The role of morphological structure during word reading in Arabic-English bilinguals: Effects of bilingual profile

by

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ABSTRACT

When bilinguals process words in one of their languages, the words in their other language are also activated. This activation can be due to shared conceptual representations or to direct cross-linguistic links between the words at the lexical level. The nature of the activation is affected by the bilingual profile of the speaker, with more proficient L2 speakers activating conceptual representations directly while less proficient speakers are more dependent on lexical level links. The aim of my research is to investigate the role of bilingual profile in the lexical organization of Arabic-English bilinguals. Bilingual profile refers to relative status of the two languages, which can depend on a number of factors for example, language dominance, age of acquisition and proficiency. In this thesis I test the lexical processing of Arabic-English bilinguals in masked and visible priming of lexical decision to written words. Arabic and English have different scripts and also differ in their morphological structure making them ideal languages for testing lexical level cross-linguistic activation. I examine the effect bilingual profile on the effect of morphological and semantically related Arabic primes and targets and the effect of Arabic morphological and translation primes on the processing of English targets.

DEDICATION

To my Parents, who have always prayed for me and supported me.

To Mohammed, who has always encouraged and helped me.

To Leen, Adel and Zeyad (my three beautiful adorable kids).

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LIST OF ACRONYMS AND ABBREVIATIONS

1. AOA: Age of acquisition.
2. ADJ: Adjective.
3. BIA+: The Bilingual Interactive Activation Plus model.
4. FEM: Feminine.
5. HRM: The Revised Hierarchical Model
6. L1: First language (Arabic).
7. L2: Second language (English).
8. LEAP-Q: The Language Experience and Proficiency Questionnaire.
8. MAS: Masculine.
9. MSA: Modern Standard Arabic.
10. N: Noun.
11. PLU: plural.
12. SING: single.
13. SOA: stimulus onset asynchronies.
14. TL: Transposed Letter.
15. V: Verb.

Introduction and overview

The aim of my research is to investigate the role of bilingual profile on the lexical organisation of Arabic-English bilinguals. Bilingual profile refers to relative status of the two languages of a bilingual which can depend on a number of factors for example, language dominance, age of acquisition and proficiency. The majority of the world's people are fluent in more than one language (Kovelman, Baker and Petitto, 2008). Evidence suggests that when one language is used the other is automatically activated. Most research investigating bilingual word processing has looked at effects of meaning and form similarity on processing in first (L1) and second (L2) languages. The majority of them have studied European languages such as English, Dutch and other Indo-European languages (e.g., Kroll & Dussias, Bogulski & Valdes Kroff. 2012; Rastle & Davis, 2008).

Current models suggest that the bilingual lexicon is heavily interconnected (see Figure 1, from Kroll & Stewart, 1994). According to the Revised Hierarchical model (Kroll & Stewart, 1994), when the bilingual person activates one language, activation will spread to the other language via semantics and via associations between the lexical and phonological form of the words. However, the model proposes asymmetries in how strongly words in each language are connected with each other and with concepts in the two languages. There are stronger links at the lexical level from L2 to L1 than vice versa, and also stronger links between lexical and conceptual levels in L1 than L2. This means that access to meaning from a word in L2 is mediated by access to the translation equivalent in L1. However, it has been proposed that once enough proficiency in L2 has been achieved, such transfer via the L1 is no longer necessary and that L1 activation is no longer a necessary part of L2 word processing (Kroll & Bialystok, 2013; Sholl, Sankaranarayanan, & Kroll, 1995).

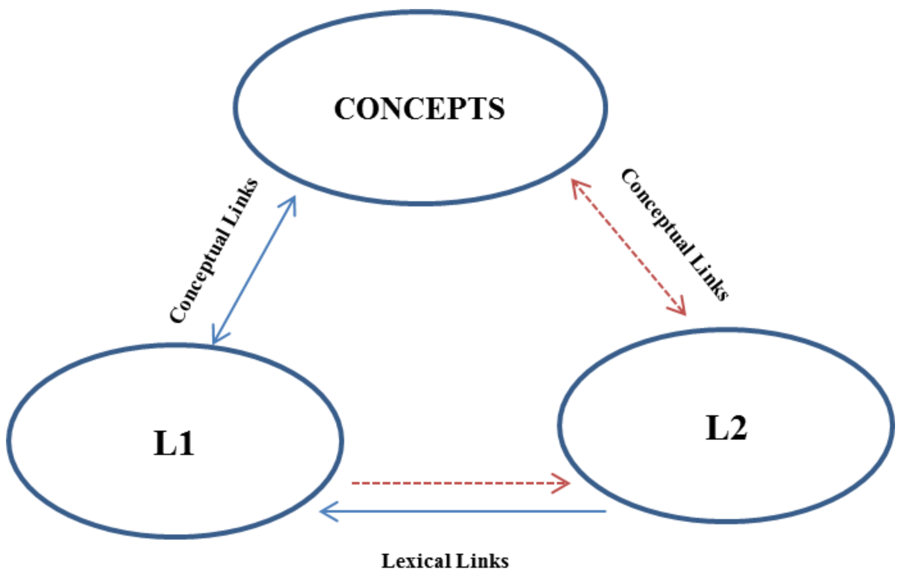

Figure 1. A representation of the relationship between languages in the Revised Hierarchical Model (Kroll & Stewart, 1994)

The focus of the present research is visual word processing in Arabic-English bilinguals. These languages come from different families (Semitic/Indo-European) and therefore have very different linguistic structures and are written in different scripts (e.g. reading/ قراءة). Both have a phonetic script but Arabic is read from right to left, which contrasts with English, which is read from left to right. In addition, Arabic often does not represent most vowel letters (e.g., Wright, 1995).

My research will investigate lexical organisation in particular morphology. Arabic and English differ in their morphological system. Morphology is concerned with the internal structure of words. A morpheme is the smallest meaningful/grammatical unit (e.g. Carstairs-McCarthy, 2007). For example, the noun *writer* is made up of two morphemes: the root *write* and the noun formation suffix *–er*; similarly *dogs* is made up of the root *dog* and the plural suffix *–s*. Arabic words, similarly to English words, are systematically parsed to roots and word patterns, but English roots and affixes combine concatenatively, whereas Arabic morphology is non-concatenative, with tri-consonantal roots filled with vowel-based affixes (e.g., Boudelaa & Marslen-Wilson, 2011; Frost, Forster & Deutsch, 1997; Wright, 1995).

The morphological structure of Semitic language is different to that of Indo-European also in terms of linearity (Indo-European languages, such as English, have a linear and relatively simple morphological system in which morphologically complex words are formed by connecting morphological units (e.g., -ness) to a stem morpheme (e.g., dark) in a linear manner (e.g., darkness). While Semitic languages have a richer and more complex morphological system in which two kinds of morphemes, the Root and the Pattern, are superimposed upon each other in a non-linear manner. For example, the Root KTB and the *word pattern -a-i-* are intertwined to create the Arabic word (كاتب -Writer). These two morphemes cannot stand alone as independent words (e.g., Norman, Degani and Peleg, 2016). Therefore, readers of Semitic languages are highly sensitive to the internal morphological structure of word. Previous studies illustrated the differences between linear and non-linear morphological processing using the masked priming paradigm. A robust finding is the Transposed Letter (TL) effect. It has been consistently reported that there is a priming effect when targets are preceded by primes consisting in the same letters as the targets but in slightly different order. This effect is very robust in studies using Indo-European word stimuli. However, Velan and Frost (2009) showed that in Hebrew no facilitation is observed when the transposed letters of the prime were part of the three consonants that form the root of the target. Moreover, if the transpose letter of the primes formed an existing root then they found inhibition. They interpreted this absence of priming as a manifestation of the different structure of the lexical space in Semitic languages. That is, while in Indo-European languages orthographic similarity is the main organizational principle, in Semitic languages the presence of a non-linear morphology makes orthographic similarity to play a less significant role. They suggest that the identification of the root is crucial for lexical access in Semitic languages. Therefore, another level (morphological units) is necessary to fully account for the processes involved in lexical access in Semitic languages. Other studies in Arabic have shown evidence in agreement with that conclusion. For instance, Boudelaa and Marslen-Wilson (2000, 2005 & 2011) showed a more robust priming effect from words sharing the same root than for words sharing the word pattern.

As you can see in Figure 2a there are three levels of number, which are singular (one), dual (two) and many (more than two). *Kalb*/dog, which means one dog (singular), the second word is *Kalban*, which means dual (two dogs) and masculine, because *Kalbatan* is dual and feminine. Finally, *Kelab* means many dogs.

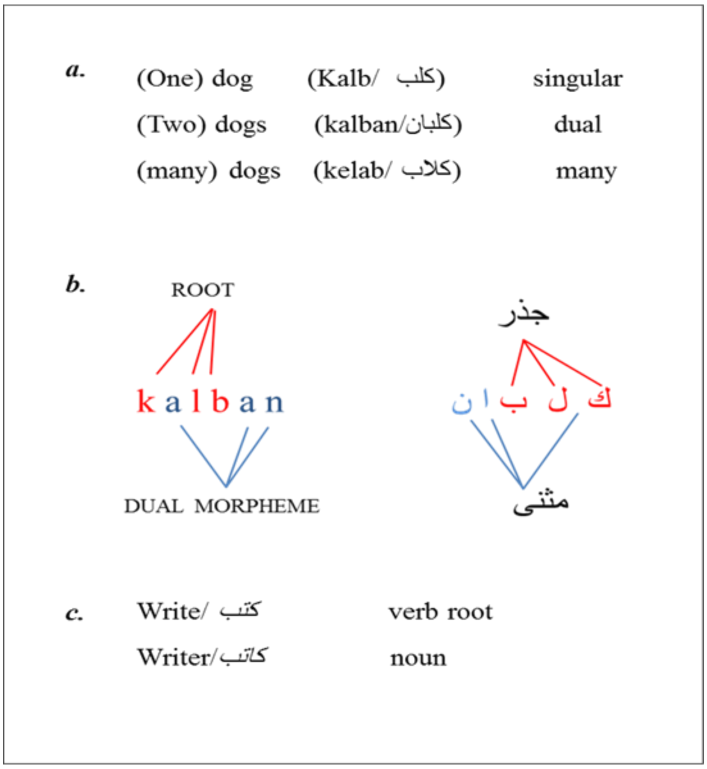

Figure 2. Examples of English and Arabic morphological structure.

As you can see in Figure 2b, for *kalban*/dogs the tri-consonantal root is *k-l-b* while the rest of letters are word pattern morphemes, namely is *{_a_ _ }* for singular, *{_a_ _aan}* for dual and *{_e_ aa_}* for many. The root conveys the general semantic meaning which will be more or less consistent across the surface forms featuring that root. For example, *Kataba* (*wrote*) has the root *k-t-b*, which is shared by *Ketab* (*book*), *Ketabatun* (*written*), *Katib* (*writer*) etc. (see Figure 2c). In contrast, in English complex words are constructed by concatenating morphemes in a linear way, e.g. *dark* + *ness*= *darkness*. (Boudelaa & Marslen-Wilson, 2011). There are therefore critical differences between Arabic and English morphology. In particular, in Arabic the root, form rather than semantics determines morphological relationships; for example, مَسكَنْ/ house and مُسَكِنْ/ painkiller share the root *s-k-n* (Carstairs-McCarthy, 2007). In contrast, in English the semantics of the root is important for determining the morphological relationship between words, e.g.

trusty, *untrusting* and *distrust* (Boudelaa, Pulvermuller, Hauk, Shtyrov and Marslen-Wilson, 2009; Rastle & Davis, 2008).

Current models of the bilingual lexicon postulate direct links between lexical representations in both languages, even for languages that differ in their scripts (Dijkstra, 2005; Gollan, Foresr & Frost, 1997; Kroll & Bogulski & MaClain, 2012; Kroll & Hermans, in 2011; Gollan, Foresr & Frost, 1997). To date, the evidence of cross-activation is restricted to orthographic, phonological and semantic overlap (Dijkstra, Grainger, & van Heuven, 1999; Duyck, 2005). However, morphological structure has been shown to be analysed very early in word reading and to have strong effects on lexical activation (Kroll, Bogulski & McClain, 2012; Rastle & Davis, 2008) and these effects have been shown to be particularly strong in Semitic languages (Boudelaa & Marslen, 2011; Boudelaa & Marslen-Wilson, 2005; Frost, Forster & Deutsch, 1997).

In summary, there is strong evidence that morphological structure is a central organising principle of the Arabic mental lexicon. Current models of bilingual word processing suggest that there are strong lexical level links between L2 and L1 words, especially for less proficient bilinguals. Most research has focused on the effects of shared form and/or meaning on bilingual word processing, while the effect of shared morphology has received little attention. The aim of my thesis is to investigate the effect of Arabic morphological structure on the activation of the English lexicon in Arabic-English bilinguals. The questions I will ask are as follows:

1. What is the role of Arabic morphological structure in Arabic visual word processing in Arabic-English bilinguals?
2. What is the role of Arabic morphological structure in the processing of English words in Arabic-English bilinguals?

3. How do the effects of morphological structure change with the language profile of bilinguals?

The structure of my thesis is as follows. In Chapter 1, I introduce the Arabic language, discussing both its diglossic nature and its morphological structure. I then review research which has investigated the role of morphological structure in visual word reading. Much of this research has used the masked priming paradigm, which examines the effects of briefly presented written primes on lexical decisions. This paradigm has been used to determine the time course of effects of orthographic, morphological and semantic overlap between prime and target words in order to determine their role in visual word recognition. Most of this research has focused on European languages and has provided evidence for early morphological decomposition, followed by access of the semantic representations of words. I then review research into word reading processes in Semitic languages such as Arabic. This research has demonstrated stronger and more persistent effects of morphological structure than in European languages, and these persistent effects are unaffected by the semantic relationship between primes and targets.

In Chapter 2 models of bilingual language processing are reviewed, with a particular focus on lexical effects in translation priming. Translation priming has been shown to be influenced by language proficiency with stronger lexical effects in L2-L1 translation than L1-L2 (e.g. Kroll & Hermans, 2011). However, the studies reviewed in Chapter 2 use very basic measures of proficiency. Chapter 3 begins with a review of studies that aim to describe bilingual language profile in more detail. These studies often use detailed questionnaires to gather information about the language history and self-reported proficiency of the languages spoken by an individual. In particular I focus on the LEAP-Q questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007), which collects such detailed information. Marian et al. (2007) performed a factor analysis on the data from 52 bilinguals from varying backgrounds and languages to determine the underlying factors that best described the language profile of their participants. In Chapter 3 I report a similar study of my own participants. I expected to see interesting differences in the underlying factors due to the different nature of my bilingual participants (they are fluent in both languages Arabic and English, high proficient on reading, writing, listening and understanding; all of them educated UG, PG MA, and PhD, with careers in English, Translation, Engenering, Medicine and Nursing. Finally, they are adult from 18-45 years old). Also, they speak local Arabic (Amiah-unformal language) at home and in general speaking, while they use academic Arabic (FusHa- formal language) at school and work places. In addition, I was interested in the effect of these factors on the early processing of both Arabic and English words.

In Chapters 4 and 5, I test lexical processing of my participants in both masked and visible priming of lexical decisions. In Chapter 4, I test the effect of morphological and semantically related Arabic primes and targets (Experiment 1 to 3). In Chapter 5 I test the effect of Arabic primes on the processing of English targets (Experiment 4 to 6). In both Chapters I analyse the effect of bilingual profile on the priming effects I observe by including the individual factors from the LEAP-Q data in my model. Finally, in the General Discussion in Chapter 6, I summarize my findings and draw some conclusions about the role of morphological structure and bilingual profile on the relationship between words in the Arabic-English mental lexicon.

Chapter 1

Arabic language: morphological structure and processing

1.1 Introduction to the Arabic language
- 1.1.1 *History of the Arabic Language*
- 1.1.2 *The Arabic language in Saudi Arabia*
- 1.1.3 *The script of Arabic Language*

1.2 The morphological structure of Arabic
1.3 The role of morphological structure in visual word recognition
1.4 First language morphological processing during visual word-recognition
1.5 Second language morphological processing during visual word recognition
1.6 The role of morphological structure in the reading of Arabic words

1.1 Introduction to the Arabic language

1.1.1 *History of the Arabic Language*

Arabic is one of the major global languages. Arabic ranks fourth globally as one of the most commonly used languages after Mandarin, Spanish and English (Abushariah, Ainon, Zainuddin, Elshafei & Khalifa, 2012; Gordon, 2005). In 1974 Arabic was recognized as an official language at the United Nations. Abushariah et al. (2012) also note that in the Middle East and North Africa, Arabic language is the first language for 250 million people (see Figure 3).

Figure 3. Countries with Arabic as a first Language (*Arabic without walls*, 2004)

The Kurds, Berbers, and Mahri have their local languages. However, they use Arabic as a second language because they live in an Arabic country. Arabic is the accepted official language in 22 countries, including African countries such as Mali, Eritrea, Djibouti, Ethiopia, Niger, Chad, and Somalia. The language is also spoken in regions of southern Turkey and south western Iran. This shows that Arabic has spread to many parts of the world as a result of migration. (Abushariah et al., 2012; Chejne, 1969; Grimes, 1996; Versteegh, 2014).

Arabic is a diglossic language with a non-regional formal version and differing spoken colloquial dialects. The formal linguistic standard form of Arabic is termed Modern Standard Arabic (MSA), and is also known as Fus'Ha. This is the form of Arabic typically used in education and the media. It is known as the 'clear language' or Classical Arabic (Cowan, 1960; Grimes, 1996). Other terms used are Literary Arabic or Qur'anic Arabic. The key point is that this form of the language is primarily associated with literacy throughout Arabic speaking world. Most Arabic speakers will learn MSA at school.

In addition, colloquial forms of Arabic are used as a general speaking mode in thirty different forms (Abushariah et al., 2012). Examples of these forms include: Gulf (Saudi or Kuwaiti), and North African (Egyptian and Moroccan). Capacity to understand different forms varies, as some of the associated accents or dialects are more pronounced. As a result of the major differences there is a reliance on Fus'Ha or MSA in media, education and entertainment. Accordingly, MSA is generally taught; however, it will be frequently blended with the speaker's dialect. In summary, there are four important regional dialects and multiple minor variations within the core language (Cowan, 1960; Owens, 2009).

The prestige of Arabic is associated with its defining role as a scholarly language. In other words, its significance has to be understood in the context of the high point of the development of Islamic culture. Both sacred and classical texts have helped to reinforce the renown of the language. In the middle ages, scholarship across a range of academic subjects was undertaken in standard Arabic (*Arabic without walls*, 2004).

There are two primary forms of Arabic writing. Modern Standard Arabic is the primary form of communication used in secular texts and documents of all types in which unambiguous words in context are often unpointed. The writing reserved for sacred purposes, such as the religious writings associated with the Qur'an and literature, is a form of MSA which is fully pointed.

1.1.2 *The Arabic language in Saudi Arabia*

As already established, there are many dialects in Saudi Arabia, as in other Arabic countries. There are five main accents in Saudi Arabia. The population in the middle part of the country, near to the capital Riyadh, speaks the Najdiah dialect- (اللهجة النجدية). The Hijazi accent (اللهجة الحجازية), which is known to have been influenced by the Egyptian dialect, is spoken in the west of the country. By comparison, southern accent is widely spoken in the south of Saudi Arabia- (اللهجة الجنوبية), whereas the northern population of Saudi Arabia converse in their distinct northern dialect- (لهجة أهل الشمال), which has been influenced by the Jordan dialect. The eastern population of Saudi Arabia use Khalijia (Gulf accent- اللهجة الخليجية), which was profoundly influenced by the Gulf countries, namely Kuwait, Bahrain, the United Arab Emirates and Qatar.

All the people across Saudi Arabia understand each other with the exception of a few words. However, the official language of the country is MSA, which, as mentioned above, is used in education, social media, news, books and many other forms of more formal communication. At school, children study MSA from the age of 7 onwards. Throughout the rest of the school years, from Year 4 to the last year in high school, they learn the rules of Arabic grammar. Pupils read and write in MSA, although they communicate between themselves in their own dialects. In fact, many Saudi people can speak a number of dialects common in the Arabic world such as the Egyptian, Syrian and Iraqi dialects, as well as the Saudi local dialects and the Khalijia (Gulf) accent. The main reasons for learning a variety of dialects is the television, as the majority of programs are broadcast in various regionally spoken languages, and literature, poetry in particular.

1.1.3 *The script of Arabic Language*

Modern Standard Arabic includes an alphabet which consists of 28 letters (see **Figure 4)**. Also, MSA is written from right to left, while numbers run in the opposite direction. Several Arabic letters are modified according to where they are positioned in a word – varying from the beginning, the middle, the end or when standing alone. Both written and typed scripts use joined up letters in Arabic (*Arabic without walls*, 2004)

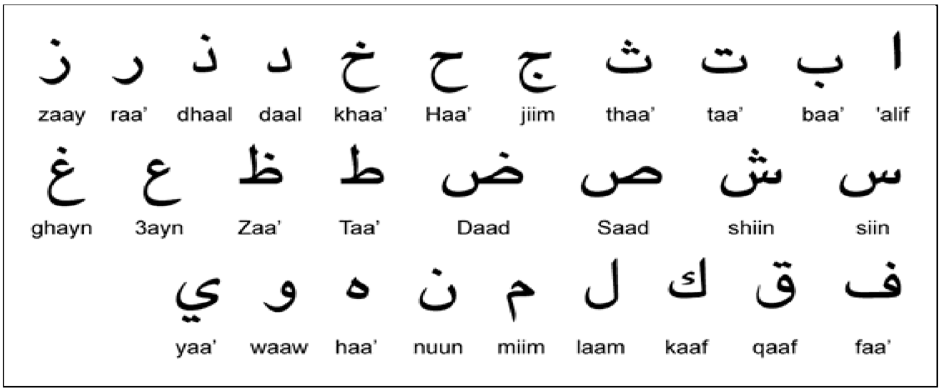

Figure 4. The Arabic alphabet consists of 28 letters. Reading occurs from right to left (*Arabic without walls*, 2004).

Upper case and lower-case letters are the same in Arabic. Letters within words are usually joined up; there are some minor variations in the main letter forms. There are three long vowels in addition to the consonants (i.e. آ/ آلف, Alef; و/ واو, Waaw; ي/ ياء, Yaa).

For example, (Alef- aə) a long ‘a’ as in cat, (Waaw- uə) long ‘u’ sound as in boot and (Yaa- iə) long ‘u’ sound as in boot (see Sawalha, Brierley & Atwell, 2014). The three short vowels are shown as tiny supplementary or diacritic marks above or below the consonants. The way in which these diacritics are used is dependent on the context in which a word appears. For example, the word *book* could be written in different ways in order to identify it in a given context, with more diacritics necessary at the beginning of a sentence (e.g. كِتَابٌ, book) and fewer used when the context makes it clear what the word should be (e.g. كتاب, book). In addition, other effects of context can change the shape of the written form (e.g., كِتَابٍ, كِتَاباً, book). Several additional marks are used in order to indicate silent vowels and doubled consonants.

Figure 5 shows how the individual letters are produced. In the process of writing further minor modifications will be required in the course of connecting the letters.

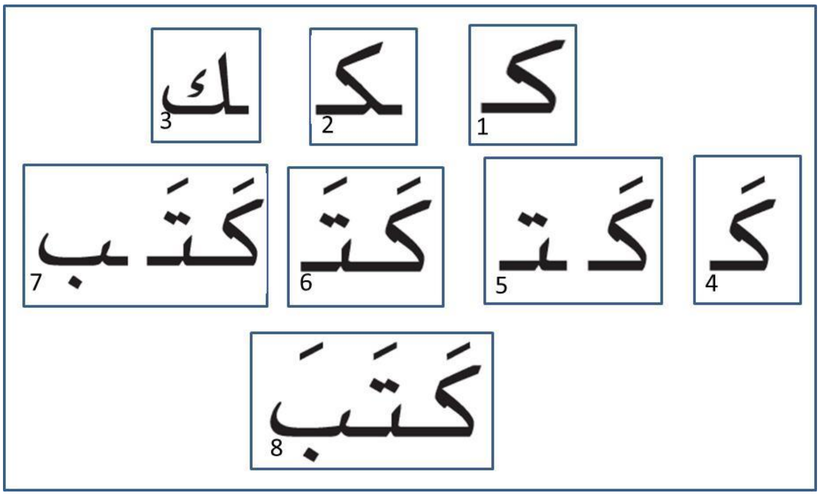

Figure 5. Example of the process of writing a word in Arabic (**Kataba-Wrote)**.

For example, when *kaaf* is used at the start of a word it appears in the form as seen in Figure 5.1 (**كـ**). If it is used between the first and the last letter of a word it is represented as in Figure 5.2 (**ـكـ**). At the end of a word, *kaaf* appears in the way shown in Figure 5.3 (**ـك**). The word *kataba* **(**to write) contains the letters *kaaf*, *taa'* and *baa'*. In order to compose this word the initial form of *kaaf* is used, together with a short "a" –vowel. Accordingly, this appears as a short stroke above the *kaaf* (**كَـ**), as in Figure 3.4. The result so far is **"**ka". The second letter is *taa'*. The isolated form of *taa'* is depicted in the Figure 5 above. However, the middle form of taa' is needed in order to join it to kaaf. The middle form of *taa'*, before joining with *kaaf*, is depicted as **كَـ تـ),** see Figure 5.5. After linking *taa'* to *kaaf*, the *"a"-vowel* is inserted above the *taa'* (**كَتَـ**), Figure 5.6. Up to this point *kata* has been written. *Baa'* is the third letter in the sequence. The isolated form of *baa'* is depicted in Figure 5.7. The end form of *baa'*, before it is linked with *taa'* is shown in Figure 5.7 **(كَتَـ ـب**). Having linked *baa'* to *taa'*, the next stage is to use a short *"a"-vowel,* which is placed above the *baa'* **(كَتَبَ)**, as in Figure 5.8. The finished word now reads *kataba*.

1.2 The morphological structure of Arabic

Morphology is concerned with organization, rules and processes of words or parts of words such as suffixes and prefixes. Morphemes are meaningful parts of a word encoding both semantic and grammatical information.

Arabic is a member of the family of Semitic languages (other members include Hebrew, Aramaic, Persian, Urdo, Kurdish, Phoenician and Syriac), which have in common a morphological root system founded on the use of consonants. Arabic morphology is extremely systematic and the system used is very different from English (e.g., Ryding, 2005; Shlonsky, 1997). The key difference between Arabic morphology and that of Indo-European languages in that it is based on discontinuous morphemes with a set of consonant roots interlocking with vowel patterns in order to make words. Most Arabic words therefore consist of two morphemes, namely a root and a word pattern, which must be used together and cannot exist in isolation. The word (*kaə **tib** -writer*) consists of two bound morphemes, the lexical root *k-t-b* and the active participle pattern *–aə-i-* (see Table 1 for examples of other word pattern combinations for this root). The system of root-pattern combinations helps understand many meanings of words and makes vocabulary learning much easier. Indeed, Arabic dictionaries prioritise lexical roots over actual spellings where all the derivatives of a root or consonant words are listed.

Table 1. Morphology examples of root and word pattern systems for the root *k-t-b*

The **root-pattern system** Verb examples from k-t-b						
كتب	يكتب	تكتب	يكتبان	تكتبان	يكتبون	يكتبن
(**k**a**t**a**b**a) *Wrote*	(ʐa**ktub)** *He writes*	(ta**ktub)** *She writes*	(ʐa**ktu**b**aə** n) *They write*	(ta**ktu**b**aə** n) *They write*	(ʐa**ktu**b**wun) *They write*	(ʐa**ktu**b**n) *They write*
Past simple verb, Masculine, plural	Present simple verb, Masculine, single	Present simple verb, Feminine, single	Present simple verb, Masculine, dual	Present simple verb, Feminine, dual	*Present simple* verb, Masculine, plural	Present simple verb, Feminine , plural
The **root-pattern system** Noun examples from k-t-b						
كِتاب	كتابان	كُتب	مكتبة	كَاتب	كاتبان	كاتبات
(Kitaə b) *Book*	**(kitaə baə** n) *Books*	(**k**uo**t**oo**b)** *Books*	(ma**kt**a**b**ah) *Library*	(kaə **tib**) *Writer*	**(kaə ti b**aə n) *Writers*	(**kaə tibaə** t) *Writers*
Noun , single Masculine	Noun,dual, Masculine	Noun, plural, Masculine	Noun, single, Feminine	Noun , single Masculine	Noun, dual Masculine	Noun, plural, Feminine

A consonant root is therefore important for both derivation and inflection and may be viewed as a nucleus from which different meanings spring to life. The root morpheme (k-t-b) is discontinuous because vowels can be inserted between the consonants under the condition that the order of the vowels needs to stay the same. Arabic usually has three consonants in a consonant root, although there may be some two-consonant, four-consonant and even five-consonant roots. Because roots relate to a meaning of a word, it can be called semantic. Altogether, there are around 5000 to 6000 lexical roots (e.g. Ryding, 2005; Shlonsky, 1997).

In contrast, a word pattern is similar to a template into which different roots are inserted to create different semantics each time. For example, derivational affixes help define grammatical functions, with *mu*- being used for participles, *ma*- for nouns of place, and *–iyy* as a suffix for adjectives. Traditionally, consonants used for pattern formation include Hamza, taa, miim, nuun, siin, yaa and waaw.

There are only a few word types in Arabic to which the root word pattern system does not apply. These incluse some compounds such as *raasmaal* which means *capital* (in the monetary sense) and has been formed by joining two words, *head* and *money*. There are also solid stems with no word patterns, such as pronouns (personal, demonstrative and relative), and function words (prepositions and conjunctions). Finally, loanwords also lack roots (e.g. *radio*, *computer*).

Arabic is a morphologically rich language. Arabic words have more grammatical categories compared to English and include number, tense, aspect, person, voice, mood, gender, case and definiteness (see examples in Table 2). Tenses are defined as linear points which extend from past into the future, whereas aspects are viewed as an action which has been completed, on-going, or yet to happen. Arabic tenses are past, perfective, present, imperfective, and future. There are thirteen person categories in Arabic, compared to just seven in English. Arabic verbs and personal pronouns are inflected with first person (*I*, *we*), second person (*you*) and third person (*he, she, they*). Some of the persons have gender distinction (e.g. second person can have five forms of *you*, masculine singular, feminine singular, dual, masculine plural and feminine plural), whereas others don't (e.g. first person).

Mood refers to contextual modalities which determine a condition of a verb and can be indicative (statements and questions), subjunctive (doubt, desire, wishes or necessity) and imperative (command). These are all marked in Arabic with different word patterns. There are only two genders, masculine and feminine, which can be marked on adjectives, pronouns, verbs and nouns. Number is also marked and can be singular, dual (meaning two) and plural (three and more). Cases are nominative, genitive and accusative and are also morphology marked, usually at the end of word patterns. There are also definite and indefinite markers added to adjectives and nouns in the form of affixes (e.g. Ryding, 2005; Shlonsky, 1997).

Table 2. Morphology examples of word pattern systems for the different grammatical classes.

	Masculine Singular	**Feminine Singular**	**Masculine Dual**	**Feminine Dual**	**Regular Masculine Plural**	**Regular Feminine Plural**	**Broken Plural**
(Noun)	كِتابٌ [kitaə buən] *Book*	كاتبةَ [kaə tebatuən] *Writer*	كاتبان [kaə tebaə n] *Writers*	كاتبتان [kaə tibataə n] *Writers*	كاتبون [kaə tibwn] *Writers*	كاتبات [kaə tibaə t] *Writers*	كتُاب [Kutaə b] *Writers*
(Verb)	ينازع [yonaə zʐ] *He disputes*	تنازع [tunaə zʐ] *She disputes*	ينازعان [j unaə zʐ aə n] *They dispute*	تنازعان [tonaə ʐ aə n] *They dispute*	ينازعون [j unaə zʐ wn] *They dispute*	يتنازعن [j atanaə zaʐ n] *They dispute*	-
(Adj)	مساعدٌ [musaə a'duən] *He is assistant*	مساعدةٌ [musaə ʐ adatuən] *She is assistant*	مساعدان [musaə ʐ idaə n] *They are assistants*	مساعدتان [musaə ʐ idataə n] *They are assistants*	مساعدون [musaə aʐ idwn] *They are assistants*	مساعدات [musaə ʐ idaə tuən] *They are assistants*	-

1.3 The role of morphological structure in visual word recognition

There is a great deal of evidence that morphological structure affects word reading. Most of this research has focused on morphologically complex words in Indo-European languages such as English, Dutch, French, and Spanish (e.g. Boudelaa et al., 2009; Solomyak & Marantz, 2010). A large number of studies investigating effects of morphological structure on early word recognition processes have used the masked priming paradigm developed by Forster and Davis (1984). This technique uses a lexical decision task to investigate visual word recognition processes. In the masked priming task a short lowercase prime is presented for around 50 to 60ms. This is followed by a backward mask (e.g. #######). Then an uppercase target is displayed, which is a word or a non-word to which the participant makes a response. In this paradigm the participants usually make either a lexical decision button-press response or name the word out loud, though other tasks such as semantic categorization have also been used (Kinoshita & Norris, 2012). Because the prime is displayed for very short time participants are usually unaware of the prime. The masking technique is advantageous since the participants' response to the target words is unlikely to be influenced by strategic, conscious processes. Thus, it eliminates the possibility of any priming effect occurring due to conscious recognition of the relationship between the prime and the target (e.g. Frost, Forster & Deutsch, 1997).

A great deal of research has shown effects of morphological structure on lexical decision times. Taft (1981) and Taft and Forster (1975) thought that morphological decomposition could occur through the analysis of sublexical orthographic information. They also believed that this decomposition could be applied to words with affixes (e.g. *re-paint*) and pseudo-affixes (e.g. *re-store*). Rastle, Davis and New

(2004) compared masked priming effects for semantically related morphological primes (e.g. *darkness-DARK*), for prime-target pairs that had no real morphological relationship (e.g. *corner-CORN*), and for prime-target pairs that had a non-morphological form relationship (e.g. *brothel-BROTH*; *-el* never functions as a suffix in English). Results showed equal facilitatory priming from *darkness* and *corner* but no priming from *brothel*. These results suggest that *darkness* and *corner* primes were being analysed in terms of their apparent morphemic constituents as form overlap alone did not result in priming (see also Diependaele, Sandra & Grainger, 2005; Longtin, Segui & Halle, 2003). These finding provide evidence of an early morphological decomposition based on orthographic but not semantic information.

Morpho-orthographic decomposition survives the regular orthographic changes found in complex words, as found in studies by McCormick, Rastle and Davis (2008). They investigated masked morphological priming effects using primes which could not be broken into their morphemic constituents because of a missing ‘e’ (e.g. *adorable- ADORE*), a shared ‘e’ (e.g. *writer-WRITE*), or a duplicated consonant (e.g. *metallic-METAL*) at the morpheme boundary. These results showed that masked priming effects found in such conditions were similar to primes that could easily be broken into their constituents. Such resistance to orthographic alteration was also evident in the decomposition of opaque words.

However, decomposition of opaque words has been shown to be limited to masked priming situations, where derived words are shown so briefly that conscious report is impossible. Priming from opaque derivations (e.g. *gingerly-ginger*) does not usually happen if primes are fully perceptible, especially in cross-modal priming (e.g. Gonnerman, Seidenberg & Andersen, 2007; Longtin, Segui & Halle, 2003; Rueckl,

& Aicher, 2008), visual priming with fully visible primes (e.g. Rastle, Davis, Marslen-Wilson, & Tyler, 2000) and long-lag priming (e.g. Drews & Zwitserlood, 1995).

Rastle et al. (2000) tested the time course of morphological, orthographic and semantic masked priming. They tested priming at three SOAs (43ms, 72ms, and 230ms). The results confirmed that morphological structure has an important role in the early visual recognition of English words, which is independent of semantic and orthographic relatedness. They found significant priming effects for semantically transparent derived forms and their stems at all SOAs and the amount of priming was similar to that observed for identity primes. These effects were significantly greater than effects of semantic relatedness and effects of orthographic relatedness, both of which showed significant priming (facilitation for semantic relatedness and inhibition for orthographic relatedness) only at longer SOAs. Priming from semantically opaque derived forms was observed only at the shortest SOA. This pattern of results provides evidence of independent effects of morphological, semantic and orthographic relatedness (see also Rastle, Davis, Marslen-Wilson, & Tyler, 2000). These findings support models of lexical representation that involve morphological decomposition rather than models that propose the full listing of all words. Other scholars have suggested that morphemes could be viewed as a regularity which takes place in the process of learning, but that words are not represented in a decomposed fashion (Plaut & Gonnerman, 2000; Plaut, McClelland, Seidenberg & Patterson, 1996; Rueckl, & Aicher, 2008; Seidenberg & Gonnerman, 2000).

1.4 *First language morphological processing during visual word-recognition*

Higher-order linguistic representations have been found to control processing of orthographic data in early stages (Carreiras, Armstrong, Perea, & Frost, 2014). As a result, it can be assumed that phonological, semantic and morphological structures of a language and its writing system are governed by visual word-recognition (Frost, 2012). Morphological processing is known to take place when morphologically complex words are being read. However, there is no evidence to suggest that this kind of processing could happen prior to this stage (Taft & Forster, 1975) or even after (Giraudo & Grainger, 2001) the full lexical representation has been activated. A complete absence of representation or activation of separate morphological units have been observed by the supra-lexical view of morphological processing (Feldman, O'Connor, & Martín, 2009). A conclusion, as a result, could be drawn that morphological processing takes place after lexical activation of the complete word. It should not happen during the process of reading morphologically constructed non-words or unfamiliar words with no lexical representations (Giraudo & Grainger, 2001).

The sub-lexical view presents a contrasting idea by stating that the activation of relevant morphological units should occur prior to lexical access. Morphologically complex and simple words and non-words would go through the process of morphological decomposition (Taft & Forster, 1975). This process can be observed in Indo-European languages, when morphologically complex words are taken apart into their constituents (Amenta & Crepaldi, 2012; Rastle & Davis, 2008). It has been evidenced that morphologically structured non-words (e.g., sportation) and words (e.g. sportive) in priming experiments can act as effective primes for those target words which have a simple morphological structure (e.g., sport) (Longtin, Segui, & Halle, 2003). It can thus be concluded that visual word recognition in Indo-European languages cannot occur without morphological decomposition (Frost, Grainger, & Carreiras, 2008).

1.5 Second language morphological processing during visual word recognition

Activation, monitoring and at least another two sets of linguistic knowledge and linguistic processing strategies are required to be used by L2 learners and bilinguals. Since both language tend to be active simultaneously (Dijkstra, 2005), linguistic features from a first language can often be transferred onto and used in a second language. As a result, it is likely that a transfer from a first language can exert a negative influence on L2 processing. This is due to the differences in the two languages which then results in the features of a first language being erroneous transferred into L2 use (MacWhinney, 2005).

A number of aspects of visual word-recognition processes in a second language get affected due to the L1-transfer. These include orthographic (Miller, 2011), phonological (Wang, Koda, & Perfetti, 2003) and morphological (Pasquarella, Chen, Lam, & Luo, 2011; Schiff & Calif, 2007). It is assumed that morphological transfer from L1 to L2 takes place with respect to the underlying functions expressed by morphological features, rather than exact morphological forms (MacWhinney, 2005). The pattern of transferring information into a first language is different in terms of it being a function of the similarity of the morphological features in the two languages (Pasquarella et al., 2011; Schiff & Calif, 2007) and as a function of linguistic proficiency in a second language (Liang & Chen, 2014). To exemplify, these could be the transfers in derivational morphology of two alphabetic languages whose derivational linear word structure is quite abundant (Schiff & Calif, 2007) in contrast to the transfers in compound morphology of the two languages whose word structures are characterised as compound (Pasquarella et al., 2011).

It has been found that learners of a second language with high levels of proficiency tend to be more sensitive to the morphological structure of the second language, compared to the low level learners (Liang and Chen, 2014). When reading in a second language, L2 learners may adopt the same strategies of morphological processing as in their L1 (Norman et al., 2016). By contrast, Dipendaele, Dunabeitia, Morris, & Keuleers (2011) maintain that they also apply the same morphological strategies as native readers. This could be an indication that L2 reading strategies are governed by L2 specific morphological characteristics. As a result, they are not affected by the L1-transfer. Yet another alternative explanation is that L2 readers, in contrast to native readers, take into account a whole-word lexical activation, whereas morphological decomposition which takes place during visual word-recognition is neglected (Silva & Clahsen, 2008). Norman et al. (2016) carried out research into how transfer of morphological processing strategies from a first language takes place. They used L2 learners of Hebrew at a beginner level, whose first language was either a Semitic (Arabic) or an Indo-European (English) language. Research into how morphological processing transfer occurs for speakers of Arabic as a first language, is, however, very limited.

1.6 The role of morphological structure in the reading of Arabic words

Research focused on languages such as Arabic and Hebrew has shown very strong evidence that morphology plays a fundamental role on the organization of the mental lexicon in Semitic languages (e.g. Boudelaa & Marslen-Wilson, 2005; Deutsch, Frost, & Forster, 1998; Frost, Forster & Deutsch, 1997; Frost, Deutsch, Gilboa, Tannenbaum, & Marslen-Wilson, 2000). The reason behind that is that morphology functions in different way in Semitic languages to Indo-european languages (i.g., English, French, Dutch, German and Finnish). As described above, in Arabic the consonants of the root, which carries the semantic load, are discontinuous as a result of being combined with the vowels of the word pattern, which carries the grammatical morphological information.

