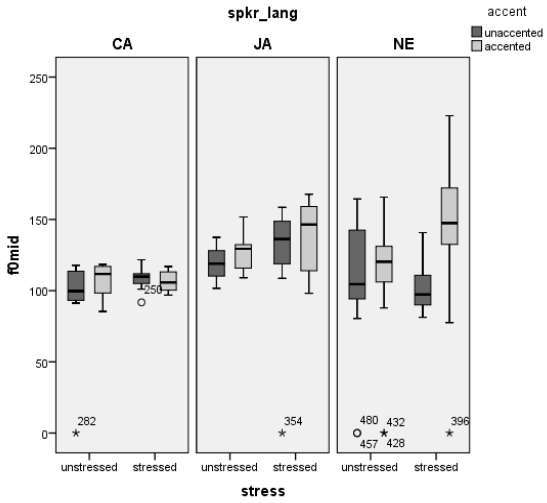
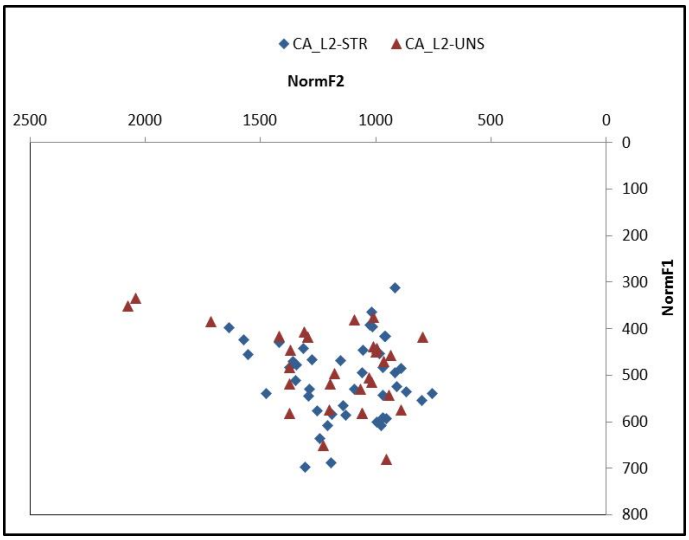


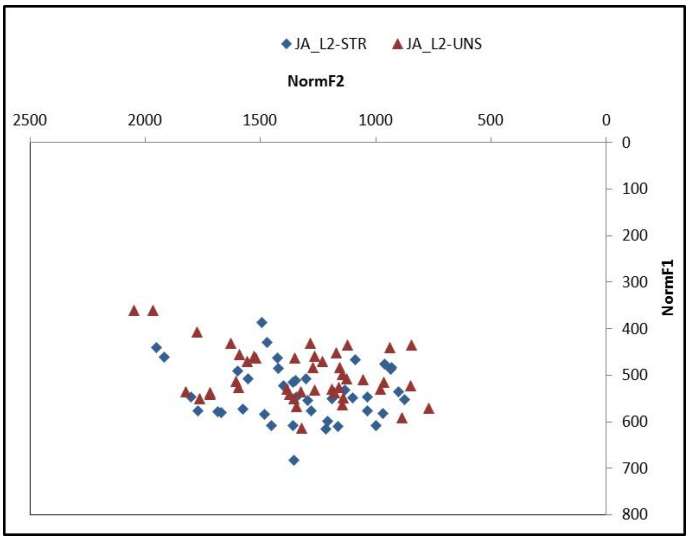
Figure 4. Median and interquartile ranges of f0 at the midpoint of the target vowel, by speaker_language, stress and accent.

We found an interaction of *speaker_language* and *stress* for intensity, F1 and F2 [intensity: F(2, 242)=4.301, p=.015; F1: F(2, 242)=11.301, p=.000; F2: F(2, 242)=11.359, p=.000]. A plot of normalised F1/F2 values shows considerable overlap in the distribution of stressed and unstressed vowels in the F1/F2 vowel space for both groups of L2 learners, in contrast to a clear separation of stressed and unstressed vowels by NE speakers (Fig. 5). There were no other significant interactions between *speaker_language* and other factors.

a)



b)



c)

