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Implications for Theories of Morphology and Lexical Processing

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Morphological and Phonological Units in the Arabic Mental Lexicon
Implications for Theories of Morphology and Lexical Processing

Abdessatar Mahfoudhi

Thesis submitted to the
Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of the requirements
for the PhD degree in Linguistics

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Abstract

This dissertation investigates the cognitive relevance of selected morphological and phonological units in the Arabic mental lexicon. The morphological units are sound and weak roots, etymons, phonetic matrices, and sound and weak patterns. The phonological units are vowels and consonants. The work is motivated by a controversy in Arabic morphology that is paralleled by a cross-linguistic debate in lexical processing. There are two views in Arabic morphology, the stem-based theory and the morpheme-based theory that is represented by two sub-theories. The first sub-theory argues that derivations are based on roots and patterns and the second proposes that the root should be replaced by the etymon and the phonetic matrix. The morpheme-based theory is congruent with lexical processing hypotheses that propose that complex words are accessed and represented as morphemes. The stem-based theory maintains that derivation is stem or word-based and is in line with the whole word hypothesis of lexical processing.

These theoretical positions on Arabic morphology and lexical processing were tested in six priming experiments. One objective of these experiments was to test which of these morphemes prime word recognition. Another objective was to test the prediction of connectionism, another lexical processing hypothesis, that priming time correlates with prime-target overlap. A third objective was to examine how abstract the processing of these morphemes could be. The cognitive status of vowels and consonants was tested using a letter-circling task.

The results of the online studies have shown that both roots and etymons facilitate word recognition significantly more than orthographic controls. However, non-ordered etymons, phonetic matrices, and patterns did not facilitate word recognition. Weak roots had priming effects only when primes and targets shared a vague semantic relationship. There was no correlation between priming time and meaning and/or form overlap. The lack of priming with non-ordered etymons suggests that there could be limits on abstractness in lexical processing. The results of the offline task suggest that root consonants are more salient than other letters. On the whole, the results support a morpheme-based theory of Arabic morphology and a localist view of lexical processing that assumes a morphemic stage in word recognition.

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Introduction

The lexicon in early generative grammar (Chomsky, 1965) was just a list of words on which syntax, the central module, operated. But recently, the lexicon has been given more importance even in mainstream syntactic theory (Chomsky, 1995). The study of the lexicon has also received a boost from the work of cognitive psychologists (e.g. Taft & Forster, 1975; Henderson, 1985), reading specialists (e.g. Rumelhart, 1977; Besner, Waller, & MacKinnon, 1985), neuropsychologists (e.g. Caramazza, 1997), and cognitive scientists (McClelland & Rumelhart, 1981; Marcus, 2001), to mention only the central disciplines. This research is growing robustly into a very rich interdisciplinary field of study known now as the mental lexicon. The mental lexicon is perceived as a dynamic entity whose function is minimally the organization, retention, and processing of words. Although a large number of studies have focused on oral/aural word representation and processing in normal and brain-damaged populations, many have concentrated on visual processing of the written word. The present study falls within the latter category.

Work on visual word recognition has used a variety of research methods, including naming with priming, long-term priming with a fragment completion task, reading-elicited errors of brain damaged patients, the eye-tracking paradigm, and brain scanning of both normals and patients. However, the major paradigm has been visual lexical decision, often with priming (see McQueen & Cutler, 1998; Frost & Grainger, 2000; or Libben & Jarema, 2004 for review of recent studies).

One of the great challenges within the lexical decision with priming research paradigm has been to tease out the differential effects on lexical processing of a number of variables. These include the relative effects of morphology, phonology and semantics, as well as the effect of semantic transparency. One major concern has been to prove that morphological priming is distinct from orthographic/phonological and semantic priming. There is evidence that orthographic priming is either short lived (Napps & Fowler, 1987) or inhibitory (e.g. Grainger, Cole, & Segui, 1991) compared to morphological priming. However, there is also evidence that orthographic overlap does lead to priming similar to morphological priming (e.g. Rastle, Davis, Marslen-Wilson, & Tyler, 2000). The role of phonology in lexical access is also controversial. Some argue that phonology is activated

early in the word recognition process (e.g. Frost, 1998; Frost, Ahissar, Gottesman, & Tayeb, 2003), but others contend that phonology is activated only after word access (e.g. Jared & Seidenberg, 1991; Coltheart, Curtis, Atkins, & Haller, 1993).