Effects of root priming in Semitic languages have also been shown to be independent of the semantic relationship between the words. For example, the Arabic word [*kaatibun*] *writer* is morphologically and semantically related to [*kitaabun*] *book* through its root k-t-b, however it is morphologically related but semantically unrelated to [*katiibatun*] *squadron*, which has the same root k-t-b but does not have the same writing-related meaning. Both of these morphologically related words show masked priming effects (Boudelaa & Marslen-Wilson, 2005).

In addition, word patterns also show significant priming in Hebrew verbs, and in Arabic verbs and deverbal nouns (i.e. nouns that share roots with verb forms) (Boudelaa & Marslen-Wilson, 2005; Deutsch, Frost & Forster, 1998; but see Abu-Rabia & Awwad, 2012). However, the time course of the priming effects for roots and word-patterns differ. Boudelaa and Marslen-Wilson (2005) used masked priming to investigate the time-course of word pattern and root activation in reading Arabic deverbal nouns and verbs. They examined the influence of morphological, orthographic and semantic relationship between prime and target on lexical decision. In their study, they studied the time course of the priming effects by using different SOAs conditions (32, 48, 64, and 80ms). They tested the hypothesis of whether different processes (morphological decomposition, semantic activation and orthographic similarity) have different time-courses. They showed that while semantic priming was only found at the longest SOA, root priming was observed at all SOAs. This is consistent with previous findings of effective priming by Arabic noun word patterns when these occur in the context of creative roots, and share the same morpho-syntactic reading across prime and target (Boudelaa & Marslen-Wilson, 2011).

More recently, it has been claimed that the etymon rather than the trisyllabic root is the key representation in Arabic morphology. The etymon is formed by two consonants in root. For Example, Root BT(بتَ) and the words from these verb بتَ- batta as well which means sever or بتَر- batara which means cut off. Etymon priming effects have also been observed (e.g. Boudelaa & Marslen-Wilson, 2001). However, the role of the three-consonantal root cannot be entirely dismissed, due to the fact that every root morpheme consists of an etymon and a third consonant, even if language processing automatically starts from an etymon. The three-consonantal root is important as it carries a core semantic meaning. My research will not focus on distinguishing between these representations.

Whether etymon or root and word pattern are the fundamental principles of Arabic morphology is a matter of debate. Clearly, the root and word pattern view has been adopted in most of psycholinguistic studies addressing Arabic morphology, including the present work. Priming studies have consistently found priming when primes and targets share the canonic three consonant roots (Boudelaa & Marslen-Wilson, 2000, 2001 and 2005). Moreover, the root view has been very useful to explain pattern of errors in production both in Hebrew with aphasic patients (Barakai, 1980) and in Arabic from one person with dyslexia (Mimouni, Béland, Danault, & Idrissi, 1995; Prunet, Beland, & Idrissi, 1998). In this case the pattern of errors is different for roots than for words patterns. In addition, it has been reported that spontaneous speech errors in Arabic are produced even for units belonging to different syllabic constituents, but this happens only if the consonants belong to the same root morphemes (Abd-Al-Jawad & Abu-Salim, 1987; Berg & Abd-Al-Jawad, 1996).

It is necessary to recognize that the three consonantal-root views as an organizational principle of Arabic morphology faces some pitfalls. It has been argued that this theory cannot account for the phonetic and semantic relationships between words (Bohas, 1997). There are cases where words share the same root but have a very little semantic similarity and there is semantic similarity between words that do not share the same root. This observation has led to the proposal that maybe there is a more fundamental unit in Arabic morphology, the etymon. This structure would consist in two consonants that would help to explain the semantic relationship among words that otherwise would have a three-consonant different root. Evidence in favor of the etymon as a processing and a representational unit calls into question the status of the three-consonantal root as a morphologically relevant unit in MSA. This does not mean, however, that the language processor would not pick up on the strong regularities offered by the three-consonantal root. Since every root morpheme comprises theoretically an etymon plus a third consonant, the effects of the root in language processing follow automatically from an etymon standpoint. Boudelaa and Marslen-Wilson, (2001) found strong morphological effects between primes and targets sharing a three-consonantal root morpheme regardless of whether the morphological relation is accompanied by semantic transparency.

I consider that more psycholinguist studies are needed to establish the effects that can be attributed to root and etymon. The present work focuses on roots because I consider that this theory is backed by a more consistent empirical work and it is more parsimonious since it establishes a general principal shared by other Semitic languages such as Hebrew. Furthermore, it is not clear that etymon and root represent exclusive views. Morphological units can be extracted from the correlational structure of language therefore there is no reason to propose that the lexical space should be sensitive only to roots or etymons.

Further evidence of the importance of the root in Arabic reading comes from research into dyslexic speakers of Arabic, which revealed that only their processing of root consonants was affected and not that of word patterns (Mimouni, Béland, Danault, & Idrissi, 1995; Prunet, Béland & Idrissi, 1998, 2000). The concept of three-consonantal root stems has been further examined in studies of Arabic speech errors, which are not affected by syllabic positional constraint, which occurs when parts belonging to similar syllabic constituents are replaced by onsets and codas for codas. In contrast to Indo-European languages, Arabic speech errors occur with parts of different syllabic elements with onset consonants and coda consonants swapping positions. Examples, such as [*ruæfa*] produced instead of [*æurfa*] (*room*), show that this happens only with the consonants from the same root morphemes (Abd-Al-Jawad & Abu-Salim, 1987; Berg & Abd-El-Jawad, 1996).

Recent studies have demonstrated that word frequency also plays a decisive role in Arabic word reading. Seraye (2016) found that the only variable that had an effect on reading comprehension and reading time was word frequency: high frequency words were processed faster than low frequency words. There was no effect of whether the texts were pointed or not. With respect to less experienced readers of Arabic, word frequency has an effect on their reading time as well, in addition to their reading comprehension. By comparison, absence of short vowels and diacritics had no effect on either of the two factors, reading speed or comprehension.

The link between low-frequency words and reading comprehension has been observed in a number of other languages, including those with different orthographies from Arabic such as Turkish and Persian (Raman & Baluch, 2001; Baluch, 2006). One main reason for this is that the fixation duration for low-frequency words tends to be longer, in both less and more advanced readers (Rayner, White, Johnson & Liversedge, 2006).

Research by Abu-Rabia and Awaad (2004) also touched upon the connection between the frequency of words and lexical decisions. According to Bybee (1995), it is frequency rather than the morphological complexity of a word, which governs the mental lexicon storage. Therefore, an assumption could be made that whole words are stored in the mental lexicon and are then retrieved in order to make a lexical decision. It could also be assumed that decomposition can only be necessary when the reader encounters new words and need to understand the meaning of the new word based on the structure (Katz, Rexer & Lukatela, 1991).

In summary, Semitic languages, particularly Arabic and Hebrew have provided evidence in support of a morphemic lexicon (e.g. Frost, Forster & Deutsch, 1997). The research reviewed above provides evidence that the mental lexicon of the users of MSA is morphologically structured and that the three-consonantal root can be considered as the basic unit underlying lexical processing and representation in MSA. However, both root productivity and word frequency modulate reading processes in Arabic (Boudelaa and Marslen-Wilson, 2013).

Finally, effects of reading proficiency on morphological processes in Arabic word processing have received little attention. The Arabic writing system is cognitively challenging to read, as all the letters, except five, are connected to each other and differ in shape in a context-dependent way. Moreover, as Arabic is diglossic, the reading language is not the same as the spoken language and both MSA and its script must be learned at school. The effects of reading proficiency in Arabic remain poorly understood.

The aim of my research is to investigate morphological processes in Arabic-English bilinguals, in particular, the effects of L1 and L2 proficiency on these processes. In the next Chapter I review theories of bilingual language processing.

Chapter 2

Bilingual language processing

2.1 The bilingual mental lexicon
2.2 The Revised Hierarchical Model (RHM)
2.3 The Bilingual Interactive Activation Plus Model (BIA+)
2.4 Masked translation priming

2.1 The Bilingual mental lexicon

Current models of bilingual processing assume a great deal of cross-activation between languages. Kroll et al. (2012) argue that both languages of bilinguals are active even when processing is occurring in one language only. They assume that the open nature of the system of bilingual people might provide good conditions for language learning. Some psycholinguistic research demonstrates that using a second language has an effect on the first language (e.g. Dussias, 2003; Van Hell & Dijkstra, 2002). In this chapter, I will describe two leading models of the bilingual mental lexicon: The Revised Hierarchical Model (RHM) (Kroll and Stewart, 1994) and The Bilingual Interactive Activation Plus Model (BIA+,Dijkstra & Van Heuven, 2002), and review relevant research in the field. Finally, I will review studies of masked translation priming.

2.2 The Revised Hierarchical Model (RHM)

Initial research on bilingualism focused on bilinguals, largely bilinguals with two Indo-European languages, who acquired both languages from birth. However many other kinds of bilingualism occur and in recent years more attention has been given to bilinguals who have acquired their languages sequentially, learning their second language in schools or later in life than their first language (Brysbaert & Duyck, 2010). A great deal of research has investigated how adult learners integrate the developing L2 into their existing language system (see also Kroll & Hermans, 2011; and MacWhinney, 2005, for reviews). This research has provided evidence that there might be an initial stage of learning in which learners rely on transfer from the L1 to L2. However, once enough proficiency in L2 has been achieved, such transfer via the L1 is no longer necessary. The RHM (Figure 1, Introduction and overview p.13) captured this shift from L1 lexical mediation to direct conceptual access. The underlying assumption is that there are asymmetries in how strongly words are connected with concepts in two languages. At the lexical level, there are stronger links from L2 to L1 than vice versa. There are also stronger links between lexical and conceptual levels in L1 than L2. However, this asymmetry is less pronounced in proficient bilinguals (Dufour & Kroll, 1999; Sholl, Sankaranarayanan, & Kroll, 1995).

Initial experiments tested the Revised Hierarchical Model by having bilinguals translate in each direction, from L1 to L2 and from L2 to L1. The model predicts that because L1 may retrieve meaning directly, translation from L1 to L2 will be conceptually mediated. However, translation from L2 to L1 may show signs of direct lexical-to-lexical connections, which exist during early stages of learning L2. If this is true, then translation from L2 to L1 may not involve conceptual processing or show any effects of semantic (meaningful) factors. Kroll and Stewart (1994) tested whether category interference would occur in bilingual translation. Dutch-English bilinguals translated written words from L1 to L2 and from L2 to L1. Words were presented in semantically blocked (e.g. all items of clothing) or random lists. The result showed that translation from L1 to L2 was slower than translation from L2 to L1, as predicted by the RHM. In addition, only translation from L1 to L2 was sensitive to semantic blocking, with slower responses in the categorized lists than the random lists.

The RHM model highlights the special role that the translation equivalent may play for L2 users (see Brysbaert & Duyck, 2012; Kroll, Van Hell, Tokowicz & Green, 2010). Other studies evaluated the model's predictions to see if participants will still rely on translation when their language proficiency in the L2 has improved (e.g., Kroll, Michael, Tokowicz & Dufour, 2002; Sunderman & Kroll, 2006). For example, Sunderman and Kroll (2006) examined lexical access in a second language. They tested two groups of English-Spanish bilingual participants. One group had a high level of Spanish fluency while the other was less fluent. The participants completed a translation recognition task, i.e. they judged whether English-Spanish word pairs were translation equivalents (e.g., *cara* = *face*). The critical pairs were not correct translations but were related either in form (e.g., *cara-card*) in meaning (e.g., *cara-head*), or related in form to the translation equivalent (e.g.., *cara-fact*). Both fluency groups were inhibited by form- and meaning-related pairs but only the less fluent group also showed interference from form-relatedness of the translation equivalent. This suggests that the learners with lower levels of L2 relied on L1 translation more than learners who had achieved a high level of L2 proficiency. These results support the claim that there has been some change from participants' reliance on a transferring meaning from the L1 to the L2, to the ability to directly conceptually process the L2 without L1's help.

However, a study by Thierry and Wu (2007) found evidence for the use of translation even by highly proficient bilinguals. Their research used proficient Chinese-English bilinguals who were living in the U.K. and their task was to decide whether two English words were semantically related or not. The ERP data showed evidence of sensitivity to these shared characters, with an amplitude reduction in the N400 occurring due to the implicit character repetition. This effect contradicts the logic of the RHM, which states that proficient learners should no longer require this sort of lexical mediation.

It is possible that the use of event related potentials (ERPs) methods can reveal processes that were hidden in the earlier studies. To test this Guo, Misra, Tam and Kroll (2012) performed a translation recognition experiment in which proficient Chinese-English bilinguals had to decide whether a Chinese word was the correct translation of an

English word or not. On the critical trials, incorrect translations were related in form or meaning to the correct translations. The ERP data showed a different time course for the two conditions, with activation of the translation equivalent occurring after access of the meaning of those words.

2.3 The Bilingual Interactive Activation Plus model (BIA+)

The BIA+ (Dijkstra & Van Heuven 2002; Lam & Dijkstra, 2010) is a model which explains both theoretically and by means of computer simulations how word recognition and word repetition in bilinguals occur. This model has been adapted for bilinguals from a well-known Interactive Activation model (IAM), originally proposed by McClelland and Rumelhart (1981) for monolingual word recognition. The BIA+ model maintains that when bilinguals recognise words, which is referred to as bilingual lexical access, information in their two languages is activated in a non-selective way. The model, according to Dijkstra and Van Heuven (2002), has been defined as a network model of bilingual visual word recognition (see Figure 6). It is made up of three levels of nodes, namely the sub-lexical orthographic level, the lexical orthographic level and the language nodes and Semantics level. Starting at the first level (sub-lexical orthographic level), individual features activate matching letter nodes, which in turn activate words at the word level (lexical orthographic). This level is comprised of letters arranged in the correct position and inhibitory links to words where letters are arranged in the wrong position. This layer has two integrated lexicons, one for each of a bilingual's language. Once words have been activated inside each of the lexicons, a signal is sent to the corresponding language node. Simultaneously, inhibition is also sent to other competing words both within the same lexicon and across the other lexicon. Recognition of words is considered complete when a word activation level exceeds a certain limit or recognition threshold. Language nodes function by gathering activation from all words in the corresponding lexicon while at the same time delivering inhibition to the other, competing lexicon.

According to the BIA+ model, lexical information from a bilingual language is represented in an integrated lexicon, where a language is activated non-selectively. Therefore it can be assumed that a bottom-up, nonselective activation of lexical information across a bilingual's languages occurs in the initial stages. This non-selectivity is immune to any external influences. For example, in a Dutch-English bilingual lexicon the English word WORK is bound to activate all Dutch words sharing (some of) these letters, e.g., *WERK*, *WOLK* and so on. The BIA+ model draws a distinction between a word identification system, or the lexicon, and a task/decision system. Dijkstra and Van Heuven (2002) and Lam and Dijkstra (2010) claim that such extra-linguistic phenomena as task demands and participant expectations exert an influence on the task/decision system. This in turn can influence the output of the word identification system, which is directly affected by linguistic factors only, namely lexical, syntactic and semantic information.

The languages' nodes function as language tags, or representations of language membership, and have no direct influence on the relative activation of words within a given language. Their only function is that of an additional representational layer. Such an arrangement therefore ensures that the language membership of the input string does not limit non-selectivity. Due to the fact that the lexical identification system in the BIA+ is determined by linguistic context, Lam and Dijkstra (2010) ascertain that effects of non-selectivity can be constrained by a sentence context and select the type of information to be activated in the non-target language.

Numerous effects in bilingual lexical access, namely cross-linguistic frequency effects, orthographic neighbourhood effects, phonological relatedness effects, cognate effects and effects of speaker proficiency, have been modelled by BIA+ simulations (see Dijkstra & Van Heuven, 2002, for reviews)**.** The BIA+ model also determines special effects shown by cognates, or words that share both meaning and form in two languages (e.g. *house/huis*, English/Dutch). Priming studies of word processing in bilinguals have shown that cognates display strong priming effects, which cannot be observed in non-cognate translations (de Groot & Nas, 1991; Sanchez-Casas et al., 1992). For example, the Spanish word *rico*, which means *rich*, primes the English word *rich* in a similar way as the within-language identity prime *rich*. In contrast, non-cognates for translation words, e.g. *mujer* and *woman*, showed no priming (Sanchez-Casas et al., 1992). These findings serve as evidence of shared representations for cognates (Dijksta et al., 2010).

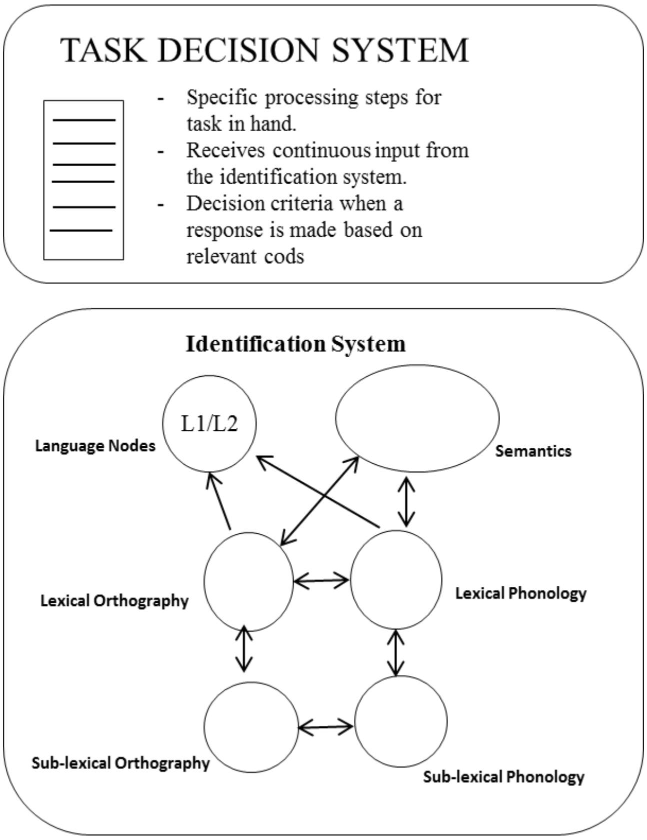

Figure 6, The Bilingual Interactive Activation Plus (BIA+) model (from Dijkstra & Van Heuven, 2002).

2.4 Masked translation priming

The masked priming paradigm (Forster & Davis, 1984) has been widely used to explore how lexical representations in the dominant (L1) and non-dominant (L2) languages interact with each other as well as the semantic representations they map onto. Although participants are not informed about the prime in the masked priming conditions, its effects can nevertheless be measured (Kinoshita & Lupker, 2003).

In bilinguals whose languages have entirely different scripts, translation equivalent priming can also be observed. Gollan, Forster and Frost (1997) researched masked priming of Hebrew-English cognates (loan words such as *televizya*) and non-cognates (sharing only meaning). Their findings revealed that both cognate and non-cognate priming took place with L1 (Hebrew) primes and L2 (English) targets in a lexical decision task.

Korean-English bilinguals demonstrated a similar case of non-cognate translation priming (Kim & Davis, 2003). This could be interpreted by assuming that priming in same-script languages is disguised by competition, caused by automatic and non-selective activation of orthography and phonology. These findings, as a result, indicate those languages whose script is different show lexical level effects.

Many bilingual studies have been influenced by the Saussurian principle, which differentiates between form and meaning of individual words (Culler1974). Such a lexical–semantic organisation process has been reflected in the bilingual lexical representation theory, particularly with respect to how translation equivalents are represented in bilingual memory. Translation equivalents can be connected in two ways, either through form-to-form associations, also known as the "word association hypothesis'' (Grainger & Frenck-Mestre, 1998), or through the shared semantic field, also known as the ''concept mediation hypothesis'' (Potter, So, Von Eckardt & Feldman, 1984).

As mentioned above, the RHM proposed by Kroll (Kroll & Sholl, 1992; Kroll & Stewart, 1994) assumes that the level of proficiency will determine the extent that bilinguals will depend on form-to-form connections or concept mediation. One criticism of this model is that L2 low-proficiency learners do not always rely on the translation links with L1 (Frenck-Mestre & Prince, 1997).

The results of the majority of studies into the effects of priming have shown that significant translation priming effects only appear during the tasks that involved L1 primes and L2 targets. They also point to the existence of an asymmetry in masked translation priming, particularly among low-proficiency bilinguals. This also indicates a possibility of cross-linguistic automatic lexico-semantic links being established during the early stages of L2 acquisition. Priming is less noticeable from L2 to L1 than from L1 to L2 (Altarriba, 1992; Keatley & de Gelder, 1992; Keatley, Spinks & de Gelder, 1994; Kroll & Sholl, 1992), which could be explained by the fact that identifying L2 words may require slightly longer periods of time (Grainger & Frenck-Mestre, 1998) as the participants many need more context for L2 words, whereas there is no such need for L1 targets.

As regards the studies into masked translation priming where lexical decisions have to be made by bilinguals with high proficiency, a masked translation priming asymmetry was observed, with consistent priming effects during the forward-translation direction with L1 primes and L2 targets, whereas only elusive effects have been observed in the backward direction with L2 primes and L1 targets (De Groot & Nas, 1991; Finkbeiner, Forster, Nicol & Nakamura, 2004; Gollan, Forster, & Frost, 1997; Grainger & Frenck-Mestre, 1998; Jiang & Forster, 2001; Kim & Davis, 2003; Voga & Grainger, 2007; Duñabeitia, Perea, & Carreiras, 2010b).

Two other studies were conducted using the masked translation priming lexical decision paradigm (Basnight-Brown & Altarriba, 2007; Duñabeitia, Dimitropoulou, Uribe-Etxebarria, Laka, & Carreiras, 2010a). The results of both studies indicated that the higher the level of L2 competence, the more likely it is that the masked translation priming asymmetry will disappear. This finding is in line with the predictions of the RHM.

Another set of studies (Grainger & Frenck-Mestre, 1998) employing the masked translation priming paradigm focused not just on making lexical decisions but also on performing semantic categorisation by English-French bilingual participants. The tasks involved being presented with non-cognate translation equivalents of the targets and performance was compared to an unrelated prime control condition. The experiments showed stronger masked translation priming effects in the semantic categorisation task than in the lexical decision task. This indicates that translation priming effects in semantic categorisation tasks are likely dependent on the way semantic memory is represented in the brain of the bilinguals, rather than the strength of connections between translation equivalents in L1 and L2.

Most previous studies using the masked translation priming paradigm focused on the type of translation, cognate or non-cognate (de Groot & Nas, 1991; Gollan et al., 1997) or on semantic categorisation (Sanchez-Casas, Davis & Garcia-Albea, 1992). A study by Grainger and Frenck-Mestre (1998) was the first to combine both. The results of This study showed that translation priming revealed consistent results for cognate translations, whereas translation priming effects for non-cognates were largely absent in lexical decision tasks and semantic categorisation.

De Groot and Nas (1991), Gollan et al. (1997) and Sanchez-Casas et al. (1992) noted that a correlation of meaning and form priming effects can be responsible for cognate translations displaying stronger priming effects, when compared to non-cognates. In their study, Gollan et al. (1997) received similar results for languages with different scripts (Hebrew and English), which is an indication that common phonology but different orthography can also result in stronger cognate priming effects

Previously, the studies of masked translation and associative priming effects postulated that only cognate translations, such as *bakker* (Dutch) and *baker* (English), would display entirely overlapping semantic representations in the memory of bilinguals (de Groot, 1992; de Groot & Nas, 1991). This is in contrast to non-cognates, whose semantic fields are thought to be only partially overlapping. Such an interpretation could explain a complete absence of priming effects in non-cognates between languages, as they do not share as many semantic features as cognates do.

However, positive semantic priming effects were also obtained for non-cognates in a study carried out by Williams (1994), who used pairs which share the same semantic features, for instance, *fence* and *haie* (French hedge), but are not related in an associative way, such as *shoe* and *pied* (French foot). These examples indicate that associative priming can be facilitated by language-specific knowledge of frequently encountered words which do not the share the same semantic representations. This could also explain the fact that associative priming effects were not observed for any non-cognate words in cross-cultural studies using the masked lexical decision task.

In addition to cross-culture studies of translation priming effects, some studies have also focussed on cross-script translation priming which allows for optimal processing of prime stimuli while interference from the target is minimalised. In the Interactive-Activation Model (McClelland & Rumelhart, 1981) priming effects depend on the compatibility of information from the prime stimulus and the target. A prime stimulus can activate a number of representations, including visual, orthographic, phonological and semantic ones during target processing. These in turn can overlap with the representations activated by the target. This influences the quality of the priming effects, which are dependent on the speed of semantic information being activated by the prime stimulus. In cases where primes and targets are cross-scripted (e.g. Arabic primes and English targets), pre-orthographic visual interference may take place and the effects of pre-lexical orthographic interference may be decreased. In addition, cross-scripted designs help to minimise cross-language interference as they indicate which language the prime stimulus belongs to at the level of whole-word form representations. Therefore, such cross-script translation priming designs are ideal to evaluate semantic representations during visual word recognition.

In summary, the focus of this research is visual word processing in Arabic-English bilinguals. These languages come from different families (Semitic/Indo-European) and have very different linguistic structures and are written in different scripts (e.g. *reading*/ قراءة). Both have a phonetic script but Arabic is read from right to left, which contrasts with English, which is read from left to right. In addition, as reviewed in Chapter 1, Arabic and English have very different morphological systems. This means that the bilingual lexicons of Arabic-English bilinguals provide an ideal environment for studying the effects of L1 and L2 proficiency on lexical processing.

Chapter 3

Assessing Language Profiles in Arabic-English Bilinguals

3.1 Different kinds of bilingualism
3.2 Measuring language status
3.3 The Language Experience and Proficiency Questionnaire (LEAP-Q)
3.4 The LEAP-Q for Arabic English bilinguals
3.4.1 *Method*
3.4.1.1 *Participants and procedure*
3.4.2 *Results*
3.5 Factor analysis
3.5.1 *Description of factors*
3.6 Summary and discussion

3.1 Different kinds of bilingualism

Bilinguals and multilinguals comprise a large proportion of the world's population today. Many developed nations such as the United States, for instance, have experienced an increase in the number of bilinguals and multilinguals who use their first, second and sometimes third languages in a variety of different settings (Marian et al., 2007). This has given rise to abundant research into bilingualism and the use of first and second languages (L1 and L2 respectively).

First languages are defined as those that bilinguals use in their home or educational environment. They are also used in the media and everyday commercial operations, from shopping to banking. By contrast, second languages are usually learnt for a specific purpose, such as economic advantage (Graddol, 1997). Quite often, if L2 is very powerful and influential, it can become more prominent than an L1 spoken by the majority of a population, as it the case of Jamaica, where students struggle to learn the second language(English), which is official language of the country, because of the prominence of their L1(Jamaican) (Pryce, 1997).

Cross-linguistic immigrant groups present a different view of bilingualism, where L1s are used in the home environment and in minority cultural and linguistic communities. L2s, by contrast, are the languages used in schools, media and commerce, as in the case of the USA. Some linguistic communities in the U.S. can be so large that non-English L1 speakers can live all their lives without having to learn English (Chiswick & Miller, 2002). Another type of bilingual speakers is the simultaneous bilingual speaker, a term which describes bilingual language learners who speak two or more languages since childhood (Chiswick & Miller, 2002). In this case, bilingual language proficiency will be also influenced by the level of parental fluency and frequency of use.

Different bilingual backgrounds can result in variations in bilingual language status, with different levels of language dominance, proficiency and preference in both first and second languages. Such a multitude of different types of bilingualism has given rise to a number of studies that investigate the effects of different aspects of bilingual language status on language processing. For example, as reviewed in Chapter 2, second language proficiency has been argued to influence access to meaning (e.g. Kroll & Tokowicz, 2005). There is also evidence indicating that first language proficiency can suffer in situations where a speaker has been immersed in the second language environment (Brysbaert & Duyck, 2010; Francis, Tokowicz & Kroll, 2014).

This thesis has a particular focus on the effects of first language morphological structure on the processing of both L1 and L2 and the degree to which any such effects are influenced by L1 and L2 language proficiency. The aim of the study reported in this chapter is therefore to collect and analyse detailed language proficiency data from the participants of the lexical decision studies reported in Chapter 4 and 5. In the sections below I first review studies relating to measures of language status and language performance, highlighting the lack of consistency in both language status and performance measures across these studies. I then describe the Language Experience and Proficiency Questionnaire (LEAP-Q, Marin et al., 2007), which is the measure I adopted for my study. LEAP-Q data were collected from all participants tested in the morphological (Arabic: Chapter 4) and translation (Arabic-English: Chapter 5) studies. The questionnaire data was then analysed using factor analysis in order to determine the optimal independent factors related to underlying language experience and proficiency constructs in the self-report data.

3.2 Measuring language status

The absence of uniform assessment instruments in bilingual research has contributed to the problem of inconsistency between studies. For instance, research by Roseberry-McKibbin, Brice & O'Hanlon, (2005) has shown that testing individuals whose language the researchers do not speak is challenging since self-assessment becomes the main tool of collecting information. However, there is evidence that self-assessment does reliably relate to language performance.

A study by Jia, Aaranson and Wu (2002) focussed on grammatical ability and used a 32-item questionnaire to evaluate four different areas of language in L1 Mandarin and L2 English. These included age and time variables linked to L2 acquisition, such AOA (age of arrival in L2 environments); environmental factors, namely the number of L2 speakers at home, frequency of communication using L2 at home and the workplace, as well as the proficiency of the parents and siblings in reading, writing and speaking in L2. The next two factors included affective variables of self-consciousness, cultural preferences, national identity and motivation; self-evaluation of proficiency in both L1 and L2 in reading, writing and speaking was the last aspect of language to be measured. L2 grammar ability of 112 bilinguals was judged using listening and reading tasks. To make the assessment of their L2 proficiency more reliable, the scholars used stimuli with 257 and 256 sentences for the listening and reading tasks respectively. Sentence stimuli can be useful as both reading and listening skills involve different performance factors (e.g. Bialystok & Miller, 1999; Go to-Butler, 2000). The grammatical structures used in the sentences were the most common English structures, namely past tense, plurals, third person singular present, and present/past progressive form. The rest of the structures dealt with syntax such as articles, pro-nominalization, particle movement, predicate structure, 3 auxiliaries, yes/no questions, wh-questions, and word order.

L1 accuracy was measured using Mandarin and English listening tasks and English reading task. A reading task was not used for Mandarin, as many participants could not read in Mandarin. Ninety-four sentences, similar to the ones used in US standard tests, made up the Mandarin grammaticality judgment task (e.g. Li & Thompson, 1981). The results revealed that participants with older AOA performed with higher accuracy in the L1 task and lower accuracy in the L2 task. This could be because the group with younger AOA tends to make L2 its dominant language, whereas the group with older AOA keeps L1 as its dominant language. Thus, the research demonstrated a strong link between AOA and task performance.

Dominance is often measured using an L1:L2 proficiency ratio (e.g. Flege, MacKay & Piske, 2002; Vaid & Menon, 2000). Frequently, it has, however, been measured subjectively (Talamas, Kroll & Dufour, 1999), which might have affected the consistency and reliability of the findings. Other studies determined language dominance through the results of vocabulary tests or speed reading (e.g. Cromdal, 1999, Favreau & Segalowitz, 1982). Using such data as language preference, language proficiency or language dominance of the bilinguals as proficiency measures has created even more confusion in this area of research (Marian & Neisser, 2000; Ortiz & Garcia, 1990). It is important to note that language preference shows participants’ subjective feelings towards the language and, as a result, fails to measure linguistic performance in a reliable way.

Moreover, some studies included a limited number of behavioural tasks, such as tasks to measure the degree of foreign accent (Flege , Yeni-Komshian & Liu, 1999) or grammaticality judgment (Jia et al., 2002). More reliable results could have been obtained if the range of behavioural tasks was much wider.

Finally, inconsistencies were observed in the manner questions and scales designed, which did not allow for cross-experimental comparisons. For example, Jia et al. (2002) used a 4- or 5-point rating scale for their questionnaires, whereas Vaid and Menon (2000) applied a 7-point scale. As a result, it has been difficult to do cross-cultural comparisons due to a lack of a valid and uniformed assessment measure.

Therefore, while self-reporting measures of language proficiency do predict language performance to some extent, it is clear that a more comprehensive language self-assessment tool likely to produce more valid and reliable results. As a result, the present study used the LEAP-Q, a self-reported measure assessing bilinguals' language status, which combines relevant proficiency and experience variables. Also, it is a comprehensive questionnaire and a more sophisticated measure of bilingual profile including the proficiency of bilingual reading skill. LEAP-Q provides objective bilingual measures. It provided detailed information about language background and use as well as self-rated proficiency data. Such self-ratings have been shown to predict performance in a range of language's tool likely to produce more valid and reliable results (Marian et al., 2007).

3.3 The Language Experience and Proficiency Questionnaire (LEAP-Q)

The LEAP-Q was developed by Marian, Blumenfeld and Kaushanskaya (2007) as a new self -assessment tool to test language proficiency and which, as already mentioned above, successfully combines proficiency and experience variables. Linguistic performance is assessed using three different measures, namely language proficiency, language dominance, and preference of language use. LEAP-Q questions target the three measures separately in reading, writing, speaking and listening, to make result interpretation easier. Language dominance questions ask the participants to indicate dominance order for the languages they speak, while the questions targeting preference ask the participants to rate reading a text in different languages.

In the present study, the main population for the administration of the LEAP-Q comprises bilingual and multilingual adults and adolescents with a range of language learning experiences and proficiency. Unlike other language tests, which mainly aid with the placement of students onto programmes, the LEAP-Q is research oriented and assesses participants taking part in research. Consequently, the participants have to be L2 proficient in order to complete standardized assessment tools.

Marian et al. (2007) tested two groups of highly proficient multilinguals and Spanish-English bilinguals. Their questionnaires used similar types of questions as those studies which assessed bilinguals's proficiency (Flege et al.,1999; Jia et al., 2002; Marian & Spivey, 2003; Vaid & Menon, 2000).

The first part consisted of nine questions in order to identify the participants' dominant language, order of language acquisition, language exposure and the percentage of this exposure, language preference in reading and speaking, cultural belonging, the number of years of formal study and living in the USA. For example, a question evaluating the degree of L2 exposure asked the participants to rate current exposure to all the languages they speak in percentage terms. A question evaluating language dominance in reading asked the participants to decide in percentage terms in which language they would choose to read a text. Part 2 of the questionnaire is mainly language-related and required information about the age of language acquisition and duration in the language environment, level of proficiency in reading, writing, listening and speaking, ways of exposure to the language, factors contributing to learning, strength of the accent and the perception of the participants as non-native speakers by others. Overall, the questionnaire consists of 16 questions, all measured in percentage terms.

The main aim of Study 1 was to establish internal validity of the LEAP-Q by analysing responses of 52 Spanish- English bilinguals through the application of factor analysis and multiple regression analyses. Factor analysis was carried out in order to identify the factor which accounted for the biggest variance. By comparison, multiple regression analyses were conducted to determine a relationship between language history and language proficiency. The former included 16 attributes of language history, for instance, acquisition and fluency ages, learning environments, exposure variables and so on.

Study 2 used a different sample of bilinguals' speakers of English - Spanish who were administered a computerized and revised version of the LEAP-Q. Once completed, participants were administered a set of standardized behavioural measures of language ability. They included an English reading fluency test (from the Woodcock–Johnson Test of Achievement WJTA) and an equivalent Spanish version (Woodcock–Munoz, WM). The participants were asked to read as many sentences as possible within a 3-min interval to determine whether the sentences were true or false. In the next stage, a passage comprehension test, Subtest 9 of the WJTA in English and the WM in Spanish was given to the participants asking them to fill in the missing words. Following this, a productive picture vocabulary test, was administered in which participants had to name pictures. A receptive vocabulary test (PPVT/TVIP), where picture identification was required following auditory instructions, and a grammaticality judgment test with 50 English and 50

Spanish sentences was also administered. The latter required participants to identify grammatically correct sentences. The last two tests also included an oral comprehension test, which required the participants to fill in the gaps from listening to passages. They also complete a sound awareness test, which included a rhyming task, a sound deletion task, a sound substitution task, and a reversal task.

Multiple regression and factor analyses were employed to analyse participants' responses. Marian et al (2007) demonstrated that L1 and L2 self-reported proficiency served as the best predictors for comprehension and judgement of grammaticality. This means that when judging one's proficiency, both the ability to understand written texts and grammar skills are taken into account. This finding supports results of the studies reviewed showing that bilinguals' proficiency levels correlate with objective measures of linguistic proficiency.

Four factors, i.e. Relative L2–L1 Competence, L1 Learning, Late L2 Learning, and L1 Non-dominant Status constituted more than 50% of the variability in the data see Table 3. All the other factors, such L2 Immersion, L1 Immersion, L2 Non-acculturation and Media-Based L1 Learning had a much smaller variance. The findings confirm the importance of L1 and L2 self-reported competencies in defining bilingual profiles, which also means that the two competencies can be interconnected. Since they account for the bulk of the variance, I will concentrate on the first four factors. As can be seen in Table 3 for the first factor, Relative L2-L1 Competence, L2-related variables loaded positively L1-related variables loaded negatively. This demonstrates that the group of the participants was L2 dominant. Such an inverse relationship between L1 and L2 variables also found by Flege, Yeni-Komshian & Liu (1999), testing bilinguals. The second factor, L1 Learning, which deals with the age that participants began learning to read in L1, age of becoming a fluent L1 reader, learning L1 from tapes, as well as proficiency in speaking, reading, and understanding L1, demonstrated both positive and negative loadings. Age-related acquisition variables showed positive loadings, indicating a late-acquisition profile. By contrast, negative loadings of proficiency variables indicatedan incompletely acquired L1, which describes the profile of bilinguals who either immigrated from an L1-speaking country at an early stage of their life, or who were educated in an L2 environment from an early age.

The third factor, Late L2 Learning, includes positive loadings for several L2 learning variables such as radio and language tapes, exposure to L2 through independent study, ages of becoming a fluent L2 speaker and reader, and self-perceived accent in L2. Together, they demonstrate an incomplete and late acquisition of L2. The only negatively loaded variable was that of L1 self-perceived accent, which is indicative of higher L1 fluency. Finally, the fourth factor, Non-dominant Status, includes positively loaded variables of ages of L1acquisition, attained L1 fluency, L1 accent (as reported by others),and preference to speak L2, all indicating an L1 lack of fluency. By contrast, negatively loaded exposure to and learning from an L1 learning from family indicated lack of L1 exposure. Similarly, the negatively loaded variables of L1 family exposure demonstrates insufficient immersion in an L1 environment. Therefore, a conclusion could be drawn that these participants prefer to use L2 in their daily communication, which in turn explains indexing their status as L1 Nondominant.

Overall, the participants reported high levels of both proficiency and immersion. The most important L1 learning factor was exposure to an L1-speaking family. For L2 learning it was reading. The highest L1 proficiency variables were shown for understanding, whereas reading was the highest variable for L2 proficiency. The participants also reported higher L1 proficiency than L2 proficiency, with comprehension and reading showing the largest discrepancy. Overall, the study confirmed the validity of the questionnaire and showed self-reported measures of language competencies can indeed serve as indicative factors of linguistic performance.

Table 3. The results of the factor analysis of the LEAP-Q data from Marian et al (2007). The resulting eight factors are shown along with their component variables and the associated loading factors.

Factor 1: Relative L2-L1 Competence	Loading values	Factor 2: L1 Learning	Loading values	Factor 3: Late L2 Learning	Loading values	Factor 4: L1 Non-dominant Status	Loading values
L1 Exposure to reading	-.872	L1 Speaking proficiency	-.929	L2 Learning from the radio	.755	L1 Age began acquiring	.871
L2 Exposure to TV	.866	L1 Age began reading	.824	L2 Age when fluent reader	.724	L1 Learned from family	-.823
L2 Exposure to reading	.844	L1 Reading proficiency	-.747	L2 Age when fluent	.654	L1 Age when fluent	.624
L1 Exposure to TV	-.811	L1 Age when fluent reader	.745	L2 Age began reading	.605	L2 Preference to speak	.577
L2 Exposure to friends	.804	L1 Comprehension	-.709	L2 Exposure to self-instruction	.561	L1 Identified accent	.526
L2 Exposure to radio	.777	proficiency	.629	L2 Learning from tapes	.557	L1 Exposure to family	-.468
L1 Exposure to radio	-.773	L1 Learning from tapes		L1 Perceived accent			
L1 Exposure (%time)	-.771			L2 Perceived accent	-.548		
L1 Exposure to friend	-.762				.452		
L2 Exposure (%time)	.759						
L2 Reading proficiency	.754						
L1 preference to read	-.713						
L2 preference to read	.696						
L2 Speaking proficiency	.580						
L1 Learning from reading	-.522						
L2 identified accent	-.496						
L2 years in the country	.474						
% Variance	25.29		12.42		9.61		7.47
Cumulative variance	25.29		37.72		47.33		54.80
Factor 5: L2 Immersion	Loading values	Factor 6: L1 Immersion	Loading values	Factor 7: L2 Non -acculturation	Loading values	Factor 8: Media-Based L1 Learning	Loading values
L2 Exposure to family	.898	L1 Years of schooling	.885	L2 Age when began acquiring	.854	L1 Learning from radio	.845
L2 Years in family	.894	L1 Years in family	.818	L2 Cultural identification	-.713	L1 Learning from TV	.816
L2 Learning from family	.747	L1 Chronological age	.766				
L2 Years of schooling	.537	L1 Years in Country	.740				
		L2 Learning from TV	-.503				
% Variance	5.93		4.86		4.09		3.83
Cumulative variance	60.74		65.60		69.69		73.53

The only difference between the present study and Marian et al. (2007) was that a factor analysis was applied to the data together with a multiple regression analysis. Factor analysis is commonly used as a statistical method in order to find groups with similar patterns of variables which can contribute to the same underlying construct across different data sets. It has been effectively used to design questionnaires and scales in order to evaluate cultural identifications (Zea, Asner-Self, Birman & Buki, 2003), measure emotional intelligence (Tapia, 2001), levels of well-being of elderly bilinguals (Tran, 1994) and caring attitudes (Wu, Larrabee & Putman, 2006; Zea, Asner-Self, Birman & Buki, 2003). When questionnaires for other studies which used the LEAP-Q were translated for bilinguals of other languages, the structure of the factors did not change. This, thus confirms that the underlying constructs do not depend on the test language (Abdel-Khalek, Tomás-Sabádo & Gómez-Benito, 2004; Ferrer, Cordoba, Garin, Olive, Flavia, Vargas et al., 2006).

