L2 processing of Arabic derivational morphology

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The current study examined how non-native speakers process the highly productive derivational morphology of Arabic in which, in contrast to Indo-European languages, word formation involves interleaving a root and template structure. Previous research shows that native speakers of Arabic decompose morphologically complex words in lexical processing. Using cross-modal priming, the current study shows that non-native speakers of Arabic (L1 English) also decompose derived forms such that there is priming between words that share a common root which is not due to semantic or phonological overlap. In spite of the typological distance, native English speakers organize their L2 Arabic lexicons in a manner similar to native Arabic speakers.

Introduction

There is a large body of research which shows that second language (L2) learners are less sensitive than native (L1) speakers to morphological structure. The majority of the research on the processing of morphology by L2 learners has focused on inflectional morphology (Babcock, Stowe, Maloof, Brovetto & Ullman, 2012; Clahsen, Felser, Neubauer, Sato & Silva, 2010; Coughlin & Tremblay, 2015; Foote, 2015; Gor & Cook, 2010; Gor & Jackson, 2013; Jacob, Fleischhauer & Clahsen, 2013; Neubauer & Clahsen, 2009; Portin, Lehtonen, Harrer, Wande, Niemi & Laine, 2008; Portin, Lehtonen, & Laine, 2007). There is conflicting evidence regarding L2 decomposition of inflectional morphology. Some studies, mostly using lexical decision tasks and overt visual, auditory, and cross-modal priming (Basnight-Brown, Chen, Hua, Kostic & Feldman, 2007; Feldman, Kostić, Basnight-Brown, Filipović Đurđević & Pastizzo, 2010; Foote, 2015; Gor & Cook, 2010; Gor & Jackson, 2013; Portin, Lehtonen, Harrer, Wande, Niemi & Laine, 2008; Portin, Lehtonen & Laine, 2007; see Gor, 2010 for a review), show decomposition of regular inflection by L2 learners. Others, mostly using masked priming, report no L2 decomposition of inflected

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words (Clahsen, Balkhair, Schutter & Cunnings, 2013; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008; see Clahsen et al., 2010, for a review). In contrast, research in L2 processing of derivational morphology has shown more consistent results in that L2 learners exhibit somewhat more native-like patterns in terms of (de)composing derived forms (Diependaele, Duñabeitia, Morris & Keuleers, 2011; Kirkici & Clahsen, 2013; Silva & Clahsen, 2008). Research in L2 morphological processing has, however, mostly targeted Indo-European languages in which inflection and derivation are largely accomplished via suffixation, and derivational morphology is much less productive than inflectional morphology. One exception is Kirkici and Clahsen's (2013) study on Turkish, a non-Indoeuropean language with highly productive derivational morphology. These derivational processes in Turkish are, however, accomplished via suffixation as in many Indo-European languages. In contrast to Indo-European languages, Semitic languages, like Arabic and Hebrew, have rich, complex and productive systems of derivational morphology involving a root and a pattern structure which are interleaved to form words (Holes, 1995; Versteegh, 1997). It is necessary to note that there is debate about the nature of Arabic and Hebrew derivation, regarding both the existence of the triliteral root, as well as the morphological versus the phonological nature of the pattern structure (Bat-El, 1994; 2003; McCarthy, 1979; 1981; Ratcliffe, 1997; 2004; Ussishkin, 2000; 2003; 2005). We review the relevant aspects of this debate below, and substantiate our choice to situate the current study with reference to the root-and-pattern model. Studies done with native speakers of Arabic show that they process the derivational morphology of Arabic in a manner similar to that of native speakers of other languages studied (Boudelaa & Marslen-Wilson, 2001; 2004; 2005; 2011; 2013), in that morphologically complex words are (de)composed during lexical processing. The vast majority of Arabic words are morphologically complex (Boudelaa, 2014), the main exception being loanwords which are sometimes only partially integrated into the morphological system (Kossman, 2013). The current study demonstrates morphological priming in L2 learners of Arabic who are native speakers of English, suggesting that these learners (de)compose derived words in a manner similar to native speakers during lexical processing.

Arabic morphology

In contrast to Indo-European morphology, which generally involves combining stems and affixes via concatenation, Semitic morphology is templatic and involves discontinuous morphemes. All words in Semitic languages are composed of at least two morphemes: a root and a pattern. Roots are made up of consonants (usually three) and carry a word's core semantic information (e.g., the root *ʕ-l-m* denotes knowledge, learning, and information). Patterns (also called templates) are composed mainly of vowels and provide syllabic structure for the word, syntactic information and some semantic information (e.g., the pattern *faːʕil*[1] is the pattern for active participles denoting a state of being related to the semantic content of the root). Words are derived by interleaving a root with a pattern. The word *ʕaːlim*, 'scholar', is, therefore, derived from the root 'ʕ-l-m' and the pattern *faːʕil* (a person in the state of possessing knowledge/learning/information).

By combining the same root with a pattern for active verbs (*faʕala*) you get *ʕalima*, 'he knew'. If you combine it with a pattern for causative verbs (*faʕʕala*), you get *ʕallama*, 'he taught' or 'he informed'. If you combine it with a pattern for adjectives (*faʕiːl*), you get *ʕaliːm*, 'informed' or 'scholarly', and if you combine it with a pattern for passive participles (*mafʕuːla*), you get *maʕluːma*, 'piece of information'.

Like derived forms in other languages, the compositional semantics of Arabic words are not always transparent with respect to the word's meaning. That is to say, while nearly all Arabic content words can be decomposed into a root and a pattern, the meaning of a given word is not always interpretable as the sum of those morphemes. For example, the root ɣ-*r*-*b*, when combined with different patterns, gives rise to the words sunset (*maɣrib*), strange (ɣ*ariːb*), and exile (ɣ*urba*).

As noted above, the root-and-pattern theory of Arabic derivation is not without dispute. Other theoretical accounts posit that Semitic derivation is better understood as a phonological phenomenon, wherein triliteral roots are replaced by stem forms, and phonological processes/constraints such as fixed prosody and melodic overwriting account for what only appear to be discontinuous morphemes (Bat-El, 1994; 2003; McCarthy, 1979; 1981; Ratcliffe, 1997; Ussishkin, 2000; 2003; 2005). These accounts may differ regarding the exact phonological processes that give rise to the structure of Arabic verbs, but they share the assumption of some fundamental stem or word, upon which phonological processes operate. In other words, an extant stem or word serves as the derivational source. In most accounts, this stem or word is manifest in the spoken language, (in contrast to the triliteral root, which is more abstract and never actually appears in the spoken language as a bare three-letter string). It is then the interaction between this derivational source and a set of phonological processes and/or requirements (e.g., melodic overwriting, prosodic constraints) that give rise to the part of the verb we have been calling the "pattern". In this set of phonological accounts, what looks like the pattern is better understood as an emergent phonological phenomenon, rather than a discontinuous morpheme.

1. Traditionally, patterns are written by substituting the three consonants 'f-ʕ-l' in the positions to be occupied by the three consonants of the triliteral root.

The phonological approaches in question also share a focus on contexts where the semantic relationship between the derivational source and the derived form is clear. These contexts include the derivation of denominal verbs (Ussishkin, 2000), irregular (i.e., broken) plural nouns (McCarthy & Prince, 1990), and the complex verbal derivation systems of Arabic and Hebrew (Bat-El, 2003; McCarthy, 1979). The phonological approaches explain phenomena such as the seemingly unpredictable medial vowel in Form 1 Arabic verbs, by positing that it is part of the derivational source or stem.

A challenge for these approaches concerns behavioral evidence that speakers of Semitic languages actually exhibit priming between semantically unrelated words that share triliteral roots: prime-target pairs like *muðakkar*, 'masculine', and *ða:kira*, 'memory'. It is difficult to identify a stem- or word-type derivational source in this context; do both words come from *tuðkar*, 'remember', do both come from *ðakar*, 'male', or something else? Unless the priming between the two forms is purely phonological (and accumulating behavioral evidence suggests that it is not), the simplest explanation would be that native speakers do in fact access the triliteral root during lexical access, and that it is the repeated access to this same root that facilitates lexical access to an otherwise unrelated target.