The empirical findings with respect to the role of semantics, relative to morphology, are also inconclusive. There is some evidence showing that semantic priming occurs later in the recognition process than morphological priming (Bentin & Feldman, 1990; Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Boudelaa & Marslen-Wilson, 2001b). But there is also evidence that semantic priming can occur very early in the word recognition process (Perea & Gotor, 1997) and would normally coincide with morphological priming.

The issue of semantic transparency is closely linked to the question of which morphological units, if any, are decomposed during lexical processing and by implication, represented in the mental lexicon. However, there is also little agreement as to the effect of semantic transparency on the decomposition of words. Some researchers found that a transparent semantic relationship between prime-target morphological relatives is necessary for decomposition in lexical decision tasks with cross-modal priming in English (Marslen-Wilson, Tyler, Waksler, & Older, 1994) and French (Longtin, Segui, & Hallé, 2003), but not in lexical decision tasks with visual masked priming (Feldman & Soltano, 1999 for English and Longtin, Segui, & Hallé, 2003 for French). In Hebrew and Arabic, by contrast, priming was obtained both in visual masked priming (Frost, Forster, & Deutsch, 1997 for Hebrew and Boudelaa & Marslen-Wilson, 2001b for Arabic) and in lexical decision with cross-modal priming (Frost, Deutsch, Gilboa, Tannenbaum, & Marslen-Wilson, 2000 for Hebrew and Boudelaa & Marslen-Wilson, 2001b for Arabic).

The controversy over decomposition goes far beyond semantic transparency. On the basis of empirical results, different hypotheses have been proposed to explain which units are decomposed, if at all, in lexical processing and represented in the mental lexicon. The full-listing hypothesis argues that words are stored and accessed as whole units (e.g. Butterworth, 1983; Manelis & Tharp, 1977). According to the decompositional hypothesis, complex words are decomposed before they are accessed in the lexicon, where they are stored as morphemes (e.g. Taft & Forster 1975; Taft, Hambly, & Kinoshita, 1986). More recently, a few hybrid theories, such as the Augmented Addressed Morphology hypothesis

(Caramazza, Laudanna, & Romani, 1988; Laudanna, Badecker, & Caramazza, 1989), have been proposed. The main assumption of these theories is that some complex words are decomposed before access and some are not. A fourth major lexical processing theory is the connectionist theory. Computational connectionist models do not assume morphological decomposition. According to these models, priming effects are obtained because of the recurrence of certain visual (e.g. McClelland & Rumelhart, 1982) or auditory patterns (e.g. McClelland & Elman, 1986). Connectionist models can be localist or distributed. In localist models (McClelland & Rumelhart, 1981, 1982) single input units correspond to a letter, a word, or a concept. In distributed models, input is the result of the activation of a number of units that may represent certain features (phonetic features in Plunkett & Marchman, 1993). These models predict a positive correlation between priming time and semantic and/or form overlap between primes and targets.

Thus, despite the large number of studies, the results are still far from being homogenous, even within the same language. Moreover, most of the work to date has been carried out on a few Indo-European languages, especially English (see Frost & Grainger, 2000 or Libben & Jarema, 2002, for a review).

The present work attempts to determine the cognitive relevance of selected morphological and phonological units in the Arabic¹ mental lexicon. As such, it fits into the research paradigm noted above and will contribute to the available literature in at least two ways. First, it will provide further empirical results related to the questions of the relationship between morphology, orthography/phonology, and semantics from a less researched language (family). Second, this work will examine some issues that are unique to Arabic (and Semitic² languages), such as the processing of very abstract morphemes and the gradation in formal and semantic overlap in similar morphemes and whether or not such overlap correlates with lexical decision response time.