3.4 The LEAP-Q for Arabic English bilinguals

The aim of this study is to establish the key factors that capture differences in the language status of the adult bilinguals and multilinguals of Saudi Arabia tested in the studies reported in Chapters 4 and 5. We need reliable measures of language status to determine whether and how these variables contributed to participants' performance on the masked priming studies (see Chapters 4 and 5). However, I am also interested in this group of bilinguals in itself because our participants have a very different language history to bilinguals tested to date. I will therefore discuss the LEAP-Q results separately in this chapter. All participants had a high proficiency in L2 English while living in the Arabic environment, which constitutes their L1 environment. This is one significant difference from the study by Marian et al. (2007), as their participants were Spanish (i.e. Spanish was their L1), and all of them had emigrated to the United States, where English was their L2. Hence, these bilinguals lived in an L2 environment. Another interesting factor with the population we tested is the fact that they are diglossic in their L1. All educated speakers of Arabic learn a local dialect but also learn academic Arabic at School (see Chapter 1). It is therefore possible that different factors underlie language status in this population.

3.4.1. Method

I used the LEAP-Q (Appendix A), with some minor modifications (detailed below). The first section of the LEAP-Q includes general questions about the participant and their general language history, such as participants' country of origin, residence, age, date of birth, handedness and gender. Participants are asked to list the languages they speak in order of dominance. Additionally, the LEAP-Q asks questions about the frequency of language use, a percentage of exposure to each language, levels of spoken and reading ability, an identifying cultural factor and that of formal education years. Finally, the name of the language in which they received instruction in school for each schooling level, was also queried, followed by a declaration of any vision and hearing problems or learning disability such as dyslexia. This was followed by a question about any possible loss of fluency in a particular language and at which age. The participants were also asked to describe in which languages they usually count, add, multiply, and do simple arithmetic, dream or express anger or affection. In addition, in this section we asked if they ever mix words or sentences from the two or more languages they speak and which ones. More questions were asked with respect to which language they were going to use for their rest of their life. They were also asked to state if there was anything else that they felt was relevant or important to their language background or language use.

The second section dealing with their first language (L1) included questions about language acquisition history, contexts of acquisition, numbers of years spent in theL1 language environment, language preference and proficiency (speaking, understanding, reading, and writing), interacting with family and friends, reading, watching TV, and listening to the radio.

This was followed by the level of exposure to family and friends, reading, media, such as TV and radio, and finally, self-rating of their accent.

The third section contained the same questions but referred to second language acquisition. Some questions, such as those referring to the age range of L2 acquisition, were presented to all of the bilingual respondents. In addition, questions required information about their L1 learning environment, including home (mother/ casual language called A'miah in Arabic-informal Language) and formal academic background (called Fos'Ha in Arabic language). The final part of the questionnaire was kept the same as in Marian et al (2007). I deleted the immigration to the United States item since all the participant lived in Saudi Arabia. Participants completed the questionnaire in approximately 25-30 min.

3.4.1.1.1. *Participants and procedure*

The questionnaire study and the experimental studies reported in Chapters 4 and 5 were approved by the University of Birmingham Ethics committee (application ERN-13-0270). The questionnaire was administered to 208 participants with 18 participants being subsequently withdrawn from the final set (due to missing data from this study and the masked priming studies reported in Chapters 4 and 5), thus making it a total of 190 participants who spoke more than two languages = (multilingual n=44) and (bilingual participants n=146). 75% were women (n=142) and 25% were men (n=48) and 95% reported right handedness. The multilinguals spoke either three (n=38), four (n=5) or even five languages (n=1). Besides Arabic, the languages spoken were English, Turkish, Kurdish, French, Malay and Spanish. The average age of the participants was 23.9 years (SD = 5.4). The participants were mainly students and staff in the departments of English and Translation Studies at the University of Imam Mohammed bin Saud in Riyadh (n=104), with a smaller proportion of them being doctors from hospitals in Riyadh (n=71), as well as a few engineers (n=15). All of the subjects used English as the language of instruction in their places of study, which ranged from 1st year of college to doctoral degree level. None reported any vision problems or learning difficulties such as dyslexia. Some of the participates filled in the questionnaire at the laboratory, whereas others submitted them electronically via email.

3.4.2 *Results*

My bilingual participants were much more uniform in their language experience than in the Marian et al.(2007) study, especially in those factors affecting language dominance. All of the participants were first language Arabic speakers who lived in Saudi Arabia, which is an Arabic environment. The 190 participants were at least bilingual and spoke Arabic as their first language. English was the second language for all participants. Some participants (20%) reported speaking three languages, while 3% of participants reported speaking four languages. Only one participant spoke 5 languages. All participants were also similar to each other in their number of formal years of education (M=16.3, SD=3.4 85% were undergraduates students, 10% were Masters Degrees students (MD) and 5% were PhD students. National identity for the majority of the participants was Arabic, as 98.9% of the participants have Saudi Arabic parents. Only twoArabic- Speakers participants hada non-Arabic mother (American and Turkish).

In terms of language preference there was slightly more variation :28% of the participants reported using both languages, Arabic and English, for counting, adding, dreaming and being affectionate, compared to just 3% of the respondents who used only English for these purposes. The remaining 69% of those surveyed used only Arabic for those purposes. Around half of the participants said that they usually mixed words in both languages. 37% of the participants expressed a desire to speak English for the rest of their lives, compared to only 4%, who wanted to speak Italian, Korean, Japanese, French, Turkish or Spanish for the rest of their lives. 59% wished to complete their life with Arabic

Participants' self-reported language history and proficiency measures can be found in Table 4. L2 acquisition ages ranged from 5 to 17 years, representing mainly young but sequential bilinguals. As can be seen, all participants reported maximal proficiency in L1 Arabic and also studied MSA since primary school. English proficiency was also reported to be high. 38% of the participants started to study English in primary school while 61% learned English at secondary school.

Participants reported their L1 exposure mainly in the family context, followed by reading in L1, communicating with friends and a smaller degree of exposure to self-instruction, watching TV and listening to the radio. With regard to their L2 exposure, the participants reported being exposed to English mainly in the context of reading, followed by communicating with friends and self-instruction, whereas exposure to watching TV, communication with family members and listening to the radio came last. The subjects reported how a combination of different factors contributed to their language learning.

Table 4. Self -reported language history and proficiency for participants in all of SOA 50, 80 and 200ms.

	Arabic L1history			**English L2 history**		
Language history measures	M	SD	Range	M	SD	Range
Self-reported proficiency						
Understanding	10.0	0.0	-	7.9	1.9	3-10
Speaking	10.0	0.0	-	7.9	1.9	3-10
Reading	10.0	0.0	-	7.6	1.7	3-10
Writing	10.0	0.0	-	7.1	1.9	3-10
Age **milestones(years)**						
Began acquiring	0.0	0.0	-	11.1	2.6	5-16
Speaking fluency	4.7	1.6	3-7	15.7	3.6	6-22
Started reading	6.8	0.7	6-10	12.5	2.9	6-20
Reading fluency	9.2	1.7	7-12	17.9	2.3	15-23
Immersion duration (years)						
In country	23.6	0.0	19-45	1.1	3.4	0-21
In family	23.8	5.3	19-45	2.2	4.9	0-22
In school	20.9	7.0	19-45	6.9	3.5	1-17
Contribution to language learning						
From family	9.6	1.0	5-10	7.9	2.7	0-10
From friends	7.4	2.6	3-10	4.7	3.2	0-10
From reading	8.5	1.9	3-10	7.2	2.4	0-10
From TV	6.5	2.8	1-10	5.3	3.4	0-10
From radio	8.5	1.9	0-10	8.2	2.8	0-10
From self –instruction	7.5	2.5	0-10	6.8	2.8	0-10
Extent of language exposure						
Friends	7.7	2.3	1-10	8.6	2.4	1-10
Reading	8.3	2.5	0-10	8.9	2.1	0-10
TV	6.6	2.8	0-10	6.6	2.7	0-10
Radio	4.5	5.2	0-10	4.1	3.1	0-10
Family	8.8	1.8	5-10	4.5	2.3	0-10
From self-instruction	6.9	2.5	1-10	8.4	1.5	0-10
Self -report of foreign accent						
Perceived by-self	5.3	3.4	0-10	1.3	1.2	0-10
Identified by others	2.5	3.3	0-10	8.7	2.3	0-3

In L1 the greatest contributing input came from the family, followed by reading and radio in an equal measure. The next set of variables was of self-instruction, friends and watching TV.

In contrast, acquisition of L2 was mainly restricted to the radio, followed by family, reading, self-instruction and watching TV, whereas friends came last. When asked to report proficiency in L1, all the participants reported maximum proficiency for all skills, namely comprehension, reading, writing and speaking. In L2 they reported the highest proficiency for comprehension, followed by reading, speaking and writing. Participants also reported that they began acquiring L1 from birth. By contrast, L2 acquisition began at around 11 years of age, which was the last year in primary school or the start of secondary school. The age for speaking fluency in L1 was estimated at 4 years of age, whereas the age for speaking fluency for L2 was at 15 years of age. Reading fluency (L1) started at around 6 years of age and L2 at the age of 17. Duration of the immersion in L1 for the participants was the same for all of them and ranged from 20 to 23 years in the country, family and school. Immersion in L2 was around 19 years.

Interestingly, speakers reported a higher degree of self-perceived accent in their L1 than in L2 and the opposite patterfor how foreign their accent would be perceived by others. After the questioning, it became apparent that the participants misinterpreted the question about how good their perceived their own accent to be. They interpreted this question as a question asking about the number of different accents which they could use in their L1 and L2. The participants estimated that they could use on average three different accents in Arabic, most likely including MSA and their local accent; however, they could only use one accent in English. However, they also thought that there was little chance that their Arabic accent might be perceived as non-native. In contrast participants reported that their English accent was very likely to be perceived as non-native.

3.5 Factor analysis

The main reason for using factor analysis was to determine if LEAP-Q data contributed to underlying constructs, which define a bilingual status. Some data on first language acquisition was removed because it showed no variation across participants. All of the participants could speak Arabic since birth; therefore data on the number of years of speaking Arabic as a first language was removed, since all of the participants were native speakers. The number of years spent in the Arabic environment such as family and school were also deleted since it was the same for all of the participants, as well as the number of years spent in the country. The information on Arabic proficiency in speaking, reading, writing and understanding was also removed due to the fact that all of them answered 10 out of 10.

A correlational matrix was calculated for the remaining variables. Only those variable that showed at least one correlation of .3 or higher with another variable were included in the factor analysis.

The data were then submitted to a factor analysis. The factor analysis compared the statistical clustering of questions with bilingual dimensions. The 28 attributes were added to the principal component analysis, which was used as an extraction method. Then a varimax rotation method was applied. The statistical software was given a maximum of 100 iterations to converge on a factor solution, and the rotation converged in 28 iterations.

The initial analysis gave 10 factors with eigenvalues greater than 1. The optimal number of factors was determined using parallel analysis (PA) as can be seen in Figure 7 below. PA plots the eigenvalues for the covariance matrix from largest to smallest and plots a set of random Eigenvalues (also ordered from largest to smallest). The number of Eigenvalues before the intersection of these two curves, determines the number of factors to use for further analysis (Courtney, 2013).

The result of the analysis is shown in Figure7. As can be seen the optimal number of factors is 8. These 8 factors explained 62% of the variance in the whole data.

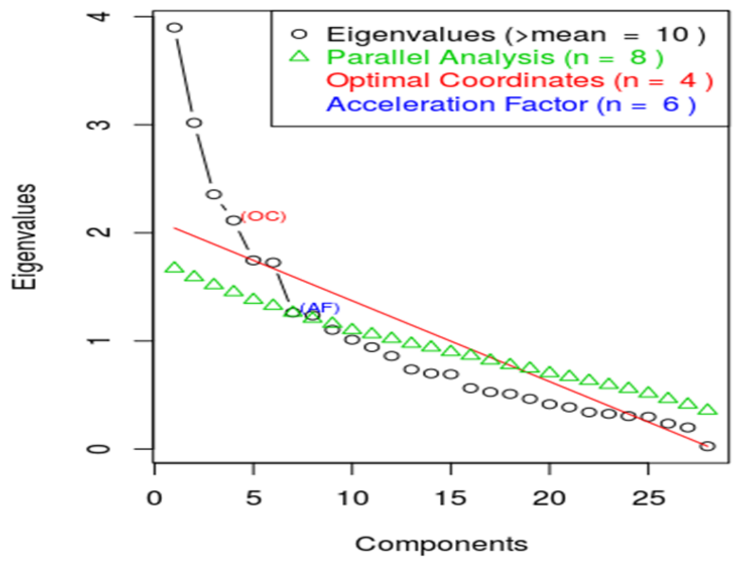

Figure 7. Determining the optimal number of factors: The plot shows Parallel Analysis, Optimal Coordinates as well as the Acceleration Factor for deciding the optimal number of factors.

The 8 factors were then examined in terms of the questions that loaded onto them. Only questions with loadings of higher than 0.3 were considered. Based on these loadings, each construct was assigned a name indicative of their component variables. These constructs and their loading factors are listed in order of the variance accounted for in Table 5. Components show positive or negative loadings. Positive loadings give inclusionary criteria and describe the underlying construct of the factor. Negative loadings provide exclusionary criteria and show an inverse relationship to the construct of the factor.

3.5.1 *Description of factors*

The first factor, which accounted for the most variance was labelled *L2 Language Proficiency* and included 6 variables. Four of these were proficiency variables, organised in order from the highest positive loading to the lowest one, and included proficiency in reading, proficiency in understanding, proficiency in speaking and proficiency in writing. In addition, two learning factors in L2 i.e., learning from reading and learning from family (both positive loading values), were also part of this factor. Together, these variables seem most strongly related to aspects of L2 Language Proficiency

The second factor included four variables, which were: L2 age of acquisition, which had highest loading value, followed by L2 age of learning to read. Next, was L2 age of speaking fluently and the lowest loading value was for L2 age of fluent reading (all positive loadings values). These variables are all clearly related to aspect of the age at which language was learned and this factor was therefore named *L2 Age of acquisition*. Because the variable loading on this factor are age-of acquisition, high values of this factor relate to lower learning duration.

The third factor was named *L2 Exposure*, and it included only two variables: L2 exposure to friends and L2 Learning from radio, both with a positive loading value. Both variables had the same high loading values, possibly reflecting the common situation of friends sitting together listening to the English radio and/or listening to English language lessons on the radio together in order to develop their L2.

The fourth factor is named *L2 Informal Learning*, as it included variables related to L2 learning and exposure from the media and friends and family. There are 6 variables in L2, all with positive loading values. These are L2 learning from friends with a high loading value, followed by L2 exposure with family, L2 exposure with radio and L2 learning TV. The lowest loading value was in L2 learning with family.

The fifth factor was the first factor associated with L1 variables and was named *L1 Formal Learning*. This factor included L1 exposure to language tapes with the highest loading value, followed by L1 learning from language tapes, L1 learning from reading. L1 exposure to reading. L1 Learning from TV, which had the lowest loading value. All loading values were positive. Most of these factors were related to learning from formal and literary sources.

The sixth factor, *L1 Informal Learning*, was also associated with L1 variables but this time related to informal avenues of learning, including media subgroups. All loading values were positive. The biggest loading value was linked to L1 learning from the radio, then L1 exposure to the radio, L1 exposure to the TV, L1 learning from the TV, and finally, with the smallest loading value, was L2 learning from the TV.

The seventh factor was named *L2 Accent* as perceived by the participant and this variable had a high positive loading value. The participants interpreted the question asking about how many foreign accents they had in L2. As a result, their answers contained references to two or three accents, namely English accent, American accent and Australian accent (high negative loading value). Also, the participants believed that their accent would identify them as non-native speakers of L2, which resulted in them awarding themselves a higher score for this question. This discrepancy accounts for the negative and positive loading of these two variables on the factor. L2 learning from language tapes came last and had the lowest positive loading value.

The eighth factor related to *L2 Formal Learning.* The 3 variables with the highest positive loading values were related to L2 exposure: L2 exposure to the TV followed by L2 exposure to the radio, and L2 learning from language tapes. These were followed by L1 exposure to watching TV and L2 learning from reading. All five variables had positive loadings values. In addition to these 5 variables, 2 other variables were included in this factor: L2 age of fluent reading and L2 age of fluent speaking. Both variables exposed negative loadings to the factor. This makes sense as the more formal learning the earlier fluency would be reached.

As can be seen, although my analysis resulted in the same number of factors as the original LEAP-Q study, there are a number of differences in how the component variables grouped in my sample of bilinguals. I now turn to a discussion of these differences.

Table 5. The result of the factor analysis of the LEAP-Q data from the Arabic-English bilinguals. The resulting eight factors are shown along with their component variables and the associated loading factors.

Factor 1: L2 Proficiency	Loading Values	**Factor 2:** L2 Age of acquisition	Loading values	**Factor3**: L2 Exposure	Loading values	**Factor 4:** L2 Informal learning	Loading values
L2 Prof.reading	0.81	L2 Age.began.acquiring	0.82	L2 Exposure.friends	0.96	L2 Learning.with.friends	0.75
L2 Prof.understanding	0.74	L2 Age.began.reading	0.78	L2 Learning.radio	0.96	L2 Exposure.family	0.65
L2 Prof.speaking	0.71	L2 Age.fluent.speaking	0.69			L2 Exposure.radio	0.60
L2 Prof.writing	0.68	L2 Age.fluent.reading	0.54			L2 Learning.TV	0.45
L2 Learning.from.reading	0.58					L2 Learning.with.family	0.30
L2 Learning with.family	0.44						
% Var	0.10		0.08		0.08		0.08
Cumulative Var	0.10		0.19		0.27		0.34
Factor5: L1 Formal Learning	Loading Values	**Factor 6**: L1 Informal learning	Loading values	**Factor7:** L2 Accent Preficiency	Loading values	**Factor8**: L2 Formal learning	Loading values
L1 Exposure lang.tapes	0.77	L1 Learning.radio	0.74	L2 Perceived by self	0.77	L2 Exposure.TV	0.67
L1 Learning lang. tapes	0.71	L1 Exposure.radio	0.68	L2 Identified by others	-0.74	L2 Exposure.radio	0.37
L1 Learning from. reading	0.61	L1 Exposure.TV	0.63	L2 Learning.lang.tapes	0.47	L2 Learning.lang.tapes	0.37
L1 Exposure. reading	0.61	L1 Learning.TV	0.55			L1 Exposure.TV	0.36
L1 Learning. TV	0.36	L2 Learning.TV	0.42			L2Learning.from.reading	0.42
						L2 Age.fluent.reading	-0.33
						L2 Age.fluent.speaking	-0.32
% Var	0.08		0.08		0.06		0.06
Cumulative Var	0.42		0.50		0.56		0.62

3.6 Summary and discussion

A comparison of the factors in this study with those of Marian et al. (2007) highlights a number of differences. Firstly, grouping of L1 and L2 variables in the participants' data is less mixed in my study. Marian et al. had 4 factors which included a mix of L1 and L2 variables. The first factor, *Relative L2-L1 Competence,* had 10 variables in L2 and 7 variables in L1. *Late L2 Learning* comprised 7 variables in L2 and only one variable in L1, whereas the last factor, *L1 Non-dominant Status*, included 5 variables in L1 and one variable in L2, L2 preference to speak. Marian et al.'s factor 5, *L1 Immersion*, included 4 variables in L1 and only one variable in L2, L2 learning from TV. The final two factors, *L2 Non-acculturation* and *Media-based L1 Learning*, included just two variables each.

In contrast, in my study six of the eight factors comprised only single language variables. Five factors consisted of only L2 variables (i.e. *L2 Proficiency, L2 AOA, L2 Exposure, L2 Informal Learning and L2 Accent*), and one factor related to L1 variables (*L1 Formal Learning*). Only two factors contain a mix of L1 and L2 variables, namely *L2 Accent* and *L1 Informal Learning*. Hence, the results from my study indicate more uniform factors than Marian et al.'s. This is most likely because of the more uniform background of the bilinguals I tested.

Marian et al. (2007) also had a number of Factors that did not explain any variance in my data, again likely due to the similarity of language background in my participants. These include L1 preference to read, L2 preference to read, L1 age began acquiring, L1 age began reading, L1 age when fluent reader, L1 identified accent, L2 identified accent, L1 perceived accent, L2 cultural identification, L1 chronological age, L2 years in a country, L2 years in family and L2 years of schooling.

However, there were also some similarities in the variables that contributed to factors across both studies. In both, L1 and L2 exposure to family, friends, reading, TV, radio and self-instruction, were included. Additionally, both studies comprised a number of similar L1 and L2 learning factors such as family, friends, reading, TV, radio and self-instruction, as well as age of L2 language acquisition, the age of beginning to read, age of reading fluently, L2 proficiency in reading, speaking and understanding.

Interestingly, my factors showed some subtle distinctions that did not emerge in the Marian et al. study. Formal and informal learning factors grouped separately for both L2 and even for L1, perhaps due to the fact that there are two Arabic languages. One of them is the informal language (A'miah), learned from family, friends, local community, and some radio and TV programmes. The other one is Arabic academic language (Fos'Ha), which is learned at schools, news, media and is referred to as the formal Arabic Language among Arabic countries. In addition, L2 can be learned in two ways, formally, at school and informally, through the TV, movies, radio, family and friends. In my data these learning styles formed separate factors suggesting my bilinguals were more sensitive to the type of language exposure, compared to Marian et al.'s (2007), whose factors did not distinguish between learning styles.

With regard to the participants of this study, they all lived in an Arabic environment and learned their second language while living there. L2, which is English, is used in education, work and society. As a result, this study is similar to Marion et al.'s in the sense that the participants had similar educational, social and cultural backgrounds, including school and family. L1 was acquired since birth, whereas L2 was acquired much later in life, at the age of 12 or 13. However, Marian et al's study was conducted using immigrants, some of whom were native English or

Spanish speakers living in an L2 environment. The age of L2 acquisition in their study ranged from 0 to 32 years.

In summary, my study has provided a set of language status factors for my Arabic English bilinguals that differ in interesting ways from a previous study on Spanish-English bilinguals using a very similar questionnaire. In the following chapters, the effects of these factors on masked priming performance will be investigated.

Chapter 4

Masked priming of Arabic morphology: Effects of language status

4.1 Introduction
4.2 Methods: Experiments 1 to 3
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4.1 Introduction

The exploration reviewed in Chapter 1 gives strong proof that morphologic structure play a fundamental role on the organization of the arabic mental lexicon. That is, morphology in Semitic languages like Hebrew and Arabic could work as an organizing principle (e.g. Boudelaa & Marslen-Wilson, 2005; Deutsch, Frost, & Forster, 1998; Frost, Deutsch, Gilboa, Tannenbaum, & Marslen-Wilson, 2000; Frost, Forster & Deutsch, 1997). The non-linear nature of morphological structures in Semitic languages could be the reason behind the preminent role assigned to morphological processing in Hebrew and Arabic. For instance, in the Arabic language, the consonants XTM (the root) carry the semantics of the verb [xatama] seal; and they are interspersed with the word pattern {_a_a_a}, which carry the sintactyc information (as talked about on Chapter 1).

Effects of root priming in Semitic languages have been shown to be independent of the semantic relationship between the words. For example, the Arabic word [kaatibun] *writer* is morphologically and semantically related to [kitaabun] *book*, both containing the root consonants KTB. However, it is morphologically related but semantically unrelated to [katiibatun] *squadron*, which has the same root KTB but does not have the same writing-related meaning. Both of these morphologically related words showed masked priming effects (Boudelaa & Marslen-Wilson, 2005). In addition, word patterns, which are non-semantic elements, also show significant priming in Hebrew verbs, and in Arabic verbs and deverbal nouns (Boudelaa & Marslen-Wilson, 2005; Deutsch et al., 1998).

Boudelaa and Marslen-Wilson (2005) investigated the time-course of word pattern and root in the recognition process of Arabic de-verbal nouns and verbs. They used incremental masked priming (SOAs: 32, 48, 64, and 80ms) and manipulated the morphological (word pattern and root), orthographic and semantic relationship between primes and targets.

They demonstrated significant root priming at all SOAs for both transparent and opaque semantic relationships. Orthographic and semantic primes showed facilitatory effects only at the longest SOA (80ms). In contrast, priming of word patterns is less often observed. In their (2011) study, Boudelaa and Marslen-Wilson demonstrated that root productivity affected masked priming of word-patterns. They showed that word pattern priming was obtained in the context of productive roots and was absent for words with roots that were less productive. In contrast, the productivity of the word pattern did not show differential effects. None of these studies showed effects of orthographic overlap over and above root overlap, however Perea, Abu Mallouh and Carreiras (2014) did show some effects of orthographic overlap and argued that the differences between Semitic and English visual word processing were quantitative rather than qualitative. My study does not test for effects of orthography and orthographic overlap is controlled in my comparisons.

In this Chapter, I will use Masked priming because it is a good measure for telling apart different morphological components. So, the advantage of masked priming is that it allows one to investigate the effect of a particular prime-target relationship without participants' awareness of the manipulation, such that they cannot develop response strategies. Thus, it is considered as a relatively pure way to probe into the machinery of lexical processing (Forster, Mohan & Hector, 2003; Forster & Davis, 1984) Also, I wanted to replicate previous studies in Arabic or Hebrew. I report the findings of three masked priming experiments which aimed to replicate and extend the findings of Boudelaa and Marslen-Wilson (2005). My interest is in the effect of L1 and L2 language status on morphological processing. As written Arabic differs from spoken Arabic, the effects of language variables on L1 Arabic word reading may be different to other languages which have a closer correspondence between spoken and written language. In addition, there is evidence that first language processing can be affected by learning a second language (e.g. Kroll & Bialystok, 2015; Kroll, Bogulski & McClain, 2012; Van Hell & Dijkstra, 2002).

My study differed from that of Boudelaa and Marslen-Wilson (2005) in a number of ways. The material set in my study included a broader range of grammatical classes and word patterns. Also, the relationship between Arabic prime and target words was more varied. Targets were nouns, verbs and adjectives, as were the primes. The word patterns were also more varied and included some that are minimally marked in their orthography and I used diacritics where necessary in order to uniquely identify the words. This means that the diacritics provided information about the word pronunciation without changing the meaning. Also, diacritics help the Arabic reader to read isolated words faster than the word without diacritics (Hermena, Drieghe, Hellmuth & Liversedge, 2015; Hermena, Liversedge & Drieghe 2016). For some short words diacritics are essential in order to understand the meaning of the word correctly, e.g. عَلَمٌ (*flag*), عِلْمْ (*science*), but this was not the case with my stimuli. Boudelaa and Marslen-Wilson (2005) did not use diacritics except Shaddah (germination mark- tashdeed) in some items for example, لخّص / laxxas'a- sum up. The majority of their stimuli did not use diacritics but used a word pattern with long vowels, which are written in the orthography.

I am also interested in the effects of the language status factors at different SOAs. At short SOAs primes are not consciously perceived and it is argued that these SOAs tap into early automatic morphological decomposition processes (e.g. Rastle, Davis & New, 2004). Root priming has been observed at short SOAs of 35-50ms (e.g., Boudelaa & Marslen-Wilson, 2000). At longer SOAs the prime is sometimes visible to participants. At SOA 80 root priming is still observed but semantic effects emerge also. At longer SOAs the prime becomes visible to participants and can be consciously processed. Varying SOA therefore allows the examination of effects of language status on both conscious and unconscious prime processing. In the Experiments reported below priming was tested at three different SOAs: 50ms in Experiment 1, 80ms in Experiment 2, and 200ms in Experiment 3. This means that both masked and visible priming of lexical decisions to Arabic words was tested. The longest SOA has not to-date been tested with Arabic. However, Rastle et al. (2000) tested masked priming in English with a prime duration of 230ms and found significant priming both for morphologically and semantically related primes. These effects suggest that morphological overlap influences even the later stages of lexical processing. Crucially this late effect of morphology was only observed when prime and targets were semantically related and was absent for semantically unrelated primes.

The conditions tested in all three experiments are shown in Table 6. As can be seen, every target word occurred in 4 priming conditions. In the Root+Semantic condition, prime and target pairs share a root and a transparent semantic meaning. In the Root condition, prime and target pairs share the same root. However, in this condition there is an opaque semantic relationship between prime and target word. Targets and primes in the Semantic condition are strongly semantically related but do not share any roots or word patterns. Finally, in the Control condition, target and prime word pairs are not morphologically or semantically related, but share two to three letters that do not constitute a root to control for the effects of orthographic overlap in the two Root-based conditions. Although effects of purely orthographic priming in Semitic languages have rarely been reported (e.g. Velan & Frost 2011), some limited evidence of orthographic priming has been observed (e.g. Perea, Abu Mallouh & Carreiras, 2014). Unlike, Boudelaa and Marslen-Wilson (2005), who had different target-prime sets for each condition, the same target is tested in all conditions. The change in word pattern was also kept constant across all primes where possible given other constraints.

Table 6. An example of an Arabic target word with its associated prime words in each of the four priming conditions of Experiments 1-3. All primes share the same word pattern, which differs from that of the target. The Arabic word is shown along with its phonetic transcription, English translation and the gloss of its word pattern. The root shared by the target and the primes in the Root+Semantic and Root conditions is also shown.

		Prime		**Target**	**Shared root**
Root+Semantic	**Root- Semantic**	**Semantic**	**Unrelated**		
مُراجعينْ	مراجعٌ	عائدونْ	أولادٌ	رجوعٌ	r ɭ ʐ
[mwr aə ɭ ʐ iən]	[m aəraəɭeʐwuə]	[ʐ aə iduən]	[aəwlaəduən]	[ruəɭwʐuən]	
reviewers	*references*	*returners*	*boys*	*return*	
Noun, Masculine, Plural	Noun, Masculine, Plural	Noun, Masculine, Plural	Noun, Masculine, Plural	Noun, Masculine, Singular	

In my study, the time-course of morphological and semantic effects will be investigated by varying the prime duration over SOAs: 50, 80, and 200 ms. Following Boudelaa and Marslen-Wilson (2005, 2011), I expect significant masked priming for the Root+Semantic and the Root conditions at the early SOAs of 50ms and 80ms, irrespective of semantic transparency. I would expect to find effects of semantic relationships alone only at the longer SOAs of 80 and 200ms. It will be of interest to see whether effects of semantic transparency on root priming emerge at the longest SOA of 200ms, where the prime words will be completely visible to the participants. In addition, I am interested in effects of bilingual status on morphological and semantic priming. It is possible that Arabic reading proficiency will affect the degree of root priming observed, and it is possible that exposure to L2 English may affect morphological processing in Arabic-English bilinguals. Specifically, we wanted to test whether factors such as Proficiency, Exposure and Age of Acquisition of a L2 with a linear morphology could modulate morphological processing on the processing of L1 word with a non-linear morphological structure. The effects of bilingual status could result in three different non-exclusive scenarios:

a) since all participants have a relatively good knowledge of English, it may be that the results observed could be substantially different to those studies with monolinguals. That is, if the pattern of priming effects and the time-course is different to those reported in Boudelaa and Marslen-Wilson (2005) it could be due to the fact that the participants in the present study have extensive contact with a second language where morphology plays a different role. To this respect I expect weaker priming effects that could be attributed to the interference caused by the activation of the L2.
b) Bilingual status could modulate priming effects at different points of the time-course. It is to be expected that the most automatic modality of priming (masked priming at a SOA of 50ms) would be relatively unaffected by the activation of L2 knowledge. Therefore, we expect similar priming effects to those obtained in Boudelaa and Marslen-Wilson (2005) in their short SOAs conditions. However, L2 knowledge could interfere with L1 priming at longer SOAs.
c) LEAP-Q factors may not interact with priming conditions but they could influence the effect of other variables. L2 Proficiency, L2 Exposure or L2 Age of Acquisition could modulate the effect of lexical variables. In this case, we predict that bilingual status could impact the effect of those variables related with morphological processing (e.g.

root frequency). For example, the effect of root frequency could be different depending on the degree of contact with English. Again, High Proficiency or low Age of Acquisition of English may interfere with the morphological processing of Arabic words.

4.2 Methods: Experiments 1 to 3

4.2.1 *Participants.*

A total of 208 participants were tested, with 18 participants being subsequently withdrawn from the final data due to missing data across the LEAP-Q study and the priming experiments. This resulted in a total of 190 participants: 66 participants in Experiment 1, 66 Experiment 2 and 58 in Experiment 3. These are the same participants who were included in the LEAP-Q study (see Chapter 3 for participant details).

4.2.2 *Materials*

Eighty Arabic experimental target words were selected. These target words came from a range of grammatical classes: verbs (n=25, past simple or present simple), nouns (n=33, masculine and feminine) and adjectives (n= 22, single, plural, dual, feminine and masculine). Each class comprised both masculine and feminine genders (masculine = 42, feminine = 36). Arabic target words were also chosen with the English translation experiments in mind (reported in Chapter 5). The English translation of each target had to form one word and be in the English vocabulary of a proficient L2 English speaker (the full list of stimuli is given in Appendix B).

For each target, four prime words were selected. These primes had a different word pattern than the target, which was, for the majority of items the same for each prime (see Table 6). The targets and primes selected were checked by an Arabic Linguist to see if the word roots, meaning and structures were correct and to check my intuitions about semantic relationships between primes and targets. Similar to the target words the priming words differed in grammatical class. In the Root+Semantic prime set and the Root-only set there were 14 adjectives, 48 nouns, and 18 verbs and each class comprised both masculine and feminine genders (masculine = 46, feminine = 34). The Semantic prime set differed only slightly (adjectives = 14, nouns = 41, verbs =15; masculine = 45, feminine = 35), and so did the control prime set (adjectives = 13, nouns = 50, verbs = 17; masculine = 48, feminine = 32). The control primes set was constructed by reassigning 85% of primes from all the other conditions. These words did not share any root or semantics with the target to which they were assigned. However, they did share three consonants that did not form the root of the target words. This was done in order to control for orthographic overlap in any root priming effect observed.

The control words were selected from the set of words of the other three conditions. To these words a 15% of new words were added. Then the control words were assigned to targets ensuring that they were not related to the targets. All of them had different roots from the critical conditions (e.g., Shared root **b s tʐ** in first condition +Root+Semantic Flatten- يبسط, in second condition +Root only Simplify- يبسَط , third condition +Semantic without Root Making space-يفسح and the Target was Flat- منبسطة. while the Control word was Follow- يتابع) which came from different root which was **t b ʐ**. However, all words here even control word shared orthographically one letter which was -ي -j -Yaa. Each control words have the same diacritics of the target words. Finally, the roots used in the control condition different overall to those in the primed conditions in the whole set of words.

The prime word sets were also matched on frequency measures using the Aralex database (Boudelaa & Marslen-Wilson, 2010), which is an MSA language database of 40 million words from modern written texts, mainly Arabic on-line newspapers. Aralex was designed to provide a platform for the study of cognitive processing of Arabic and provides statistics for Arabic words such as: phonological length, orthographic length and frequency, and root and word-pattern frequency. I calculated the average of targets and primes for a number of measures (see Table 7).

I excluded some variables as those were not related to my experiment. The excluded variables were based on un – pointed variables, whereas my study design was based on pointed variables such as including diacritics and frequency. Further I included targets in numbers of length and frequency to match the priming as a surface processing measure, and, shared stem based measure of root productivity as a deep processing measure. Boudelaa and Marslen-Wilson (2005, 2010). The examples of those priming conditions were matched for length in terms of numbers of letters and phonemes, and for the surface orthographic frequency of the prime words. In addition, the conditions were matched for the type frequency of their roots and word patterns. Word-pattern type frequency is a type count of the number of words that share the same stem, also known as "family size". For example, in English *black* occurs in derived words such as *blackness* and compounds such as *blackbird*, and they would be part of its family. Root-type frequency is therefore a stem-based measure of root productivity. This is the same measure of root productivity tested by Boudelaa and Marslen-Wilson (2011).

Table 7. The lexical statistics for the Arabic target and prime word sets. The lexical frequencies were extracted from the ARALEX database.

	No. of letters	No. Of phonemes	Orthographic frequency	Root type frequency	Word pattern type frequency
Target	4.7	8.7	6.0	23.7	452.7
Prime					
Root+Semantic	4.7	8.4	19.7	23.5	444.6
Root	4.5	8.2	21.5	23.2	453.6
Semantic	4.7	8.4	16.1	18.4	519.9
Control Arabic	4.5	8.1	17.2	21.7	504.9

In addition, 120 filler target items (100 non-words, 20 words) were selected along with filler primes. The non-words were formed by changing existing Arabic words that were not part of the experimental set. The 100 non-words were orthographically legal, formed by changes to an existing form (e.g., *[tʐ aw j latun] tall* changed into *[tʐ aw j atn]*), or *[Sukuwnun] Quaite* transformed into *[Shukunun]*). The primes for the non-words were also orthographically legal non-words constructed in the same way, but had no morphological or semantic relationship with the target. The primes for the filler words were similarly unrelated words. The amount of form overlap between the word/non-word pairs matched as closely as possibly the experimental word/word pairs. All the 120 Arabic filler items also used diacritics.

4.2.3 *Design*

Every participant responded to each target once only, with 20 occurring in each of the four prime conditions. The four sets of target words were rotated around condition across participants, making four versions of the experiment that differed in the assignment of primes to targets. Because each participant responded equally to targets in each condition and each target occurred equally in each condition across participant, priming was a within subjects and within items variable. As different groups of participants were tested in each experiment, SOA was a between subjects variable.

The actual experiment consisted of 200 trials. The 200 trials were organized into 4 blocks of 50 words. Each block included 20 experimental targets (5 words from each priming condition) and 30 filler words (25 non-word trials and 5 filler word trials). This means there were equal numbers of yes and no responses in each block. The order of trials within each block was randomized. The order of blocks was also rotated across participants in order to counterbalance for practice effects. Participants completed a block of 20 practice trials prior to the experimental blocks (10 words, 10 non-words, mixed within). These were similar to the experimental blocks but did not contain any of the experimental words.

As Arabic has no uppercase letters, primes and targets were presented in different font sizes to prevent low-level visual overlap. All primes were presented in 24-point traditional Arabic font size with diacritics. Word and non-word targets were presented in a 34 point Arabic font size with diacritics. The order of events for a trial is illustrated in Figure 8. Each trial started with a fixation cross for 500ms. This was followed by a forward mask of 6 hashes (######) in a 30-point Arabic font size for 500ms. The prime was presented at different SOAs in each experiment: Experiment

1 = 50ms, Experiment 2 = 80ms, and Experiment 3 = 200ms, followed by the presentation of a target word.

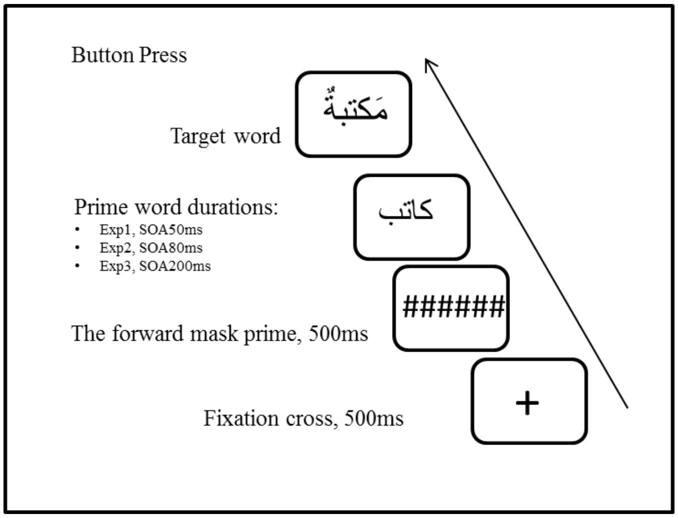

Figure 8. The timing of events of trials for Experiments 1 to 3. The three experiments reported in this Chapter differed only in their prime duration.

4.2.4 *Procedure*

The participants were recruited via their University tutors using student emails, and some through informal contacts. Each participant was tested individually in a quiet private room and all the participants were tested using the same Samsung laptop. E-prime software was used to run the experiments.

All participants were informed that their information and results were confidential. Then they read the experiment instructions in Arabic and I answered any questions. Some participants filled in the LEAP-Q on the same day and some emailed their completed LEAP-Q form to me after taking part in the lexical decision experiments. Before the experiments started, participants were required to sign the consent form (Appendix C), and answer a few questions about any vision or hearing problems, and whether or not they were dyslexic. Participants were instructed that they would be seeing a series of letter strings presented one at a time. They were asked to make judgments as quickly and accurately as possible using YES or NO buttons. Participants were given a maximum of 2000ms to identify whether the strings shown were existing Arabic words. Participants made their responses by pressing “Yes” and "No” push buttons connected to a laptop. No participants were willing to accept payment as this was part of their religion and culture to help anyone for free. Instead they were given a piece of chocolate, coffee and juice.