The section that follows reviews the behavioral evidence that triliteral root morphemes have psychological reality for native speakers of Semitic languages.

L1 processing of Arabic derivational morphology

Some of the first psycholinguistic evidence for the distinct representations of Arabic roots and patterns comes from Prunet, Beland and Idrissi's (2000) case study of an Arabic/French bilingual patient with aphasia, called ZT. ZT completed word reading, picture-naming, and spoken repetition tasks in both his languages. The authors found that he produced far more metathesis errors in Arabic than French. Further, these errors consisted almost exclusively of permuting root consonants; they rarely affected the patterns (whereas the few metatheses he produced in French affected vowels and consonants indiscriminately). The authors concluded that his behavior was evidence that Arabic root consonants "float" at some level of representation in the minds of native speakers, and drew supporting connections with the observed permutability of Arabic root letters in tongue-slips among neurotypical native speakers, as well as in Arabic word games.

Further evidence for the mental representation of Arabic roots comes from Perea, Abu Mallouh, and Carreiras's (2010) investigation of transposed-letter (TL) priming in Arabic. The background for their study is a body of findings for Indo-European languages like English and Spanish, in which nonwords created by transposing two medial letters in a real word will prime that real word (e.g., *jugde* primes *judge*; Perea & Lupker, 2003). The authors found that Arabic prime words transposing the letters of the target words will speed RTs to those targets only when the transposition affected the order of the pattern letters. Transpositions affecting root letter order did not. The authors explained these findings in terms of the important role that roots play in Arabic lexical access. However, caution is appropriate in comparing their findings to those from the Indo-European studies, because while the latter employed nonword primes for real word targets, Perea and colleagues used all real word primes for real word targets. Thus, the transposed pattern-letter condition was also a morphological (root) priming condition, whereas the transposed root-letter condition was not.

In a series of experiments, Boudelaa and Marslen-Wilson (2000; 2004; 2005; 2011; 2013) sought to determine whether native speakers of Arabic decompose words into roots and patterns during lexical access or if they access whole word forms. Using cross-modal priming, Boudelaa and Marslen-Wilson (2000) compared priming effects when visual targets were paired with auditory primes that shared a common root and had a semantically transparent morphological relationship (*ʔidxaːlun-duxuːlun*, inserting-entering), primes that shared a common root where the relationship was opaque (*mudaːxalatun-duxuːlun*, conference-entering), primes that were semantically but not morphologically related (*manfaðun-duxuːlun*, outlet-entering) and primes that were not semantically or morphologically related (*qahwatun-duxuːlun*, coffee-entering). They found significant priming for all three related conditions compared to word-pairs in the unrelated condition. Priming was, however, greater in the two shared-root conditions (semantically transparent and opaque) than in the semantically (but not morphologically) related condition. The amount of priming did not differ between the two shared-root conditions. The larger effects for morphologically related words, regardless of semantic relationship, indicate that the morphological facilitation is not due to semantic relatedness but priming from the common root via decomposition of the root-pattern structure during lexical access. The finding of morphological priming in the absence of a transparent semantic relationship contrasts with findings for Indo-European languages, which only show morphological priming among semantically transparent forms. For example, in a cross-modal priming study, Marslen-Wilson, Tyler, Waksler and Older (1994) found that semantically transparent forms prime each other (*involvement* primes *involve*) but opaque forms do not (*department* doesn't prime *depart*). Other studies have found priming among semantically opaque forms, but this priming is reduced compared to that of transparent forms, both in the context of masked priming tasks (Diependaele et al., 2011; Diependaele, Sandara & Grainger, 2005; see Feldman, O'Connor, Moscoso and Prado Martín (2009) for meta-analysis) and unmasked priming tasks (Feldman, Barac-Cikoja &

Kostić, 2002; Feldman & Soltano, 1999). In keeping with Boudelaa and Marslen-Wilson's findings, Frost, Deutsch, Gilboa, Tannenbaum and Marslen-Wilson (2000) found root priming regardless of semantic relationship for Hebrew (another Semitic language with templatic morphology, similar to Arabic) suggesting that morphological priming in the absence of semantic transparency effects is characteristic of Semitic language processing. Boudelaa and Marslen-Wilson (2000) also examined word pattern priming by comparing word pairs which shared the same pattern with pairs that shared the same phonological structure but not a morphological relationship, and found significant priming in the shared pattern condition. The findings of root and pattern priming were replicated in another cross-modal priming study (Boudelaa & Marslen-Wilson, 2004) and an auditory priming study (Boudelaa & Marslen-Wilson, 2013). Bouldelaa and Marslen-Wilson (2004) also examined the impact of root allomorphy (context-induced variation in the surface representation of the root consonants) on root priming. For example, *w-f-q* is a weak root such that it undergoes allomorphic variation. Its first phoneme is faithful in the surface form *waːfaqa*, 'agreed' but it appears as a /t/ in the surface form *ittifaːq*, 'agreement'. They found that root priming obtained (for both semantically transparent and opaque words), even when the surface forms showed allomorphic variation. Furthermore, there was no priming in a control condition with word pairs that were phonologically related in the absence of morphological or semantic relationships. This indicates that the priming observed in the shared-root conditions was truly morphological and not due to phonological overlap.

While these studies found significant priming effects for both roots and word patterns, Boudelaa and Marslen-Wilson (2005) suggested that root priming is more robust. Boudelaa and Marlsen-Wilson's (2005) masked priming experiment found that while root priming was significant at an SOA of 32ms, pattern priming did not emerge until 48ms. Also, while pattern priming was only significant at SOAs of 48ms and 64ms, root priming was significant at all SOAs tested (32ms, 48ms, 64ms and 80ms). Semantic priming between morphologically unrelated forms was only significant at the latest SOA. As before, root priming obtained even when the word meaning was opaque with respect to the root. Boudelaa and Marslen-Wilson (2011) showed that word-pattern priming was dependent on the productivity (neighborhood size) of the root, such that word pattern priming only occurred with highly productive roots, regardless of the productivity of the word pattern.

In conclusion, Boudelaa and Marslen-Wilson's research in Arabic indicates that native speakers decompose words into roots and patterns during lexical access, suggesting that root and pattern morphemes are independent at some level of mental representation. Furthermore, root priming appears to be the faster, more robust process. The goal of the current study is to determine if non-native speakers of Arabic represent and access triliteral roots in a manner similar to native speakers (i.e., will they show root priming) and, if so, whether the effect will be sensitive to semantic transparency. To date, these questions have not been addressed in L2 learners of Arabic, or Semitic languages generally. The following is a brief sketch of the extant research on L2 processing of derivational morphology, all of which was conducted with speakers of Indo-European languages.

L2 processing of derivational morphology

Most of the research into L2 morphological processing so far has focused on inflectional morphology possibly because, in Indo-European languages, inflectional morphology is more complex and productive. Derivational morphology does, nevertheless, play an important role in the development of L2 proficiency. For example, in a study on morphological awareness in middle-school students, Kieffer and Lesaux (2008) found that Spanish-speaking learners of English who were sensitive to derivational morphology (as evidenced by performance on a production-based decomposition task) showed better L2 reading comprehension. While a number of studies have found morphological priming in non-native speakers to be reduced or absent for inflection, whereas others have reported L2 sensitivity to inflection (see Introduction above), the findings are more consistent for derivational morphology. Silva and Clahsen (2008) examined the processing of inflectional and derivational morphology in non-native speakers of English (with Chinese, German or Japanese as L1) in a masked priming study. They found that though non-native speakers did not show priming from inflected to uninflected stem forms, there was partial priming between derived nominals and their corresponding adjective stems. They compared priming between a derived prime and corresponding stem form (neatness-neat), an identity prime (neat-neat) and an unrelated prime (dark-neat). In native speakers, there was no difference between the morphologically related and identity conditions (RTs for both were faster than the unrelated condition) whereas for non-native speakers, RTs in the morphologically related condition were faster compared to the unrelated condition, but that priming was not as great as in the identity condition. In other words, the non-native speakers showed partial morphological priming for derived forms (compared to native speaker's full priming). Silva and Clahsen (2008) suggested that, because derivational morphology does not require the same kind of combinatorial rule application as inflectional morphology, L2 learners are more likely to be able to process it. In a replication study, however, using the same materials as Silva and Clahsen (2008) and L1 speakers of Greek as participants, there was a full priming effect recorded for both derivations and inflections (Voga & Giraudo, 2014).