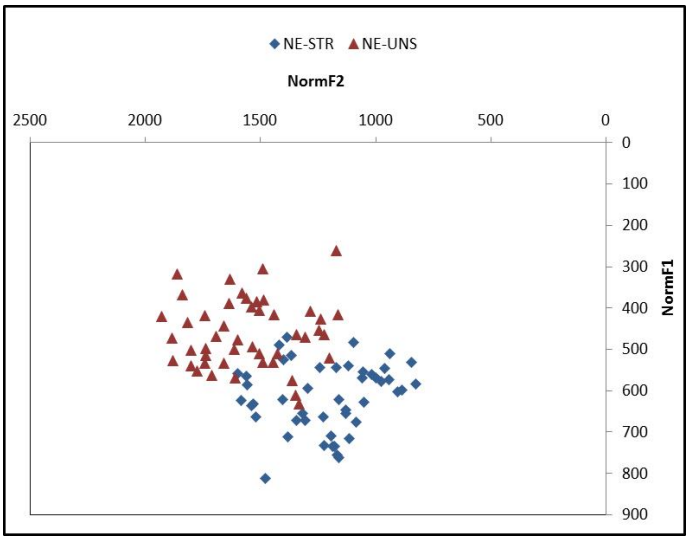


Figure 5. normalised F1/F2 measured at the midpoint in stressed (squares) vs. unstressed (triangles) target vowels in English for a) CA speakers, b) JA speakers, and c) NE speakers.

There is therefore some evidence of L1 transfer in the phonetic realisation of stress, in the speech productions of the L2 learners of English, in that the learners are marking stress in English with 'too much' f0 and 'not enough' vowel reduction.

If we compare this to the learners' phonological accuracy, in terms of categorical stress placement, we find a much smaller transfer effect. The results of the categorical error analysis are shown in Table 3. The error rate for each learner is very low (5% or less in all cases), and incorrect placement of stress within the word accounts for less than 10% of all observed errors. The main pattern of phonological transfer observed is in

assignment of (phrase-level) accent, the most common being non-native like placement of accent on a non-contrastive function word (cf. Ghazali & Bouchhioua 2003). Other non-native-like patterns include incorrect stress placement within a compound noun phrase and lack of deaccenting of words which are discourse-old.

Table 3. Categorical error types observed during auditory transcription of read speech data.

	# target words in text	within-word stress position errors	function word errors	compound errors	deaccenting errors	Total:
egca-m4	368	1	6	4	2	13
egca-m8	368	1	9	4	0	14
joam-m3	276	1	8	1	0	10
joam-m9	276	2	10	1	1	14
Total:		5 (10%)	33 (65%)	10 (20%)	3 (6%)	51

DISCUSSION

In summary then, the present study found no real difference in the phonetic correlates used to realise stress in CA vs. JA, but did show that the correlates of stress differ between the Arabic dialects explored here and British English. Stress is marked in Arabic (in the present data) by means of f0, duration and intensity, whereas stress is marked in English using duration and F1/F2; in English f0 primarily marks (phrase-level) accent. In the experimental production data, the L2 learners were found to be marking stress in their L2 English productions with 'too much' f0 and 'not enough' vowel reduction; they are marking accent with f0, but less so than NE speakers. In the read speech narrative production data, there was little sign of L1 phonological transfer in assignment of word-stress within words; the few errors that are observed are in the distribution of (phrase-level) accent.

The results support our hypothesis that we would find evidence of greater L1 transfer in the phonetic (gradient) realisation of stress than in its phonological (categorical) realisation. Some evidence of phonological transfer was observed, primarily in the form of non-native-like

assignment of accents to non-contrastive function words. This transfer could, in principle, be analysed as an effect of learner intonation (Mennen et al., 2010), though it is to be noted that the participants in the present study are well beyond beginner level.

The most salient phonetic difference between the L2 English and NE productions is the lack of vowel reduction in unstressed syllables as produced by the L2 learners. Teaching of unstressed vowel reduction is explicitly excluded from the Lingua Franca Core (Jenkins, 2002), however, it is possible that lack of vowel reduction in unstressed syllables would hinder identification of stress in these L2 productions by native English listeners. In a perception study, Taylor and Hellmuth (2012) found that some British English listeners were unable to identify the stressed syllable in disyllabic nonsense word stress minimal pairs when the stressed syllable was marked only with duration, intensity and f0, without reduction of the vowel in the adjacent unstressed syllable (cf. Cutler & Pasveer, 2006). The present study thus leads us to hypothesise that Arabic-speaking L2 learners of English will be able to identify the position of stress in our participants' production data, but that native English listeners may not be able to do so reliably. We hope to test this hypothesis in a future perception study.

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