4.3 Results

The reaction times (RTs) to targets were trimmed, excluding all RTs less than 300ms and greater than 1500ms. This resulted in the loss of only 4 data points (< 1%). Average RTs, SDs and the percentage error rates for each priming condition at each SOA, are shown in Table 8.

Table 8. Means for lexical decisions for each condition are shown for Experiment 1 to 3: Reaction times (in milliseconds) and percent error rates.

	SOA50			**SOA 80**			**SOA 200**		
Priming condition	**RT**	**SD**	**% err**	**RT**	**SD**	**% err**	**RT**	**SD**	**% err**
Root +Semantic	730	211	9.4	700	187	8.8	727	210	11.7
Root	735	211	10.5	711	191	9.9	736	210	11.5
Semantic	745	212	10.5	714	183	10.4	740	202	12.2
Unrelated	752	208	10.2	710	192	9.2	742	210	12.4

Linear mixed effect models were run including Condition as a fixed effect (dummy coded with the unrelated condition as the intercept) and the LEAP-Q factors as continuous variables (using lme4 package, version 1.1-10; Bates, Maechler, & Bolker, (2012) in R, R Core Development Team, 2011). The log root-type frequency and log orthographic frequency of the target word were included as continuous variables, crossed with condition and the LEAP-Q factors (see Appendix D for the full model listing). All continuous variables were centered. In all cases, I began with the maximal random structure including interactions of condition with both subjects and items (Barr, Levy, Scheepers, & Tily, 2013). If this did not converge the random structure was simplified until convergence was obtained. The minimal model in the fixed effects structure was isolated using the drop1 function, which identifies the most complex fixed effect explaining the least variance. Fixed effects were removed until the model with the minimal AIC was reached. Factors with a *t*-value of greater than 2 are considered significant (Baayen, Davidson & Bates, 2008). Reaction time models were run on log RTs. To test for significant interactions with Condition, ANOVAS on model output were also run ("car" package, using Type III Wald chisquare tests). Because of my interest in the pattern of effects at different SOAs, I report the models for each SOA independently below.

4.3.1 *Experiment 1: SOA 50, Results*

The maximal model for the SOA 50 RT data set converged with both item and subjects crossed with Condition in the random structure. The minimal model with the same random structure is shown in Table 9. As can be seen the 22ms facilitation effect of priming in the Root+Semantics condition was significant as was the 17ms facilitation effect of priming in the

Root condition. However, there was no significant effect of priming (7ms) in the Semantic condition. The ANOVA on model output yielded a significant effect of condition ($p < .05$). To test for a significant difference between Root+Semantic and Root priming, the model was rerun with the Root condition as the intercept. No significant effect of Root+Semantic priming was observed.

There were no significant main effects of the LEAP-Q factors. The only lexical variable that approached significance was the orthographic frequency of the target word. Log RTs showed a slight decrease as orthographic frequency increased.

Table 9. The minimal model output for RTs at SOA 50ms.

Fixed effects	Estimate	Std. Error	t value
(Intercept)	6.594e+00	1.509e-02	436.9
Priming conditions			
Root+Semantic	-3.337e-02	1.153e-02	-2.9*
Root	-2.762e-02	1.092e-02	-2.5*
Semantic	-9.008e-03	1.047e-02	-0.9
Leap-Q factors			
L2 Proficiency	4.236e-03	1.331e-02	0.3
L2 Informal Learning	-7.052e-05	1.070e-02	0.0
L2 Exposure	-8.021e-05	1.311e-02	0.0
L1Formal Learning	1.106e-02	1.236e-02	0.9
Lexical variables			
Target Orthographic Frequency	-7.701e-03	4.079e-03	-1.9
Target Root Frequency	5.765e-03	1.879e-02	0.3
Condition specific effects			
Root+Semantic: L2 Proficiency	6.213e-03	1.035e-02	0.6
Root+Semantic: Target Root Frequency	1.673e-02	2.140e-02	0.8
Root+Semantic: Target Orthographic Frequency	8.440e-03	4.665e-03	1.8
Root+Semantic: L2 Proficiency: Target Root Frequency	2.407e-02	1.867e-02	1.3
Root: L2 Proficiency	2.178e-03	9.799e-03	0.2
Root: Target Root Frequency	-1.753e-02	2.102e-02	-0.8
Root: Target Orthographic Frequency	1.102e-02	4.563e-03	2.4*
Root: L2 Proficiency: Target Root Frequency	-8.607e-04	1.873e-02	0.0
Semantic: L2 Proficiency	-3.835e-03	1.005e-02	-0.4
Semantic: Target Root Frequency	-1.149e-02	1.988e-02	-0.6
Semantic: Target Orthographic Frequency	5.072e-03	4.289e-03	1.2
Semantic: L2 Proficiency: Target Root Frequency	5.736e-02	1.852e-02	3.1*
Interactions			
L2 Proficiency: Target Root Frequency	-1.406e-02	1.333e-02	-1.1
L2 Informal Learning: Target Orthographic Frequency	2.013e-03	1.249e-03	1.6

L2 Proficiency: Target Orthographic Frequency	-2.625e-03	1.428e-03	-1.8
L2 Informal Learning: Target Root Frequency	-6.252e-03	5.671e-03	-1.1
L2 Exposure : Target Root Frequency	1.790e-02	6.686e-03	2.7*
L2 Exposure: Target Orthographic Frequency	2.558e-03	1.490e-03	1.7

The ANOVA also yielded a significant interaction of Condition with L2 Proficiency and Target Root frequency (see Figure 9). This interaction was only significant in the Semantic priming condition ($p < .01$). Participants with a high L2 proficiency showed a positive relationship between RT and Target Root frequency. The reverse pattern was observed for low L2 proficient participants: faster RTs for high-frequency root Targets compared with Targets with a low-frequency root.

Please note that for all plots in this and the next chapter, in order to visualize the effects, the continuous LEAP-Q data were recorded in binary variables (high vs. low). The

recoding was done by splitting the data of a variable in two sets so that the number of data points per set was as closely matched as possible.

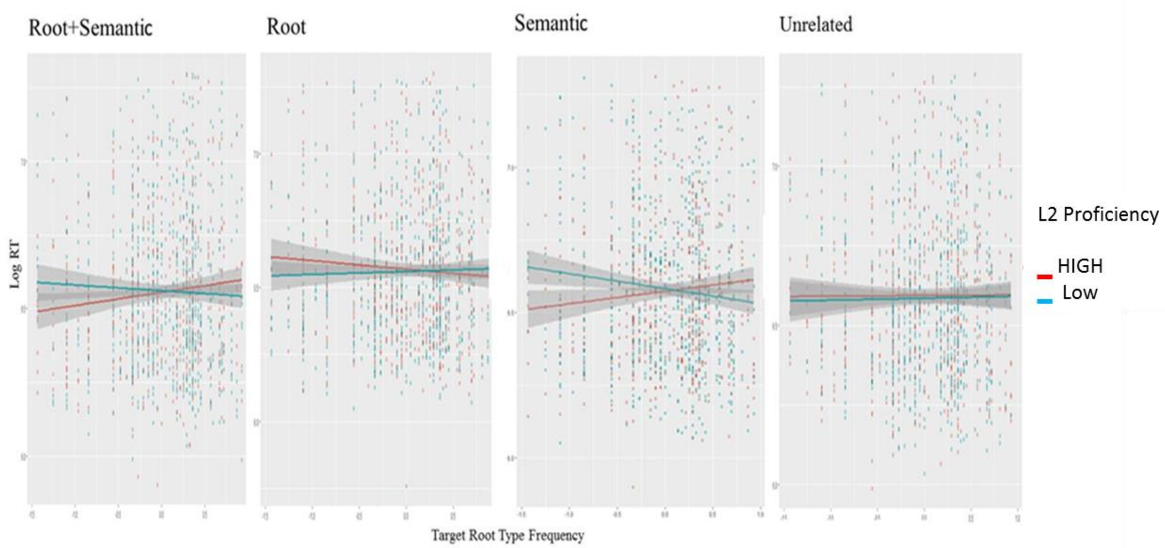

Figure 9. Experiment 1, Arabic SOA 50: The effect on RT in all four conditions of Target Root frequency for participants with high and low levels of the L2 Proficiency factor. Results are shown for Log RT against the centred variable in the regression plot (based on model output).

There was a significant effect of orthographic frequency in the Root priming condition. This effect is shown in Figure 10 compared to the effect of orthographic frequency in the unrelated condition. As can be seen the negative relationship between orthographic frequency and RT observed in the unrelated condition is reduced in the Root priming.

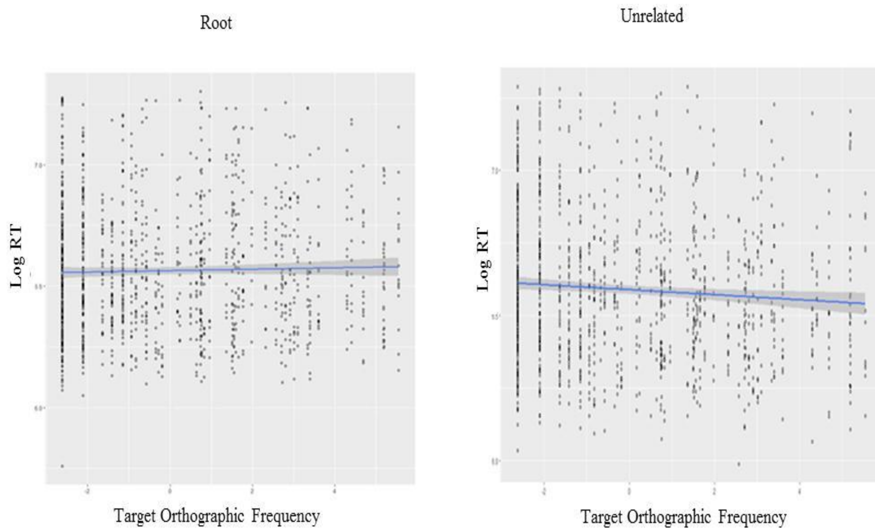

Figure 10. Experiment 1, Arabic SOA 50: The effect on RT of Target Orthographic-frequency in the Root Priming condition compared to the unrelated Condition. Results are shown for Log RT against the centred lexical variable.

There was also a significant interaction of L2 Exposure and Target Root frequency. As can be seen in the regression plot in Figure 11, participants with a high L2 exposure show a positive relationship between RT and Target Root frequency, with RT increasing as root frequency increases. In contrast, participants with low L2 exposure show the opposite pattern (RT decreasing as Target Root Frequency increases).

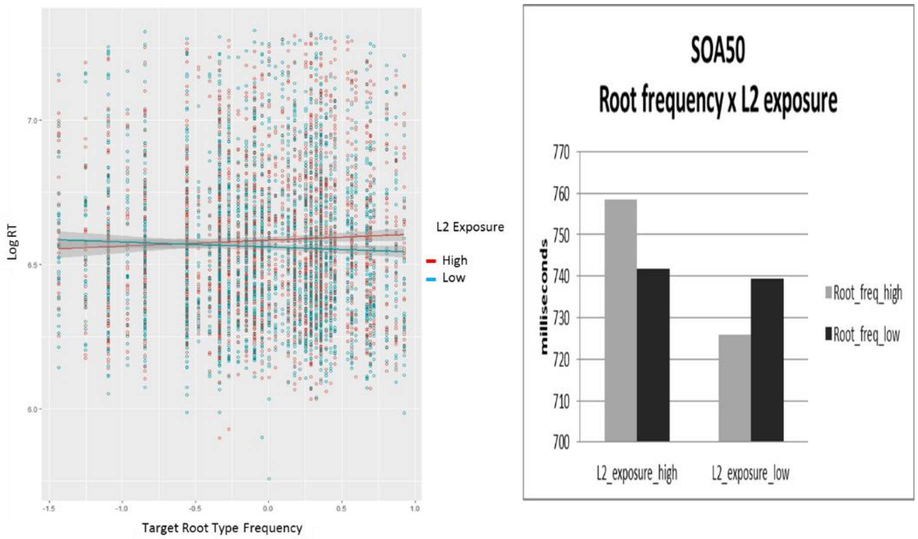

Figure 11. Experiment 1, Arabic SOA 50: The effect on RT of Target Root Frequency for participants with high and low levels of L2 Exposure. Results are shown for Log RT against centred variables in the regression plot (based on model output). For illustration purposes only the histogram shows a median split of both variables of interest on raw RTs.

A similar logit analysis of percentage error rates was run using glmer for binomial data. No full model of the data converged. The minimal model for the RTs also failed to converge for the error data. Only the minimal model including condition in the fixed effects and items and subjects as random factors converged. The output is shown in Table 10.

Table 10. The minimal model output for error rates at SOA50.

Fixed effects	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.55634	0.15603	-16.384	<2e-16 ***
Root+Semantic	-0.09824	0.13461	-0.730	0.466
Root	0.04563	0.13142	0.347	0.728
Semantic	0.05133	0.13137	0.391	0.696

4.3.2 *Experiment 2: SOA 80, Results*

The maximal model for this RT data set converged with both item and subjects crossed with conditions in the random structure. The minimal model with the same random structure is shown in Table 11.

Table 11. The minimal model output for RTs at SOA 80ms.

Fixed effects	Estimate	Std. Error	t value
Intercept	6.540756	0.016075	406.9
Priming conditions			
Root+Semantic	-0.014664	0.010316	-1.4
Root	0.001733	0.010758	0.2
Semantic	0.007241	0.009413	0.8
Leap-Q factors			
L2 Proficiency	0.009051	0.014114	0.6
L2 Age of acquisition	0.007020	0.012098	0.6
L2 Formal learning	-0.027681	0.014221	-1.9
L1 Formal learning	-0.004253	0.010852	-0.4
Lexical variables			
Target Root Frequency	0.010253	0.015726	0.7
Target Orthographic Frequency	-0.001822	0.003484	-0.5
Two way interactions			
L2 Proficiency: Target Root Frequency	-0.012966	0.006994	-1.9
L2 Age of acquisition: Target Root Frequency	-0.013227	0.005989	-2.2*
L2 Proficiency: Target Orthographic freq	-0.002686	0.001515	-1.8
L1 Formal learning :Target Root Freq	-0.009513	0.005446	-1.7

As can be seen the 10ms facilitation effect of priming in the Root+Semantics condition was not significant and neither was the 1ms facilitation effect of priming in the Root condition. Also, there was no significant effect of priming in the semantic condition (4ms). The ANOVA of the model output yielded no significant effect of Condition or interactions with it. There were again no significant main effects of the LEAP-Q Factors, although the effect of L2 Formal learning variable approached significance due to a tendency for RTs to decrease as L2 Formal Learning increased. There was only a significant two-way interaction of Root Type frequency and L2 Age of acquisition. This interaction is shown in Figure 11. For the low L2 Age of acquisition group, Log RT increases with increasing root frequency. In contrast, target root frequency has a smaller effect on log RTs for the low L2 Age of acquisition group.

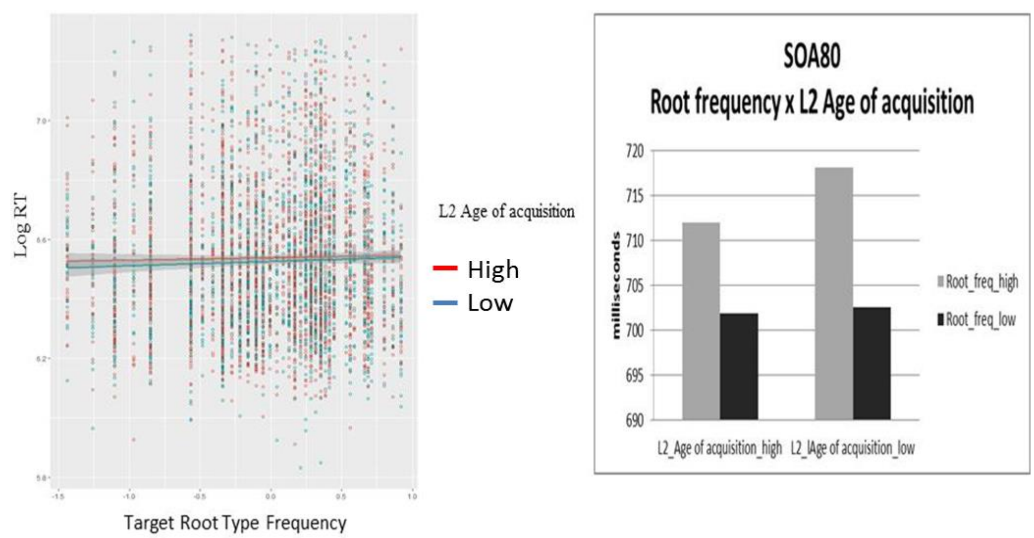

Figure 11. Experiment 2, Arabic SOA 80: The effect on RT of Target Root Frequency for participants with high and low levels of L2 Age of acquisition.

A full logit analysis of percentage error rates failed to converge, as did the minimal model from the RT data applied to the error data. The minimal model including Condition in the fixed effects and a random structure including items and subjects crossed with condition converged. The output is shown in Table 12. As with SOA 50, there were no significant effects of condition on error rates.

Table 12. The minimal model output for error rates at SOA80.

Fixed effects	Estimate	Std. Error	t value
(Intercept)	710.583	11.518	61.69
Root+Semantic	-5.445	7.927	-0.69
Root	3.734	7.936	0.47
Semantic	1.193	8.033	0.15

4.3.3 *Experiment 3: SOA 200, Results*

The maximal model for this RT data set converged with both item and subjects in the random structure and an interaction of subjects with Condition. The minimal model with the same random structure is shown in Table 13. As can be seen, the 15ms facilitation effect of priming in the Root+Semantics condition was significant, however, there was no significant effect of priming in the Root condition (6ms) or in the semantic condition (2ms). The main effect of Condition did not reach significance in the ANOVA of the model output.

The only significant LEAP-Q factor was L1 Informal learning. The effect of this factor on RTs is shown in Figure 12. As can be seen, Log RT increases as L1 informal learning increases.

Table 13. The minimal model output for RTs at SOA 200ms.

Fixed effects	**Estimate**	**Std. Error**	**t value**
Intercept	6.580231	0.017378	378.7
Priming conditions			
Root+ Semantic	-0.022796	0.010870	-2.1*
Root	-0.006622	0.010490	-0.6
Semantic	-0.000534	0.010834	0.0
Leap-Q factors			
L2 Proficiency	0.022318	0.013449	1.7
L1 Informal Learning	0.033132	0.015654	2.1*

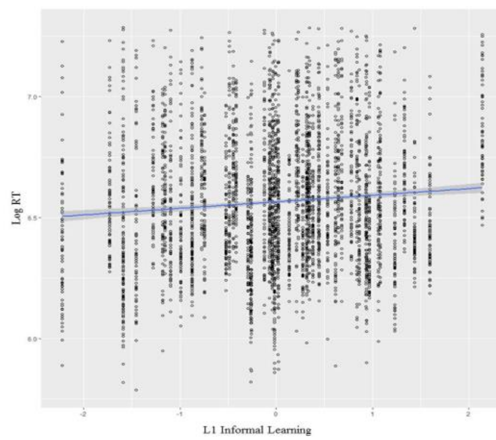

Figure 12. Experiment 3, Arabic SOA 200: The effect on RT of level of L1 Informal learning.

Again the full analysis of percentage error rates failed to converge. However the minimal model for the RTs did converge. The output is shown in Table 14. As can be seen, there were again no significant effects on error rates.

Table 14. Error rates across priming condition in SOA200.

Fixed effects	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.26061	0.14621	-15.462	<2e-16 ***
Root+Semantic	-0.07047	0.13234	-0.532	0.594
Root	-0.10358	0.13278	-0.780	0.435
Semantic	-0.01627	0.13120	-0.124	0.901
L2.proficiency	0.03944	0.07705	0.512	0.609
L1.informal.learning	0.09791	0.08849	1.106	0.269

4.4 Summary and discussion

In my study, I used three different SOAs, 50, 80, and 200 ms to investigate morphological and semantic effects in the recognition of Arabic words. Based on Boudelaa and Marslen-Wilson's (2005) study, I expected to find significant facilitation for the Root+Semantic and Root conditions at the early SOAs of 50ms and 80ms, and no effect of semantic transparency.

The results for SOA 50 were as predicted. Significant priming was observed for Root+Semantic and Root priming condition and the size of these priming effects did not significantly differ. There was no effect of Semantic priming at this SOA. This confirms that at such short prime durations root overlap rather than semantic overlap determines lexical activation. This effect cannot be due to orthographic overlap because our unrelated words had orthographic overlap with the targets. This effect replicates previous findings (Boudelaa & Marslen-Wilson's, 2005; Frost et al., 1997) in an experiment with a more varied range of Arabic words than have previously been tested, and more importantly with a within items design. The selected set of words were matched morphologically, semantically and by orthographic similarity. For example, the Arabic word [Sight -منظر] is morphologically and semantically related to [Look -تنظرْ], both containing the root consonants N- ðʐ-R. However, it is morphologically related but semantically unrelated to [Counterpart- نظير], which has the same root N- ðẓ-R but does not have the same related meaning. Finally, Semantically related but morphologically not related [Viewer- مشاهدٌ], preceded the same target. All of that were improvements in the design with respect to Boudelaa and Marslen-Wilson's, 2005; Frost et al., studies. In their studies they used different target with each prime. For example, in Boudelaa and Marslen-Wilson's, (2005) study they used in the orthographic condition, Seat مقعد, with the target, Room غرفة, and in the condition +Root+Semantic, Happy سعيد , the target was Happiness سعادة. So, non-matched features of primes and targets could have caused the differences between the present results and previous results. In the present experiments the unrelated primes had an orthographic overlap with the targets therefore the conditions to observe priming were stricter than in previous studies were the priming effect was obtained by the difference between the related conditions (e.g. +Root) and a completely unrelated primes. Although orthographic effects are weaker in Arabic it is a matter of debate that they are non-existent. For example, Boudelaa and Marlen-Wilson (2005) found facilitation (from 9 to 41ms) caused by orthographic overlap. Thus, the fact that the unrelated condition here had some orthographic overlap with the target could be partially responsible of the apparent discrepancies between the present result and those previously reported.

A second aim was to investigate the effects of bilingual status on the priming effects observed. As predicted, priming for Root and Root+Semantic was obtained at 50ms SOA. Therefore, the fact that participants are bilinguals did not have an impact on the facilitation caused by morphological overlap. Interestingly, no priming effect was observed at 80 ms and only the Root+Semantic condition showed a significant amount of priming at 200ms. This absence or weak priming can be related with the fact that when primes are presented enough time participants could be more sensitive to lexical organizational principles of the L2. This could produce that the morphological overlap between Arabic words would be less effective at producing facilitation. This would be evidence of parallel activation of the knowledge of different languages in bilinguals. A prediction then follows: if bilinguals are sensitive to the lexical organizational principles of both languages then orthographic similarity (which is crucial in English but not in Arabic; see Velan & Frost, 2009) effects (transposed letter effect) could be observed with Arabic words.

There were some interesting effects of the LEAP-Q factors and lexical variables at SOA 50. I saw a significant interaction of Condition with L2 Proficiency and Target Root frequency due to the Semantic priming condition. In this condition participants with a high L2 proficiency were slower to respond as Target Root Frequency increased. In contrast low L2 proficient participants showed the opposite effect. In other words, for participants with better English proficiency the effect of semantic priming is to slow down RTs for targets with higher root frequency. This effect seems to be due to the existence of a semantic relationship between prime and target because a similar (albeit insignificant pattern) occurs in the Root+Semantic condition, while to the pattern for the root only condition is different. It is interesting that the effect of target root frequency, which is a measure of productivity, is conditioned by proficiency in L2. A possible explanation is that participants with high L2 proficiency have a broader activation of L2 English words whilst processing Arabic and that this slows Arabic word recognition. This is therefore possibly an example of a detrimental effect of L2 proficiency on L1 processing. In addition, this suggests that for some portion of bilinguals semantic priming does influence word recognition even at an early SOA insofar as it is conditioned by root productivity.

A similar explanation is possible for the significant interaction of L2 Exposure and Target Root type frequency. Participants with a high L2 exposure show a positive relationship between RT and Target Root type frequency with the opposite effect observed for participants with low L2 exposure. Once again high exposure to L2 looks to be exerting a detrimental effect on L1 processing for productive targets.

Finally, the Root priming condition showed only an effect of target orthographic frequency, such that the faster processing of target with high orthographic frequency, which was observed in the unrelated condition was significantly reduced in the Root priming condition. A similar direction of effects (although insignificant) was observed mainly for the Root+Semantic condition. This suggests that targets with lower orthographic frequency are facilitated more by root overlap than those with high orthographic frequency.

At SOA 80 the current data do not replicate previous findings. Boudella and Marslen-Wilson (2005) observed root priming for both semantically related and semantically opaque primes and also semantic priming in the absence of root overlap between prime and target. However, I observed no significant priming in this experiment in any condition. It is not clear why no priming is observed at this SOA. One possibility is that this group of participants differed significantly in their bilingual profile from those at SOA 50 and SOA 200. The LEAP-Q data for each participant group are given in Appendix F. There are no large differences between the groups that might explain the difference in priming effects. I predicted that if the participants were less proficient in L2 then significant priming effect could have been found because they will take time to get to morphological processing. While in high proficient participants in L2 they will be faster than low group because of the effect of L2 proficiency. This kind of disadvantage of the second language might affect the speed and accuracy of L1 lexical access. Behavioral studies show that bilinguals are slower and less accurate when performing mental control (which means controlled processes are processes in the mind that require a great deal of a person's mental resources to ignore the irrelevant word and focus on the relevant one. Generally, controlled processing is best performed when only one controlled activity is taking place) in their L2 language than in their L1(Lin, Imada and Kuhl, 2011).

So, reffering to the LEAP-Q, it can be seen that at SOA 80 there was only a two-way interaction of Root Type frequency and L2 Age of acquisition. Participants with high L2 Age of acquisition were relatively unaffected by target root frequency, whereas those with low L2 Age of acquisition were slower as target root frequency increased. At SOA 80 primes are more visible to participants leading to larger interference effects for highly productive roots in participants with less L2 Age of acquisition. Again, if an increase in L2 Age of acquisition has a detrimental effect on the L1 Arabic lexicon, one could predict that interference would be higher in bilinguals with a larger Arabic lexicon.

Finally, at SOA 200 there is again significant priming in the Root+Semantic condition but no priming in the Root and Semantic conditions. However, the main effect of condition did not reach significance. What is surprising here is that at the longest SOA, where the primes are fully visible to participant we again fail to see semantic priming where there is no shared root. One possibility is that our semantic primes were not well chosen and did not have a strong relationship to the targets despite the care with which they were chosen. In order to test this possibility, I collected some semantic similarity ratings for prime-target pairs from 40 Arabic speakers who had not taken part in the study. Targets and primes were subdivided into four lists of 80 pairs of words. Each list had all target words occurring in one condition only, with an equal number of primes from each condition overall. Each list was rated by 10 Arabic native speakers using a scale from 1-9 (1 not related, 9 strongly related). The average ratings for each condition were Root+Semantic =7.3, Root = 5.2, Semantic = 6.2, and unrelated 2.0. An ANOVA showed a main effect of condition and post hoc pairwise comparisons showed that all conditions significantly differed from each other. These ratings do not explain the pattern of effects at any SOA and certainly not the pattern at SOA 200. If semantic relatedness was the only factor influencing priming then both Root+Semantic and Semantic priming should have facilitated RTs with Root priming showing a reduced effect. This is not what we observe.

A second possible explanation is related to the fan effect proposed in spreading activation models of semantic memory (Cohen& Kjeldsen,1987). The fan effect entails that the activation spreading from a representation is divided among the concepts it spreads to. In the present experiments if the semantic primes are associated with many different words, the semantic effect would be expected to be weaker or absent as observed. In the Root+Semantic condition, priming was found because the semantic representation of the target was pre-activated by the lexical activation from the overlapping root.

Final at SOA 200 we see an effect on RTs of a LEAP-Q factor related to Arabic: L1 informal. Interestingly, the effect of increased L1 informal learning is to slow RTs to Arabic words when primes are visible. The informal learning factor is related to Arabic language experience from radio and TV rather than with experience with the written form of Arabic. This suggests that not all forms of language experience will be beneficial in all tests of language processing.

In summary, my experiments partially replicated the previous findings in the literature. At SOA 50 we observe facilitation from root overlap independent of semantic overlap. At SOA 200 we observe Root priming but only for semantically transparent pairs. In addition, I observed effects of bilingual factors related to L2 proficiency and L2 Age of acquisition, especially at the early SOAs. These L2 proficiency factors interacted with the root frequency of the target and are consistent with detrimental effects of second language proficiency on the very early stages of first language processing. Effects of bilingual factors related to L1 were limited to SOA 200 when primes were fully visible to participants.

Chapter 5

Arabic to English morphological and translation priming

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5.1 Introduction

Evidence suggests that when bilingual individuals read in one language their other language is activated automatically and current models propose that bilingual lexicons are heavily interconnected (Kroll, Bobb & Hoshino 2014; Kroll & Hermans, 2011). The nature of the relationship between L1 and L2 has been linked to language proficiency. The suggestion is that the recognition of L2 words in less proficient L2 users involves the activation of the L1 translation in order to access meaning. In other words, there are stronger lexical links from L2 to L1 in less proficient L2 users. In contrast, for more proficient L2 users, such transfer via the L1 is no longer necessary as direct links to meaning have been developed. This shift from L1 lexical mediation to direct conceptual access was captured by the RHM (see Kroll & Hermans, 2011; and MacWhinney, 2005, for reviews). As reviewed in Chapter 2, the RHM predicts that because words in L1 have direct links to meaning, translation from L1 to L2 will be conceptually mediated. However, translation from L2 to L1 may show signs of direct lexical-to-lexical connections and therefore be less influenced by semantic factors, especially for less proficient L2 language users. Evidence consistent with this hypothesis has come from studies showing semantic effects in L1-L2 translation but not L2-L1 translation (e.g. Kroll & Stewart, 1994) and evidence of activation of the form of translation equivalents only in less proficient L2 users (Sunderman & Kroll, 2006).

Evidence for the predictions of the RHM also comes from masked translation priming, which has been shown to be stronger for L2–L1 priming than for L1–L2 priming. Indeed L1-L2 translation priming for lexical decision is often nonsignificant except for cognate words (e.g. de Groot & Nas, 1991; Sanchez-Casas et al., 1992). However, significant effects of L1-L2 masked translation priming on lexical decision for non-cognate pairs have been shown in languages with different scripts, such as Hebrew (Gollan et al., 1997) and Korean (Kim & Davis, 2003). These studies are still the exceptions as most of the research on cross-language lexical activation has looked at European bilinguals (e.g. Kroll & Hermans, 2011).

The focus of this Chapter is on the effect of L1 Arabic primes on lexical decisions to L2 English words. The experiments reported here test translation and morphological priming in Arabic-English bilinguals. These languages come from different families (Semitic/Indo-European) and therefore have very different phonetic scripts read in different directions (e.g., reading/قراءة , see Chapter 1). The aim was to investigate the relationship between L1 and L2 lexicons in Arabic & English bilinguals. In particular I wished to see whether the morphological structure of L1 Arabic influences lexical activation of L2 English and to investigate the relationship between morphological and semantic overlap. In these experiments, we measured lexical decision responses to English target words following Arabic primes. The related Arabic primes were the translation equivalents of the English target words or were morphologically and/or semantically related to translations of the English targets (see Table 15).

Effects of cross-language semantic primes have been observed but only for visible primes (e.g. Basnight-Brown & Altarriba, 2007). Research into monolingual speakers also shows that semantic priming is absent in the masked design (Forster & Davis, 1984). One possibility is that masked translation priming occurs via direct lexical connections between the pairs, without access to semantic representations (de Groot & Nas, 1991). However, the translation priming effect has also been explained in terms of semantic overlap (de Groot & Nas, 1991) as both semantic and translation word pairs share similar conceptual features.

In the present study I expected to replicate the effect of early translation priming shown in languages with different scripts but not yet shown in Arabic. Since Arabic is a semitic language, I expect the results to be similar to that of Hebrew (Gollan,1997). In addition, I will look for effects of morphological and semantic relationships between the words in each language. I will also investigate effects of bilingual status on any priming effects observed. An example of an experimental word set is given in Table 15. The English target word here is *quiet*. This target has four primes. In the first condition the prime shares both the Root+Semantics of the Arabic translation of the English target. In the second condition the prime shares only the root of the Arabic translation of the English target. In the third condition the prime is the Arabic translation of the English target. In the final condition the prime is a morphologically and semantically unrelated word. The effect of these primes was investigated at the same three SOAs as were tested in Experiments 1 to 3: namely SOA 50, 80 and 200.

Table 15. An example of an English Target word with its associated Arabic prime words in each of the four priming conditions of Experiments 4-6. The Arabic word is shown along with its phonetic transcription, English translation and the gloss of its word pattern. The root shared by the target and the primes in the Root+Semantic and Root conditions is also shown.

Prime				Target	Shared root
Root+Semantic	**Root-Semantic**	**Arabic Translation**	**Unrelated**		
مُسَكِّنٌ	سَكَنٌ	ساكنةٌ	مُستشارٌ	quiet	S k n
[musakin uən]	[sakan uən]	[s aəkenat uən]	[must aə r̂ ar uən]		
painkiller	house	quiet	advisor		
Noun, Masculine, Plural	Noun, Masculine, Plural	Noun, Masculine, Plural	Noun, Masculine, Plural		

5.2 Methods: Experiments 4 to 6

5.2.1 *Participants.*

The same 208 participants were tested as in the Leap-Q study and in the Arabic Experiments 1-3, reported in Chapter 3. The same groups of participants were assigned to the same SOA in both the Arabic and English experiments. All participants completed the Arabic experiments prior to taking part in the English version following a short break.

5.2.2 *Materials*

The experimental materials consisted of 80 sets of four Arabic prime words and one English target word (see Table 15 and Appendix A). The English target words were the translation of the Arabic target words tested in Experiments 1-3. The English target words came from a range of grammatical classes, with roughly equal numbers in each grammatical class: verbs (n=25), nouns (n=33) and adjectives (n= 22).

Each English target word was associated with four Arabic prime words. The prime words in the Root+Semantic and Root conditions were identical to those used as primes in Experiments 1-3. The new set of primes contained the Arabic translation of the English words. A new set of unrelated Arabic primes was also selected, which were selected randomly from the other Arabic conditions. The English target words were checked with an Arabic linguist to ensure that the translation was correct. The frequency of the English target words was calculated using N-Watch, which is based on the CELEX database (Davis, 2005). The mean frequency and number of letters of the English target words is shown in Table 16, along with the lexical characteristics of the Arabic primes. These were well matched except for the orthographic frequency of the translation primes, which was lower than the other prime conditions.

Table 16. The lexical statistics for the English targets and the Arabic prime word sets.

	Target Frequency	Letters	Phonemes	Orthographic Frequency	Root Frequency	Word pattern Frequency
Target	104.7	6.7	-	-	-	-
Prime						
Root+ Semantic		4.7	8.4	19.7	23.5	444.6
Root		4.5	8.2	21.5	23.2	453.6
Translation		4.7	8.7	6.0	23.7	452.7
Unrelated		4.7	8.3	22.4	22.7	470.9

5.2.3 *Design & Procedure*

The main experimental design was the same as for Experiments 1-3 reported in Chapter 4, except that the Semantic priming condition was replaced by the Translation priming condition. The procedure was also the same, except that all the instructions were presented in English. The timing of prime and target presentations across the three experiments (Experiments 4-6) was identical to that of Experiments 1-3 (See Figure 9).

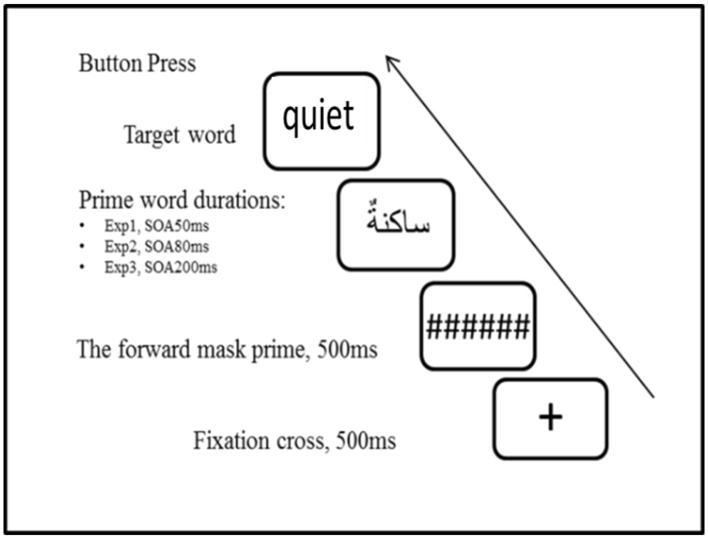

Figure 9. The timing of events on trials for Experiments 4 to 6. The English experiments used the same SOAs has the Arabic experiments.

5.3 Results

The results from the same 190 participants that were analysed in Chapters 3 and 4 were included in the analyses of the English target data: 66 for SOA 50ms, 66 for SOA 80ms and 58 for SOA 200ms. The target data were subjected to the same minimal trim such that trials with RTs less than 300ms and over 1500ms were removed. This resulted in the loss of only 28 data points (< 1%). Only correct trials were included in the RT analyses. The RT and percentage error rates per condition are shown in Table 15.

Table 17. Means for lexical decisions in each condition are shown for English Experiments 4 to 6: Reaction times (in milliseconds) and percent error rates.

	SOA50		SOA 80		SOA 200	
Priming condition	**RT**	**% error**	**RT**	**% error**	**RT**	**% error**
Root +Semantic	820	13.3	734	13.6	715	14.8
Root	827	15.3	753	12.4	739	15.4
Translation	807	12.6	739	11.6	718	13.4
Unrelated	825	16.4	769	13.7	755	14.9

As with Experiments 1-3, linear mixed effect models were run including Condition as a fixed effect (dummy coded with the unrelated condition as the intercept) and the LEAP-Q factors as continuous variables. Two target variables and two prime variables were included as continuous factors crossed with condition and the LEAP-Q factors. For the English targets, word frequency and word length in terms of number of letters were included. For the Arabic prime words log root-type frequency and log orthographic frequency were included. All continuous variables were centred. The models were reduced using the same procedure as outlined in Chapter 4. Reaction time models were again run on log RTs. I report the models for each SOA independently below.

5.3.1 *Experiment 5: SOA 50, Results*

The maximal model for the SOA 50 RT data set converged with both items and subjects in the random structure and only subjects crossed with condition. The minimal model with the same random structure is shown in in Table 17. As can be seen the (5ms) facilitation effect of priming in the Root+Semantics condition did not reach significant. The effect of priming in the Root condition (-2ms) was also insignificant. However, there was a significant effect of priming (18ms) in the Translation condition. The ANOVA of the model output yielded a significant effect of Condition ($p < .01$). To test for significant differences between Translation priming and the other priming conditions the model was rerun with the Translation condition coded as the intercept. Against translations, Root+Semantic primes showed a borderline significant effect ($t = 1.9$) and Root priming showed a significant effect ($t = 2.8$), indicating that translation primes facilitated target word processing significantly more than Root and Root+Semantic primes.

The only significant effect of the LEAP-Q Factors was L2 Proficiency. Unsurprisingly, RT decreased as L2 Proficiency increased (see Figure 10). There were no significant main effects of the lexical variables for the prime and target word.

Table 18. The minimal model output for Experiment 4. English targets at SOA 50ms.