Further evidence for the accessibility of derivational morphology in non-native speakers comes from Kirkici and Clahsen (2013), a study with L2 speakers of Turkish, a language with rich, productive, agglutinative morphology. In their masked priming study, they examined priming between a derived prime and stem form (*yorgunluk* 'tiredness'/*yorgun* 'tired') compared to targets with unrelated derived primes, as well as between inflected primes and stem forms (*sorar* 's/he asks'/ *sor* 'ask'). They found priming of derived but not inflected forms in L2 speakers. While there was no identity condition like the one in Silva and Clahsen (2008), the effect sizes of the priming between derived and stem forms were similar for L1 and L2 speakers (Cohen's $d = .34$ and .32, respectively), suggesting full priming. In contrast, Neubauer and Clahsen's (2009) study of L2 speakers of German (L1 Polish) found that non-native speakers did not show evidence of (de)composition of *-ung* nominalizations (*Zünd-ung* 'ignition' /*zünd-en* 'ignite') in a masked priming paradigm. The effect they showed for derived forms was that of surface frequency (in a separate lexical decision task) indicating full-form storage. The targets in their experiment, however, differed from those used by Silva and Clahsen (2008) and Kirkici and Clahsen (2013) in that they contained a derivational morpheme (the suffix "*-en*" indicating an infinitive verb). Their results, therefore, indicate a lack of priming between two derived forms in non-native speakers and do not contradict the other two studies' (Silva & Clahsen, 2008; Kirkici & Clahsen, 2013) findings that derived forms are decomposed into stems and affixes, thus priming the stem form. This distinction (i.e., between derived forms priming their stems versus derived forms priming other derived forms) is relevant to the current study, and will be revisited in the discussion section below.

To study the role of semantic transparency in L2 processing of derivational morphology, Diependaele, Duñabeitia, Morris & Keuleers (2011) used masked priming at three levels of semantic relatedness: transparent (e.g., *viewer-view*), opaque (e.g., *corner-corn*), and unrelated-but-form-matched (e.g., *freeze-free*). They found that non-native speakers of English from different L1 backgrounds (Spanish and Dutch) showed the same pattern of priming as the native speakers in the same study, including the semantic transparency effect. They found priming in both morphologically related conditions (not in the form-matched condition), but the degree of priming was greater when the semantic relationship was transparent.

The goal of the current study was to determine if non-native speakers of Arabic would show (de)composition of derivational morphology in a manner similar to native speakers. While the research on L2 processing of derivational morphology suggests that non-native speakers are as likely to (de)compose derived forms as inflected forms, it is unclear how they would perform in Arabic. The highly productive derivational morphology of Arabic renders it in some ways more comparable to the inflectional morphology of Indo-European languages. Furthermore, it is unknown how or whether native speakers of non-Semitic languages assimilate the discontinuous, templatic morphological system. If non-native speakers show priming effects among words that share roots, it would indicate that they do organize their lexicons similarly to native speakers. Another question concerns semantic transparency; the presence or absence of semantic transparency effects in non-native speakers of Arabic will give insights into how native-like their lexical representations are.

Methods

The section that follows describes the current study's adaptation of Boudelaa and Marslen-Wilson's (2000) cross-modal priming task to look for evidence of morphological processing in L2 learners of Arabic by examining root priming. Given that this study represents a partial replication, the materials were created based on Bouldelaa and Marslen-Wilson (2000), the original study.

Participants

Forty-eight L2 learners and 29 native speaker participants were recruited from Arabic language programs and Arab student associations at the University of Maryland and other American universities (including Georgetown University, American University, the University of Texas at Austin, Penn State University and Brigham Young University), by posting flyers on campuses and emailing student listservs. A short questionnaire was given to volunteering participants to determine that they were either (a) native-speakers who were born in and had lived in Arabic-speaking countries for at least the first 10 years of their lives, or (b) L2 learners of Arabic who had studied Arabic for at least two years, and had not been exposed to the language before high school. Twelve L2 participants and one L1 participant were excluded from the analysis due to task performance issues. The majority of the excluded L2 participants were excluded due to low task accuracy (see below for criteria). The only excluded L1 participant likewise failed to meet the task accuracy cutoff, but this individual turned out to have misunderstood the experimental task (this was confirmed via post-experiment correspondence with the individual). A total of 36 L2 participants and 28 L1 participants were, therefore, included in the analysis.

The L2 learners were adults between the ages of 19 and 38 (Mean = 25.4) who had between 2.5 and 7 years of formal Arabic study (Mean = 3.8) and had spent between 0 and 2.5 years (Mean = 1.4) living in an Arabic-speaking country. The native speakers were adults between the ages of 19 and 44 (Mean = 29.5) who came from various countries: Egypt (n = 9), Iraq (n = 5), Saudi Arabia (n = 5), Jordan (n = 3), Lebanon (n = 3), Syria (n = 2), Oman (n = 1).

Materials

In the experimental stimuli, the factors root (R) and semantic relatedness (S) were manipulated creating four conditions with respect to the relationship between primes and targets: shared root with semantic relatedness (+R+S), shared root without semantic relatedness (+R−S), different roots with semantic relatedness (−R+S) and different roots without semantic relatedness (−R−S). The design, therefore, allowed the exploration of priming between words that share roots, regardless of semantic relationship (+R+S, +R−S), and the comparison of priming between semantically related words which do and do not share a common root (+R+S, −R+S).

Prime words were classified into semantically related [+S] or unrelated [−S] conditions based on native speaker ratings; all [+S] primes were judged by 5 native Arabic speakers to have an average semantic association of 7 or higher, on a 9 point scale, with their respective targets. All [−S] primes were judged to have an average semantic association of 3 or lower with their targets, on the same scale.

Furthermore, a fifth condition was included with primes that were phonologically related to the targets in the absence of morphological or semantic relationship, in order to ascertain that the priming between words that share roots is morphological and not phonological. The phonological control condition adhered to the same criterion used by Boudelaa and Marslen-Wilson (2000): that the phonological control word have, at minimum, two consonants in common with the target word. There is some disagreement in the literature regarding the standards for measuring phonological relatedness in Semitic languages, and given that the current study is an adaptation of the study by Boudelaa and Marslen-Wilson (2000), we applied the same approach to calculating phonological overlap when we developed additional items to add to theirs. This matter is addressed in greater detail in the discussion section below. 70 quintuplets were created such that every target word was paired with the five different types of primes (see Table 1). A full list of stimuli, with their English translations and IPA transliterations can be found in Appendix 1.