¹ Unless otherwise indicated, Arabic refers to Modern Standard Arabic and Hebrew refers to Modern Hebrew. Modern Standard Arabic, the variety examined in this work, is the written variety used for education and administration. It is the variety shared, with some differences, by all Arab countries. The spoken varieties are highly diverse and can be very different from the standard variety.

² Semitic is used as a cover term for all Semitic languages, but any generalization to languages that are not well studied is only speculative. Arabic and Hebrew are among the very few Semitic language that are relatively well-researched from both theoretical and psycholinguistic perspectives. Where relevant results found in Hebrew are discussed.

The cognitive relevance of selected Arabic morphological units will be examined in lexical processing by means of lexical decision tasks with masked priming at stimulus onset asynchrony (SOA) of 50 ms. The research is structured to test three major theories of Arabic (and Semitic) morphology, as well as the related assumptions of the above mentioned theories of lexical processing. The major theoretical controversy in Arabic morphology³ is over the status of the root (and the pattern) and, more recently, the etymon and the phonetic matrix and, by implication, their role in lexical representation and processing. There are two major opposing views with respect to these theoretical constructs. On one side, there is the morpheme-based theory, with two main sub-theories. The proponents of the first sub-theory (e.g. Cantineau, 1950a, 1950b; McCarthy, 1981) argue that derivations are based on the process of intercalating roots in patterns. More recently, Bohas (1997, 2000) has proposed that the root should be replaced by the bi-consonantal etymon and the related notion of the phonetic matrix. On the opposite side, there is the stem-based theory (e.g. Ratcliffe, 1997) which maintains that the consonantal root, and by extension the etymon, has no importance in Arabic morphology and that derivation is stem-based, as is the case in concatenative languages. This controversy has implications for lexical representation and lexical processing. The stem-based theory is in line with the tenets of the full-listing hypothesis of lexical processing, which assumes that words are represented and accessed as whole units. The morpheme-based theory is congruent with both the decompositional and the dual-access hypotheses of lexical processing, both of which assume that (at least some) complex words are accessed and represented as separate morphemes.

Although there has been some empirical research using lexical decision tasks on some of the aforementioned Arabic morphological units, the results are inconclusive. Whereas Boudelaa and Marslen-Wilson (2001b) found a rather persistent priming effect of the root in lexical decision tasks with masked priming in verbal nouns and verbs, Abu-Rabia and Awwad (2004) did not find any facilitatory effect in nouns using the same methodology. The only study on the etymon morpheme was carried out by Boudelaa and Marslen-Wilson (2001a), who used lexical decision tasks with masked and cross-modal

³ There is a similar controversy in Hebrew, mainly over whether derivation is based on roots and patterns or on words (e.g. Ussishkin, 1999). The question of the etymon has also been discussed in Hebrew, but only in the theoretical literature (e.g. Bohas, 2000), as opposed to the psycholinguistic literature.

priming. Their results were, however, met with much scepticism (e.g. Bentin & Frost, 2001; Idrissi & Kehayia, 2004). The phonetic matrix, the more abstract morpheme underlying etymons, has never been studied experimentally. There are also contradictory results concerning the pattern morpheme. Boudelaa and Marslen-Wilson (2001b), who used a masked priming paradigm, reported inconsistent priming depending on the SOA. Using a similar method, Abu-Rabia and Awwad (2004) did not find any priming with patterns.

The present work will examine all these morphemes using the same methodology, namely lexical decision with masked priming. With respect to the root, the present work will try to replicate previous results. As for the etymon, in addition to attempting to replicate Boudelaa's and Marslen-Wilson's (2001a) findings, the present work will test whether the order of the consonants of the etymon has an effect on (the degree of) priming, an issue that has not been examined. Sound patterns will also be revisited, but with a focus on the relative role of weak patterns and weak roots in Arabic lexical processing. The phonetic matrix will be studied for the first time.