Fixed effects	Estimate	Std. Error	t value
(Intercept)	6.696e+00	1.615e-02	414.7
Priming conditions			
Root+ semantic	-1.169e-02	9.660e-03	-1.2
Root	-1.053e-0	9.905e-03	-0.1
Translation	-2.936e-02	9.905e-03	-3.0*
Leap-Q factors			
L2 Age of acquisition	-2.149e-02	1.417e-02	-1.5
L1 Formal Learning	-3.425e-03	1.451e-02	-0.2
L2 Exposure	5.488e-03	1.507e-02	0.4
L2 Accent	-1.072e-04	1.809e-02	0.0
L2 Formal Learning	1.127e-02	1.319e-02	0.9
L2 Proficiency	-4.605e-02	1.394e-02	-3.3*
L1 Informal Learning	-1.001e-02	1.455e-02	-0.7
L2 Informal Learning	-2.814e-03	1.238e-02	-0.2
Lexical variables			
Target Letters	7.306e-03	6.221e-03	1.2
Prime Root Frequency	1.736e-02	1.345e-02	1.3
Log Target Frequency	-6.592e-03	7.559e-03	-0.9
Prime Orthographic Frequency	-1.706e-03	2.757e-03	-0.6
Condition specific effects			
Translation: L2.learning duration	7.623e-04	1.005e-02	0.1
Translation: Target Letters	-1.825e-03	5.479e-03	-0.3
Translation: L1 Formal Learning	-7.747e-03	1.005e-02	-0.8
Translation: Prime Root Type Frequency	-4.615e-03	2.131e-02	-0.2
Translation: Log Target Frequency	-7.967e-03	6.668e-03	-1.2
Translation: L2 Exposure	4.059e-03	1.091e-02	0.4
Translation: L2 Accent	-1.032e-02	1.275e-02	-0.8
Translation: L2 Formal Learning	4.131e-03	9.497e-03	0.4
Translation: L2 Proficiency	2.259e-02	9.786e-03	2.3*
Translation: L2 Informal Learning	8.918e-03	8.627e-03	1.0

Translation: L2 Age of acquisition: Target Letters	9.144e-03	4.053e-03	2.3*
Translation: L1 Formal Learning: Prime Root Type Frequency	2.991e-03	1.678e-02	0.2
Translation:L1 Formal Learning:Log Target Frequency	1.270e-02	5.135e-03	2.5*
Translation: L2 Exposure Prime Root Type Frequency	-1.744e-02	1.904e-02	-0.9
Translation: L2 Accent : Log Target Frequency	-1.723e-02	8.351e-03	-2.1*
Translation: L2 Accent : Target letters	-1.666e-02	6.684e-03	-2.5*
Translation: L2 Formal Learning: Target letters	-9.135e-03	4.160e-03	-2.2*
Root+Semantic: L2 Age of acquisition	8.011e-05	9.925e-03	0.0
Root+Semantic: Target Letters	7.597e-04	5.468e-03	0.1
Root+Semantic: L1 Formal Learning	-8.073e-03	9.954e-03	-0.8
Root+Semantic: Prime Root Type Frequency	-2.690e-02	2.187e-02	-1.2
Root+Semantic : Log Target Frequency	-8.976e-04	6.638e-03	-0.1
Root+Semantic: L2 Exposure	-6.740e-04	1.076e-02	-0.1
Root+Semantic: L2 Accent	-6.494e-03	1.255e-02	-0.5
Root+Semantic: L2 Formal Learning	8.440e-04	9.429e-03	0.1
Root+Semantic: L2 Proficiency	1.357e-02	9.606e-03	1.4
Root+Semantic: L2 Informal Learning	-6.297e-03	8.672e-03	-0.7
Root+Semantic: L2 Age of acquisition: Target Letters	1.714e-03	3.928e-03	0.4
Root+Semantic: L1 Formal Learning: Prime Root Type Frequency	-3.471e-02	1.811e-02	-1.9
Root+Semantic: L1 Formal Learning: Log Target Frequency	1.142e-02	5.042e-03	2.3*
Root+Semantic: L1 Formal Learning: Log Target Frequency	8.428e-03	5.109e-03	1.6
Root+Semantic: L2 Exposure : Prime Root Type Frequency	2.801e-02	1.866e-02	1.5
Root+Semantic: L2 Accent : Log Target Frequency	-1.327e-02	8.394e-03	-1.6
Root+Semantic: L2 Accent : Target letters	-9.495e-03	6.636e-03	-1.4
Root+Semantic: L2 Formal Learning : Target letters	-3.687e-04	4.348e-03	-0.1
Root: Target Letters	1.171e-04	5.490e-03	0.0
Root: L1 Formal Learning	-2.284e-02	1.015e-02	-2.2*
Root: Prime Root Type Frequency	-5.859e-03	2.134e-02	-0.3
Root: Log Target Frequency	-5.025e-03	6.829e-03	-0.7
Root: L2 Exposure	-4.884e-03	1.098e-02	-0.4
Root: L2 Accent	-4.378e-02	1.294e-02	-3.4*
Root: L2 Formal Learning	6.665e-03	9.632e-03	0.7
Root: L2 Proficiency	2.780e-02	1.006e-02	2.8*
Root: L2 Informal Learning	-1.354e-02	8.813e-03	-1.5
Root: L2 Age of acquisition: Target Letters	-1.346e-03	4.104e-03	-0.3
Root: L1 Formal Learning: Prime Root Type Frequency	1.704e-02	1.703e-02	1.0
Root: L2 Exposure: Prime Root Type Frequency	-2.209e-02	1.800e-02	-1.2
Root: L2 Accent: Log Target Frequency	-1.952e-02	8.633e-03	-2.3*
Root: L2 Accent :Target letters	-1.319e-02	6.828e-03	-1.9
Root : L2 Formal Learning :Target letters	7.759e-05	4.111e-03	0.0
Leap-Q specific effects			
L2 Age of acquisition: Target Letters	-2.128e-03	2.999e-03	-0.7
L1 Formal Learning: Prime Root Type Frequency	6.707e-03	1.153e-02	0.6
L1 Formal Learning: Log Target Frequency	-7.564e-03	3.637e-03	-2.1*
L2 Exposure : Prime Root Type Frequency	1.457e-02	1.274e-02	1.1
L2 Accent : Log Target Frequency	1.798e-02	5.924e-03	3.0
L2 Accent : Target Letters	1.139e-02	4.626e-03	2.5*
L2 Formal Learning : Target Letters	1.710e-03	3.124e-03	0.5
L2 Proficiency : Prime Root Type Frequency	1.411e-02	6.421e-03	2.2*
L1 Informal Learning :Target Letters	4.270e-03	1.516e-03	2.8*
L2 Age of acquisition: Log Target Frequency	3.324e-03	2.277e-03	1.5
L2 Age of acquisition: Prime Root Type Frequency	-1.018e-02	6.359e-03	-1.6
L2 Exposure :Target Letters	2.531e-03	1.595e-03	1.6
L2 Formal Learning: Prime Orthographic Frequency	4.315e-03	2.216e-03	1.9

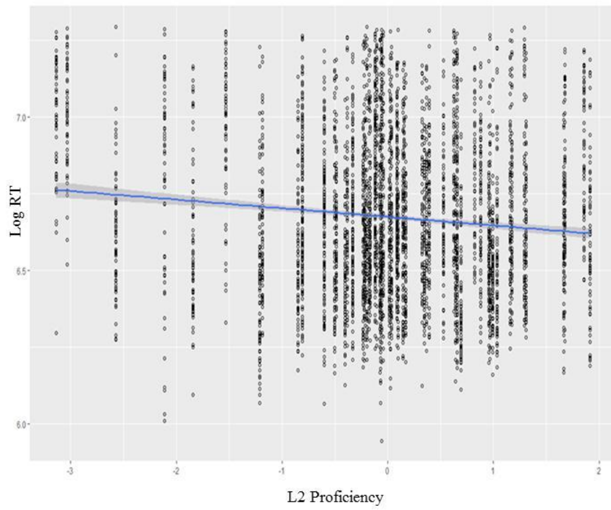

Figure 10. Experiment 4, English SOA 50: The effect on RT of L2 Proficiency. Results are shown for Log RT against the centred lexical variable.

The ANOVA for the model output showed a number of significant interactions with condition. First L2 Proficiency interacted significantly with Condition (p < .05). This interaction is shown in Figure 11. As can be seen, the effect of priming for the low L2 Proficiency participants tends to be facilitatory while the facilitation is much reduced for high L2 Proficiency participants. As can be seen in Table 18, only Translation and Root priming show a significant effect of L2 Proficiency on RTs. As can be seen in the regression plot, L2 Proficiency has a smaller effect on RTs in these two conditions, when compared to the effect on the unrelated baseline condition. In general, therefore the only facilitation is seen in the low proficiency participants.

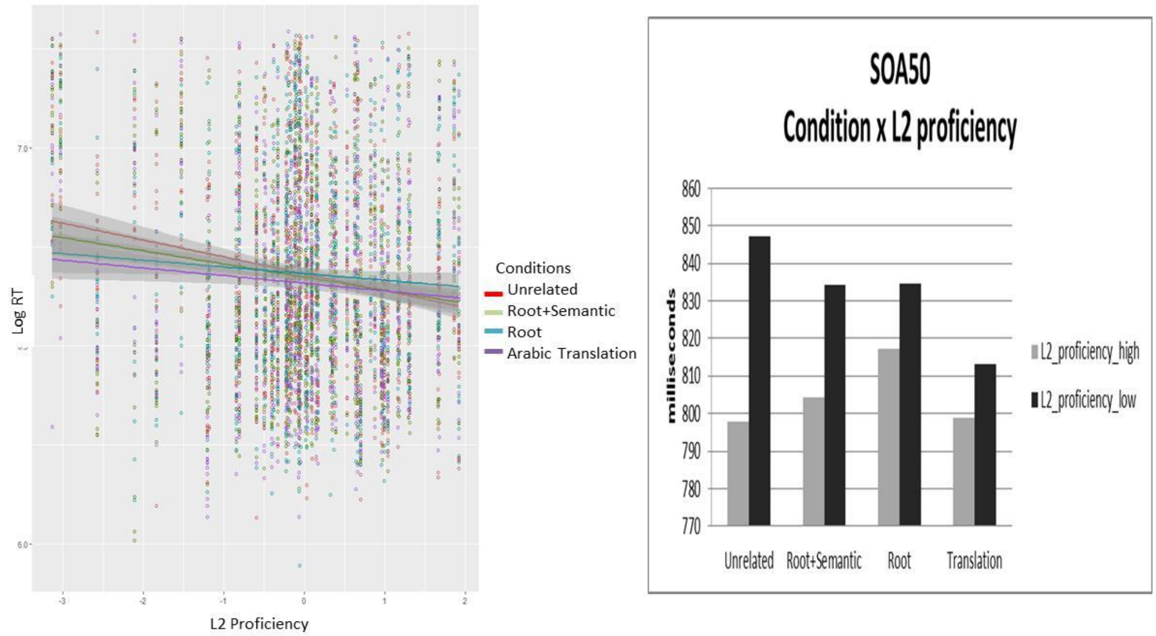

Figure 11. Experiment 4, English SOA 50: The effect on RT of L2 Proficiency in the four priming conditions. Results are shown for Log RT against the centred variable in the regression plot (based on model output). For illustration purposes only, the histogram shows a median split of the variable of interest on raw RTs.

There was also a significant three-way interaction of Condition with Target letters and L2 Formal learning ($p < .05$). This interaction is shown in Figure 12. Overall, as expected, RTs increase with target length. As can be seen in Table 18, only the Translation condition shows a significant interaction of L2 Formal learning and Target letters. The effect of translation priming is to increase the effect of target word length but only for low L2 Formal learning participants.

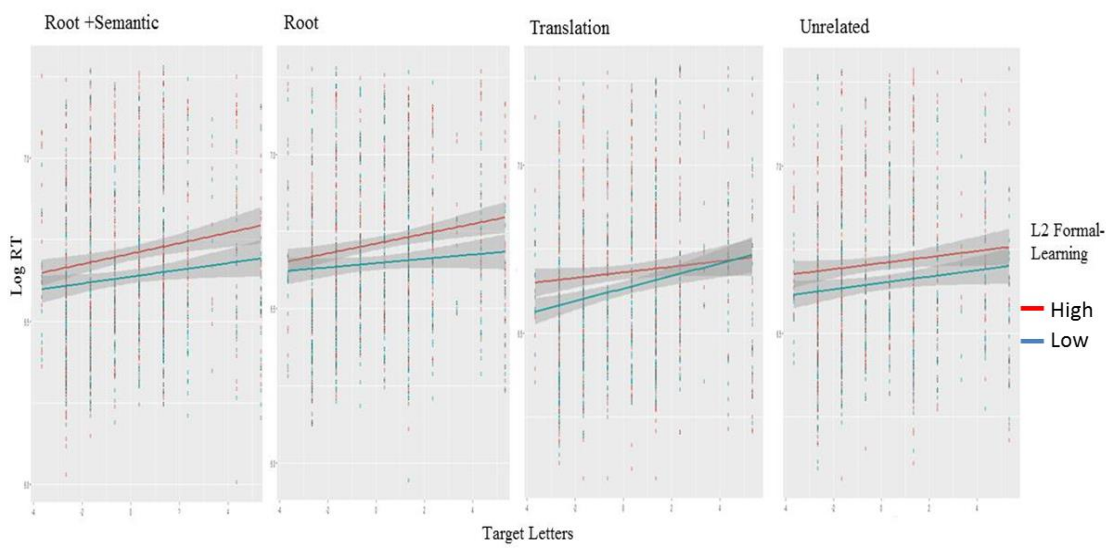

Figure 12. Experiment 4, English SOA 50: The effect on RT of Target letters for L2 Formal learning in the four priming conditions. Results show the effect on RT of Target letters for participants with high and low levels of L2 Formal learning.

There was also a significant interaction between L1 Formal learning and Prime root frequency ($p < .05$). This interaction is shown below (Figure 13). In general RTs were faster as Prime root frequency increased. This pattern was observed throughout for participants with high L1 Formal learning. In contrast the same pattern was observed for low L1 Formal leaning participants only in the three related priming conditions. Table 18 shows that none of the individual interactions with Condition were significant. In general, this pattern is consistent with more interference from higher-frequency unrelated roots (i.e. in the unrelated primes) for participant with lower Arabic formal learning.

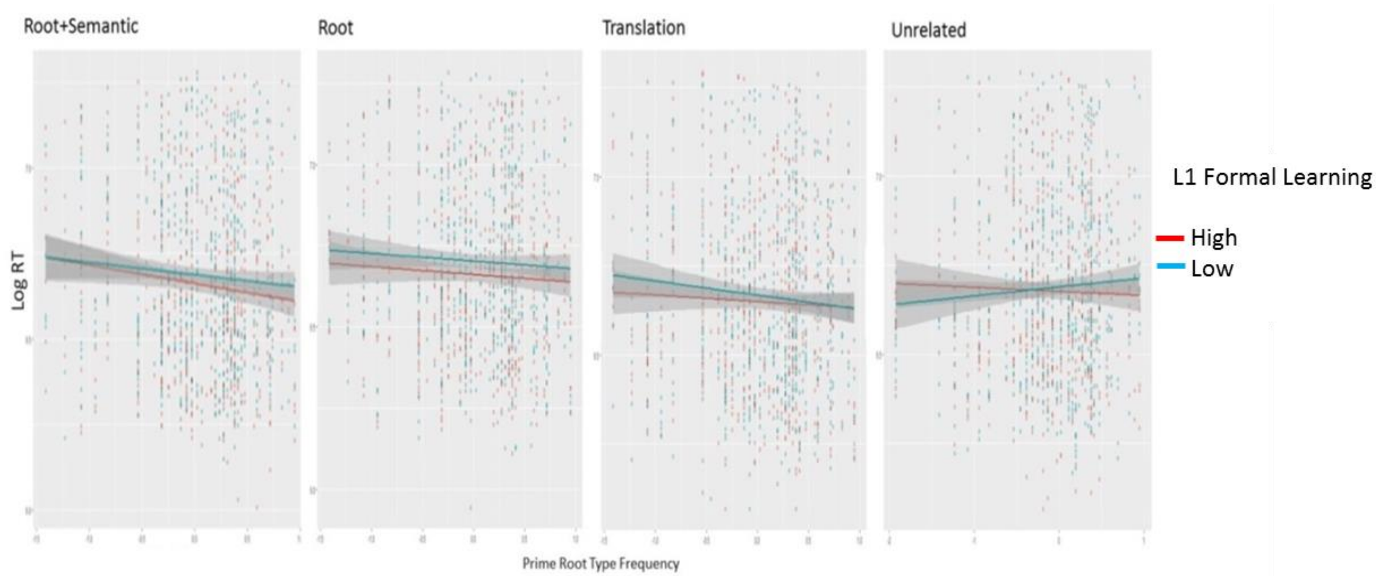

Figure 13. Experiment 4, English SOA 50: The effect on RT of Prime root frequency words for L1 Formal learning in the four priming conditions. Results show the effect on RT of Prime root frequency for participants with high and low L2 Formal learning.

There was also a significant three-way interaction of Condition with Prime root frequency and L2 Exposure ($p < .05$). This interaction is shown in Figure 14. In general RT tended to decrease when prime root frequency increased, except for the high L2 Exposure participants in the unrelated condition. The effect may again be due to increased interference from high-frequency unrelated Arabic primes in the high exposure English participants. However, none of the individual priming conditions showed a significant interaction (see Table 18).

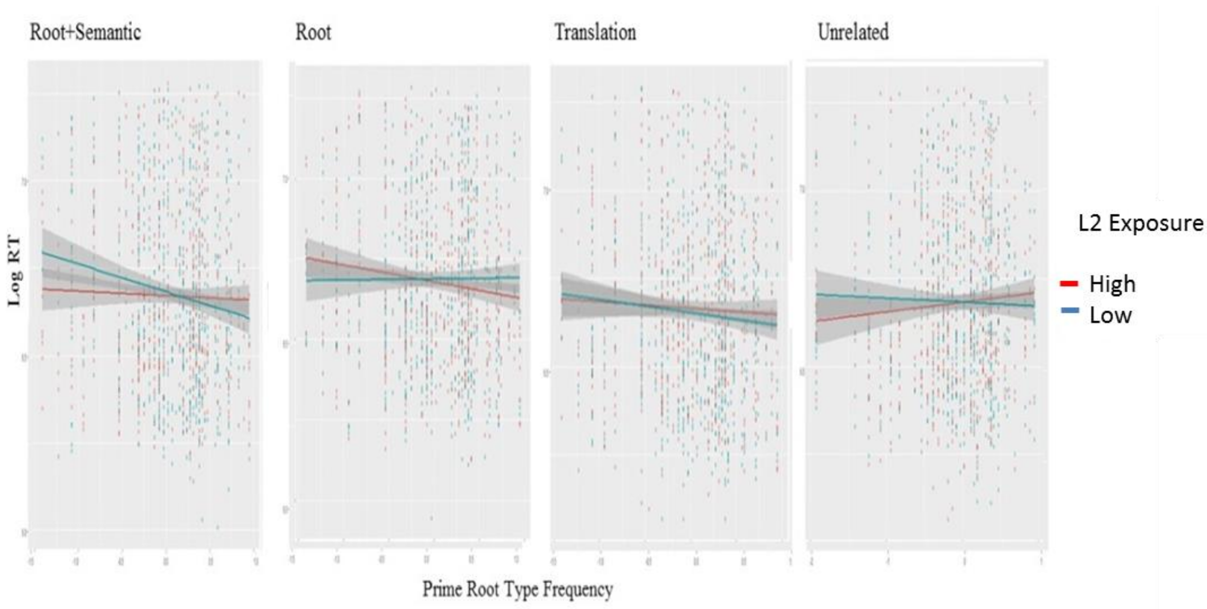

Figure 14. Experiment 4, English SOA 50: The effect on RT of Prime root frequency words for L2 Exposure in the four priming conditions. Results show the effect on RT of Prime root frequency for participants with high and low L2 Exposure.

There were a number of significant interactions within each priming condition (Table 18). Starting with Translation priming, there were two interactions with the length of the target word in letters (see Figure 15). In general, RTs to the English targets increased with length, except for participants with high L2 Age of acquisition in the unrelated condition, i.e. those participants with later acquisition of English. Target length also interacted with L2 Accent in the translation priming condition (see Figure 15). This interaction is not large and is difficult to interpret. In general the effect of translation priming seems to be to speed responses mainly for the participants with better L2 Accents.

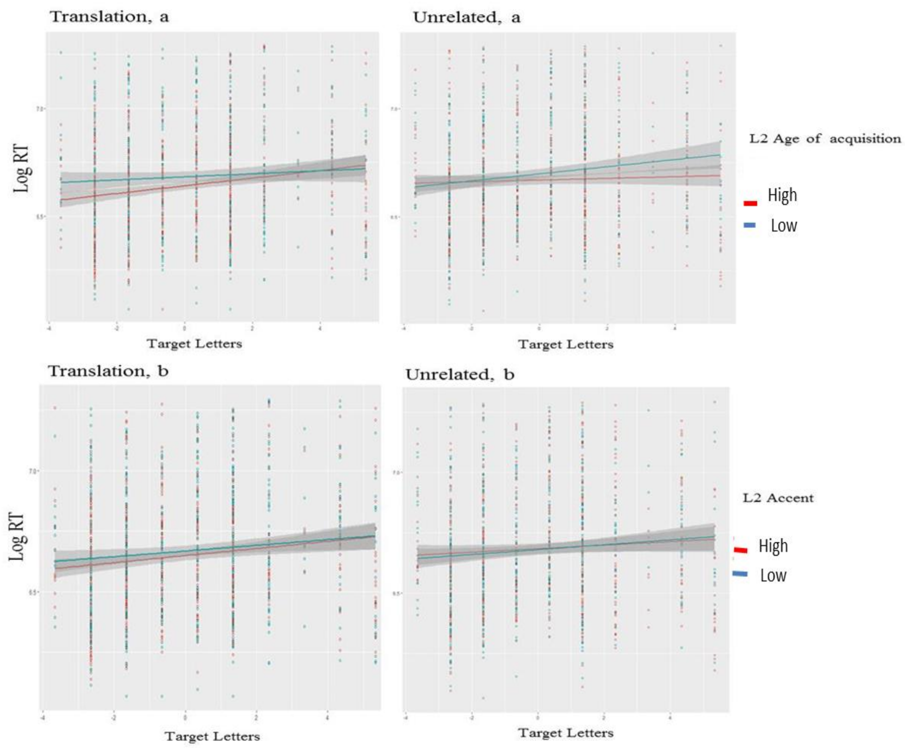

Figure15. Experiment 4, English SOA 50 Translation: The effect on RTs of target length is shown across L2 Age of acquisition in panels a and L2 Accent in panels b.

Translation priming also showed two interactions with Target frequency. As we can see in Figure 16, translation priming increased the effect of target frequency but only for the participants with low L1 Formal learning (panel a). The effect of target frequency was larger mainly for the high Accent participants in the translation priming condition (panel b) than in the unrelated condition (panel b).

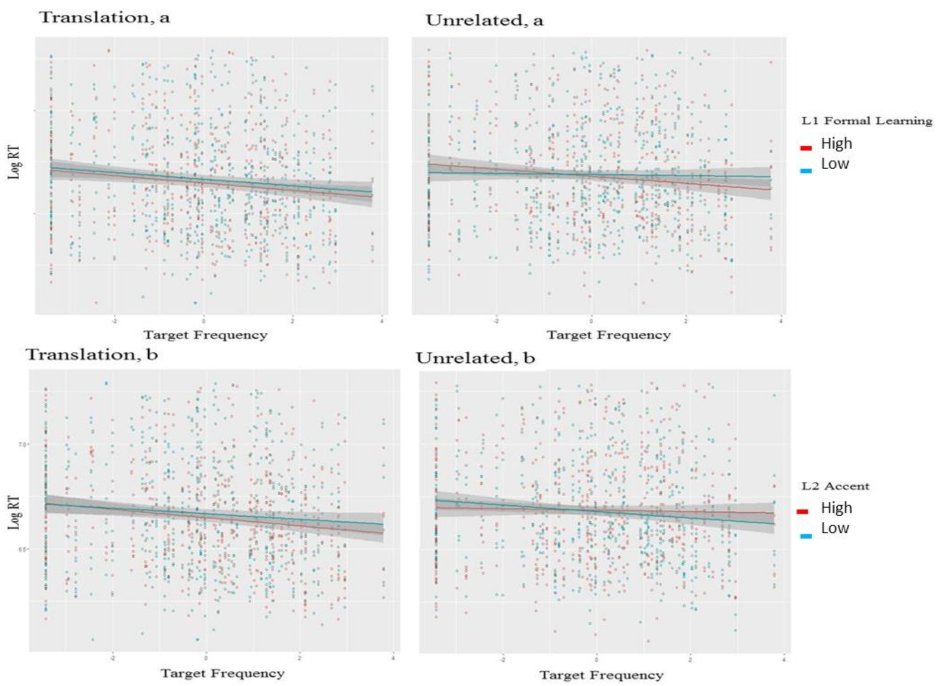

Figure16. Experiment 4, English SOA 50 Translation: The effect on RTs of target frequency is shown across L1 Formal learning (panels a) and L2 Accent (panels b).

Root+Semantic priming also showed a significant negative relationship with L1 Formal learning (see Table 18). As can be seen in Figure 17, priming increased the effect of target word frequency compared to the unrelated condition but only for the participants with low L1 Formal learning.

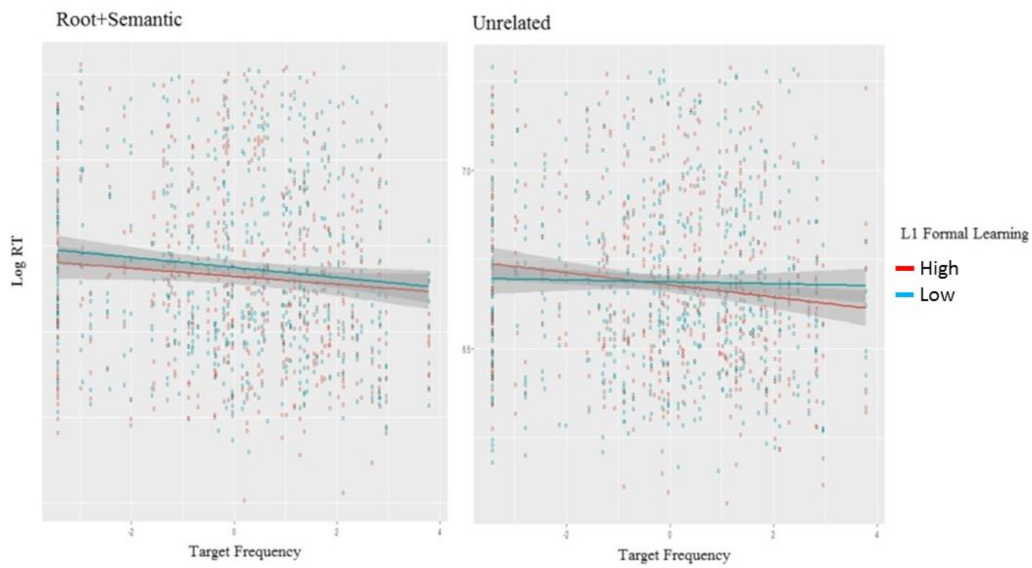

Figure 17. Experiment 4, English SOA 50 Root+Semantic: The effect on RTs of target frequency is shown across L1 Formal learning.

Root priming showed significant effects of L1 Formal learning and L2 Accent. Increased L1 Formal learning is associated with a decrease in RTs in the primed compared to the unrelated condition (see Figure 18a). A similar pattern is observed for L2 Accent (see Figure 18b).

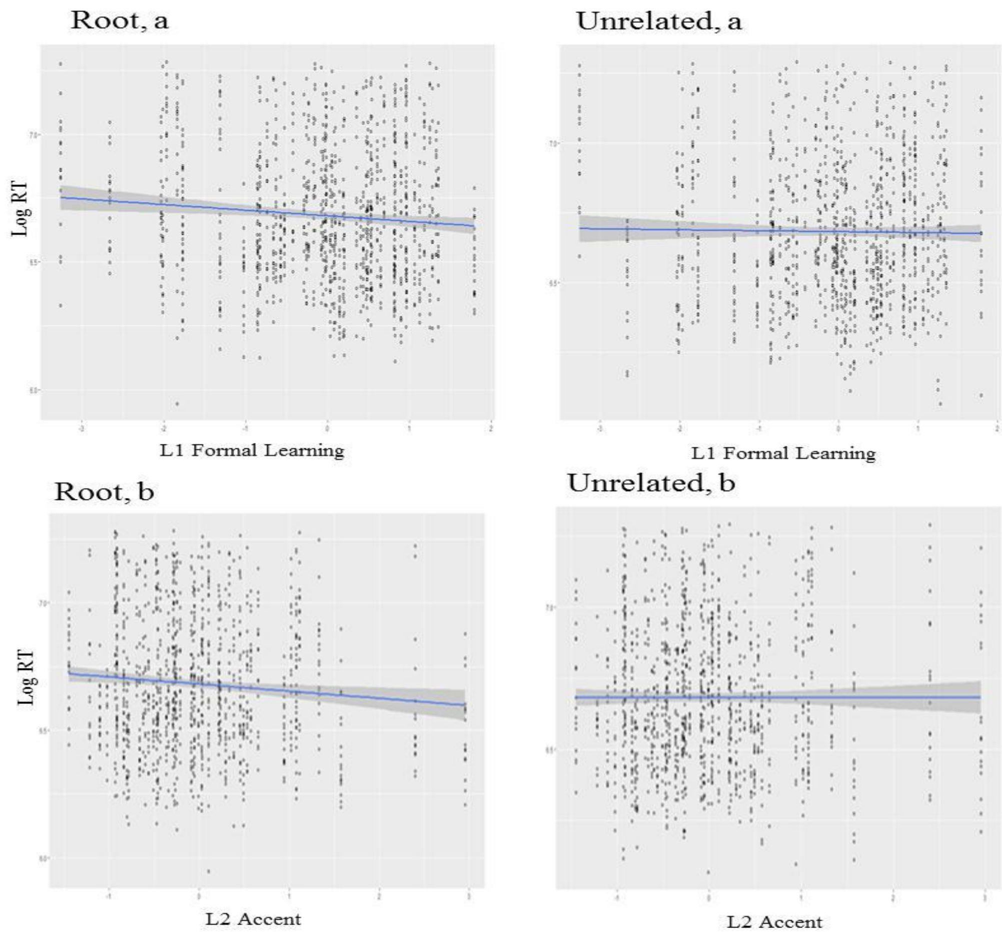

Figure 18. Experiment 4, English SOA 50 (Root): The main effects on RT of L1 Formal Learning in panels a and of L2 Accent in panels b.

RTs in the Root priming condition also showed a significant interaction of Target Frequency with L2 Accent (see Figure 19). Similar to previous effects, the effect of target frequency increased in the root priming condition for participants with a higher L2 Accent score.

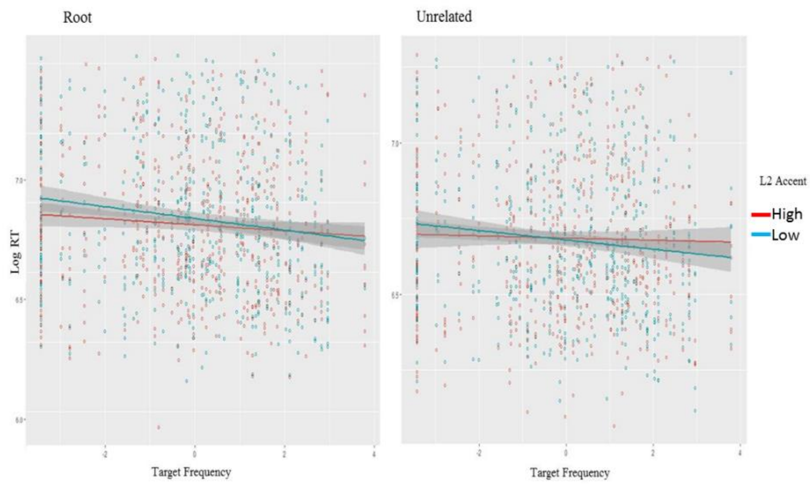

Figure 19. Experiment 4, English SOA 50 (Root): The effect on RT of Target Frequency for high and low L2 Accent.

Finally, there were a number of additional significant interactions between the LEAP-Q factors and the lexical variables that did not occur in interactions with condition. The effect of increasing Prime root frequency was again to speed RTs and this effect was slightly larger in the case of low L2 Proficiency participants (Figure 20a). Target word length interacted with L2 Informal learning (Figure 20b) as participants with higher L2 Informal learning showed a stronger effect of target length. These effects fit with the general pattern that high LEAP-Q factors in a given language are associated with stronger effects of lexical variables in the language.

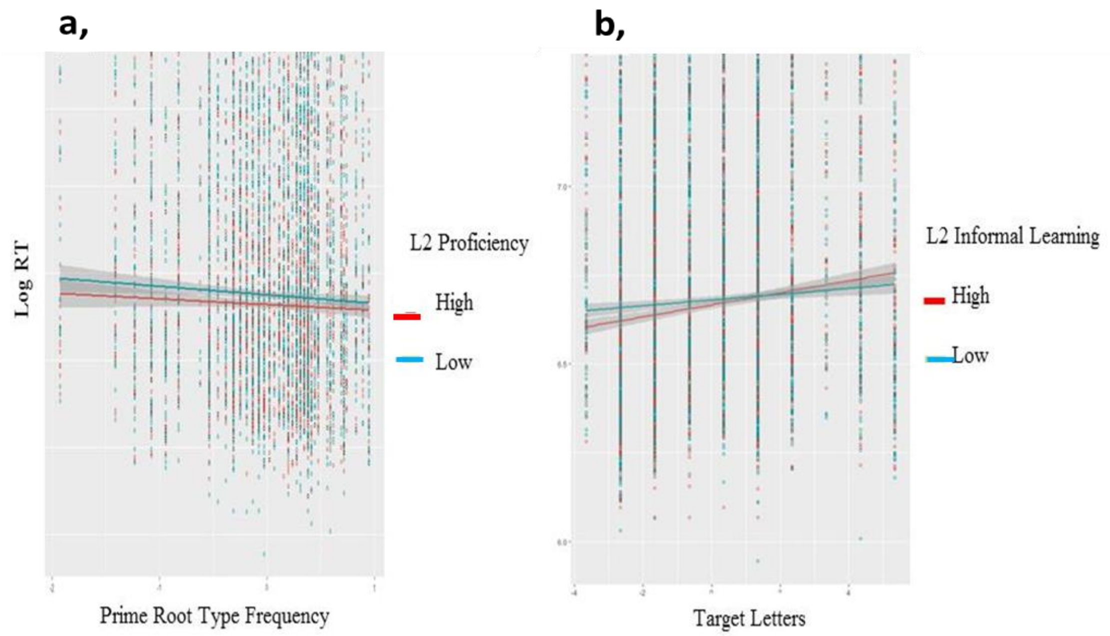

Figure 20. Experiment 4, English SOA 50: Two-way interaction effects between the LEAP-Q factor and the lexical variable.

A logit analysis of percentage error rates was run using glmer for binomial data. No full model of the data converged. The minimal model taken from the RTs also failed to converge for the error data. Only the minimal model including condition in the fixed effects and items and subjects as random factors converged. The output is shown in Table 19. Both Root+Semantic and Translation priming significantly reduced error rates.

Table 19. The minimal model output for error rates at English SOA 50.

Fixed effects:	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.88382	0.13404	-14.054	< 2e-16 ***
Root+ semantic	-0.26148	0.11433	-2.287	0.02219 *
Root	-0.08206	0.11126	-0.738	0.46077
Translation	-0.33963	0.11578	-2.933	0.00335 **

5.3.2 Experiment 5: SOA 80, Results

The maximal model for the SOA 80 RT data set converged with both items and subjects in the random structure and only subjects crossed with condition. The minimal model with the same random structure is shown in Table 20. As can be seen the facilitation effect of priming in the Root+Semantics condition (35ms) was significant. The effect of priming in the Root condition (16ms) and the Translation condition (30ms) were also significant. The ANOVA of the model output yielded a significant effect of Condition ($p < .001$). To test for significant differences between Root priming and the other priming conditions the model was rerun with the Root condition coded as the intercept. Compared to Root priming, both Root+Semantic (t = -2.5) and Translation priming showed a significant effect (t = -2.5).

Table 20. The minimal model output for Log RTs at SOA 80ms

Fixed effects	Estimat	Std. Error	t value
(Intercept)	6.6212025	0.0165990	398.9
Priming conditions			
Root+semantic	-0.0452008	0.0096845	-4.7*
Root	-0.0228624	0.0091332	-2.5*
Arabic Translation	-0.0515061	0.0094845	-5.4*
Leap-Q factors			
L2 Proficiency	-0.0105719	0.0150981	-0.7
L2 Learning dur	0.0024019	0.0130199	0.2
L2 Exposure	0.0100803	0.0122628	0.8
L2 Informal Learning	-0.0107469	0.0133199	-0.8
L2 Accent	0.0137307	0.0124164	1.1
L2 Formal Learning	0.0334018	0.0144378	2.3*
L1 Formal Learning	-0.0170101	0.0112413	-1.5
Lexical variables			
Log Target Frequency	-0.0145406	0.0087377	-1.7
Target Letters	0.0128806	0.0071660	1.8
Prime Orthographic Frequency	0.0018832	0.0050583	0.4
Prime Root Type Frequency	-0.0055219	0.0093054	-0.6
Condition specific interactions			
Translation: L2 Proficiency	-0.0041076	0.0103081	-0.4
Translation : Target Letters	-0.0010621	0.0050796	-0.2
Translation : L2 Learning duration	0.0189731	0.0094778	2.0*
Translation : Prime Orthographic Frequency	-0.0094366	0.0081882	-1.2
Translation : L2 Informal Learning	-0.0068227	0.0094692	-0.7
Translation : L2 Exposure	-0.0142298	0.0084500	-1.7
Translation: L2 Accent	-0.0014729	0.0087343	-0.2
Translation: L2 Proficiency: Log Target Frequency	-0.0084231	0.0072562	-1.2

Translation: L2 Proficiency: Target letters	-0.0098699	0.0058145	-1.7
Translation: L2 Age of acquisition : Prime Orthographic Frequency	0.0134429	0.0069535	1.9
Translation : L2 Exposure: Log Target Frequency	0.0178894	0.0058938	3.0*
Translation : L2 Exposure :Target Letters	0.0117118	0.0046529	2.5*
Translation : L2 Informal Learning : Log Target Frequency	0.0137478	0.0051233	2.7*
Root+Semantic: L2 Proficiency	-0.0049170	0.0112717	-0.4
Root+Semantic: Target Letters	-0.0025873	0.0050697	-0.5
Root+Semantic :L2 Age of acquisition	0.0010174	0.0098837	0.1
Root+Semantic :Prime Orthographic Frequency	-0.0004916	0.0070199	-0.1
Root+Semantic :L2 Informal Learning	-0.0055963	0.0101852	-0.5
Root+Semantic :L2 Exposure	-0.0205958	0.0092093	-2.2*
Root+Semantic :L2 Accent	0.0084629	0.0095194	0.9
Root+Semantic: L2 Proficiency: Log Target Frequency	-0.0113602	0.0072735	-1.6
Root+Semantic :L2 Proficiency: Target letters	-0.0073580	0.0059512	-1.2
Root+Semantic:L2 Age of acquisition :Prime Orthographic Frequency	0.0131440	0.0060112	2.2 *
Root+Semantic : L2 Exposure: Log Target Frequency	0.0164988	0.0058121	2.8 *
Root+Semantic: L2 Exposure : Target Letters	0.0089362	0.0046142	1.9
Root+Semantic: L2 Informal Learning: Log Target Frequency	0.0065159	0.0050365	1.3
Root:L2 Proficiency	0.0015889	0.0105892	0.2
Root :Target Letters	-0.0004979	0.0050699	-0.1
Root :L2 Learning duration	0.0014629	0.0094231	0.2
Root: Prime Orthographic Frequency	0.0040127	0.0068993	0.6
Root :L2 Informal Learning	-0.0087345	0.0094717	-0.9
Root : L2 Exposure	-0.0010518	0.0086485	-0.1
Root: L2 Accent	-0.0170424	0.0088758	-1.9
Root:L2 Proficiency: Log Target Frequency	-0.0226064	0.0072099	-3.1 *
Root: L2 Proficiency: Target letters	-0.0150354	0.0059158	-2.5 *
Root: L2 Age of acquisition :Prime Orthographic Frequency	0.0027415	0.0057019	0.5
Root: L2 Exposure: Log Target Frequency	0.0015848	0.0057788	0.3
Root: L2 Exposure : Target Letters	0.0027740	0.0046454	0.6
Root: L2 Informal Learning :Log Target Frequency	0.0035589	0.0049649	0.7
Leap-Q specific interactions			
L2 Proficiency: Log Target Frequency	0.0077607	0.0050866	1.5
L2 Proficiency: Target Letters	0.0066853	0.0040878	1.6
L2 Age of acquisition :Prime Orthographic Frequency	-0.0052381	0.0042701	-1.2
L2 Exposure : Log Target Frequency	-0.0043744	0.0041310	-1.1
L2 Exposure: Target Letters	-0.0022534	0.0032640	-0.7
L2 Accent : Target Letters	0.0025355	0.0013452	1.9
L2 Age of acquisition : Target Letters	-0.0030738	0.0018230	-1.7
L2 Proficiency: Prime Root Type Frequency	-0.0135059	0.0070561	-1.9
L2 Exposure: Prime Root Type Frequency	-0.0110092	0.0054092	-2.0 *
L2 Learning duration : Log Target Frequency	-0.0057134	0.0022255	-2.6*

There was a significant positive relationship between RT and L2 Formal learning. Surprisingly at this SOA, increased L2 Formal learning was associated with slower RTs. The lexical variables showed no significant main effects on RT.

The ANOVA on the model output again showed a number of significant interactions with Condition. L2 Accent interacted significantly with Condition ($p < .05$). This interaction is shown in Figure 21. As can be seen, the effect of higher levels of L2 Accent in the unrelated condition is to slow RTs. However, when primed this effect is reduced. As can be seen in Table 20 only Root priming shows a borderline significant effect of L2 Accent on RTs.