Table 1. Sample stimuli

Prime conditions					Target
+R+S	**+R−S**	**−R+S**	**Phon**	**−R−S**	
مجاملة mud͡ʒa:mala flattery	جملة d͡ʒumla sentence	وسيم wasi:m handsome	جيل d͡ʒi:l generation	ساعة sa:ʕa wristwatch	جميل d͡ʒami:l pretty
مجزر mad͡ʒzir slaughterhouse	جزيرة d͡ʒazi:ra island	لحم laħm meat	جار d͡ʒa:r neighbor	نفط naftˤ petrol	جزار d͡ʒazzar butcher
متبادل mutaba:dal reciprocal	بدلة badla suit	تجارة tid͡ʒa:ra trade	بدوي badawi: Bedouin	خريف xari:f autumn	تبادل taba:dul exchange
مبرد mabrid refreshing	بريد bari:d postcard	ثلج θald͡ʒ ice	بدون bidu:n without	شخصية ʃaxsˤi:ja personality	بارد ba:rid cold
ضعف dˤaʕf weakness	مضعّف mudˤaʕʕaf doubled	مريض mari:dˤ sick	عنيف ʕani:f violent	شوربة ʃurba soup	ضعيف dˤaʕi:f weak

Five lists were created such that each target appeared once per list with the prime condition for each target counterbalanced across lists. Each list contained 14 items in each condition. The materials of the current study consisted of 45 of the original prime-target quintuplets used in Boudelaa & Marslen-Wilson (2000) as well as 25 additional quintuplets created for this experiment. 70 filler pairs with nonword targets were also included in order to maintain a 1:1 ratio between word and nonword targets. The nonwords were created by combining nonexistent triliteral roots (e.g., *b-k-t*) with existing word patterns, following the convention used in Boudelaa & Marslen-Wilson (2000). In order to prevent learners from associating phonological similarity between prime and target with the target's lexical status, 42 of the nonword trials were preceded by prime words that shared at least two of their consonants. The number of nonword trials in which the target and prime were phonologically related matched that of the experimental stimuli.

Vocabulary post-test

Following the lexical decision task (LDT), L2 participants completed a vocabulary test during which they were given a list of all the real Arabic words that had appeared in the lexical decision task, and asked to write an English translation of each. Their performance on this vocabulary test was used to filter the lexical decision items for analysis; if a participant could not translate both words in a prime-target pair, that item was excluded from analysis.

Procedure

After signing a consent form and completing a language history questionnaire, participants performed the experimental tasks. Stimuli were presented via the DMDX software package (Forster & Forster, 2003). Participants completed the tasks either by way of a local or a remote procedure. Participants at the University of Maryland met with the primary investigator on campus and completed the experimental tasks using the investigator's laptop computer. Participants from other universities were invited to participate remotely by way of the DMDX remote testing capability.

At the beginning of each trial, a fixation cross appeared in the center of the screen. After 200ms, the *.wav file of the auditory prime word was played over headphones, during which time the fixation cross remained on the screen. At the offset of the prime word, the fixation cross was replaced by the written target word in a 30-point traditional Arabic font, on which participants had to make a lexical decision. Participants responded by pressing the Right or Left Control Key on the keyboard (Right for a word, left for a non-word). The target stayed on the computer monitor for 1000 ms. After the first 1000 ms, the target word would disappear, leaving a blank screen. If no response was given, the trial would time-out after 5000 ms, and a new fixation cross would appear. Reaction times were measured from the onset of the target word. Prior to presentation of the experimental items, participants were given 15 practice trials to get accustomed to the timing and response keys. After the cross-modal priming task, L2 participants were instructed to complete the vocabulary test. The overall duration of the experimental session was between 60 and 90 minutes. All participants were compensated for their time.

Analysis

Repeated measures ANOVAs were run with Root (shared, not shared) and Semantic Relatedness (related, not related) as within-subjects factors, and Language Group (native, non-native) as the between-subjects factor. To test for effects of Shared Root compared to phonological similarity, a repeated measures ANOVA was run with Priming Condition (shared root; phonological relatedness) as the within-subjects factor and Language Group as the between-subjects factor. Planned, separate ANOVAs were also run for the two language groups (native and non-native) for both analyses described above. In addition, ANOVAs were also run on the L2 data with Proficiency Level (high, low) as a between-subjects factor.

Participants whose accuracy on the lexical decision task fell below 70% were excluded from further analysis. This lead to the exclusion of one L1 participant and 12 L2 participants. Outliers (RTs ± 2.5 standard deviations from a subject's mean) were removed from the data analysis.

Furthermore, only those L2 data points for which the L2 participant knew both the target and the prime word (as determined by the vocabulary test) were retained. This resulted in the mean loss of 26% of data for each L2 participant. L2 participants were divided into high and low proficiency groups, via median split, based on their performance on the vocabulary survey. The maximum possible score on the vocabulary test was 140. The grand average score for the vocabulary test was 103.7 and the median was 102. After the split, the High Vocabulary group had a mean score of 119.4 (n = 22) and the Low Vocabulary group's mean was 85.2 (n = 14).

Results

Table 2 shows the means and standard deviations for response time (RT) by condition for each language group.

Table 2. RT means and standard deviations by language group and condition

Language group		**Mean RT (S.D.)**				
		−R−S	**+R+S**	**+R−S**	**−R+S**	**Phonological**
L1		776 (175)	718 (144)	727 (145)	740 (162)	776 (190)
L2		1205 (442)	1072 (342)	1099 (386)	1130 (358)	1231 (526)
	High Vocabulary	1058 (267)	949 (252)	1002 (262)	1024 (400)	1036 (262)
	Low Vocabulary	1465 (570)	1291 (378)	1269 (509)	1316 (463)	1576 (693)

Figures 1 and 2 depict priming (i.e., difference from baseline RT) by condition for the L1 and L2 language groups, respectively.