The first major objective of this work is to experimentally investigate the cognitive relevance of the root, the pattern, and the etymon as separate entities. This will be accomplished by examining the role of these constructs in Modern Standard Arabic lexical processing by means of four online priming studies. Related to the first objective are two other objectives. First, by using the same methodology in all experiments, the present work will examine whether there is a gradation in priming effects that correlates with semantic and/or formal overlap in the following related morphemes: sound roots, weak roots, and etymons (ordered and non-ordered). This will allow us to test the assumptions of (distributed) connectionist models of representation and processing that predict a gradation in priming, in contrast to those of theories that adopt an entry-opening conception of lexical processing (i.e. the decompositional hypothesis and the hybrid hypothesis). Second, this work will examine just how abstract lexical processing of these related abstract morphemes can be. The abstractness of these morphemes is gradient. Weak roots are more abstract than sound roots; non-ordered etymons are more abstract than ordered etymons; and the phonetic matrix is more abstract than the related notion of the etymon (ordered or non-ordered).

Another major objective of this work is to examine the cognitive relevance of consonants and vowels in the Arabic mental lexicon. I advance and test the hypothesis that because of their morphological and orthographic status in Arabic (and probably in other similar Semitic languages), certain letters/phonemes are perceived differently than others. I first propose that because of the importance of root consonants within a morpheme-based theory of Arabic (Semitic) morphology, these consonants are more salient than other consonants in a word. I also hypothesize that because of the consonantal nature of the script of Arabic, readers of these languages might develop a bias towards consonants as more “important” than vowels. These two hypotheses will be tested by means of a paper-and-pencil task in which participants will be advised to circle a maximum of three letters of their choice in any given word.

The dissertation is organized as follows. Chapter 1 outlines the controversy over the status of the root, the etymon, and the phonetic matrix in theories of Arabic (and by extension Semitic) morphology. It also briefly presents a relevant overview of Arabic phonology and morphology. Chapter 2 provides a general background to theories of lexical processing, with focus on the controversy discussed in the first chapter, as well as a review of studies on the cognitive relevance of the root, the pattern, and the etymon, mainly with respect to their role in lexical processing in Arabic. Chapter 3 presents the methodology and the results related to the different morphological units. Chapter 4 contains the methodology and the results related to the phonological units. Chapter 5 summarizes and discusses all the results and interprets their implications for theories of morphology, theories of lexical processing, and future research.

Chapter One

Arabic Morphology, Phonology, and Orthography

Implications for the Study of the Arabic Mental Lexicon

1.0 Introduction

The purpose of this chapter is to present the theoretical issues to be investigated empirically in this study, namely the cognitive relevance of some morphological (roots, patterns, etymons, and phonetic matrices) and phonological units (consonants and vowels) in the Arabic mental lexicon. The first part of this theoretical chapter discusses the issue of what morphological units should be included in a theory of Arabic morphology and, by implication, in the Arabic mental lexicon. There are two major theories of Arabic morphology: the morpheme-based theory and the word-based theory. The proponents of the first approach (e.g. McCarthy, 1981) contend that the derivation is based on roots and patterns. A more recent offshoot of this theory (e.g. Bohas, 1997, 2000) proposes the etymon, a two-consonant morpheme, as a substitute for the root. The main tenet of the word-based theory (e.g. Ratcliffe, 1997) is that the stem is the basis of derivation, as is the case in concatenative languages. The second part of the chapter briefly discusses Arabic phonemes and their featural structure in relation to the morphological notion of the phonetic matrix. The third part of the chapter provides an overview of Arabic orthography. The overview of phonology and orthography will provide a background for the discussion of the second major part of the research topic, that is, the relative cognitive status of consonants and vowels in the Arabic mental lexicon. The chapter closes with a summary and the identification of the implications of these theories of morphology for the present work.