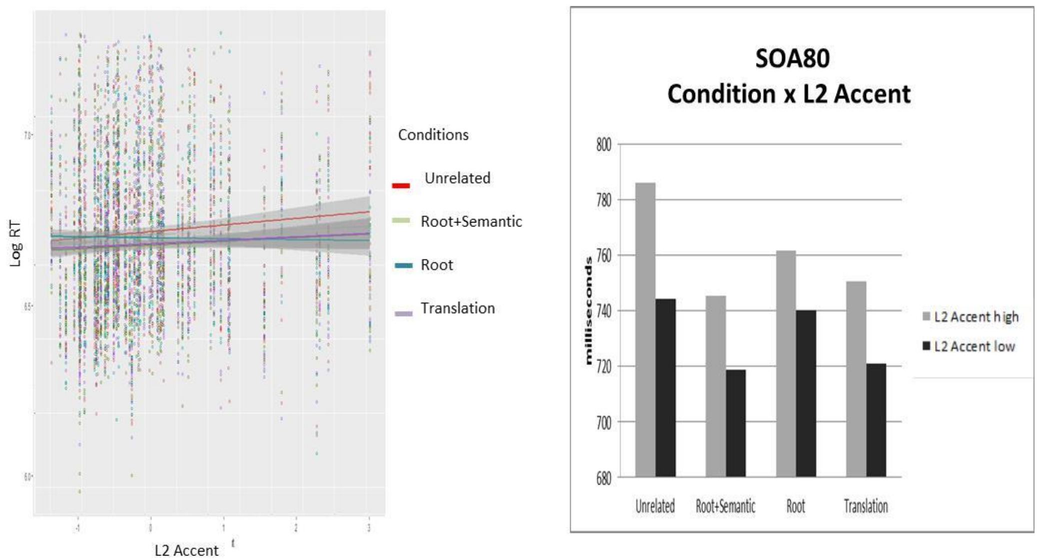

Figure 21. Experiment 5, English SOA 80: The effect on RT of L2 Accent for four conditions. Results show the effect on RT of L2 Accent on the four experimental conditions. For illustration purposes only the histogram shows a median split of the variable of interest on raw RTs

There was also a significant interaction of Condition with L2 Proficiency and Target word frequency ($p < .05$). This interaction is shown in Figure 22. RTs to high-frequency targets were faster than those to low-frequency target words across all conditions. This effect did not differ between high and low L2 Proficiency participants in the unrelated condition. Table 20 shows that the only significant interaction was for the Root condition. In this condition root priming reduced the effect of Target frequency for the low L2 Proficiency participants.The high L2 Proficiency participants were relatively unaffected compared to the Unrelated condition.

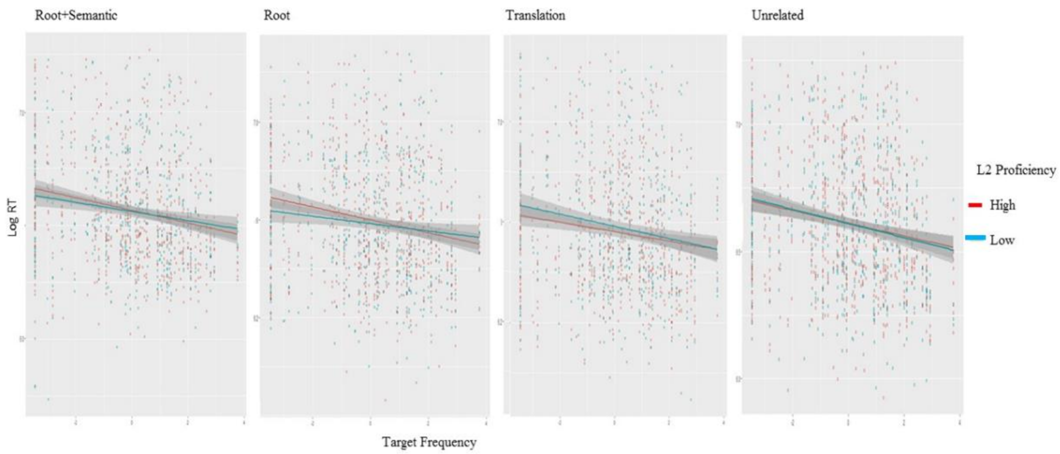

Figure 22. Experiment 5, English SOA 80: The effect on RT of Target frequency for L2 Proficiency in the four priming conditions. Results show the effect on RT of Target Frequency for participants with high and low levels of L2 Proficiency.

There was also a significant interaction of condition with L2 Exposure and Target word Frequency ($p < .01$). This interaction is shown in Figure 23. Again, RTs to high-frequency targets were faster than to low-frequency target words across all priming conditions. The interaction was significant for Translation priming and for Root priming. Looking at the figure this interaction is difficult to interpret. The effect of priming seems to be to reduce the difference between the L2 Exposure groups mainly for the low-frequency targets.

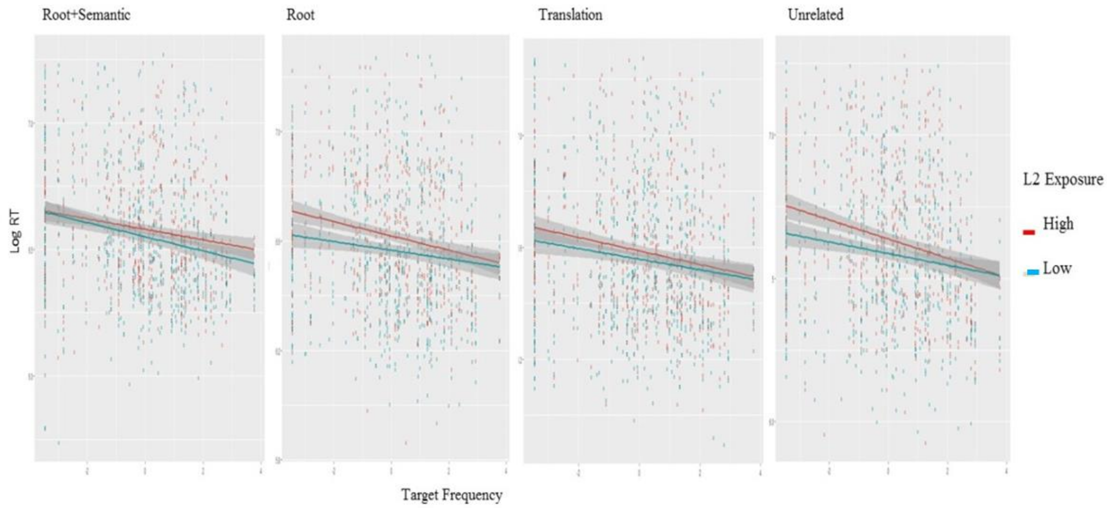

Figure 23. Experiment 5, English SOA 80: The effect on RT of Target frequency for L2 Exposure in the four priming conditions. Results show the effect on RT of Target frequency for participants with high and low levels of L2 Exposure.

Condition also interacted with L2 Exposure and Target letters (*p* <. 05, see Figure 24). RTs to short target words were faster than to long targets across all conditions. Once again participants with high L2 Exposure were slower than participants with low L2 Exposure across all conditions. Table 20 shows that a significant interaction of L2 Exposure and Target letters occurred in the Translation condition and a borderline effect occurred in the Root+Semantic condition. In both of these conditions the effect of priming was to reduce the difference between the exposure groups but, only for the shorter target words.

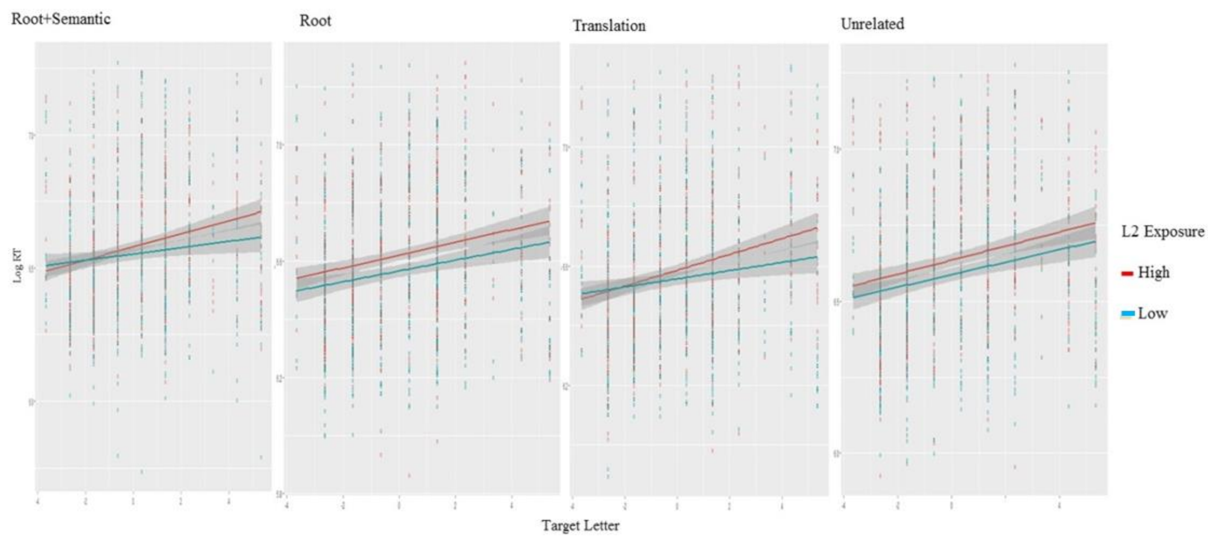

Figure 24. Experiment 5, English SOA 80: The effect on RT of Target letters for L2 Exposure in the four priming conditions. Results show the effect on RT of Target letters for participants with high and low levels of L2 Exposure.

Translation priming also showed an additional positive relationship between RT and L2 Age of acquisition: RT increased as L2 Age of acquisition increased.

Translation priming also showed a significant interaction of L2 Informal learning and Target frequency. This interaction is shown in Figure 25. Compared to the unrelated condition the effect of translation priming is to reduce the effect of target frequency mainly for the participants with low L2 Informal learning. The result is to remove the difference between the two participant groups.

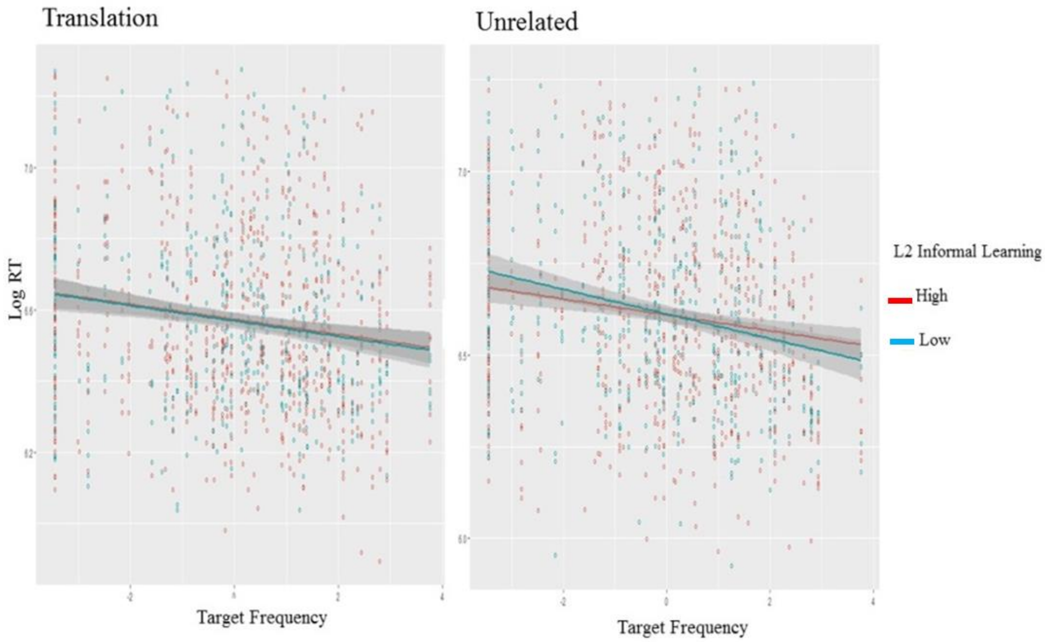

Figure 25. Experiment 5, English SOA 80 Translation: The effect on RT of Target frequency for L2 Informal learning. Results show the effect on RT of Target frequency for participants with high and low L2 Informal learning.

In the Root+Semantic priming condition, L2 Age of acquisition interacted significantly with the priming root frequency of the prime in the Root+Semantic condition (see Figure 26). In the unrelated priming condition, the effect of Prime root frequency is greater for the participants with low L2 Age of acquisition and the effect is slightly positive, such that RTs are longer for primes with higher Prime root frequency, i.e. an interference effect. In comparison, in the Root+Semantic priming condition this pattern is reversed, with a greater interference for increasing Prime root frequency for the participants with high L2 Age of acquisition.

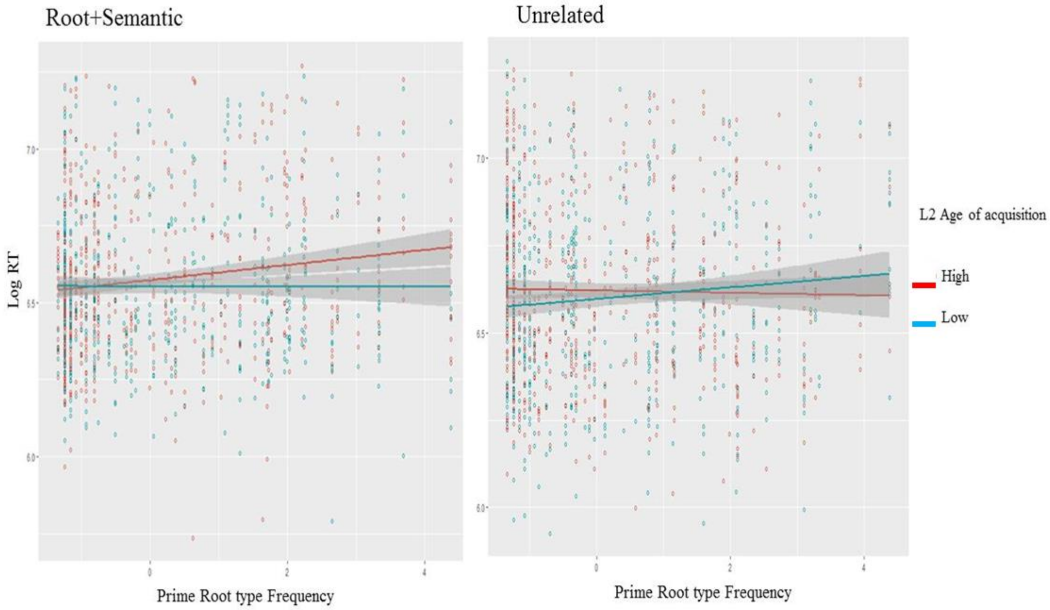

Figure 26. Experiment 5, English SOA 80 Root+Semantic: The effect on RT of L2 Age of acquisition for Prime orthographic frequency. Results show the effect on RT of L2 Age of acquisition for words with high and low levels of Prime orthographic frequency.

RTs in the Root priming condition only showed an additional interaction with L2 Proficiency and Target letters (see Figure 27). There was a positive relationship between RT and Target letters. Compared to the unrelated condition, Root priming reduced the effect of L2 Proficiency mainly for the longer target words, reducing the difference between the high and low L2 Proficiency participants.

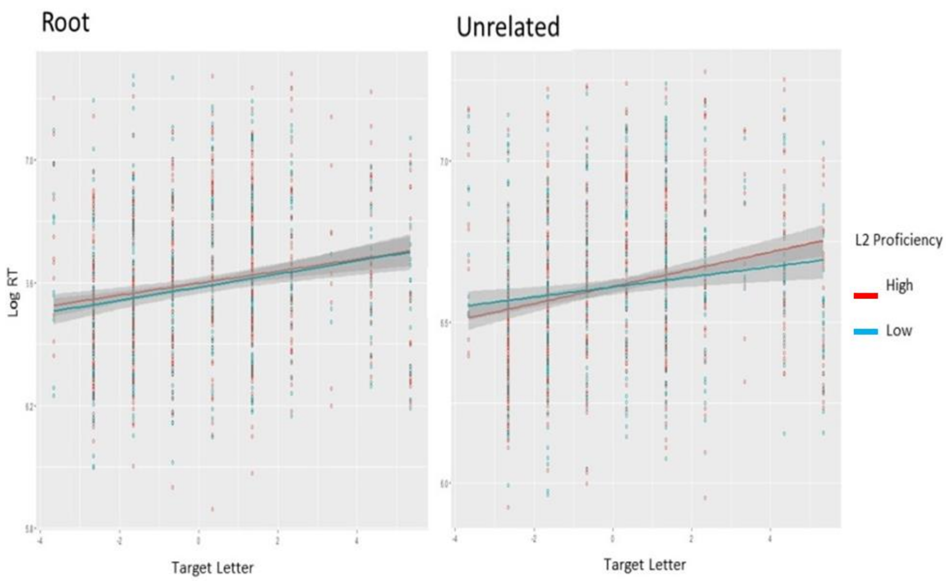

Figure 27. Experiment 5, English SOA 80 Root: The effect on RT of Target letters for L2 Proficiency. Results show the effect on RT of Target length for participants with high and low levels of L2 Proficiency.

Finally, there were two additional significant interactions of the LEAP-Q factors with lexical variables (see Figure 28 a&b). As can be seen in Figure 28a, the effect of increasing Prime root frequency was again to reduce RTs, and this effect was stronger for the participants with high L2 Exposure. Figure 28b shows the interaction with L2 Age of acquisition and target frequency. Participants with high L2 Age of acquisition, i.e. participants who learned English at a later age, recognized targets more slowly than participants with low L2 Age of acquisition, and showed a stronger effect of target frequency.

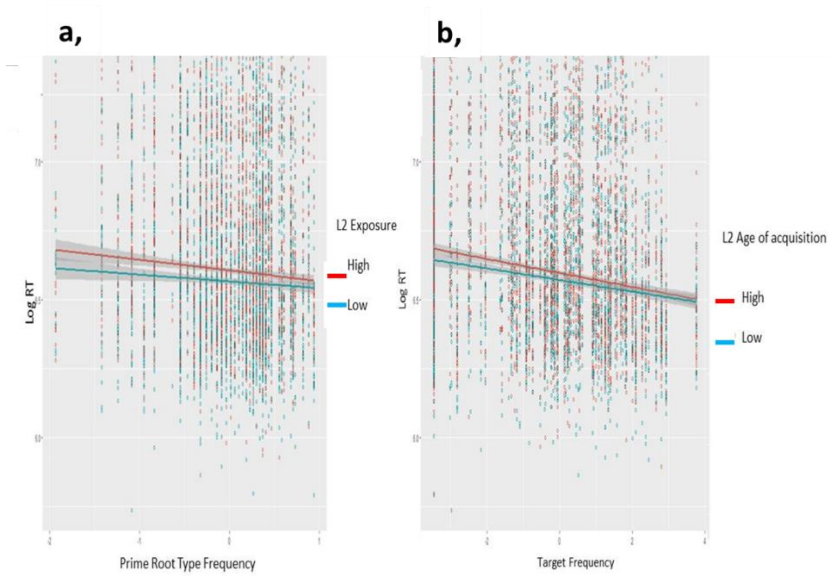

Figure 28. Experiment 5, English SOA 80: The effect on RT of Prime root type frequency is shown across L2 Exposure in panels a and L2 Age of acquisition in panels b.

A full logit analysis of percentage error rates failed to converge, as did the minimal model based on the RT analyses. The minimal model including Condition in the fixed effects and a random structure including items and subjects converged. The output is shown in Table 21. As with SOA 80 there were no significant effects of Condition on error rates.

Table 21. The minimal model output for error rates at English SOA 80.

Fixed effects	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.25897	0.16312	-13.848	<2e-16 ***
Root+Semantic	-0.06644	0.12196	-0.545	0.586
Root	-0.17164	0.12439	-1.380	0.168
Translation	-0.20601	0.12547	-1.642	0.101

5.3.3 *Experiment 6: SOA 200, Results*

The maximal model for the SOA 200 RT data set converged with both items and subjects in the random structure and only subjects crossed with condition. The minimal model with the same random structure is shown in Table 22. As can be seen the facilitation effect of priming in the Root+Semantics condition (40ms) was significant. The effect of priming in the Root condition (16ms) was insignificant. In addition, there was a significant effect of priming (37ms) in the Translation condition. The ANOVA of the model output yielded a significant effect of Condition ($p < .001$). To test for significant differences between Root priming and the other two priming conditions, the model was rerun with the Root condition coded as the intercept. Compared to Root priming, Root+Semantic showed a significant effect ($t = -3.2$), as did Translation priming ($t = -3.7$).

There were no significant main effects of the LEAP-Q factors. The only significant main effect of a lexical variable was Prime Root type frequency, which was negatively related to RT: RTs were faster as prime root frequency increased.

Table 22. The minimal model output for (English) Log RTs at SOA 200ms

Fixed effects	Estimate	Std. Error	t value
(Intercept)	6.5882856	0.0194175	339.3
Conditions			
Root+Semantic	-0.0518621	0.0117350	-4.4*
Root	-0.0142746	0.0117610	-1.2
Translation	-0.0600975	0.0123610	-4.9*
Leap-Q factors			
L2 Proficiency	0.0079390	0.0181559	0.4
L2 Age of acquisition	0.0122009	0.0220803	0.6
L2 Exposure	0.0198852	0.0232324	0.9
L2 Informal Learning	0.0407894	0.0267349	1.5
L2 Accent	-0.0072658	0.0189311	-0.4
L1 Formal Learning	0.0113332	0.0221490	0.5
L1 Informal Learning	0.0353558	0.0196453	1.8
L2 Formal Learning	0.0249800	0.0168621	1.5
Lexical variables			
Prime Orthographic Frequency	0.0030172	0.0065949	0.5
Target Letters	0.0038327	0.0063849	0.6
Log Target Frequency	-0.0151739	0.0077980	-1.9
Prime Root Type Frequency	-0.0404289	0.0174379	-2.3*
Condition specific interaction			
Translation:L2 Proficiency	0.0206513	0.0120744	1.7
Translation:Prime Orthographic Frequency	-0.0168586	0.0106799	-1.6
Translation:L2 Age of acquisition	-0.0127260	0.0138150	-0.9
Translation:Target Letters	0.0074875	0.0067654	1.1
Translation:L2 Exposure	-0.0239347	0.0153175	-1.6
Translation:Log Target Frequency	0.0060875	0.0082065	0.7
Translation:L2 Informal Learning	-0.0078958	0.0163741	-0.5
Translation:L2 Accent	0.0044198	0.0121194	0.4
Translation:Prime Root Type Frequency	0.0326208	0.0261788	1.2
Translation:L2 Proficiency:Prime Orthographic Frequency	0.0200072	0.0086602	2.3*
Translation:L2 Age of acquisition:Target Letters	0.0151999	0.0059973	2.5*
Translation:Prime Orthographic Frequency :L2 Age of acquisition	-0.0043125	0.0094420	-0.5
Translation:L2 Exposure:Log Target Frequency	0.0118059	0.0077250	1.5
Translation:Target Letters:L2 Informal Learning	0.0073009	0.0071934	1.0
Translation:L2 Accent:Prime Root Type Frequency	0.0324137	0.0203314	1.6
Root+Semantic:L2 Proficiency	0.0012905	0.0116864	0.1
Root+Semantic:Prime Orthographic Frequency	-0.0021534	0.0091297	-0.2
Root+Semantic:L2 Age of acquisition	0.0010934	0.0134843	0.1
Root+Semantic:Target Letters	0.0002168	0.0068023	0.0
Root+Semantic:L2 Exposure	0.0144883	0.0153843	0.9
Root+Semantic:Log Target Frequency	0.0040217	0.0083459	0.5
Root+Semantic:L2 Informal Learning	-0.0273070	0.0164420	-1.7
Root+Semantic:L2 Accent	0.0055066	0.0124135	0.4
Root+Semantic:Prime Root Type Frequency	0.0396550	0.0264268	1.5
Root+Semantic: L2 Proficiency:Prime Orthographic Frequency	0.0023300	0.0074674	0.3
Root+Semantic: L2 Age of acquisition :Prime Orthographic	-0.0198960	0.0083298	-2.4*
Root+Semantic:L2 Age of acquisition:Target Letters	0.0114437	0.0060370	1.9
Root+Semantic:L2 Exposure:Log Target Frequency	-0.0026145	0.0078070	-0.3
Root+Semantic: L2 Informal Learning :Target Letters	-0.0113339	0.0074758	-1.5
Root+Semantic:L2 Accent:Prime Root Type Frequency	-0.0109793	0.0220233	0.5
Root:L2 Proficiency	0.0054115	0.0116165	0.5

Root:Prime Orthographic Frequency	-0.0043847	0.0091151	-0.5
Root:L2 Age of acquisition	-0.0129926	0.0134304	-1.0
Root:Target Letters	-0.0010628	0.0067904	-0.2
Root:L2 Exposure	-0.0048459	0.0152822	-0.3
Root:L2 Accent	0.0013725	0.0123159	0.1
Root:Log Target Frequency	0.0069627	0.0083951	0.8
Root:L2 Informal Learning	-0.0280690	0.0164532	-1.7
Root:Prime Root Type Frequency	0.0470521	0.0266739	1.8
Root:L2 Proficiency: Prime Orthographic Frequency	-0.0035043	0.0072594	-0.5
Root:L2 Age of acquisition: Target Letters	0.0019817	0.0059442	0.3
Root: Target Letters: L2 Informal Learning	0.0098189	0.0073380	1.3
Root: Prime Orthographic Frequency : L2 Age of acquisition	-0.0089125	0.0079667	-1.1
Root:L2 Exposure: Log Target Frequency	0.0153981	0.0077527	2.0*
Root:L2 Accent: Prime Root Type Frequency	0.0322316	0.0189197	1.7
Leap-Q specific interaction			
L2 Proficiency:Prime Orthographic Frequency	-0.0021796	0.0053321	-0.4
L2 Age of acquisition :Prime Orthographic Frequency	0.0079094	0.0059452	1.3
L2 Age of acquisition:Target Letters	-0.0070022	0.0042783	-1.6
L2 Exposure: Log Target Frequency	-0.0083660	0.0055167	-1.5
L2 Informal Learning :Target Letters	-0.0043467	0.0052030	-0.8
L2 Accent: Prime Root Type Frequency	-0.0306187	0.0131742	-2.3*
L1 Formal Learning :Target Letters	-0.0037260	0.0023550	-1.6
L2 Proficiency: Target Letters	-0.0037191	0.0018343	-2.0*
L2 Age of acquisition: Prime Root Type Frequency	0.0294054	0.0083390	3.5*
L2 Accent :Log Target Frequency	0.0067383	0.0028755	2.3*
L2 Accent: Target Letters	0.0071963	0.0023676	3.0*

There was a significant interaction of condition with L2 Proficiency and Prime Orthographic frequency ($p < .05$). This interaction is shown in Figure 29. Table 22 shows that the only significant interaction of these variables occurred in the Translation condition. Compared to the unrelated condition, the effect of Translation priming was to increase the facilitatory effect of increasing prime orthographic frequency, but only for participants with low L2 Proficiency.

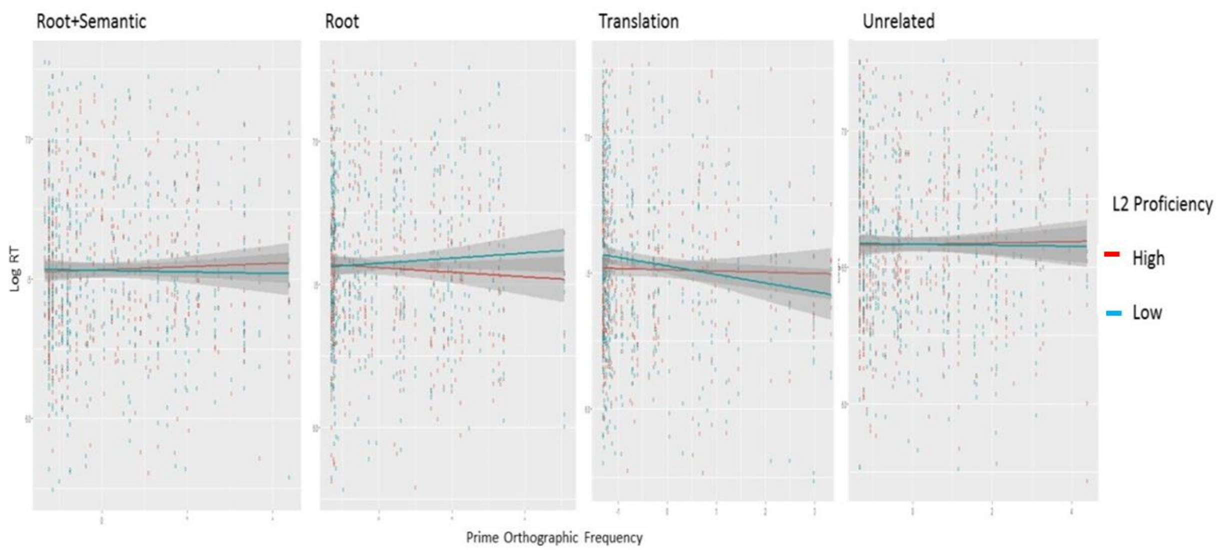

Figure 29. Experiment 6, English SOA 200: The effect on RT of Prime Orthographic frequency for L2 Proficiency in the four priming conditions. Results show the effect on RT of Prime Orthographic frequency for participants with high and low levels of L2 Proficiency.

There was also a significant interaction of Condition with L2 Age of acquisition and Target letters ($p < .05$). This interaction is shown in Figure 30. RTs to short targets were faster than to long targets. Table 22 shows that the only significant interaction condition was again in the Translation condition, although a similar borderline pattern is seen in the Root+Semantic condition. Compared to the unrelated condition, the effect of Translation priming was to decrease the inhibitory effect of increasing target length, but only for participants with low L2 Age of acquisition. Surprisingly, also the participants with a lower L2 Age of acquisition responded more slowly in general than those with a higher L2 Age of acquisition.

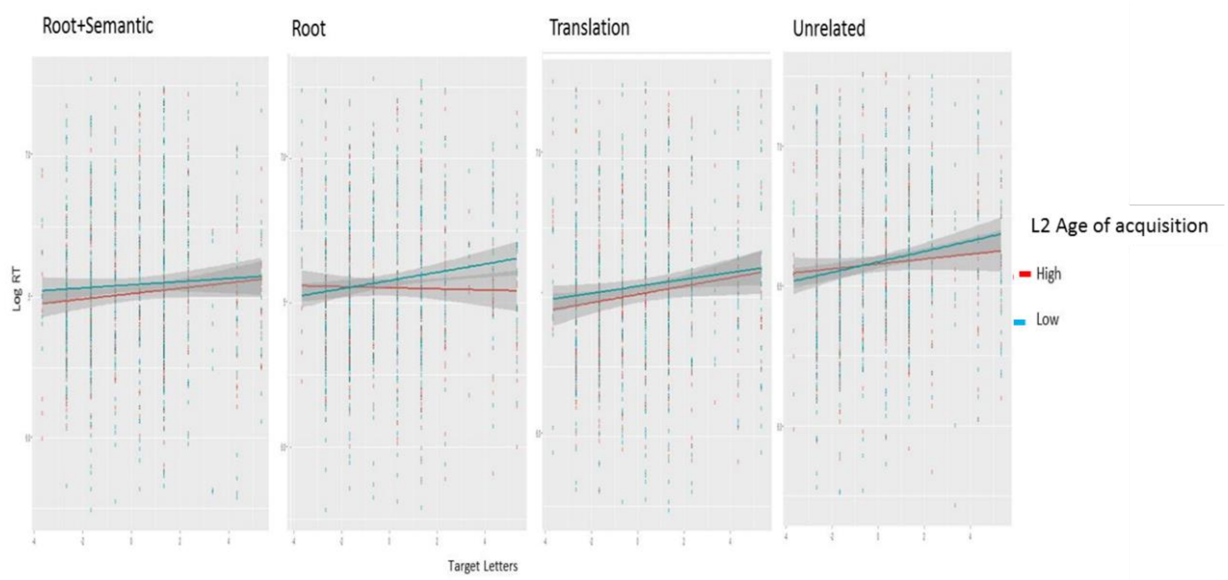

Figure 30. Experiment 6, English SOA 200: The effect on RT of Target Letters for L2 Age of acquisition in the four priming conditions. Results show the effect on RT of Target letters for participants with high and low levels of L2 Age of acquisition.

Condition also interacted with L2 Informal learning and Target letters (p < .05). This interaction is shown in Figure 31. Overall, RTs to short targets were again faster than to long targets. Compared to the unrelated condition, the effect of target length was reduced in the Root condition for the participants with low L2 Informal learning and in the Root+Semantic condition for the participants with high L2 Informal learning. However, none of these effects are significant as Table 22 shows no significant interactions in the individual priming conditions.

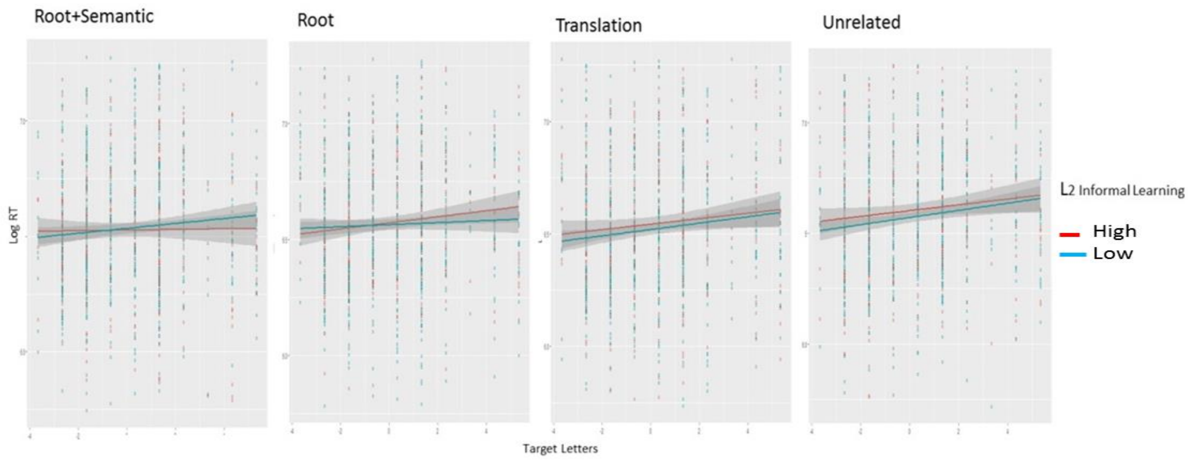

Figure 31. Experiment 6, English SOA 200: The effect on RT of Target letters for L2 Informal learning in the four priming conditions. Results show the effect on RT of Target letters for participants with high and low levels of L2 Informal learning.

RTs in the Root+Semantic condition also showed a significant interaction of L2 Age of acquisition and Prime orthographic frequency (Table 22). Participants with a higher L2 Age of acquisition showed more interference from unrelated high orthographic frequency primes. Root+Semantic related priming reversed this effect.

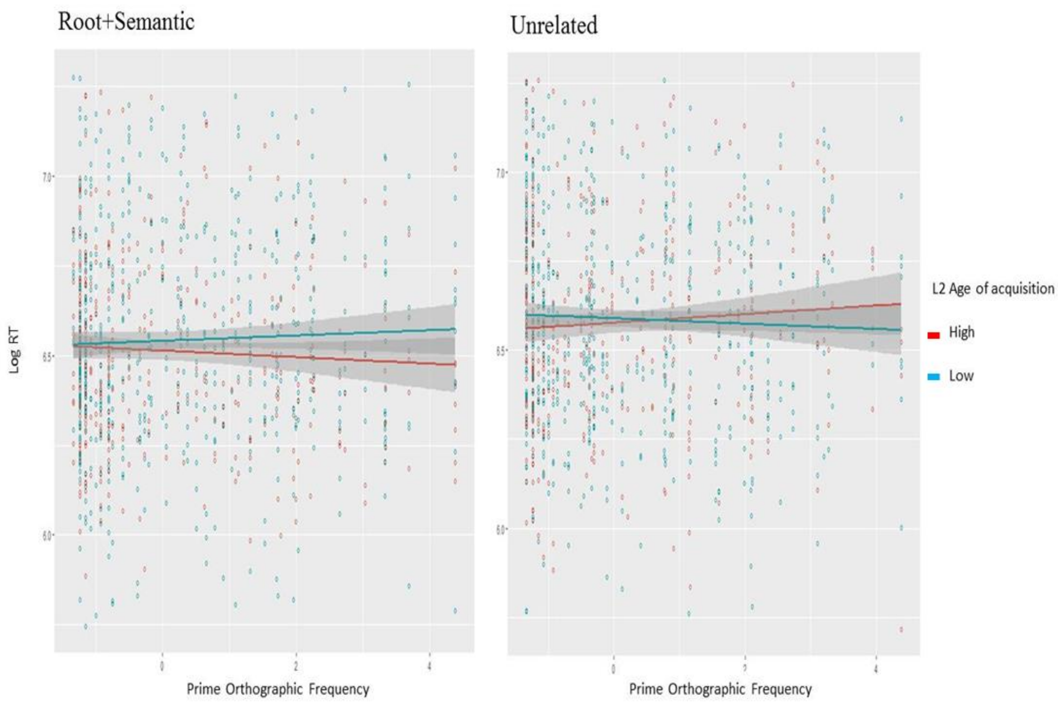

Figure 32. Experiment 6, English SOA 200, Root+Semantic: The effect on RT of Prime orthographic frequency for L2 Age of acquisition. Results show the effect on RT of Prime orthographic frequency for participants with high and low levels of L2 Age of acquisition.

RTs in the Root condition also showed a significant interaction of L2 Exposure by Target frequency (Figure 33). The effect of Root priming seems to be to reduce the effect of target frequency, mainly for participants with high L2 Exposure.

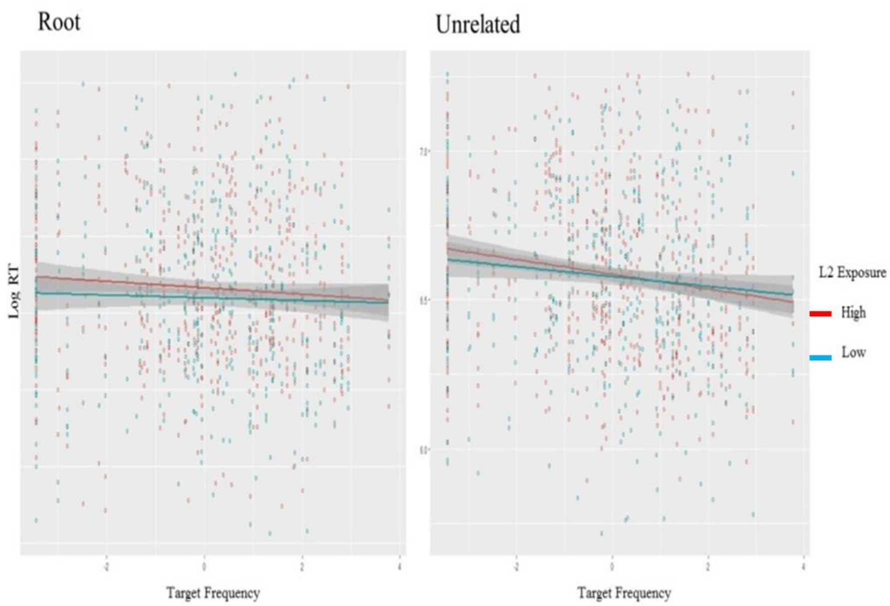

Figure 33. Experiment 5, English SOA 200, Root: The effect on RT of Target frequency for L2 Exposure. Results show the effect on RT of Target frequency for participants with high and low levels of L2 Exposure.

Finally, there were a number of significant interactions between the LEAP-Q factor L2 Accent and three lexical variables that did not occur in any interactions with Condition (See Figure 34, a-c). Prime Root type frequency interacted with L2 Accent (Figure 34 a). The effect of increasing prime root frequency is to speed RTs, and this effect is larger for participants with high L2 Accent . The effect of target length was to increase RTs (see Figure 34 b). Again, this effect was greater for participants with high L2 Accent. This suggests that bilinguals with better English show stronger effects of prime root frequency. However, the effect of target frequency is greater for participants with low L2 Accent (Figure 34 c).

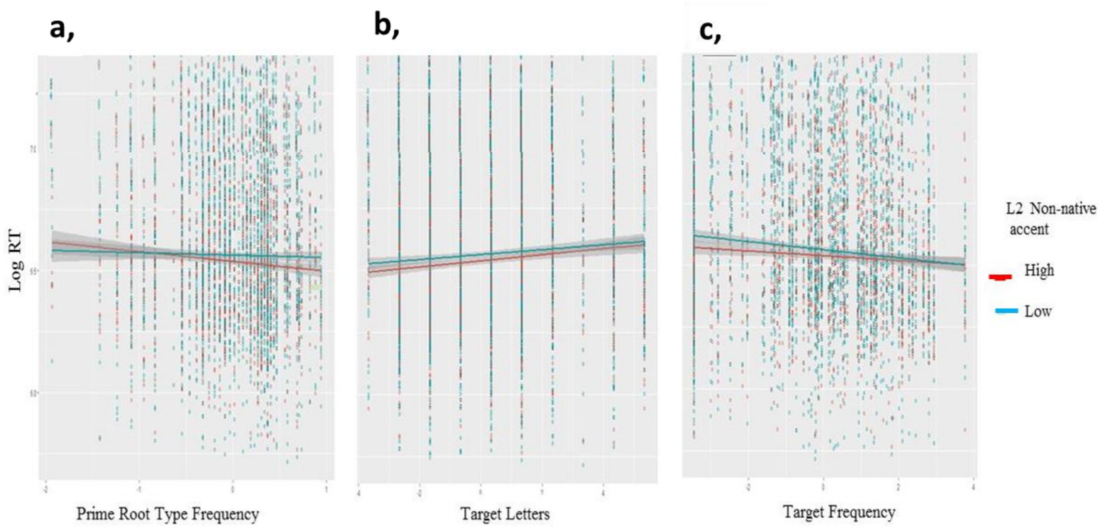

Figure 34. Experiment 4, English SOA 50: Two-way interactions between the LEAP-Q factors and the lexical variable.

A full logit analysis of percentage error rates failed to converge, as did the minimal model taken from the RTs. The minimal model including Condition in the fixed effects and a random structure including items and subjects converged. The output is shown in Table 23. As with SOA 50, there were no significant effects of condition on error rates.