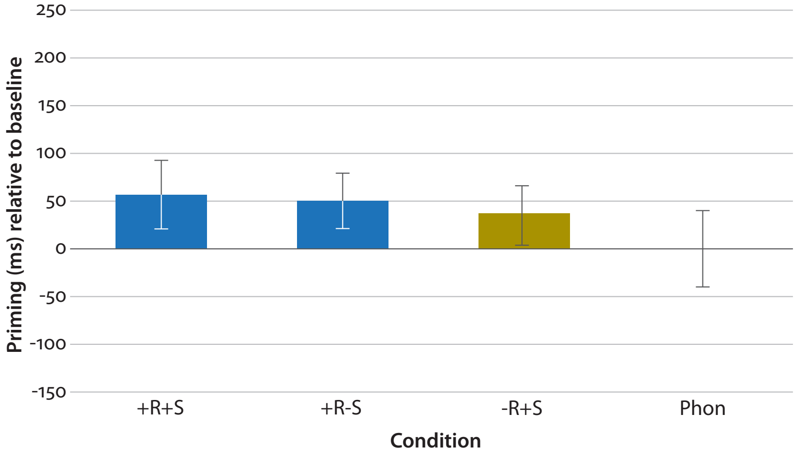

Figure 1. Priming relative to baseline by condition for L1 language group

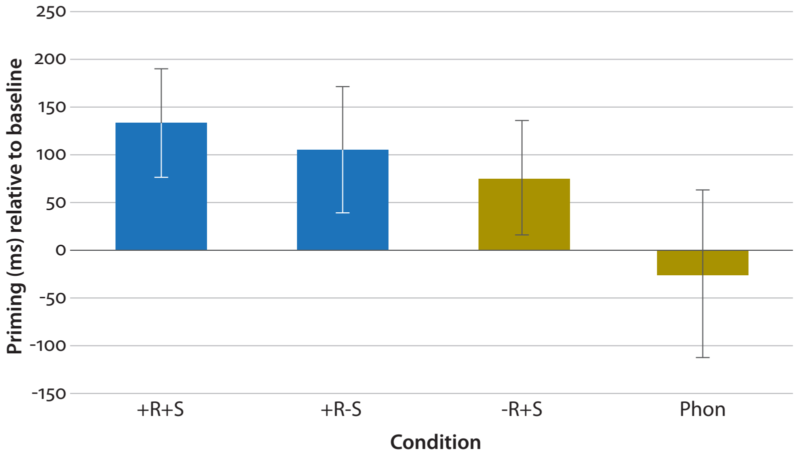

Figure 2. Priming relative to baseline by condition for L2 language group

Root vs. semantic priming

The ANOVA examining root versus semantic priming in native and non-native speakers showed a significant main effect for Language Group ($F1(1, 62) = 30.7$, $p < .001$, $\eta_p^2 = .33$; $F2(1,265) = 478.5$, $p < .001$, $\eta_p^2 = .644$) such that reaction times for non-native speakers were longer. There was also a significant effect of Shared Root ($F1(1, 62) = 12.9$, $p < .005$, $\eta_p^2 = .17$; $F2(1,265) = 8.13$, $p < .01$, $\eta_p^2 = .03$) and a significant effect of Semantic Relatedness in the by-subjects analysis only ($F1(1, 62) = 4.48$, $p < .05$, $\eta_p^2 = .07$; $F2(1,265) = .003$, $p > .9$). The lack of interaction between the two within-subjects factors indicates that root priming obtained in the absence of a semantic relationship. Also, these effects did not interact with Language Group, indicating that both native and non-native speakers showed root priming to a similar degree. Planned, separate analyses of native and non-native speakers indicated that native speakers showed main effects of Shared Root ($F1(1,27) = 10.1$, $p < .01$, $\eta_p^2 = .27$; $F2(1,276) = 8.34$, $p < .01$, $\eta_p^2 = .029$) and Semantic Relatedness in the by-subjects analysis only ($F1(1,27) = 7.22$, $p < .05$, $\eta_p^2 = .21$; $F2(1,276) = 2.10$, $p > .1$), while non-native speakers showed a main effect of Shared Root ($F1(1,35) = 8.86$, $p < .01$, $\eta_p^2 = .20$; $F2(1,265) = 5.35$, $p < .05$, $\eta_p^2 = .02$) but no significant effect of Semantic Relatedness (*p*s > .10). Figure 1 represents the mean RTs for the Shared Root (+R+S and +R−S) and morphologically related conditions (−R +S and −R−S) for native and non-native speakers. When Vocabulary Level was included as a factor in the non-native speakers, there was a significant effect of Vocabulary Level ($F1(1, 34) = 9.37$, $p < .005$, $\eta_p^2 = .22$; $F2(1,135) = 79.4$, $p < .001$, $\eta_p^2 = .37$), such that low proficiency speakers had longer reaction times. There was also a significant effect of Shared Root but in the by-subjects analysis only ($F1(1, 34) = 9.35$, $p < 0.005$, $\eta_p^2 = .22$; $F2(1,135) = 2.12$, $p > .1$). The effect of Semantic Relatedness did not reach significance ($p > .10$), nor were there any interactions with Shared Root, Semantic Relatedness or proficiency group.

Root priming vs. phonological priming

The ANOVA comparing root to phonological priming in the two language groups showed a significant effect of Language Group ($F1(1,62) = 24.5$, $p < .001$, $\eta_p^2 = .28$; $F2(1,126) = 176.9$, $p < .001$, $\eta_p^2 = .584$), and an effect of Condition in the by-subjects analysis only ($F1(1, 62) = 5.57$, $p < .05$, $\eta_p^2 = .08$; $F2(1,126) = .991$, $p > .3$) with no significant interactions. Word pairs that shared a root elicited faster reaction times than those that were phonologically related in both native and non-native speakers. When native and non-native speakers were analyzed separately, the native speakers showed a main effect of Condition ($F1(1,27) = 6.63$, $p < .05$, $\eta_p^2 = .20$;

$F2(1{,}138) = 6.24$, $p < .05$, $\eta_p^2 = .043$) while the effect in the non-native speakers was significant in the by-subjects analysis only ($F1(1{,}35) = 3.99$, $p = .05$, $\eta_p^2 = .10$; $F2(1{,}126) = .505$, $p > .4$). The analysis of high versus low proficiency non-native speakers showed a significant effect of Vocabulary Level ($F1(1, 34) = 9.73$, $p < 0.005$, $\eta_p^2 = .22$; $F2(1{,}57) = 18.6$, $p < .001$, $\eta_p^2 = .246$), as well as Condition in the by-subjects analysis only ($F1(1, 34) = 6.67$, $p < .05$, $\eta_p^2 = .16$; $F2(1{,}57) = .007$, $p > .9$). There was also a significant interaction of Condition and Vocabulary Level in the by-subjects analysis only ($F1(1{,}34) = 4.28$, $p < .05$, $\eta_p^2 = .11$; $F2(1{,}57) = 0$, $p > .9$) suggesting that priming was greater in the low vocabulary participants but simple comparisons revealed no significant effects. In sum, both high and low proficiency L2 participants showed faster reaction times in the shared root condition than in the phonological relatedness condition.

Discussion

The results of the current study provide evidence that both native and non-native speakers of Arabic show morphological priming. The priming in word pairs with shared roots is not modulated by semantic transparency or proficiency level, and does not appear to reflect mere phonological overlap.

A caveat is in order here, because researchers differ regarding standards for measuring phonological overlap in Semitic languages. In the current study, we adopted the standard of Boudelaa and Marslen-Wilson (2000) that the phonological control word have, at minimum, two consonants in common with the target word, in order to make direct comparisons between their findings for native speakers of Arabic and ours for non-native speakers. In contrast, research in Hebrew conducted by Ram Frost and colleagues, measures phonological overlap in terms of the strict count of phonemes that primes and targets share in common (e.g., Frost, Deutsch, Gilboa, Tannenbaum & Marslen-Wilson, 2000). According to this criterion (wherein all phonemes in common, including long and short vowels were included in the counts), the current study's phonological control condition has a mean overlap of 3.74 phonemes (standard deviation 0.81), while the +R–S condition has a mean overlap of 4.41 phonemes (standard deviation = 1.11),

As a paired samples t-test revealed this difference to be statistically significant ($t(69) = -4.09$, $p < 0.001$), a subset of 50 items from the current study was selected to adhere to Frost and colleagues' stricter standard. In this subset, the phonological overlap measured between the target-prime pair in the phonological condition, and the corresponding target-prime pair in the baseline condition never differed by more than one phoneme (that is, 16 pairs were perfectly phonologically balanced between the phonological and baseline condition, and 34 pairs had a one-phoneme discrepancy). Further, no phonological control primes in the subset analysis involved transposed variants of the target's root letters.[2] In this subset, the phonological control condition has a mean overlap of 4.06 phonemes (standard deviation = 1.11), while the +R–S condition has a mean overlap of 4.26 phonemes (standard deviation = 0.83); this difference is not significant ($t(49) = -1.02$, $p = 0.31$).

Under this stricter criterion, the phonological condition still showed no priming relative to the unrelated baseline condition in either the native (phonological mean = 756.20 ms, standard deviation = 154.14, baseline mean = 777.54 ms, standard deviation = 174.60 ms, $t(27) = 1.37$, $p = 0.18$), or the non-native groups (phonological mean = 1189.95 ms, standard deviation = 528.58, baseline mean = 1182.87 ms, standard deviation = 442.76, $t(35) = -.07$, $p = 0.48$).

The issue of an appropriate phonological control condition in Arabic, nevertheless, remains a thorny one. It is not possible to create controls that include the same three root consonants in the same order, as that would become a shared root condition. Transposing root letters, so the prime and target share the same three root consonants but in a different order is not a viable alternative as it has been established that the transposed letter priming effect found in European languages (Perea, et al., 2003) does not obtain in Semitic languages (Perea, et al., 2010; Velan & Frost, 2009). The structure of the templates can constrain opportunities to achieve greater degrees of phonological overlap. While we did our best to adhere to the established standards in the field, we acknowledge this potential weakness in our study and the examination of morphological priming in Semitic languages in general. Given the complexity of the issue, we cannot rule out a potential influence of phonological similarity on the priming effects. Nevertheless, our study failed to find empirical support for such effects.

While it not possible to completely dismiss the role of phonology, the evidence nevertheless points to the root priming found in our study being morphological in nature. Both our primary and post-hoc analyses support the conclusion that morphology is driving the root priming effects. Furthermore, effects of phonological overlap are typically inhibitory in nature, especially when the overlap is initial (Slowiaczek & Hamburger, 1992; Hamburger & Slowiaczek, 1996). It is also important to note that Bouldelaa and Marslen-Wilson (2004) found root priming in context of root allomorphy, which means a reduction in phonological overlap between prime and target. The persistence of root priming in that condition provides additional support for the morphological nature of these effects.