1.1 Arabic morphology: Stems, roots, or etymons and matrices?

Morphology and phonology will be discussed in separate sections for organizational purposes only. The two sections are very much related and the reader is invited to see them as such. Before moving to the discussion of the major theories of morphology in Arabic (and Semitic), a brief introduction on the difference between

concatenative and non-concatenative morphology is presented to explain the nature of the consonantal root. Semitic languages are mainly non-concatenative and Indo-European languages, for instance, are mostly concatenative.

1.1.0 Introduction: Concatenative vs. non-concatenative morphology

Most world languages are mostly concatenative; they add affixes to roots (in bold) in linear fashion to make up words, as shown in (1).

- (1) Derivation from the French root ‘form’
- a. **form**-er ‘to form, to make, to train’
 - b. **form**-at-ion ‘making, training’
 - c. trans-**form**-at-ion ‘transformation’
 - d. trans-**form**-at-eur ‘transformer’

In non-concatenative languages, particularly Semitic languages, word-formation relies, in addition to concatenation, on another process of word formation that transforms the stem internally, in a way similar to irregular word formation in English. Stems in Semitic are composed of roots and patterns. The root is usually composed of three consonants and carries the core meaning of the words that are derived from it. The affixal consonants and/or vowels of the pattern express grammatical information such as voice and tense. Taken separately, roots and patterns are abstract unpronounceable units. The root (in bold)⁴ is shown in the words in the data in (2), from Frost, Forster, and Deutsch (1997, p. 830), but the patterns are presented separately. The slots in the patterns represent the place where the root consonants are intercalated.

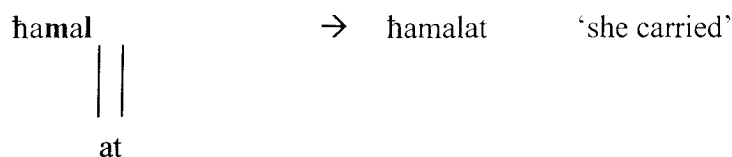
⁴ Throughout the thesis, roots, as well as etymons, are marked in bold to distinguish them from patterns/templates. For the phonetic transcription, the IPA conventions are used.

(2) Derivations from the Hebrew root ‘z, m, r’

	Word	Gloss	Pattern
a.	zamar	‘a male singer’	-a-a-
b.	zimra	‘singing’	-i- -a
c.	zamir	‘a nightingale’	-a-i-
d.	tizmoret	‘an orchestra’	ti- -o-et

Affixes, both prefixes and suffixes, can be concatenated to the product of root and pattern merger, as in the Arabic word *ḥamalat* ‘she carried’ in example (3). After the mapping of the root *hml* into the pattern *CaCaC* to give *ḥamal*, the affix *at* is added in a concatenative fashion to form the final product *ḥamalat*. A multi-linear analysis of this word, in line with McCarthy’s (1981) prosodic morphology, is provided in (5), below.

(3) Concatenative affixation in Arabic



1.1.1 The morpheme-based theory

While the common traditional root and pattern theory for Arabic relies on partly specified patterns, the recent prosodic morphology hypothesis (e.g. McCarthy, 1981) awards separate morphemic status to both the vowels and the affixal consonants of the pattern. In contrast with the two theories mentioned, the etymon theory proposes that the root should be replaced by the etymon, a two consonant morpheme.

1.1.1.1 The classical root-and-pattern theory

The traditional view, clearly laid out in the work of modern structuralists (e.g. Cantineau, 1950a, 1950b) and still common among Arabic scholars (e.g. Rajhi, 1974), is

based on the work of the old Arab grammarians.⁵ It postulates that the derivation is based on the mapping of the root (*ḥurūf ʔasliya* ‘original sounds’) onto a pattern (*wazn* ‘measure’). This analysis is the same as the one discussed in the previous section (see example (2) and discussion thereof).