Table 23. Error table for SOA 200ms

Fixed effects:	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-2.06882	0.15596	-13.265	<2e-16 ***
Root+Semantic	-0.02980	0.12279	-0.243	0.808
Root	0.01557	0.12223	0.127	0.899
Arabic Translation	-0.14653	0.12526	-1.170	0.242

5.4 Summary and discussion

The three priming experiments reported in this chapter were designed to investigate the effects of translation and morphological priming on lexical decisions to English words. At SOA 50, the results replicate previous studies (e.g. Duyck, 2005; Gollan, Forster & Frost, 1997) showing only significant effects of masked translation priming on RTs but extend this finding to Arabic-English translations. At this short SOA there were no effects of priming from Arabic words sharing the root of the Arabic translations word. This pattern of results is consistent with early lexical mediated activation of the English translations rather than semantically mediated activation, as there is no priming from the Root+Semantic primes, which share semantics with the English translations. So, the participants here failed to show any priming effect in the first and second conditions which were (+Root+Semantic) and (Root only) because at such brief durations primes fail to activate sufficiently the corresponding lexical representations. However, in the case of direct translation, Arabic primes would result in the activation of the lexical representations in both languages that naturally result in a facilated lexical decision. However, consistent with previous research, effects of semantic relationships emerge at the longer SOAs, with both Translation priming and Root+Semantic priming showing significant effects at SOAs 80 and 200 (e.g. Voga & Grainger, 2007). These effects are consistent with growing conceptually mediated cross-linguistic activation as the Arabic prime words become more visible and can be processed in more depth prior to target word onset.

Interestingly, significant Root priming is observed at SOA80 but not at SOA200. This effect might be related to effects of the morphological structure of the Arabic lexicon on the activation of the English lexicon. It is possible that this effect is due to morphologically mediated activation of the Arabic translation word. As we saw in Experiment 1, the Root prime activates all Arabic words sharing its Root and this includes the Arabic translation of the target word. In the English experiments at SOA50 there may be insufficient time for this root mediated activation to spread, whereas at SOA80 Root primes are able to activate the English target via its Arabic translation. By SOA 200 semantic relationships dominate and root priming is no longer observed. In addition, I think that the effect was semantic and morphological more than just semantic. As commented in the previous chapter, even at 200ms, in Arabic experiment number 3, no semantic facilitation was observed in the absence of morphological overlap. Thus, I think that morphological facilitation is at play in this condition. Since semantic priming was not observed in the Arabic experiment, I believe that the Root+Semantic priming is due to the joint facilitation of both Root and Semantic similarity. Finally, the Translation condition is the Arabic translation of the English target and carry the root and semantic overlap, which is another factor that indicates that morphological processes might be partically responsible of this facilitation.

However, it is also possible that at SOA80 conceptual representations begin to have an effect as significantly greater priming is observed for the Root+Semantic condition which primes to the same extent as the Arabic translation. Moreover, the overall pattern of effects at SOA80 and 200 is very similar despite the lack of significant priming in the Root condition. In addition, the ratings collected for semantic similarity (reported in the Discussion of Chapter 4) showed that primes in the Root condition did have a higher semantic similarity rating than the unrelated primes. Therefore, the effect of Root priming may also be attributable to this shared semantics activating the English target via conceptual links. However, if this is the case one might argue that such semantic priming should increase rather than decrease with increasing prime exposure.

In general, the effects of the lexical factors on RTs were as expected. There was only one significant main effect of a lexical variable on RTs: an effect of Prime root frequency at SOA200. However, lexical variables associated with both the English target words (i.e. word, frequency and length) and with the Arabic prime words (i.e. root frequency and orthographic frequency) did interact with condition and the LEAP-Q variables. There were only two main effects of the LEAP-Q variables on RTs: a negative relationship with L2 Proficiency at SOA50 and, surprisingly, a positive relationship with L2 Formal learning at SOA80. A number of LEAP-Q factors also interacted with priming conditions and with lexical variables. We discuss these interactions for each SOA below.

As one would expect, L2 Proficiency affected RTs on the English lexical decision task and, as with the Arabic priming experiments, the strongest effects of L2 Proficiency are seen at the earliest prime duration. The factor based on participants' ratings of their English proficiency significantly predicted their RTs at SOA 50, which were faster for higher proficiency participants. Interestingly, proficiency level also determined the degree of priming that was observed in SOA 50. More priming was observed for lower proficiency participants, even within the set of very proficient and relatively homogenous bilinguals tested.

Many significant condition-specific interactions at SOA50 involved the lexical characteristics of the English target words, namely target word length (in letters) and target word frequency. The general pattern that emerges from these interactions indicates that priming, where it had a significant effect, tended to influence participants with lower levels of factors related to bilingual status more than participants with higher levels. The effect of priming was often to reduce the difference between the effects of lexical variables in the two participant groups. For example, RTs generally increased with the length of the English target word in letters and the effect of translation priming was to increase this effect of length, but only for participants with low L2 Formal learning and high L2 Age of acquisition (i.e. participants who acquired L2 later).

A similar pattern at SOA50 is seen with the effect of Target frequency. The effect of translation priming was to increase the effect of target frequency for low L1 Formal learning and a similar effect was seen for Root+Semantic priming. The effect of L2 Accent again failed to conform to this pattern, with translation priming increasing the effect for high L2 Accent participants.

There were also two significant interactions involving prime root frequency, although none of these interactions reached significanlce in the individual priming conditions. Prime root frequency interacted with Condition and L1 Formal learning and with Condition and L2 Exposure. Participants with low L1 Formal learning showed increasing RTs with Prime root frequency, but only in the unrelated condition. The same was true for participants with high L2 Exposure, suggesting increased activation from unrelated words, causing interference for these groups of participants.

Finally, Root type frequency interacted with L2 Proficiency and Target length with L2 Informal learning, with stronger effects for low L2 Proficiency and high L2 Informal learning, both factors that are associated with longer RTs. Overall, therefore, the general pattern is that stronger effects of lexical variables in a given language are observed for participants with higher LEAP-Q factors associated with a stronger profile in that language. Overall, at SOA50, when primed by related words, the effect of lexical factors becomes more apparent, mainly for participants with lower levels of LEAP-Q factors. This is consistent with related primes facilitating processing such that less able language users become more like more able language users in terms of the effect of lexical variables on RTs. Similar trends are observed at SOA80 and SOA200. However, at these longer SOAs, we also observe that participants with high bilingual status started to be affected by related primes such that their pattern of effects differed more frequently from the unrelated condition. This is likely due to the increasing visibility of the primes to participants. At SOA200 the Arabic prime words were fully visible to all participants. At this SOA we see the only main effect of Prime root frequency, with faster RTs overall to prime words with higher frequency roots.

Despite similarities in the effects of lexical variables on processing, not all of the LEAP-Q factors affected processing speed in the predicted direction. In particular, L2 Informal learning tended to show a positive relationship with RTs. It is not clear why this factor behaved differently from the other factors related to L2 status. One possibility is that this factor relates to language experience in terms of spoken rather than written communication. Therefore participants with more of this kind of language experience might be predicted to do worse in a speeded visual lexical decision task. Additionally, the L2 Accent measure often behaved in unexpected ways, with participants who judged themselves to have a better accent responding more slowly than those who judged themselves to have a worse English accent. There are a number of problems with this measure, however. The LEAP-Q factor contains information from two contrasting variables, one of which was due to misinterpretation of a question by participants (see Chapter 3). Accent remains an interesting issue, however it is likely that a more detailed and reliable measure is required to fully understand this aspect of language proficiency on performance.

Chapter 6

Summary and General discussion

6.1 Summary of aims
6.2 Summary of findings
6.2.1 *Effects of morphological structure and bilingual profile in Arabic visual word processing*
6.2.2 *Effects of Arabic morphological structure and bilingual profile in English visual word processing*
6.3 Conclusions

6.1 Summary of aims

The aim of my research was to investigate the role of bilingual profile in the lexical organization of Arabic-English bilinguals. There is a great deal of evidence now showing that processing one language results in the automatic activation of the other language in bilinguals (e.g. Kroll & Hermans, 2011; Kroll, Hell, Tokowicz & Green, 2010). Bilingual profile has been shown to affect aspects of the cross-linguistic activation of words in the bilingual mental lexicon (e.g. Kroll & Bialystok, 2013; Sholl, Sankaranarayanan, & Kroll, 1995). However, most studies of language processing to date have used simple measures of language proficiency and dominance to test these effects. More detailed studies of bilingual language profile have shown a more complex relationship between different aspects of a bilingual's language background and self-rated proficiency with objective tests of language performance (e.g. Marian et al., 2007). One aim of my research was to bring these approaches together to perform a sophisticated test of bilingual profile on written word processing.

Another aim was to extend the research on processing in non-Indo-european bilinguals. The majority of experimental studies have investigated European languages such as English, Dutch and other Indo-European languages (e.g. Kroll, Dussias, Bogulski & Valdes Kroff, 2012). My research investigated visual word processing in Arabic-English bilinguals. There is strong evidence that morphological structure is a central organizing principle of the Arabic mental lexicon (e.g. Boudella & Marslen-Wilson, 2005) and the morphological structure of Arabic is very different to that of English. Current models of bilingual word processing suggest that there are strong lexical level links between L2 and L1 words, especially for less proficient bilinguals. The lack of a shared script and the difference in morphological structure makes Arabic-English bilinguals an ideal participant group for testing lexical level cross-linguistic activation during language processing. As outlined in the overview, my thesis aimed to address the following questions:

1. What is the role of Arabic morphological structure in Arabic visual word processing in Arabic-English bilinguals?
2. What is the role of Arabic morphological structure in the processing of English words in Arabic-English bilinguals?
3. How do the effects of morphological structure change with the language profile of bilinguals?

6.2 Summary of findings

6.2.1 *Effects of morphological structure and bilingual profile in Arabic visual word processing*

My Arabic-Arabic experiments confirmed the importance of Root structure in the processing of written words in Arabic (Boudelaa & Marslen-Wilson, 2005; Frost et al., 1997). The results of the three Arabic priming experiments are shown in Figure 35. As can be seen, primes that shared roots primed lexical decisions to Arabic targets at SOA50 irrespective of the degree of semantic relationship. At the longest SOA200 root priming only facilitated when there was also shared semantics between prime and target. Indeed, my results suggest a stronger role for root structure as the presence of a root was necessary even with visible primes for semantic relationships to play a role. Looking at the graphs we can clearly see that no priming was observed at SOA80, however what is also clear from these graphs is that these participants were also in general faster in their responses than the other two participant groups. However, it is not unusual for increased general speed of response to be associated with smaller positive effects of priming.

The Arabic experiments also showed some effects of bilingual profile and interestingly most of the effects were related to LEAP-Q factors associated with L2 English especially at the shorter SOAs (these effects are summarized in Table 24 below). At SOA50 participants with high L2 Proficiency and L2 Exposure took longer to respond to targets with high compared to low root frequency while the opposite pattern was observed for participants with low L2 Proficiency and low L2 Exposure. At SOA80, participants who acquired L2 English at a younger age (i.e. low L2 Age of acquisition) also showed slower RTs as target root frequency increased. All of these effects support the idea that a high bilingual status in L2 can have detrimental effect on L1 processing speed (e.g. Jia, Aaronson & Wu, 2002). One explanation is that increased activation in the L2 lexicon of the most competent participants in L2 competes with Arabic word processing. However, this explanation contradicts the RHM which proposes that high proficiency bilinguals have direct access to meaning from lexical items in both languages and reduced cross-linguistic lexical activation. An alternative explanation is that a high L2 profile is associated with a general reduction in L1 use which directly affects L1 processing speed i.e. a general frequency of use effect. In other words, the more frequently you are exposed to a word in a language, the less bottom-up evidence you need in order to recognize it. Evidence of a bilingual disadvantage in L1 lexical processing has more frequently been observed in language production studies (Ivanova & Costa, 2008).

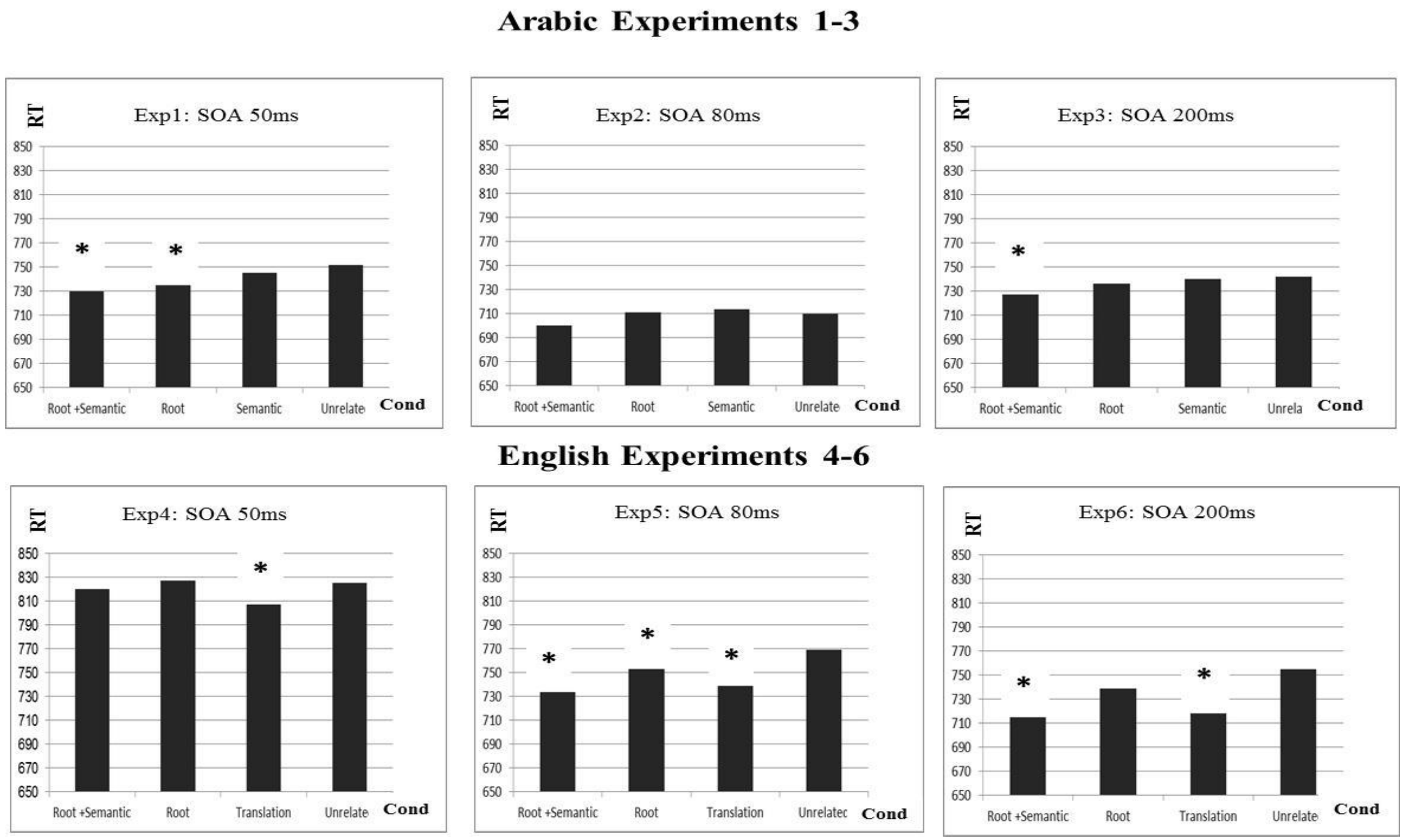

Figure 35. RTs are shown for the six priming experiments. Significant priming effects compared to the unrelated conditions are marked with an asterisk

Table 24. Significant effects in Arabic priming experiments 1-3

SOA	Fixed effects	Estimate	Std. Error	t value
50ms	***Condition specific effects***			
	Root: Target Orthographic Frequency	1.102e-02	4.563e-03	2.4
	Interactions			
	L2 Exposure: Target Root Frequency	1.790e-02	6.686e-03	2.7
	Semantic: L2 Proficiency: Target Root Frequency	5.736e-02	1.852e-02	3.1
80ms	***Two way interactions***			
	L2 Learning duration: Target Root Frequency	-0.013227	0.005989	-2.2
200ms	***Leap-Q factors***			
	L1 Informal Learning	0.033132	0.015654	2.1

It is only at the longest SOA200, when primes are fully visible, that effects of L1 profile are observed. At this SOA we see an effect of L1 Informal learning; surprisingly, higher levels of this factor were associated with slower responses to Arabic words. Indeed, a similar positive relationship was observed between processing speed and L2 Informal learning in the English lexical decision experiments summarized below. As suggested earlier, this may well be due to the relationship between the LEAP-Q factors and the particular language task investigated. The informal learning factors included variables more related to experience with spoken rather than written language, such as listening to the radio and watching TV. It is possible therefore, that high levels of this factor would have a different relationship on performance in tasks involving the processing of spoken rather than written language.

6.2.2 *Effects of Arabic morphological structure and bilingual profile in English visual word processing*

The evidence for effects of Arabic morphological structure on the processing of English words is less clear. The pattern of results across the three SOAs is shown in Figure 35. As the SOA increased response latencies decreased but at each SOA the priming pattern can be explained in terms of the degree of semantic relationship between the Arabic primes and English targets. At no point was the effect Root+Semantic priming similar to that of Root alone. Instead the pattern of effects is most consistent with priming due to direct lexical links between translation words at early SOAs and increasing effects of semantic mediation as the prime words become more visible. The root frequency of the Arabic prime did have an overall effect on processing speed when the primes were visible (at SOA200), with higher frequency roots speeding responses compared to lower frequency roots. However, this effect might also be attributed to semantic rather than morphological effects as more productive roots would activate more words related in meaning to the target.

The English experiments also showed effects of bilingual status (see Table 25). There were a number of interactions with Prime root frequency. In general, participants with higher L1 profiles showed stronger effects of Prime root frequency on English word processing consistent with more semantically-mediated processing. The effect of related priming was in general to increase the effect of Prime root frequency observed for participants with lower L1 profiles who showed increased RTs when primed by unrelated Arabic words with high-frequency roots, suggesting that they were susceptible to interference from these unrelated words.

However, the bulk of the interactions with priming across all SOAs involved lexical factors associated with the English target words. Shorter and higher-frequency English words

Table 25. Significant effects in English priming experiments 4-6

SOA	Fixed effects	Estimate	Std. Error	t value
50ms	***Leap-Q factors***			
	L2 Proficiency	-4.605e-02	1.394e-02	-3.3
	Condition specific effects			
	Translation: L2 Proficiency	2.259e-02	9.786e-03	2.3
	Translation: L2 Learning duration: Target Letters	9.144e-03	4.053e-03	2.3
	Translation: L1 Formal Learning: Target Frequency	1.270e-02	5.135e-03	2.5
	Translation: L2 Non-native accent: Target Frequency	-1.723e-02	8.351e-03	-2.1
	Translation: L2 Non-native accent: Target letters	-1.666e-02	6.684e-03	-2.5
	Translation: L2 Formal Learning: Target letters	-9.135e-03	4.160e-03	-2.2
	Root+Semantic: L1 Formal Learning: Target Freq	1.142e-02	5.042e-03	2.3
	Root: L1 Formal Learning	-2.284e-02	1.015e-02	-2.2
	Root: L2 Non-native accent	-4.378e-02	1.294e-02	-3.4
	Root: L2 Proficiency	2.780e-02	1.006e-02	2.8
	Root: L2 Non-native accent: Target Frequency	-1.952e-02	8.633e-03	-2.3
	Leap-Q specific effects			
	L1 Formal Learning: Target Frequency	-7.564e-03	3.637e-03	-2.1
	L2 Non-native accent: Target Frequency	1.798e-02	5.924e-03	3.0
	L2 Non-native accent: Target Letters	1.139e-02	4.626e-03	2.5
	L2 Proficiency: Prime Root Type Frequency	1.411e-02	6.421e-03	2.2
	L1 Informal Learning: Target Letters	4.270e-03	1.516e-03	2.8
80ms	***Leap-Q factors***			
	L2 Formal Learning	0.0334018	0.0144378	2.3
	Condition specific interactions			
	Translation: L2 Learning duration	0.0189731	0.0094778	2.0
	Translation: L2 Exposure: Target Frequency	0.0178894	0.0058938	3.0
	Translation: L2 Exposure: Target Letters	0.0117118	0.0046529	2.5
	Translation: L2 Informal Learning: Target Frequency	0.0137478	0.0051233	2.7
	Root+Semantic: L2 Exposure	-0.0205958	0.0092093	-2.2
	Root+Semantic: L2 Learning duration :Prime Orthographic Frequency	0.0131440	0.0060112	2.2
	Root+Semantic : L2 Exposure: Target Frequency	0.0164988	0.0058121	2.8
	Root: L2 Proficiency: Log Target Frequency	-0.0226064	0.0072099	-3.1
	Root: L2 Proficiency: Target letters	-0.0150354	0.0059158	-2.5
	Leap-Q specific interactions			
	L2 Exposure: Prime Root Type Frequency	-0.0110092	0.0054092	-2.0
	L2 Learning duration : Log Target Frequency	-0.0057134	0.0022255	-2.6
200ms	***Lexical variables***			
	Prime Root Frequency	-0.0404289	0.0174379	-2.3
	Condition specific interaction			
	Translation:L2 Proficiency:Prime Orthographic Freq	0.0200072	0.0086602	2.3
	Translation:L2 Learning duration: Target Letters	0.0151999	0.0059973	2.5
	Root+Semantic: L2 Learning duration :Prime Orthographic Frequeincy	-0.0198960	0.0083298	-2.4
	Root: L2 Exposure:Log Target Frequency	0.0153981	0.0077527	2.0
	Leap-Q specific interaction			
	L2 Non-native accent: Prime Root Type Frequency	-0.0306187	0.0131742	-2.3
	L2 Proficiency: Target Letters	-0.0037191	0.0018343	-2.0
	L2 Learning duration: Prime Root Type Frequency	0.0294054	0.0083390	3.5
	L2 Non-native accent :Target Frequency	0.0067383	0.0028755	2.3

were responded to faster than longer and lower-frequency targets. In general, these effects were stronger for participants with higher L2 profiles, and priming made the pattern of effects showed by lower L2 profile participants more similar to those of higher L2 profile participants.

Unsurprisingly, L2 Proficiency predicted processing speed at SOA50 and, even amongst a set of (overall) high-proficiency bilinguals, the facilitatory effects of related primes were limited to participants with a lower L2 profile. This is an important finding as it emphasizes how critical small differences in bilingual profile can be to the priming effects observed in such tasks. In other words, a high level of proficiency in L2 could have a detrimental effect (disadvantages visual processing) in L1 lexical recognition process. Increased activation in L2 lexicon competes with Arabic word processing. According to the RHM working in L2 required stronger suppression of L1 than vice versa. Participants with high L2 profile showed stronger effects of prime- Root-Frequency on English word processing. In Arabic high proficiency in L2 affect L1 processing, and in English the opposite. So, that confirms the important of proficiency as emphasized by RHM.

As with the Arabic experiments, however, the relationships observed between bilingual profile and processing speed were not all as one might expect. since Arabic is a semitic language, I expected the results to be similar to the Hebrew. Also, the profile of participants was different from Boudelaa & Marslen-Wilson (2005) study, since the participants in this study were high proficiency bilinguals and have high education. Also, all of them were above 18 years old. Finally, the Arabic in Saudi Arabia develops in exclusively Arabic invironment which have two Arabic diglossic (Amiah and FusHa).while Arabic in Tunicia the French is mixed in the Arabic environment. In Boudelaa & Marslen-Wilson (2005) study, they have used very short SOAs while this study has used a bit longer SOAs in order to investigate the phenomenon further.

Two factors showed somewhat surprising effects on processing speed: L2 Formal learning and L2 Accent. Higher levels of L2 Formal learning were associated with longer rather than shorter responses. The reason for this is not clear. A potential explanation is that these participants have a greater English vocabulary and that this might slow access to the target word. However, this explanation is entirely post-hoc as we have no direct evidence that this is indeed the case. Similarly, L2 Accent also showed contradictory effects on processing. Again, it is unclear why, and I discussed some potential explanations in Chapter 5.

6.3 Conclusions

The aim of my thesis was to examine the effects of bilingual profile on cross-linguistic lexical activation in a way that has not been done previously. I examined a large number of highly proficient Arabic-English bilinguals. In Chapter 3, I reported a factor analysis of the results of a detailed questionnaire that elicited data relevant to language history, exposure, and self-rated proficiency. The result of this study was a set of independent factors for each participant that described in detail their bilingual profile. In Chapters 4 and 5, I reported the results of masked and visible priming experiments that tested the effect of Arabic primes on Arabic and English target words, respectively. Critically, even for my relatively homogeneous group of bilinguals, their profile had significant effects on the priming patterns observed and on a number of lexical variables that usually affect word processing, such as word length and frequency. What my research demonstrates is that simple estimates or measures of language proficiency are unlikely to capture the full picture of someone’s bilingual profile or be a sufficient predictor of their performance in the kinds of cognitive tasks usually studied in bilingual research. We are still some way from a full understanding of the effect of bilingual profile on the relationship between words in the bilingual mental lexicon.

Future research should address these issues in detail. For example, I suggest that the present study should be extended to a population of monolinguals to examine the discrepancies between the present results and those of previous studies. Since there many innovative aspects in the present study (whithin-items design, bilingual sample of participants, words with diacritics) an exhaustive investigation of these factors is in order. I propose to compare bilinguals and monolinguals in a similar whithin-items design as the one used here with the objective of isolating the effect of bilingualism on the modulation of morphological priming. Also, the profile of bilinguals shoul be examined further. It would be very interesting to test the case of bilinguals whose L2 shares a similar non-linear morphology. L1 Arabic speakers learning Hebrew as a L2 would allow to test whether the morphological properties of L2 can modulate the pattern of priming obtained from morphological overlap in Arabic. That is, some of the present results could be partially explained by the fact that morphological properties of both languages (Arabic and English) are structurally different. Therefore, it is potentially interesting to examing the case were these structural differences are not present.

Another interesting line for future research is to explore how orthographic processing can be modulated by the fact of learning a L2 where orthographic factors play a fundamental role. To this respect one could take advantage of the fact that orthographic facilitation is extremely weak in Semitic languages. Consequently, a study where orthographic effects (e.g. transposing letters) were targeted and the sample of participants were similar to the one in the present study. The rationale behind this line of research would be that since learning a L2 where the lexical organizing principles are different could interfere (as the present results suggest) with the processing of L1 words, it is possible and potentially interesting to address the issue of a possible transfer of L2 morphological principles to L1 morphological processes. The prediction then would be that Arabic learners of English would show more orthographic effects relative to Arabic monolinguals.

In conclusion, the present results are an excellent example about how the study of bilingualism can serve to improve our understanding of some basic psycolinguistic processes. The role played by morphology in lexical access has been a matter of debate during the last decades. This study and others exploring bilinguals' performance in a range of psycholinguistic tests could suppose a significant step forward for the field.

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APPENDIX A

Language Experience and Proficiency Questionnaire (LEAP-Q)

Section 1

Full name: Age: Date of birth: Male/Female:
Country of origin: Handedness: Left /right:
Country of residence:

1. Please list all the languages you know in order of dominance

1	2	3	4	5

2. Please list all the languages you know in order of acquisition (native language first).

1	2	3	4	5

3. Please list what percentage of time you are **currently** and **on average** exposed to each language (percentages should add up to 100.)

List language here				
List percentage here				

4. When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original text was written in another language, which is unknown to you (percentages should add up to 100).

List language here				
List percentage here				

5. When choosing language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? (percentages should add up to 100).

List language here				
List percentage here				

6. Please name the cultures with which you identify. Using the scale below from 0 to 10 please rate the extent to which you identify with each culture (the middle of the scale 5=moderate).

0	1	2	3	4	5	6	7	8	9	10
No identification	Very low identification				Moderate identification					Complete identification

List cultures here				
Identification rating				

7. How many years of formal education do you have? _____________

8. What is the highest education level you have achieved or its approximate equivalent (e.g., high school, undergraduate, Masters, professional training, PhD, M.D. etc).

____

9. Write down the name of the language in which you received instruction in school, for each schooling level:

Primary/Elementary School		
Secondary/Middle School		
High School		
College/University		

10. Have you ever had a vision problem □, hearing impairment □, language disability (e.g., dyslexia) □?
Check all applicable. If yes please explain (including any corrections).

____

11. If you have taken a standardized test of proficiency for languages other than your native language (e.g., TOEFL or IELTS), please indicate the scores you received for each.

Language	Scores	Name of the Test

Do you feel that you have lost any fluency in a particular language? ________ 12.
If yes, which one? ____________________________ At what age? _______

In which languages do you usually: 13.

Count, add, multiply, and do simple arithmetic	
Dream	

Express anger or affection	

14. When you are speaking, do you ever mix words or sentences from the two or more languages you know?

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

If yes, which ones? ________

15. If you had to choose which language to use for the rest of your life, which language would it be?

____

16. If there is anything else that you feel is interesting or important about your language background or language use, please comment below.

____

____

____

____

____

Section 2: All questions below refer to your knowledge of ARABIC

1. Age when you .....

Began acquiring	Became fluent in speaking	Began reading	Became fluent in reading

2. Please list the number of years and months you spent in each language environment:

	Years	Months
A country where this language is spoken		
A family where this language is spoken		
A school/work place where this language is spoken		

3. Using the scale below from 0 to 10, please indicate your level of **proficiency** in *speaking, understanding* and *reading* (the middle of the scale 5=adequate).

0	1	2	3	4	5	6	7	8	9	10
None	Very low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very good	Excellent	Perfect

Speaking		Understanding spoken language		Reading		Writing	

4. Using the scale below from 0 to 10, please indicate how much the following factors contributed to your learning (the middle of the scale 5=moderate).

0	1	2	3	4	5	6	7	8	9	10
Not a contributor	Minimal contributor				Moderate contributor					Most important contributor

Interacting with friends		Language tapes/self-instruction	
Interacting with family		Watching TV	
Reading		Listening to the radio	

5. Using the scale below from 0 to 10, please rate to what extent you are currently exposed to this language in the following contexts (the middle of the scale 5=half of the time).

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

Interacting with friends		Listening to radio/music	
Interacting with family		Reading	
Watching TV		Language tapes/self-instruction	

6. In your perception, how much of a foreign accents do you have in this language (the middle of the scale 5=moderate). Please circle a number on the scale below:

0	1	2	3	4	5	6	7	8	9	10
None	Almost none	Very light	Light	Some	Moderate	Considerable	Heavy	Very heavy	Extremely heavy	Pervasive

7. Please rate how frequently others identify you as a non-native speaker based on your accent in this language (the middle of the scale 5=half of the time). Please circle a number on the scale below:

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

Section 3: All questions below refer to your knowledge of ENGLISH

1. Age when you .....

Began acquiring	Became fluent in speaking	Began reading	Became fluent in reading

2. Please list the number of years and months you spent in each language environment:

	Years	Months
A country where this language is spoken		
A family where this language is spoken		
A school/work place where this language is spoken		

3. Using the scale below from 0 to 10, please indicate your level of **proficiency** in *speaking, understanding* and *reading* (the middle of the scale 5=adequate).

0	1	2	3	4	5	6	7	8	9	10
None	Very low	Low	Fair	Slightly less than adequate	Adequate	Slightly more than adequate	Good	Very good	Excellent	Perfect

Speaking		Understanding spoken language		Reading		Writing	

4. Using the scale below from 0 to 10, please indicate how much the following factors contributed to your learning (the middle of the scale 5=moderate).

0	1	2	3	4	5	6	7	8	9	10
Not a contributor	Minimal contributor				Moderate contributor					Most important contributor

Interacting with friends		Language tapes/self-instruction	
Interacting with family		Watching TV	
Reading		Listening to the radio	

5. Using the scale below from 0 to 10, please rate to what extent you are currently exposed to this language in the following contexts (the middle of the scale 5=half of the time).

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

Interacting with friends		Listening to radio/music	
Interacting with family		Reading	
Watching TV		Language tapes/self-instruction	

6. In your perception, how much of a foreign language do you have in this language (the middle of the scale 5=moderate). Please circle a number on the scale below:

0	1	2	3	4	5	6	7	8	9	10
None	Almost none	Very light	Light	Some	Moderate	Considerable	Heavy	Very heavy	Extremely heavy	Pervasive

7. Please rate how frequently others identify you as a non-native speaker based on your accent in this language (the middle of the scale 5=half of the time). Please circle a number on the scale below:

0	1	2	3	4	5	6	7	8	9	10
Never	Almost Never				Half of the time					Always

APPENDIX B

The material 80 sets of words

Root+Semantic		Root		Semantic		Arabic-Unrelated		Target		Shared root	English-unrelated	
مُراجعينْ [muraəʈiz'jin] Reviewers	N, mas, plu	مراجعٌ [maraəʈiz'uən] References	N, mas, plu	عائدونْ [ʐaəƵdwn] returners	N, mas, plu	أولادٌ [aəwlaədwn] boys	N, mas, plu	رجوعٌ [rwʈwʐwn] return	N, Mas, sing	**r ʈ ʐ**	مُهاجرونْ [mwhaəʈjrwn] Immigrants	N, mas, plu
مُسَكِّن ٌ [musaəkinuən] Painkiller	N,Mas,sing	سَكنٌ [sakanuən] house	N, Mas ,sing	هدوءٌ [hudwƵuən] calm	N, Mas ,sing	إمتحانٌ [imtiħaənuən] quiz	N, Mas ,sing	ساكنةٌ [saəkinaətuən] quiet	Adj, Fem, sing	**s k n**	مستشارٌ [Muə staʕaəruən] Advisor	N, Mas ,sing
متحدثٌ [muətaħadiθuən] speaker	N,Mas,sing	حادثٌ [Haədiθuən] accident	N, Mas ,sing	خطابٌ [xitʐabuən] script	N, Mas ,sing	تصميمٌ [tasʐmiəmuən] Design	N, Mas, sing	محادثةٌ [muħaədatθatuən] conversation	N, Fem sing	**ħ d θ**	جراحٌ [ʈaraəħuən] surgeon	N, Mas, sing
طابعٌ [taəbiʐuən] stamp	N, Mas,sing	طَبعٌ [tabʐuən] Quality	N, Mas, sing	نَاشرٌ [naəʕiruən] publisher	N, Mas, sing	مستشارٌ [mustaʕaəruən] Advisor	N, Mas, sing	طباعةٌ [tibaəʐttuən] printing	N, Fem, sing	**tʐ b ʐ**	مُصمِمٌ [musʐamimuən] designer	N,Mas, sing
قناعةٌ [qanaəʐtuən] satisfaction	N, Fem ,sing	مُقنَّعَةٌ [muqannaʐtuən] masked	Adj, Fem ,sing	عفيفةٌ [ʐafifauən] modest	Adj, Fem, sing	جموعٌ [ʈumwʐuən] people	N, Mas, plu	قنوعٌ [qanwʐuən] Satisfactory	Adj, mas, sing	**q n ʐ**	مَنظرٌ [manðʐaruən] sight	N, Mas ,sing
جسامةٌ [ʈasaəmatuən] greatness	N, Fem ,sing	مجسمةٌ [moʈasamatuən] manikin	Adj, Fem ,sing	عظيمةٌ [ʐaðʐimatuən] great	Adj, Fem, sing	مساعدةٌ [musaʐadtuən] helpful	Adj, Fem, sing	جَسيمٌ [ʈasjimuən] bulky	Adj, mas, sing	**ʈ s m**	الثالثةُ [aəθaəliθatu] third	Adj, Fem, sing
حكمةٌ [ħikmatuən]	N,Mas, Plu	حكّامٌ [ħokaəmuən]	N,Mas, Plu	تجاربٌ [taʈrubuən]	N,Mas, Plu	مراجعٌ [maraə ʈizuə n]	N, mas, plu	حكميةٌ [ħakimatuə n]	Adj, Fem, sing	**ħ k m**	أولادٌ [aəwlad uə n]	N, mas, plu

sayings		rulers		Experiences		References		wise			boys	
محبوبتانْ [ma ħ bubat aə n] Lovers	adj, Fem,dual	حبتانْ [ħ abat aə n] tablets	N, Fem,dual	عاشقتانْ [ʐ aə ʕ iqat aə n] enamoured	adj, Fem,dual	مَسكنَانْ [maskan aə n] houses	adj, Fem,dual	حَبيبٌ [ħ abib uə n] darling	Adj, mas, sing	ħ b b	مُساعِدتان [mus aə ʐ idat aə n] Assistants	adj, Fem,dual
مَنظرٌ [man ðʐ ar uə n] sight	N, Mas ,sing	نظيرٌ [na ðʐ j r uə n] counterpart	N, Mas ,sing	مُشاهدٌ [mu ʕ aə hid uə n] viewer	N, Mas, sing	حادثٌ [ħ aə di θ uə n] accident	N, Mas ,sing	تنظرُ [tan ðʐ uru] look	V, Fem, sing, Present	n ðʐ r	طابعٌ [tʐ abi ʐ uə n] stamp	N, Mas,sing
مظلوماتٌ [ma ðʐ lwum aə t uə n] Wronged	Adj, Fem , plu	ظلماتٌ [ðʐ ulum aə t uə n] Dark	Adj, Fem , plu	مستبداتٌ [mustabid aə t uə n] dictotorial	Adj, Fem ,plu	مجسماتٌ [mu ɭ asam aə t uə n] manikins	Adj, Fem ,plu	ظالمٌ [ðʐ aə lim uə n] unfair	Adj, Mas, sing	ðʐ l m	مجادلاتٌ [mu ɭ aə dil aə t uə n] argumentatives	Adj, Fem, plu
كتابٌ [kitaə b uə n] book	N, Mas ,sing	مكتبٌ [maktab uə n] office	N, Mas ,sing	نصٌ [na sʐ uə n] text	N, Mas, sing	قناعٌ [qin aə ʐ uə n] mask	N, Mas, sing	مكتباتٌ [maktab aə uə n] Libraries	N, Fem, Plu.	k t b	جامعٌ [ɭ aə mi ʐ uə n] mosque	N, Mas, sing
يراقبُ [j r aə qibu] observe	V, Mas, sing, present	يترقبُ [j ataraqabu] expect	V, Mas, sing, present	يتابعُ [j ut aə bi ʐ u] Follow	V, Mas, sing, present	يطبعُ [j a tʐ ba ʐ uo] Print	V, Mas, sing, present	مُراقبةٌ [muraqabat uə n] observation	Adj,Fem, sing	r q b	يحاضرُ [j u ħ aə dʐ iru] lecture	V, Mas, sing, present
سقطَةٌ [saqtat uə n] drop	N, Fem, sing	ساقطةٌ [s aə qi tʐ at uə n] fallen person	N, Fem, sing	وقعةٌ [waq ʐ at uə n] fall	N, Fem, sing	تجربةٌ [ta ɭ rubat uə n] experiment	N, Fem, sing	يسقطُ [j a sʐ qut u] Fall	V, Mas, sing, Present	s q tʐ	مشاجرةٌ [mu ʕ a ɭ arat uə n] fighting	N,Fem, sing
تطعمُ [tu tʐ ʐ imu] feed	V, Fem, sing, present	تَتَطَعمُ [tata ʐ amu] inoculate	V, Fem, sing, present	تَتَغذى [tata dz a ð a] eat	V, Fem, sing, present	تعشقُ [ta ʐ ʕ aqu] loves	V, Fem, sing, present	طعامٌ [tʐ a ʐ am uə n] Food	N, Mas,plu	tʐ ʐ m	تتخرجُ [tata x ara ɭ u] graduate	V, Fem, sing, present
تعليماتٌ [ta ʐ limat uə n] Instructions	N, Fem, plu	علاماتٌ [ʐ al aə m aə t uə n] Signs	N, Fem, plu	طالباتٌ [tʐ aə lib aə t uə n]] students	N, Fem, plu	مُشاهداتٌ [mu ʕ ahad aə t uə n] viewers	N, Fem, plu	معلمةٌ [mu ʐ limat uə n] teacher	N, Fem, sing	ʐ l m	مُسَكِّنَاتٌ [musakin aə t uə n] Painkillers	N, Fem, plu
تُحققُ		تَستحقُ		تتثبتُ		تستبدُ		تَحَققَ		ħ q q	تَتعاونُ	