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2. See the discussion of Perea, Abu Mallouh, and Carreiras's (2010) findings regarding transposed letter priming in Semitic languages, in the section above on L1 Processing of Arabic derivational morphology.

In sum, our findings for native speakers are consistent with those of Boudelaa and Marslen-Wilson (2000; 2004; 2005; 2011; 2013) for Arabic, which in turn are part of a growing body of evidence of morphological processing during lexical access among native speakers of other Semitic languages as well, including Hebrew (Bentin & Frost, 1994; Deutsch & Frost, 2003; Feldman, Frost & Pnini, 1995) and Maltese (Ussishkin, Dawson, Wedel & Schluter, 2015).

The fact that the non-native speakers in the current study exhibited morphological priming regardless of semantic relationship, while native speakers showed semantic sensitivity in the related root condition, strengthens the conclusion that nonnative facilitation is purely morphological. Importantly, as seen in Figure 2, the nonnative priming pattern is trending in the same direction as that of native speakers; however, the nonnative semantic priming effect does not reach significance. Taken together, these results provide evidence that non-native speakers of Arabic perform morphological (de)composition in a similar manner to native speakers, though they differ in semantic processing ability. This suggests that non-native speakers are able to organize their L2 lexicons according to the same principles as native Arabic speakers, even though these principles differ significantly and qualitatively from the ones by which their L1 lexicons are organized.

As previously discussed, much of the body of literature on L2 morphological processing identifies ways in which L2 learners' access to and command of morphological information is deficient. The results of the current study show that morphological (de)composition is not the source of these deficits. The fact that L2 learners of Arabic benefit from morphological overlap between prime and target words when those shared morphemes are discontinuous and when their semantic contribution is opaque suggests that these learners can, if nothing else, isolate the roots of Arabic content words from those words' patterns, and use the root information to aid in accessing the appropriate lexical entry.

While the finding of decomposition of derived forms by non-native speakers in the current study is consistent with Clahsen and colleagues' findings supporting non-native decomposition of derivational morphology (Kirkici and Clahsen, 2013; Silva & Clahsen, 2008), the same theoretical account cannot be easily applied to Semitic morphology. Silva & Clahsen (2008) note that derived forms constitute lexical entries (stored in declarative memory) and can be the input to inflectional processes or additional derivational processes, for which their internal morphological structure is relevant. Derived forms, they posit, constitute combinatorial lexical entries containing morphological information which is available for retrieval in declarative memory (in contrast to inflected forms). If every derived form has its own combinatorial entry which subsumes its sublexical structure (e.g., stem and affixes), it stands to reason that accessing that entry would prime a learner to access that same stem again, and, crucially, this is what most of the studies in our summary of research on L2 derivational morphological processing were testing: RTs to a stem target, following a prime that was a derived form that included that same stem. Combinatorial entries that come with morphological structure packaged inside them are less helpful in explaining priming that spreads from one derived form to another derived form, when neither form completely subsumes the other. In Arabic, of course, virtually all content words are derived from the interleaving of roots and patterns and priming between derived forms is what the current study demonstrates. As a single combinatorial entry would not contain both derived forms, it could not account for the activation spreading from one to the other. Rather, in the critical conditions of the current study, learners are isolating the discontinuous root morpheme as the first step of retrieving the prime word; this leaves them primed to retrieve another word derived from the same root morpheme. Furthermore, Silva and Clahsen's (2008) combinatorial entries account depends heavily on the distinction between derivational and inflectional morphology; however, there is evidence (Voga & Giraudo, 2014) of decomposition of both types by non-native speakers. We conclude that the combinatorial entries account is not a viable model of L2 derivational processing of Semitic languages such as Arabic.

If non-native speakers can decompose both derivational and inflectional morphology, a more general approach for their deficits is warranted. One such approach based in processing difficulty provides a different perspective on the current results. McDonald (2006) argues that there is substantial overlap in the grammatical knowledge of native and non-native speakers. The implementation of this knowledge is impaired in non-native speakers due to the increased working memory demands associated with L2 processing. This conclusion is based on her findings that working memory capacity is substantially reduced during L2 processing compared to L1. Furthermore, native speakers show similar morphosyntactic deficits to non-natives when working memory resources are limited via high processing load, stress or time pressure (McDonald, 2006). The deficiencies exhibited by non-native speakers are due not to lack of grammatical knowledge but to the increased demands on attention and working memory resources associated with processing in the second language, which makes the application of grammatical knowledge difficult (McDonald, 2006). In the current study, we observed a main effect of group, such that non-native speakers were always slower than native speakers, which provides some support for the processing account. Importantly, though non-native speakers showed significant root priming effects, the effect sizes were smaller in non-natives compared to natives ($\eta_p^2 = .20$ and $\eta_p^2 = .27$, respectively). This suggests that while non-native speakers were able to make use of morphological information (i.e., grammatical knowledge) in a manner similar to native speakers, they did it to a slightly lesser degree than native speakers. Whether this was due to the general processing constraints, problems with the application of morphological knowledge in the second language or both remains an open question. Crucially, it should be noted that McDonald's account could be combined with other theoretical accounts. Thus, non-native-like behavior on the part of a second language learner could arise in addition to non-native-like mental representations, and this would hold true whether those representations were phonological (Ratcliffe, 1997; 2004; Ussishkin, 2000; 2003; 2005) or morphological (Boudelaa & Marslen-Wilson, 2000; 2001; 2004; 2005; 2011; Frost et al., 2000; Perea et al., 2010; Prunet et al., 2000).

Indeed, Gor and Cook (2010) and Gor and Jackson (2013) found evidence of morphological decomposition in non-native processing of Russian inflection. At the same time, they concluded that non-native ability to perform decomposition was not always efficient (the deficits were especially evident in the face of morphological complexity). Accordingly, they also cited the reduced or inefficient decomposition abilities as the key problem in L2 processing of inflectional morphology.

Lastly, one major difference between non-native and native speakers in the current study is the former's lack of significant semantic priming effects. Previous research has shown that morphological structure becomes available before semantic information (Boudelaa & Marslen-Wilson, 2005; Longtin, Segui & Hallé, 2003; Rastle, Davis, Tyler & Marslen-Wilson, 2000). A recent neurolinguistic study supports the form-then-meaning characterization of visual word processing (Rastle, Lavric, Elchlepp & Crepaldi, 2015). It is possible that, given that non-native speakers are slower to process their second language, the later semantic effects were obfuscated by the processes relating to morphological (de)composition and/or task demands. It is also possible that this reduced sensitivity reflects the relatively weak connections between L2 words and concepts (Jiang, 2000; Kroll & Stewart, 1994), or weak form-meaning mappings in the L2 (Cook & Gor, 2015). Jiang (2000) argues that, for the most part, the lexical representations of L2 learners bear little morphological specifications, and have very weak links to concepts. Our results do not support this model entirely, because they demonstrate robust morphological specification. At the same time, the lack of significant semantic priming is in conformity with Jiang's (2000) claim regarding weak connections to conceptual representations as a contributor to the reduced proficiency of non-native speakers.

In conclusion, this study offers evidence that non-native speakers of Arabic who are native speakers of English are able to assimilate the discontinuous, templatic morphological system of Arabic and exhibit native-like processing of derived words. The results of the current study indicate that triliteral word roots are independent at some level of representation in non-native speakers and, therefore, that their Arabic lexicons are organized in a manner similar to native speakers. Further research will examine word pattern priming in non-native speakers, the impact of allomorphy on (de)composition in non-native speakers and how non-native speakers process the inflectional morphology of Arabic.