According to this theory, the Arabic lexicon contains verbs and nouns that are made of three or less frequently two or four consonant-roots (often referred to as trilateral, biliteral, and quadrilateral respectively) and patterns. There are 15 patterns for trilateral verbs (classified in the “Western” literature using Roman numerals). Only the first ten of them are still used in Modern Standard Arabic.⁶ These ten forms are listed here with their grammatical meaning and any associated affixes.⁷ Form I (**faʔala**) is often considered basic because it is supposed to be the source from which the other forms are derived either by adding some affixal consonants or doubling one root consonant. The most common patterns of trilateral verbs are the first four.

I. **faʔala**⁸ (active, no affix, e.g. *waqafa* ‘to stand up’)

II. **faʔʔala** (causative, intensive, doubling of the second radical in I, e.g. *dammara* ‘to destroy completely’),

III. **faaʔala** (reciprocal/causative, lengthening of the first vowel in I, e.g. *ʔaaraka* ‘to participate’),

IV. **ʔafʔala** (causative/factitive, prefix *ʔa*, e.g. *ʔarkaba* ‘to make ride’),

⁵ For an overview of these theories, the reader is referred to Bohas and Guillaume (1984). Bohas and Guillaume emphasize that unlike the modern structuralist Semitists (e.g. Cantineau, 1950a, 1950b) who suggest that all derivations are a mapping of a root to a template, the old Arab grammarians propose word-to-word derivations in many cases. It is, however, possible to propose root to scheme mapping while still proposing that words are derived from others with some additions, deletions of suffixes as well as a change in vowels as done by Watson (2002). That is, we can acknowledge word-to-word derivation but still maintain that roots and patterns (or skeletons in a prosodic morphology terms) are separate morphemes in both the input and the output. This could very well be what the late Arab grammarians mean, especially that they keep insisting on a root (*ʔasʔl*) and a pattern (*wazn*) in the derivation of any word.

⁶ The other five forms are: XI. *ʔifʔaalla*, XII. *ʔifʔawʔala*, XIII. *ʔifʔawwala*, XIV. *ʔifʔanlala*, and XV. *ʔifʔanlaa* (see Wright, 1967 or Reig, 1983 for a detailed discussion of all forms).

⁷ It would be interesting to investigate whether these affixes are actually represented on a separate tier as proposed by McCarthy (1981) in his prosodic morphology hypothesis, discussed in § 2.2.2.

⁸ I follow the traditional Arabic convention of using the (root) consonants {f, ʔ, l}, which has the core meaning ‘to do’, to mark the place of the root consonants in words.

- V. *tafaʿʿala* (reflexive and intensive/ translated in English as passive, prefix *ta*, e.g. *tafaʿʿara* ‘to explode’),
- VI. *tafaaʿala* (reflexive/ reciprocal, prefixing *ta* to form III, e.g. *tayaafala* ‘to be off one’s guard’),
- VII. *ʔinfaʿala* (reflexive/middle voice close to passive, prefixing *n* to form I, the *ʔ* is prosthetic, e.g. *ʔinxadaʿa* ‘to be deceived’),
- VIII. *ʔiftaʿala* (reflexive or middle voice/reciprocal, infixing the *ta* to form I, the *ʔ* is prosthetic, e.g. *ʔiftaxara* ‘to be proud of’),
- IX. *ʔiʿʿalla* (intensive, from form I by doubling the third radical, the *ʔ* is prosthetic, e.g. *ʔiswadda* ‘to become black’)
- X. *ʔistaʿʿala* (reflexive/middle, from form I by prefixing *st*, the *ʔ* is prosthetic, e.g. *ʔistayfara* ‘to ask for pardon’).

Some of the common quadriliteral verbal forms are the following:

- I. *faʿʿala* (similar meaning to the second form of the trilaterals, that is causative and/or intensive (e.g. *daħradʒa* ‘to roll’).
- II. *tafaʿʿala* (similar meaning as the fifth trilateral form, e.g. *tadaħradʒa* ‘to roll along (reflexive)’).
- III. *ʔiʿʿanlala* (similar in meaning to the seventh trilateral form, e.g. *ʔislantaħa* ‘to lie on one’s face). This form is less common than the other quadriliteral forms.
- IV. *ʔiʿʿalalla*. (similar to the ninth trilateral form, intensive intransitive action or state, e.g. *ʔidʿmaħalla* ‘to disappear totally’).