[tu ħ aqiqu]	V, Fem, sing, present	[tasta ħ iqu]	V, Fem, sing, present	[tata θ abatu]	V, Fem, sing, present	[tastabidu]	V, Fem, sing, present	[ta ħ aqaqa]	V, Mas, sing, past		[tataʐ aə wanu]	V, Fem, sing, present
ensure		worth		ensure		dictate		ensured			Cooperate	
مُنتَظرةٌ		نظريةٌ		مرتقبٌ		عاشقةٌ		إنتظارٌ		**n ðʐ r**	موثقةٌ	
[muntaðʐ aratuə n]	Adj, Fem, sing	[naðʐ arij tuən]	Adj, Fem, sing	[muortaqibun]	Adj, Mas, sing	[ʐ aə r̂ iqatuə n]	Adj, Fem, sing	[ʐ ntiðʐ aruə n]	N, Mas, sing		[mawaθ aqa tuən]	adj, Fem, sing
expectant		Theoretical		expectant		enamored		wait			formal	
يَبْسُطُ		يُبَّسِطُ		يفسحُ		يتابعُ		مُنبسطةٌ		**b s tʐ**	يحدثُ	
[j ab s tʐ u]	V, Mas, sing, present	[j uə basi tʐ u]	V, Mas, sing, present	[j uə f si ħ u]	V, Mas, sing, present	[j utabi ʐ u]	V, Mas, sing, present	[munbasi tʐ at uə n]	Adj, Fem ,sing		[j u ħ du θ u]	V, Mas, sing, present
flatten		simplify		making space		Follow		flat			happen	
إعترضَ		عرضَ		رفضَ		درسَ		مُعترضٌ		**ʐ r dʐ**	إفترضَ	
[ʐ ʐ tara dʐ a]	V, Mas, sing, past	[ʐ ara dʐ a]	V, Mas, sing, past	[rafa dʐ a]	V, Mas, sing, past	[darasa]	V, Mas, sing, past	[mu ʐ tari dʐ uə n]	Adj, Mas ,sing		[aə ftara dʐ a]	V, Mas, sing, past
stopped		showed		rejected		Studied		disagreeing			Assumed	
عملٌ		عميلٌ		وظيفةٌ		صدقٌ		إستعملنَ		**ʐ m l**	كتابٌ	
[ʐ amal uə n]	N, Mas, sing	[ʐ am iə l uə n]	N, Mas ,sing	[wa ðʐ ifat uə n]	N,Fem,sing	[sʐ iə dq uə n]	N, Mas, sing	[ʐ sta ʐ malna]	V, Fem, plu, past		[kit aə b uə n]	N, Mas ,sing
Work		customer		job		truth		used			book	
مُصّغرٌ		صغيرٌ		ضئيلٌ		مُراجِعٌ		صغيرةٌ		**sʐ dz r**	أسودٌ	
[mu sʐ a dz ar uə n]	Adj, Mas ,sing	[sʐ a dz ir uə n]	Adj, Mas ,sing	[dʐ a ʐ j l uə n]	Adj, Mas ,sing	[mura ʅ i ʐ uə n]	Adj, Mas ,sing	[sʐ a dz irat uə n]	Adj,Fem, sing		[aə swad uə n]	Adj, Mas, sing
smallest		male childish		tiny		Reviewer		small			black	
قطعةٌ		مقاطعةٌ		قصاصةٌ		زهرةٌ		يقطعُ		**q tʐ ʐ**	مُراجِعةٌ	
[qi tʐ ʐ at uə n]	N, Fem, sing	[muq aə tʐ a ʐ t uə n]	N, Fem, sing	[qu sʐ aə sʐ at uə n]	N, Fem, sing	[zahrat uə n]	N,Fem, sing	[j aq tʐa ʐ u]	V, Mas, sing, present		[mur aə ʅ i ʐ at uə n]	N, Fem, sing
piece		state		clip		flower		cut			Reviewer	
تحدثَتْ		حَدَثَتْ		قالتْ		وضحّتْ		يتحدثُ		**ħ d θ**	بَنَتْ	
[ta ħ ada θ at]	V, Fem, sing, past	[ħ ada θ at]	V, Fem, sing, past	[q aə lalat]	V, Fem, sing, past	[wa dʐ a ħ at]	V, Fem, sing, past	[ʐ ata ħ adat θ u]	V, Mas, sing, present		[banat]	V, Fem, sing, past
spoke		happened		said		explained		speak			built	
صديقٌ		صدقٌ		رفيقٌ		طابعٌ		صداقةٌ		**sʐ d q**	متحدثٌ	
[sʐ ad j q uə n]	N, Mas,sing	[sʐ idq uə n]	N, Mas, sing	[raf j q uə n]	N, Mas, sing	[tʐ aə bi ʐ uə n]	N, Mas,sing	[sʐ ad aə qat uə n]	N,Fem, sing		[muta ħ ade θ uə n]	N,Mas,sing
Friend		truth		fellow		stamp		friendship			speaker	
معبأً		عبءٌ		مملوءٌ		مُسوَّدٌ		عبأَتْ		**ʐ b b**	جامعيٌّ	

[mua ʐ ab aə Z uə n] Filling	Adj, Mas, sing	[ʐ ib uə n] stressed	Adj, Mas, sing	[mamlu Z uə n] Full	Adj, Mas, sing	[muswad uə n] Blackish	Adj, Mas, sing	[ʐ ab aə Z t] filled	V, Fem, sing, past		[ḷ aə mi ʐ j uə n] academic	adj, Mas, sing
خروفٌ [x arwf uə n] Lamb	N, Mas, sing	خرفٌ [x araf uə n] divagation	N, Mas, sing	ماعزٌ [m aə ʐ iz uə n] Goat	N, Mas, sing	مقصٌ [miqa sz uə n] scissors	N, Mas, sing	خِرَافٌ [x ir aə f uə n] Sheep	N, Mas, Plu.	x r f	عملٌ [ʐ amal uə n] Work	N, Mas, sing
ترفعُ [tarfa ʐ u] Raise	V, Fem, sing, present	تترافعُ [tatar aə fa ʐ uə] advocate	V, Fem, sing, present	تعلوُ [ta ʐ lw] rise	V, Fem, sing, present	تحكمُ [ta ħ kum uə] rule	V, Fem, sing, present	رفيعٌ [raf j ʐ uə n] high	adj, Mas, sing	r f ʐ	تطعمُ [to tʐ ʐ im uə] feed	V, Fem, sing, present
مُطَّلِعٌ [mu ðʐ ali ʐ uə n] insider	Adj, Mas ,sing	مَطْلَعٌ [ma tʐ la ʐ uə] beginning	Adj, Mas, sing	مثقفٌ [muθ aqaf uə n] Cultured	Adj, Mas, sing	محبوبٌ [maHbobon] Lovable	Adj, Mas, sing	مُطَّلِعونٌ [moTalea'oun] insiders	N,Mas, Plu.	θ q f	مُصَغرٌ [mosagharun] smallest	Adj, Mas ,sing
شجرةٌ [ʕ a ḷ arat uə n] Tree	N, Fem, sing	مشاجرةٌ [mu ʕ a ḷ ara uə n] fighting	N,Fem, sing	زهرةٌ [zahrat uə n] flower	N,Fem, sing	نظارةٌ [na ðʐ arat uə n] Glasses	N,Fem, sing	أشجارٌ [aə ʕ jar uə n] trees	N,Fem, Plu.	ʕ ḷ r	حكمةٌ [ħ ikmat uə n] sayings	N,Fem,sing
إسقبلَ [Z staqbala] Received	V, Mas, sing, past	قابلَ [qabala] met	V, Mas, sing, past	إستضافَ [Z sta dʐ afa] Hosted	V, Mas, sing, past	ظلمَ [ðʐ alama] Wrong	V, Mas, sing, past	تستقبلُ [tastaqbilu] Receives	V, Fem, sing, present	q b l	هَجَرَ [ha ḷ ara] abandoned	V, Mas, sing, past
تنخفضُ [tan x afi dʐu] decline	V, Fem, sing, present	تُخَفِضُ [tu x afidu] sell	V, Fem, sing, present	تنحدرُ [tan ħ adiru] descend	V, Fem, sing, present	تكتبُ [taktubu] write	N, Mas ,sing	منخفضٌ [mun x afid uə n] low	adj, Mas, sing	x f dʐ	تتذكرُ [tatað akru] Remember	V, Fem, sing, present
يبرقُ [j abruqu] shimmer	V, Mas, sing, present	يُبْرِقُ [j ubriqu] telegraph	V, Mas, sing, present	يلمعُ [j almazu] shine	V, Mas, sing, present	يراقبُ [ʐ uraqibu] observe	V, Mas, sing, present	بَرقٌ [barq uə n] lightning	N, Mas, sing	b r q	يَبْسُطُ [j absu tʐu] flatten	V, Mas, sing, present
حلوىً [ħ alw aə]	N,Fem, sing	حُليةٌ [ħ uliat uə n]	N, Fem, sing	سكرةٌ [sukarat uə n]	N, fem, sing	سقطَةٌ [saq tʐ at uə n]	N, Fem, sing	حلوياتٌ [ħ alawi j aə t uə n]	N , Mas, plu	ħ l aə	سجَادةٌ [sa ḷ ad aə t uə n]	N, Fem, sing

sweet		jewel		sugar		drop		Sweets			rug	
تَرفيةٌ		تُرفةٌ		ثروةٌ		تطعيمةٌ		ترفٌ		**t r f**	سقطَةٌ	
[tarf j h uə n]	N, Fem,sing	[turfat uə n]	N,Fem, sing	[θ arwat uə n]	N,Fem, sing	[ta ʐ imat uə n]	N,Fem, sing	[taraf uə n]	N,Mas, sing		[saq tʐ at uə n]	N, Fem, sing
fun		joke		riches		inoculation		Luxury			drop	
يضيفُ		يستضيفُ		يُلحقُ		يُعطيْ		مضافةٌ		**dʐ j f**	يَبرقُ	
[j u dʐ j fu]	V, Mas, sing, present	[j asta dʐ j fu]	V, Mas, sing, present	[j ul ħ iqu]	V, Mas, sing, present	[j u ʐ tʐ j]	V, Mas, sing, present	[mu dʐ afat uə n]	Adj, Fem, sing		[j abruqu]	V, Mas, sing, present
Add		Host		Add		give		Additional			shimmer	
سجّادةٌ		سَجدةٌ		فرشةٌ		حقيقةٌ		سجادٌ		**s ʆ d**	قناعةٌ	
[sa ʆ aə dat uə n]	N, Fem, sing	[sa ʆ dat uə n]	N,Fem, sing	[far ʕ at uə n]	N, fem, sing	[ħ aqiqat uə n]	N, fem, sing	[si ʆ aə d uə n]	N, Mas, Plu.		[qan aə ʐ t uə n]	N, Fem ,sing
rug		bow		Mattress		fact		carpets			satisfaction	
سكينٌ		مسكَنٌ		مقصٌ		منظرٌ		سَكاكينٌ		**s k n**	صديقٌ	
[sikj n uə n]	N, Mas, sing	[maskan uə n]	N, Mas, sing	[miqa sʐ uə n]	N, Mas, sing	[manðʐ ar uə n]	N, Mas, sing	[sakak j n uə n]	N,Mas, Plu.		[sʐ ad j q uə n]	N, Mas,sing
Knife		house		scissors		View		knifes			Friend	
متشابكةٌ		شَبكةٌ		متداخلةٌ		مقاطعةٌ		تشبكُ		**ʕ b k**	حُليةٌ	
[muta ʕ aə bikat uə n]	N,Fem, sing	[ʕ abakat uə n]	N,Fem, sing	[mutad x ilat uə n]	N,Fem, sing	[muq aə tʐ a ʐ at uə n]	N,Fem, sing	[ta ʕ buku]	V, Fem, sing, present		[ħ ul j at uə n]	N, Fem, sing
overlap		net		Overlapping		state		link			jewel	
جَاهزٌ		جهازٌ		مستعدٌ		صغيرٌ		يجهزُ		**ʆ h z**	مَطْلَعٌ	
[ʆ aə hiz uə n]	Adj, Mas, sing	[ʆ ih aə z uə n]	Adj, Mas, sing	[mustaʐ id uə n]	adj, Mas, sing	[sʐ a dz j r uə n]	adj, Mas, sing	[j u ʆ ahizu]	V, Mas, sing, present		[mu tʐ al ʐ uə n]	Adj, Mas, sing
ready		Trousseau		ready		male childish		prepare			beginning	
كُؤوسٌ		كساءٌ		كُوبٌ		عملٌ		كَاسةٌ		**k a s**	خرفٌ	
[kuwZ us uə n]	N, Mas, plu	[kis aə uə n]	N, Mas, sing	[kuwbuə n]	N, Mas, sing	[ʐ amal uə n]	N, Mas, sing	[k aə sat uə n]	N, Fem, sing		[x aruf uə n]	N, Mas, sing
glasses		cover		cup		Work		glass			divagation	
يكرمُ		يَتَكَرَمُ		يُعطيْ		يَعترضُ		كَريمٌ		**k r m**	يُبْرِقُ	
[jukrimu]	V, Mas, sing, present	[jatakramu]	V, Mas, sing, present	[juʐ tʐj]	V, Mas, sing, present	[jaʐ taridʐu]	V, Mas, sing, present	[karjmuən]	adj, Mas, sing		[jubriqu]	V, Mas, sing, present
honor		be kind		give		stop		generous			telegraph	
نُزلاء		منازلٌ		مُستأجرين		عائدونْ		نزيلةٌ		**n z l**	مجموعٌ	
[nuzalaəZ]	N, Mas, plu	[manaə ziluə n]	N, Mas, plu	[mustaə ʆ irj n]	N, Mas, plu	[ʐ aə Z idwn]	N, mas, plu	[nazj latuə n]	N, Fem, sing		[majmwʐ uə n]	N, Mas, plu

Guests		Houses		renters		returners		Guest			totals	
شِراعٌ	N, Mas, sing	شارعٌ	N, Mas, sing	قُماشٌ	N, Mas, sing	خرفٌ	N, Mas, sing	أشرعةٌ	N,Fem, Plu.	ʃ r ʐ	سَكَنٌ	N, Mas, sing
[ʃ iraəʐ uə n]		[ʃ aə ri ʐ uə n]		[qum aə ʃ uə n]		[x araf uə n]		[aə ʃ ʐat uə n]			[sakan uə n]	
Sail		street		Canvas		divagation		Sails			house	
ثَراءٌ	adj, Mas, sing	ثرى	Adj, Mas, sing	غَنىٌ	Adj, Mas, sing	مَطْلَعٌ	Adj, Mas, sing	ثروةٌ	N ,Fem, sing	θ r ʐ	تجريبيٌ	Adj, Mas, sing
[θ ar aə Z uə n]		[θ ar aə]		[dz in aə]		[ma tʐ la ʐ]		[θ arwat uə n]			[tajr j b j uə n]	
Wealthy		sandy		Rich		beginning		wealth			experimental	
ستارةٌ	N, Fem, sing	سُترةٌ	N, Fem, sing	حاجبةٌ	N, Fem, sing	عبوةٌ	N, Fem, sing	ستائرٌ	N,Mas, Plu.	s t r	تُرفةٌ	N,Fem, sing
[sit aə rat uə n]		[sutrat uə n]		[ħ aə ɉ ibat uə n]		[ʐ ubwat uə n]		[sat aə Z r uə n]			[turfat uə n]	
curtain		sweater		opaque curtain		can		curtains			joke	
بانتْ	V, Fem, sing, past	بَنَتْ	V, Fem, sing, past	وضحَتْ	V, Fem, sing, past	حَدَثَتْ	V, Fem, sing, past	يبينُ	V, Mas, sing, present	b aə n	عبأَتْ	V, Fem, sing, past
[b aə nat]		[banat]		[wa dʐ a ħ at]		[ħ ada θ at]		[j oba j enu]			[ʐ ab aə Z t]	
showed		built		explained		happened		Show			filled	
جريدةٌ	N, Fem, sing	جرادةٌ	N, Fem, sing	مقالةٌ	N, Fem, sing	مرافعةٌ	N, Fem, sing	مجردٌ	Adj, Mas, sing.	ɉ r d	سَجدةٌ	N,Fem, sing
[ɉ ar j dat uə n]		[ɉ ar aə dat uə n]		[maq aə lat uə n]		[mur aə fa ʐ at uə n]		[mu ɉ arad uə n]			[sa uə dat uə n]	
newspaper		grasshopper		article		Pleading		just			bow	
خاتَمٌ	N, mas, sing	ختاماً	N, mas, sing	دبلةٌ	N, fem, sing	صدقٌ	N, mas, sing	خواتمٌ	N, Mas, Plu.	x t m	شارعٌ	N, Mas, sing
[x aə tim uə n]		[xit aə m aə n]		[diblat aə n]		[sʐ idq aə n]		[xaw aə tim aə n]			[ʃ aə ri ʐ uə n]	
Ring		Conclusion		wedding ring		truth		Rings			street	
قِصتانْ	N, Fem,dual	قُصاصتانْ	N, Fem,dual	روايتانْ	N, Fem,dual	مُشاجرتانْ	N, Fem,dual	تقصصْ	V, Fem, sing, present	q sʐ sʐ	كِسوتانْ	N, Fem,dual
[qisʐ ataə n]		[qusʐ aə sʐ aə taə n]		[riwaə j ataə n]		[muʃaə ɉ arataə n]		[taqsʐ usʐ]			[kiswataə n]	
stories		two halves		Novels		fighting		tell			covers	
أَحْجَارٌ	N,Fem, Plu.	حُجُراتٌ	N,Fem, Plu.	حَصَواتٌ	N,Fem, Plu.	مُقابلاتٌ	N,Fem, Plu.	حَجَرٌ	N, Mas, sing	ħ ɉ r	تعليماتٌ	N, Fem, plu
[aə ħ ɉ aə ruə n]		[ħuɉ uraə tuə n]		[ħ asʐ awaə tuə n]		[muqaə ba laə tuə n]		[ħ aɉ aruə n]			[taʐlj maə tuə n]	
Stones		rooms		gravel		interviews		Stone			Instructions	
حواجزٌ		حجوزاتٌ		عوائقٌ		خوافضٌ		حَاجزٌ		ħ ɉ z	منازلٌ	

[ħ awaəʟ izuə n]	N, Mas, Plu.	[ħ uʟ uzaə tuə n]	N, Fem, Plu.	[dz waə iquə n]	N, Mas, Plu	[xwaə fixuə n]	N, Mas, Plu	[ħ aəʟ eezuə n]	N, Mas, sing		[manaə ziluə n]	N, Mas, plu
Blocks		reservation		liability		painkiller		Block			Houses	
يسافرُ		يسفرُ		يغادرُ		يُبْرِقُ		سافرتْ		s f r	يستضيفُ	
[j usaəfiru]	V, Mas, sing, present	[j usfiru]	V, Mas, sing, present	[j u dz aədiru]	V, Mas, sing, present	[j ubriqu]	V, Mas, sing, present	[saəfarat]	V, Fem, sing, past		[j asta dʐ j fu]	V, Mas, sing, present
Travel		Result		leave		telegraph		travelled			Host	
معاملةٌ		عمليةٌ		مهمةٌ		حُليةٌ		عمالٌ		ʐ m l	سُترةٌ	
[mu ʐ aə malat uə n]	N, Fem, sing	[ʐ mal j at uə n]	N, Fem, sing	[muhimat uə n]	N, Fem, sing	[ħ ul j at uə n]	N, Fem, sing	[ʐ um aə l uə n]	N, Mas,plu		[sutrat uə n]	N, Fem, sing
task		operation		task		jewel		workers			sweater	
قراراتٌ		مقرراتٌ		مراسيمٌ		تُرفاتٌ		قرارٌ		q r r	حُجُراتٌ	
[qaraəraətuə n]	N,Fem, Plu.	[muqararaətuə n]	N,Fem, Plu.	[maraəsjmuə n]	N, **Mas,** plu	[turafaətuə n]	N,Fem, Plu.	[qaraərtuə n]	N, Mas, sing		[ħuʟ uraətuə n]	N,Fem, Plu.
decisions		models		Decrees		jokes		decision			rooms	
أخطأً		خُطىً		أغلاطٌ		جهازٌ		أخطأتْ		X tʐ a	السادةُ	
[aəx tʐaəun]	adj, Mas, plu	[x utʐaəun]	N, Mas, plu	[aədz laətʐun]	adj, Mas, plu	[ʟ ihaəz]	adj, Mas, plu	[aəx atʐaəƵt]	V, Fem, sing, past		[aəsaədatu]	Adj, Mas, Plu
mistaken		steps		wrong		Trousseau		sinned			Gentlemenly	
مؤسسٌ		أساسيٌ		نشوءٌ		سَكَنٌ		أسسَ		aə s s	ختاماً	
[mwasisuə n]	N, mas, sing	[aə sasj uə n]	N, mas, sing	[nuʕ wuə n]	N, mas, sing	[sakanuə n]	N, mas, sing	[aə sasa]	V, Mas, sing, past		[x itaə maə n]	N, mas, sing
founder		basic		establishment		house		established			Conclusion	
ضربةٌ		ضريبةٌ		خَدْشةٌ		سَجدةٌ		ضرباتٌ		dʐ r b	شَبكةٌ	
[dʐ arbatuə n]	N, Fem, sing	[dʐ arj batuə n]	N, Fem, sing	[x adʕ atuə n]	N, Fem, sing	[saʟ datuə n]	N, Fem, sing	[dʐ araə batuə n]	N, Mas, Plu.		[ʕ abakatuə n]	N,Fem, sing
hurt		tax		scratch		bow		hits			_net	
ينزعُ		ينازعُ		يقصُ		يشبكُ		نزعَ		n z ʐ	يَتَكَرّمُ	
[j anzaʐ u]	V, Mas, sing, present	[j unaə ziʐ uo]	V, Mas, sing, present	[j aquszu]	V, Mas, sing, present	[j aʕ buku]	V, Mas, sing, present	[nazaʐ a]	V, Fem, sing, past		[j atakramu]	V, Mas, sing, present
remove		fight		cut		links		removed			be kind	
ينتقلُ		منقلةُ		يُغيّرُ		يستضيفُ		نقلٌ		n q l	يسفرُ	
[j antaqilu]	V, Mas, sing, present	[minqalatuə n]	N, Fem, sing	[judz j ru]	V, Mas, sing, present	[j astadʐ j fu]	V, Mas, sing, present	[naqlun]	N,Mas, sing		[j usfiru]	V, Mas, sing, present
transporting		Protractor		change		Hosts		transport			Result	

هاجرَ [haə jara] emigrated	V, Mas, sing, past	هَجَرَ [hajara] abandoned	V, Mas, sing, past	رحلَ [raħ ala] left	V, Mas, sing, past	كَسَى [kasaə] covered	V, Mas, sing, past	تهجيرٌ [tahȴ iruə n] emigrate	V, Fem, sing, present	**h ȴ r**	قابلَ [qaə bala] met	V, Mas, sing, past
مساعدةٌ [musaə ʓ datuə n] helpful	adj, Fem, sing	سعادةٌ [saʓ aə datuə n] happyness	adj, Fem, sing	متعاونةٌ [mutaʓ aə winatuə n] Collaborator	adj, Fem, sing	عظيمةٌ [ʓ ðʓ imatuə n] great	Adj, Fem, sing	مُساعدٌ [musaə ʓ iduə n] Assistant	Adj, mas, sing	**s ʓ d**	مُنتَظرةٌ [muntaðʓ aratuə n] expectant	Adj, Fem, sing
إستشارةٌ [aə stiʢ aratun] consultation	N, Fem, sing	إشارةٌ [aə iʢ aə ratun] signal	N, Fem, sing	نصيحةٌ [nasʓ j ħ atuə n] advice	N, Fem, sing	مستأجرةٌ [mustaə ȴ aratuə n] renters	N, Fem, sing	مستشارٌ [mustaʢ aruə n] Advisor	N,Mas, sing	**ʢ aə r**	جرادةٌ [ȴ araə datuə n] grasshopper	N, Fem, sing
تصميمٌ [tasʓ mj muə n] Design	N, Mas, sing	صمّامٌ [sʓ maə muə n] tap	N, Mas, sing	شكلٌ [ʢ akluə n] form	N, Mas, sing	قُماشٌ [qumaə ʢ uə n] Canvas	N, Mas, sing	مُصمِمةٌ [musʓ amimatuə n] designer	N,Fem, sing	**sʓ m m**	أساسيٌ [aə saə sej uə n] basic	N, mas, sing
إمتحانٌ [aə imtiħ aə nuə n] quiz	N, Mas, sing	مِحنْ [miħ an] problem	N, Mas, sing	إختبارٌ [aə ixtibaə ruə n] exam	N, Mas, sing	غناءٌ [dz inaə un] Singing	N, Mas, sing	إمتحاناتٌ [aə mtiHaə naə tun] quizzes	N,Fem, Plu.	**m ħ n**	صمّامٌ [sʓ maə mun] tap	N, Mas, sing
جموعٌ [ȴ umwʓ uə n] people	N, Mas, plu	مجموعْ [maȴ mwʓ uə n] totals	N, Mas, plu	تجمهرٌ [taȴamhuruə n] crowds	N, Mas, plu	حاجبٌ [ħ aȴ ibuə n] opaque curtain	N, Mas, sing	جماعةٌ [ȴamaə ʓ atuə n] group	N, Fem, sing.	**ȴ m ʓ**	حضورٌ [ħ udwruə n] attenders	N, Mas, plu
ولاداتٌ [wilaədaətuə n] births	N, Fem, plu	مُوَّلداتٌ [muwalidaətuə n] motors	N, Fem, plu	قابلاتٌ [qaəbilaətuə n] midwifes	N,Fem, Plu.	إيضاحاتٌ [aəidʓ aəhaətuə n] definition	N,Fem, Plu.	توليدٌ [tawliduə n] generate	V, mas, sing, present	**w l d**	مجروحاتٌ [majrwhaətuə n] strickens	Adj, fem, plu
ثلاثةٌ [θ alaə θ atuə n] three	N, Mas, sing	مثلثٌ [muθ alaθ uə n] triangle	N, Mas, sing	إثنينْ [aə iθ naj n] two	N, Mas, plu	صحفٌ [sʓ uħ ufuə n] newspapers	N, Mas, plu	الثالثُ [aə θ aə liθ u] third	Adj, Mas, sing	**θ l θ**	جامعٌ [ȴ aəmiʓ uə n] mosque	N, Mas, sing
جامعةٌ [ȴ aəmiʓa tuə n] university	N, Fem, sing	جامعٌ [ȴ aəmiʓ uə n] mosque	N, Mas, sing	باحثةٌ [baəħ iθ atuə n] researcher	N, Fem, sing	دبلةٌ [diblatuə n] wedding ring	N, fem, sing	جامعيٌ [ȴ aəmʓ j uə n] academic	adj, Mas, sing	**ȴ m ʓ**	عمليةٌ [ʓ amaljatuən] operation	N, Fem, sing

جدلٌ [ɭ adaluə n] argument	N, Mas, sing	جدولٌ [ɭ adwaluə n] Schedule	N, Mas, sing	نقاشٌ [niqaə ʕ uə n] discussion	N, Mas, sing	شِعرٌ [ʃ iʐruə n] poetry	N, Mas, sing	مجادلةٌ [muɭ adalatuə n] argumentative	Adj, Fem, sing	**ɭ d l**	مِحنٌ [miħ an] problem	N, Mas, sing
جِراحاتٌ [ɭ iraħ aə tuə n] surgeries	N, Fem, plu	مجروحاتٌ [maɭ ruhaə tuə n] strickens	Adj, fem, plu	عملياتٌ [ʐ amlj aə tuə n] operations	N,Fem, Plu.	حَصَواتٌ [ħ asʐ awaə tuən] gravel	N,Fem, Plu.	جراحٌ [ɭ araə ħ uən] surgeon	N, Mas, sing	**ɭ r ħ**	حُجوزاتٌ [huɭ uzaə tuən] reservation	N, Fem, Plu.
مُجَرّبٌ [muɭ arabuə n] experimentor	N, Mas, sing	جوربٌ [ɭ awrabuən] sock	N, Mas, sing	مختبرٌ [muxtabaruə n] tested	Adj, Mas, sing	جدالٌ [ɭ idaə luə n] argument	N, Mas, sing	تَجريبي [taɭ rj bj uə n] experimental	Adj, Mas, sing	**ɭ r b**	جهازٌ [ɭ ihaəz] Trousseau	Adj, Mas, sing
حادثٌ [ħaədiθun] accident	N, Mas, sing	حديثٌ [ħadj θuə n] conversation	N, Mas, sing	مُصابٌ [musʐ aəbuə n] disaster	N, Mas, sing	مغادرٌ [muaədz diruə n] traveler	N, Mas, sing	حدثَ [ħadaθa] happened	V, Mas, sing, past	**ħ d θ**	مثلثٌ [muθalaθuə n] triangle	N, Mas, sing
وَثائقيٌ [waθ aəƷiq juə n] documented	adj, Mas, sing	موثوقٌ [mwθ uquə n] honest	adj, Mas, sing	مؤكدٌ [mwƷakaduən] assured	adj, Mas, sing	غلطٌ [dzalatʐ uən] wrong	adj, Mas, sing	موثقةٌ [mwaθ aqatuən] formal	adj, Fem, sing	**w θ q**	سعيدٌ [saʐ j duən] happy	adj, Mas, sing
محاضرونْ [muħ aə dʐ irwn] leacturers	N, Mas,plu	حضورٌ [ħ udʐ uruə n] attenders	N, Mas, plu	معلمونْ [muʐ alimuə n] teachers	N, Mas, plu	مراسيمٌ [marasj muə n] Decrees	N, Mas, plu	يحاضرُ [j uħa dʐ iru] lecture	V, Mas, sing, present	**ħ d r**	جواربٌ [jawaribuə n] socks	N, Mas, plu
عونٌ [ʐ awnuə n] aid	N, Mas, sing	معينةٌ [muʐ ijnatuə n] specific	N, Fem, sing	خدمةٌ [x idmatuə n] service	N, Fem, sing	مهمةٌ [muhimatuə n] task	N, Fem, sing	يتعاونُ [jataʐ aə wanu] Cooperate	V, Mas, sing, present	**ʐ w n**	إشارةٌ [aə iʕ aratuə n] signal	N, Fem, sing
بابٌ [baə buə n] chapter	N, Mas, sing	بابٌ [baə buə n] door	N, mas, sing	تصنيفٌ [tasʐnifuə n] Classification	N, Mas, sing	نشوءٌ [nuʕ wƷuə n] establishment	N, mas, sing	بَوّبَ [bawaba] classify	V, Fem, sing, present	**b o b**	جدولٌ [ɭ adwaluə n] Schedule	N, Mas, sing
تخرَّجَ [tax araɭ a] graduated	V, Mas, sing, past	خرجَ [x araɭ a] left	V, Mas, sing, past	نجحَ [naɭ aħ a] passed	V, Mas, sing, past	قصَ [qasʐ a] cut	V, Mas, sing, past	تتخرجُ [tatax arɭ u] graduate	V, Fem, sing, present	**x r ɭ**	بَوّبَ [bawaba] classified	V, Fem, sing, past

فرضيةٌ		فريضةٌ		مُسَلَّمَةٌ		خَدْشَةٌ		تفترضُ		**f r dʐ**	ضريبةٌ	
[faradʐ j atuə n]	N, Fem, sing	[farj dʐ atuə n]	N, Fem, sing	[musalamatuə n]	N, Fem, sing	[x adʕ atuə n]	N, Fem, sing	[taftaridʐ u]	V, Fem, sing,present		[dʐ arj batuə n]	N, Fem, sing
hypothesis		obligation		presupposition		scratch		Assume			tax	
ذاكرةٌ		تذكرةٌ		تنبيهٌ		مُعيقةٌ		تتذكرُ		**ð k r**	فريضةٌ	
[ð aə kiratuə n]	N, Fem, sing	[tað kiratuə n]	N, fem, sing	[tanbihuə n]	N, Fem, sing	[muʐ j qatuə n]	N, Fem, sing	[tatað akru]	V, Fem, sing, present		[farj dʐ atuə n]	N, Fem, sing
memory		ticket		reminder/admonition		Disabling		Remember			obligation	
التسويدْ		السادةُ		غوامقٌ		رَحَّالُونْ		أسودٌ		**s w d**	خُطىً	
[aə taswj d]	Adj, Mas, Plu	[aə sadatu]	Adj, Mas, Plu	[dz awaə miquə n]	Adj, Mas, Plu	[raħ aə lwn]	Adj, Mas, Plu	[aə swaduə n]	Adj, Mas, sing		[x utʐ aə n]	N, Mas, plu
blackening		Gentlemen		dark		travelling		black			steps	

APPENDIX C

Psycholinguistics Lab: Participant Consent Form

Name: ____

Have you ever been diagnosed with a speech or language disorder?

Yes [ ] No [ ]

Have you been diagnosed with dyslexia?

Yes [ ] No [ ]

Date:________________________

I have read the experimental instructions. I am here out of my own free will, and I understand that I can leave at any moment during the experiment without explaining myself to the experimenter.

Signature: _________________________

APPENDIX D

Arabic Model

The full linear mixed effects model structure used for the analysis of the Arabic data.

```
Arabicmodel <- lmer(Logrt ~ 1  +  cond * CL2.proficiency * CT_Root_Type_Frq
            + cond * CL2.proficiency * CT_Orth_Freq
            + cond * CL2.learning.dur * CT_Root_Type_Frq
            + cond * CL2.learning.dur * CT_Orth_Freq
            + cond * CL1.formal.learning * CT_Root_Type_Frq
            + cond * CL1.formal.learning * CT_Orth_Freq
            + cond * CL2.exposure * CT_Root_Type_Frq
            + cond * CL2.exposure * CT_Orth_Freq
            + cond * CL2.informal.learning * CT_Root_Type_Frq
            + cond * CL2.informal.learning * CT_Orth_Freq
            + cond * CL1.informal.learning * CT_Root_Type_Frq
            + cond * CL1.informal.learning * CT_Orth_Freq
            + cond * CL2.non.native.accent * CT_Root_Type_Frq
            + cond * CL2.non.native.accent * CT_Orth_Freq
            + cond * CL2.formal.learning * CT_Root_Type_Frq
            + cond * CL2.formal.learning * CT_Orth_Freq

            + (1+ cond | item ) + (1 + cond | sub),
            data = Arabicdata, REML = FALSE)
```

APPENDIX E

English Model

```
EnglishModel <- lmer(Logrt ~ 1   + cond * CL2.proficiency * CP_Root_Type_Frq
             + cond * CL2.proficiency * CP_Orth_Freq
             + cond * CL2.proficiency * CLogT_Freq
             + cond * CL2.proficiency * CT_letters
             + cond * CL2.learning.dur * CP_Root_Type_Frq
             + cond * CL2.learning.dur * CP_Orth_Freq
             + cond * CL2.learning.dur * CLogT_Freq
             + cond * CL2.learning.dur * CT_letters
             + cond * CL1.formal.learning * CP_Root_Type_Frq
             + cond * CL1.formal.learning * CP_Orth_Freq
             + cond * CL1.formal.learning * CLogT_Freq
             + cond * CL1.formal.learning * CT_letters
             + cond * CL2.exposure * CP_Root_Type_Frq
             + cond * CL2.exposure * CP_Orth_Freq
             + cond * CL2.exposure * CLogT_Freq
             + cond * CL2.exposure * CT_letters
             + cond * CL2.informal.learning * CP_Root_Type_Frq
             + cond * CL2.informal.learning * CP_Orth_Freq
             + cond * CL2.informal.learning * CLogT_Freq
             + cond * CL2.informal.learning * CT_letters
             + cond * CL1.informal.learning * CP_Root_Type_Frq
             + cond * CL1.informal.learning * CP_Orth_Freq
             + cond * CL1.informal.learning * CLogT_Freq
             + cond * CL1.informal.learning * CT_letters
             + cond * CL2.non.native.accent * CP_Root_Type_Frq
             + cond * CL2.non.native.accent * CP_Orth_Freq
             + cond * CL2.non.native.accent * CLogT_Freq
             + cond * CL2.non.native.accent * CT_letters
             + cond * CL2.formal.learning * CP_Root_Type_Frq
             + cond * CL2.formal.learning * CP_Orth_Freq
             + cond * CL2.formal.learning * CLogT_Freq
             + cond * CL2.formal.learning * CT_letters

          + (1 |1 + item ) + (1 + cond | sub),
          data = Englishdata, REML = FALSE)
```

APPENDIX F

Table 1.a Self -reported language history and proficiency in L1&L2.

	ARABIC L1/ENGLISH L2		
SOAs	**50ms**	**80ms**	**200ms**
	M (SD)	**M (SD)**	**M (SD)**
Self-reported measures			
Current % Arabic exposure			
Average exposure to Arabic	57.0 (18.7)	65.2 (14.4)	72.0 (14.4)
Read texts available in Arabic	45.2 (21.4)	37.9 (18.3)	45.5 (18.3)
Speak fluently in Arabic	53.5 (24.0)	58.3 (19.6)	63.0 (19.9)
Current % English exposure			
Average exposure to English	43.0 (18.7)	34.7 (14.4)	28.0(14.4)
Read texts available in English	55.0 (21.5)	62.1 (18.3)	54.5 (19.8)
Speak fluently in English	46.5 (24.0)	41.7 (19.6)	37.0(19.9)
Formal education (years)	16.5 (3.3)	15.9 (3.0)	16.4 (3.0)
Experimental proficiency measure			
Proficiency data Arabic			
Percentage error	9.0 (14.6)	13.1 (16.3)	16.3 (18.2)
Reaction time	804.2 (101)	781.3 (102)	810.6 (111)
Proficiency data English			
Percentage error	44.3 (11.1)	42.5 (12.6)	44.5 (11.6)
Reaction time	863.0 (113)	800.7 (107)	790.2 (142)

Table 1.b Self -reported language history and proficiency data: L1 Arabic

		ARABIC L1	
SOAs	**50ms**	**80ms**	**200ms**
	M (SD)	M (SD)	M (SD)
Self -reported proficiency			
Understanding	10.0 (0.00)	10.0 (0.00)	10.0 (0.00)
Speaking	10.0 (0.00)	10.0 (0.00)	10.0 (0.00)
Reading	10.0 (0.00)	10.0 (0.00)	10.0 (0.00)
Writing	10.0 (0.00)	10.0 (0.00)	10.0 (0.00)
Age milestones (years)			
Began acquiring	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)
Speaking fluently	4.24 (1.71)	5.01 (1.56)	4.95 (1.41)
Started reading	6.79 (0.67)	6.88 (0.69)	6.87 (0.81)
Reading fluently	9.18 (1.77)	9.39 (1.86)	9.13 (1.35)
Contribution to language learning			
From family	9.47 (1.00)	9.62 (1.09)	9.77 (0.95)
From friends	7.02 (2.67)	8.06 (2.55)	7.63 (2.54)
From reading	8.42 (2.04)	8.68 (1.82)	8.68 (1.86)
From TV	6.53 (2.91)	6.65 (2.76)	6.48 (2.56)
From radio	4.95 (3.16)	4.88 (2.81)	4.98 (2.89)
From self –instruction	7.36 (2.57)	7.27 (2.66)	7.88 (2.11)
Extent of language exposure			
Family	9.17 (1.55)	8.97 (1.53)	8.85 (1.90)
Friends	7.95 (2.32)	7.38 (2.05)	7.85 (2.41)
Reading	7.89 (2.80)	8.32 (2.16)	8.60 (1.66)
TV	6.45 (3.04)	6.39 (2.89)	6.87(2.69)
Radio	4.56 (3.16)	4.29 (3.10)	4.70 (3.36)
Independent study	6.83 (2.61)	7.03 (2.51)	6.78 (2.04)

Table 1.c. Self -reported language history and proficiency data: L2 English

	ENGLISH L2		
SOAs	**50ms**	**80ms**	**200ms**
	M (SD)	M (SD)	M (SD)
Self -reported proficiency			
Understanding	7.9 (1.9)	8.4 (1.7)	7.6 (2.0)
Speaking	7.1 (1.8)	7.6 (1.9)	6.8 (2.0)
Reading	7.4 (1.9)	8.0 (16)	7.4 (1.7)
Writing	6.9 (2.1)	7.4 (1.9)	7.0 (1.8)
Age milestones (years)			
Began acquiring	11.4 (2.6)	11.0 (2.7)	10.9 (2.4)
Speaking fluently	15.6(3.5)	16.2 (3.5)	15.3 (38)
Started reading	12.4 (3.1)	12.7(3.0)	12.3 (2.6)
Reading fluently	17.5 (2.2)	18.0 (1.9)	18.3 (2.8)
Contribution to language learning			
From family	4.5 (3.1)	5.0 (3.2)	4.5 (2.9)
From friends	7.03(2.9)	7.5 (3.0)	7.0 (3.1)
From reading	7.9 (2.7)	8.2 (2.6)	7.8 (2.9)
From TV	7.0 (2.8)	7.1(2.4)	6.4 (3.1)
From radio	5.5 (3.7)	5.7 (3.2)	4.4 (3.2)
From self –instruction	7.3 (2.4)	7.4 (2.1)	7.1 (2.7)
Extent of language exposure			
Family	5.7 (3.2)	6.1 (3.1)	4.5 (2.4)
Friends	8.1(2.7)	8.1 (3.0)	8.5(2.5)
Reading	8.5(2.4)	8. 2 (3.0)	9.0(2.1)
TV	7.2 (2.9)	7.1 (2.3)	6.8(2.7)
Radio	5.2 (3.4)	4.5 (3.3)	4.1 (3.1)
Independent study	7.5 (2.3)	7.3 (2.4)	8.4(1.5)

Table 1.d No Variation or misunderstanding data.

	ARABIC L1/ENGLISH L2		
SOAs	**50ms**	**80ms**	**200ms**
	M (SD)	M (SD)	M (SD)
Cultural identify	10.00 (0.00)	9.84 (0.86)	9.83 (0.90)
(L1) Immersion duration (years)			
In a country	24.71(5.99)	23.03 (4.72)	23.10 (5.96)
In a family	24.79 (5.87)	23.07 (4.66)	23.50 (5.18)
In a school	23.27 (7.37)	20.24 (6.94)	19.13 (5.94)
(L2) Immersion duration (years)			
In a country	0.9 (3.1)	1.3 (3.8)	1.5 (4.1)
In a family	2.3 (4.8)	3.2 (6.0)	0.8 (2.8)
In a school	7.0 (3.5)	6.9 (3.0)	6.8 (4.0)
(L1) Self -report of foreign accent			
Perceived by-self	6.03 (3.27)	6.24 (3.42)	3.30 (2.87)
Identified by others	1.80 (2.94)	2.62 (3.27)	3.27 (3.66)
(L2) Self -report of foreign accent			
Perceived by-self	1.2 (0.8)	1.6 (1.5)	1.0 (1.1)
Identified by others	8.0 (2.2)	8.5 (2.5)	9.0 (2.1)