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Appendix 1. Complete items list with IPA transliterations and English translations

+R+S	+R−S	−R+S	Phon	−R−S	Target
مجاملة mud͡ʒa:mala flattery	جملة d͡ʒumla sentence	وسيم wasi:m handsome	جيل d͡ʒi:l generation	ساعة sa:ʕa wristwatch	جميل d͡ʒami:l pretty
مجزر mad͡ʒzir slaughterhouse	جزيرة d͡ʒazi:ra island	لحم laħm meat	جار d͡ʒa:r neighbor	نفط naftˤ petrol	جزار d͡ʒazzar butcher
متبادل mutaba:dal reciprocal	بدلة badla suit	تجارة tid͡ʒa:ra trade	بدوي badawi: bedouin	خريف xari:f autumn	تبادل taba:dul exchange
مبرد mabrid refreshing	بريد bari:d postcard	ثلج θald͡ʒ ice	بدون bidu:n without	شخصية ʃaxsˤi:ja personality	بارد ba:rid cold
ضعف dˤaʕf weakness	مضعّف mudˤaʕʕaf doubled	مريض mari:dˤ sick	عنيف ʕani:f violent	شوربة ʃariba soup	ضعيف dˤaʕi:f weak
حرّية ħurrija freedom	حرير ħari:r silk	استقلال ʔistiqla:l independence	أحمر ʔaħmar red	كلب kalb dog	تحرير taħri:r liberation
محاضرة muħa:dˤara lecture	حضارة ħadˤa:ra civilization	موجود mawd͡ʒu:d present	حركة ħaraka movement	غداء ʁada:ʔ lunch	حضور ħudˤu:r presence
مختلف muxtalif different	خلف xalf behind	متميز mutamaijiz distinct	خلال xila:l during	صعب sˤaʕb difficult	إختلاف ʔixtila:f difference
تذكر taðakkur remembering	مذكر muðakkar masculine	دراسة dira:sa lesson	آذار ʔa:ða:r March	شقة ʃaqqa apartment	ذاكرة ða:kira memory
ظهر ðˤahara reveal	مظاهرة mudˤa:hara protest	وضوح wudˤu:ħ clarification	سهر sahira stay up late	نوع nawʕ type	إظهار ʔiðˤha:r display
تعبير taʕbi:r expression	اعتبار ʔiʕtiba:r consideration	كلام kala:m speech	برنامج barna:mid͡ʒ program	سجن sid͡ʒn prison	عبارة ʕiba:ra expression
اقتصار ʔiqtisˤa:r limiting	قصر qasˤr palace	صغير sˤaʁi:r small	قصّة qisˤsˤa story	أدب ʔadab literature	قصير qasˤi:r short

(*continued*)

+R+S	+R–S	–R+S	Phon	–R–S	Target
ضيافة dˤija:fa hospitality	اضاف ʔadˤa:f connect	فندق funduq hotel	فضة fudˤa silver	حلم ħulm dream	استضافة ʔistidˤa:fa hospitality
تواصل tawa:sˤul communication	وصول wusˤu:l arrival	مراسل mura:sil correspondent	صليب sˤali:b cross	فستان fusta:n dress	إتّصال ʔittisˤa:l contact
تطلّب tatˤallaba to require	طالب tˤa:lib student	حاجة ħad͡ʒa need	طابق tˤa:biq level	دفتر daftar folder	مطلوب matˤlu:b required
إجتماع ʔid͡ʒtima:ʕ society	جامع d͡ʒa:miʕ mosque	حزب ħizb party	جعل d͡ʒaʕala cause	طريق taˤri:q way	مجموعة mad͡ʒmu:ʕ group
إفتقر ʔiftaqara to be in need	فقرة faqara paragraph	مسكين maski:n bad off	فقط faqatˤ only	هاتف ha:tif phone	فقير faqi:r poor
قعد qaʕada sit	قواعد qawa:ʕid grammar	كرسي kursi: chair	قدر qaddara amoung	مطر matˤar rain	مقعد maqʕad seat
مقارن muqa:rin comparative	قرن qarn century	أشبه ʔaʃbaha resemble	قنون qanu:n law	حليب ħali:b milk	قارن qa:rana compare
حرم ħaram wife	حرام ħara:m forbidden	نساء nisa:ʔ women	حار ħa:r hot	شباب ʃaba:b youth	حريم ħarim haram
رحلة riħla trip	مرحلة marħala stage	سفر safr traveling	مرحوم marħu:m deceased	بكاء buka:ʔ crying	رحّالة raħħa:la traveler
سار sa:ra walk	سيرة si:ra epic	قاد qa:da drive	سكر sukkar sugar	ملابس mala:bis clothing	سيارة saija:ra car
صدر sˤadara come out	مصدر masˤdar deverbal noun	نشر naʃara publish	صدمة sˤadma shock	عجيب ʕad͡ʒi:b astonishing	أصدر ʔasˤdara publish
إستكشف ʔistakʃafa explore	كشاف kaʃʃa:f sensor	وجد wad͡ʒada find	مشكلة muʃkila problem	تمر tamr date	إكتشف ʔiktaʃafa discover
مدخل madxal inlet	مداخلة muda:xala conference	إيلاج ʔi:la:d͡ʒ insertion	خليّة xalijja cell	قهوة qahwa coffee	دخول duxu:l entering
إرجاع ʔird͡ʒa:ʕ returning	مراجعة mura:d͡ʒaʕa revision	عودة ʕawda coming back	مجاعة mad͡ʒa:ʕa famine	غزال ʁaza:l gazelle	رجوع rud͡ʒu:ʕ coming back

+R+S	+R−S	−R+S	Phon	−R−S	Target
إشراق ʔiʃra:q shining	مستشرق mustaʃriq orientalist	صباح sˤabba:ħ morning	قرابة qara:ba closeness	دجاج dad͡ʒa:d͡ʒ chicken	شروق ʃuru:q sunrise
إبراز ʔibra:z displaying	مبارز muba:riz contender	جليّ d͡ʒali: obvious	إزار ʔiza:r shawl	أصيل ʔasˤi:l afternoon	بروز buru:z prominence
مسكّن musakkin tranquilizer	مسكن maskan house	هادي ha:di quiet	كسوة kuswa a dress	إجازة ʔid͡ʒa:za holiday	سكون suku:n tranquility
محادثة muħa:daθa speaking	مستحدث mustaħdaθ modern	خطاب xitˤa:b a speech	إتحاد ʔittiħa:d union	أستاذ ʔusta:ð teacher	محدّث muħaddiθ speaker
مسبح masbaħ swimming pool	مسبّح musabbiħ praiser	عوم ʕawm floating	محبرة miħbara ink jar	عنوان ʕanwa:n address	سباحة siba:ħa swimming
حلّاق ħalla:q barber	حلقة ħalaqa circle	لحية laħija beard	مقابلة muqa:bala match	مساوة musa:wa equality	حلاقة ħila:qa shaving
مطبعة matˤbaʕa printer	تطيع tutˤi:ʕa taming	ناشر naʃir editor	مطاع mutˤa:ʕ obeyed	حفرة ħufra hole	طباعة tˤiba:ʕa printing
عاجل ʕa:d͡ʒil swift	عاجلة ʕa:d͡ʒila life in this world	مسرع musarraʕ quick	معول maʕwal pickaxe	تمساح tumsa:ħ crocodile	عجول ʕud͡ʒu:l rush
مصابرة musˤa:bara endurance	مصبّرات musˤabbara:t canned goods	مجالدة mud͡ʒa:lada patience	بركة burka blessing	كنيسة kani:sa church	صبور sˤabu:r enduring
مقتنع muqtanaʕ satisfied	مقنع muqannaʕ masked	عفيف ʕafi:f modest	ناقة na:qa camel	خزانة xazna a safe	قنوع qanu:ʕ easy to satisfy
جسامة d͡ʒasa:ma bulkiness	جسم d͡ʒism body	هامّ hamm bath	جمهوري d͡ʒumhu:ri republican	نزاع niza:ʕ a dispute	جسيم d͡ʒasi:m bulky
حكمة ħikma wisdom	حاكم ħa:kim a judge	مجرّب mud͡ʒarrab experienced	مكان maka:n place	طبور tˤabu:r a queue	حكيم ħaki:m wise
محبّة muħabba love	حبّة ħabba a grain	ولهان walha:n in love	محبرة miħbara ink well	جمهور d͡ʒumhu:r crowd	حبيب ħabi:b beloved
مضروب madˤru:b knocked	إضراب ʔidˤra:b a union strike	مصفوع masˤfu:ʕ smacked	بركان barka:n volcano	ختام xitˤa:m an end	ضربة dˤarba a knock

(*continued*)

+R+S	+R−S	−R+S	Phon	−R−S	Target
سفر sifr travelling	سفير safi:r ambassador	رحيل raħi:l departure	مرفق mirfaq elbow	منجل mand͡ʒil scythe	سفرة sufra a trip
منظر munaðˤðˤar sight	منتظر muntaðˤar awaiting	مشاهدة muʃa:hada viewing	مرونة maru:na flexibility	إنشاء ʔinʃa:ʔ dissertation	نظرة naðˤra a look
غدر ʁadar disloyalty	مغادرة muʁa:dara leaving	مخادع muxa:diʕ swindler	مراد mura:d goal	حانوت ħa:nu:t shop	غدّار ʁadda:r disloyal
خفقان xafaqa:n palpitation	إخفاق ʔixfa:q failure	مرتعش martaʕiʃ trembling	منافق muna:fiq hypocrite	سمعة sumʕa reputation	خفّاق xaffa:q palpitant
مرتبة martaba status	رتابة rata:ba monotony	معدّل muʕaddal average	عربة ʕariba vehicle	جنون d͡ʒunu:n madness	رتبة rutba rank
مقاطعة muqa:tˤaʕa separation	إقطاع ʔiqtˤa:ʕ feudalism	جزء d͡ʒuziʔ a piece	نطق natˤaq pronunciation	شرح ʃarħ explanation	قطّع qatˤaʕa cut apart
فرق farq distinction	فريق fari:q team	تشتيت taʃti:t dispersion	مرق maraq broth	لعب laʕb playing	فرّق farraqa distinguish
مفجّر mufad͡ʒd͡ʒir exploder	فاجر fa:d͡ʒir adulterer	نسف nasif explosion	رجل rad͡ʒul man	ضاحك dˤa:ħik laughing	فجّر fad͡ʒd͡ʒara explode
مخاصم muxa:sˤim quarreler	مخصوم maxsˤu:m subtracted	عراك ʕira:k quarrel	صخرة sˤaxra rock	نعجة naʕd͡ʒa ewe	خاصم xa:sˤim contending
كتاب kita:b book	كتيبة kati:ba squadron	رسالة risa:la letter	مكبح mikbaħ brake	ضفدع dˤufdaʕ toad	كتب kataba write
مراقب mura:qib supervisor	مرتقب murtaqab expected	متابعة muta:baʕa tracking	مقرّ maqarr abode	محلّ maħall location	راقب ra:qaba monitor
سقوط suqu:tˤ falling	تسقّط tasqutˤ gradual learning	وقعة waqʕa a fall	إسطول ʔistˤu:l fleet	مظلّة miðˤalla parachute	أسقط ʔasqatˤa drop
مطّلع mutˤallaʕ informed	متطلّع mutatˤallaʕ aspiring	إخبار ʔixba:r informing	ألم ʔalam pain	جذع d͡ʒuðʕ trunk	أطلع ʔatˤlaʕa inform
طعام tˤaʕa:m food	طعم tˤaʕm bait	ماكل maʔkal food	أعمى ʔaʕma: blind	تراب tura:b sand	أطعم ʔatˤʕama feed

+R+S	+R−S	−R+S	Phon	−R−S	Target
معلّم	معلم	متدرّب	تمثال	كثافة	تعلّم
muʕallim	maʕlim	mutadarrib	timθa:l	kaθa:fa	taʕallama
teacher	landmark	trained	idol / statue	density	learn
متحقّق	مستحقّ	متثبّت	تفّاح	فضاء	تحقّق
mutaħaqqiq	mustaħiqq	mutaθabbit	tufa:ħ	fadˤa:ʔ	taħaqqaqa
ensurer	worthy	verifier	apple	space	ensure
متدبّر	مدبر	حلّ	ترسانة	عملاق	تدبّر
mutadabbir	mudbir	ħall	tarasa:na	ʕamla:q	tadabbara
reflector	runaway	solution	arsenal	giant	reflect
عقل	اعتقال	رزانة	عسل	عافية	تعقّل
ʕaql	ʔiʕtiqa:l	raza:na	ʕasl	ʕa:fi:ja	taʕaqqala
reason	imprisonment	composure	honey	well being	reason
مندثر	متدثّر	مختف	إنتداب	إذاعة	اندثر
mandaθar	mutadaθθar	muxtafin	ʔintida:b	ʔiða:ʕa	ʔindaθara
extinct	wrapped	invisible	appointment	stable	go extinct
منبسط	بساطة	مسرور	إسطبل	مغارة	إنبسط
manbasitˤ	bisa:tˤa	masru:r	ʔistˤtˤabl	maʁa:ra	ʔinbasatˤa
happy	simplicity	happy	stable	grotto	be happy
منتفض	منفضة	رعشة	إنفاق	خطورة	إنتفض
mantafidˤ	minfadˤa	raʕʃa	ʔinfa:q	xutˤu:ra	ʔintafadˤa
shaken off	ash tray	shiver	spending	danger	be shaken off
معترض	عريض	رافض	إمتعاض	كهف	اعترض
muʕtaridˤ	ʕari:dˤ	ra:fidˤ	ʔimtiʕa:dˤ	kahf	ʔiʕtaradˤa
opponent	large	refusing	annoyance	cavern	oppose
ملتمس	ملمس	أراد	إمتثال	خطوة	التمس
maltamis	malmis	ʔara:da	ʔimtiθa:l	xutˤwa	ʔiltamasa
requester	feel	want	obedience	step	request
متفرّس	إفترس				
muftaris	mutafarris	dˤaħija	ʔibra	nad͡ʒaħ	ʔiftarasa
devourer	scrutinzier	victim	needle	success	devour
خلاصة	خلاص	نتيجة	إستخفاف	فرضيّة	إستخلص
xula:sˤa	xala:sˤ	nati:d͡ʒa	ʔistixfa:f	faradˤi:ja	ʔistaxlasˤa
deduction	sincerity	deduction	disdain	hypothesis	deduce
خليفة	مخالفة	ولاية	إستبخال	عدالة	استخلف
xali:fa	muxa:lafa	wila:ij	ʔistibxa:l	ʕada:la	ʔistaxlafa
successor	violation	succession	stinginess	fairness	appoint
إصدار	متصدّر	إنتاج	إستدارة	مفردة	أصدر
ʔisˤda:r	mutasˤaddir	ʔinta:d͡ʒ	ʔistida:ra	mufrada	ʔasˤdara
issuing	leading	production	roundness	a word	to issue
عمل	عميل	توظيف	إستحالة	مؤاجذة	إستعمل
ʕaml	ʕami:l	tawðˤi:f	ʔistiħa:la	muʔa:xara	ʔistaʕmala
work	disloyal	employing	impossibility	blame	utilize

(*continued*)

+R+S	+R−S	−R+S	Phon	−R−S	Target
منتزه mantazah park	منزه munazzah infallible	تجوّل tad͡ʒawwul promenade	هزيمة hazi:ma a defeat	غبار ʁuba:r dust	نزهة nuzha a walk
تعقيد taʕqi:d entanglement	إعتقاد ʔiʕtiqa:d belief	مشكلة muʃkila problem	معدن maʕdin metal	مذهب maðhab ideology	عقدة ʕuqda knot

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