Other quadriliteral forms are made in the following fashion:

- (a) The reduplication of a bilateral root: *waswasa* ‘to whisper’
- (b) The addition of fourth letter/phoneme to a trilateral verb: *ʃamxara* ‘to be proud (from *ʃamaxa* ‘to be high’).

(c) Denominatives from nouns with more than three consonants: *dʒalbaba* ‘to put on a garment called *dʒilbaab*’.

Nouns are either primitive or derived. Primitive nouns do not share a root with any other word. Derived nouns are of two types: deverbal and denominative, which have numerous forms.⁹ Deverbal nominals can be divided into at least six types: (i) *masdars* (often called the infinitive), which have over forty patterns, (ii) agent and patient nouns (active and passive participles) (iii) nouns of action (single activity), (iv) nouns of kind (v) nouns of place and time and (vi) nouns of instrument. Denominative nouns can also be divided into six types: (i) nouns of unity, (ii) nouns of abundance, (iii) nouns of vessel/container, (iv) nouns of reference, (v) nouns of quality and (vi) diminutive nouns (cf. Wright, 1967).

Apart from lacking a formalism that explains in an economical way how roots are intermixed with templates, the classical theory does not account for certain alternations in the vocalic system. The passive, for instance, is usually expressed by the vowels *u i*, as shown in (4). The classical theory lists all word patterns (with specified consonants and vowels) corresponding to every grammatical function, such as the passive, and does not capture this regularity.

- (4) Passive forms in Arabic
- | | |
|--------|------------------|
| kutiba | ‘it was written’ |
| sumiʿa | ‘it was heard’ |

1.1.1.2 Prosodic morphology

Prosodic morphology (e.g. McCarthy, 1979/1982; McCarthy & Prince, 1990a) has undergone two major phases: CV-morphology and prosodic morphology.

⁹ Only the patterns of the verbal forms are included first because they are not numerous compared to those of nouns and, second, because verbs are the focus of this work.

1.1.1.2.1 CV-morphology

CV-morphology (McCarthy, 1979/1982, 1981) is based on the main tenets of autosegmental phonology (Goldsmith, 1976), particularly the representation on separate tiers of different elements of the word. The main assumption in autosegmental phonology is that certain features are not an integral part of segments but are represented on separate tiers. This proposal elegantly accounts for phenomena such as floating tones, which the traditional generative theory could not adequately deal with.

The main principles of autosegmental phonology have been used to account for morphological phenomena, which brought about CV-morphology. In CV-morphology, Arabic morphemes making up words are represented on four separate tiers. One tier hosts the root and on a second tier hosts the vocalic melody made of vowels. Affixes are represented on a third tier.¹⁰ On the fourth tier is the CV-skeleton on which the three other tiers converge after being linearized/conflated. The template is composed of vocalic and consonantal slots. McCarthy (1981) proposes that, because of their specific semantic identity in Arabic, not only the root and the affixes but also the vowels are separate morphemes, each attached to a morpheme node ‘ μ ’, as illustrated in (5a) below. Thus, the major additions that McCarthy brought to the classical theory are the CV-skeleton and the assignment of a separate tier and a morphemic status to vowels. McCarthy’s work was done on Arabic but was applied to many languages with non-concatenative morphology such as reduplication (e.g. Marantz, 1982 (re: Agta) and Broselow & McCarthy, 1983 (re: Samoan)).

The association of the morphemic levels to the skeleton obeys three conventions:

- “i. If there are several unassociated melodic elements and several unassociated melody-bearing elements, the former are associated one-to-one from left to right with the latter.
- ii. If, after application of the first convention, there remain one unassociated melody-bearing element and one or more unassociated melody-bearing elements, the former is associated with the latter.

¹⁰ The assignment of a separate tier to vowels and affixal consonants is not without its critics (e.g. Hudson, 1986, 1991).

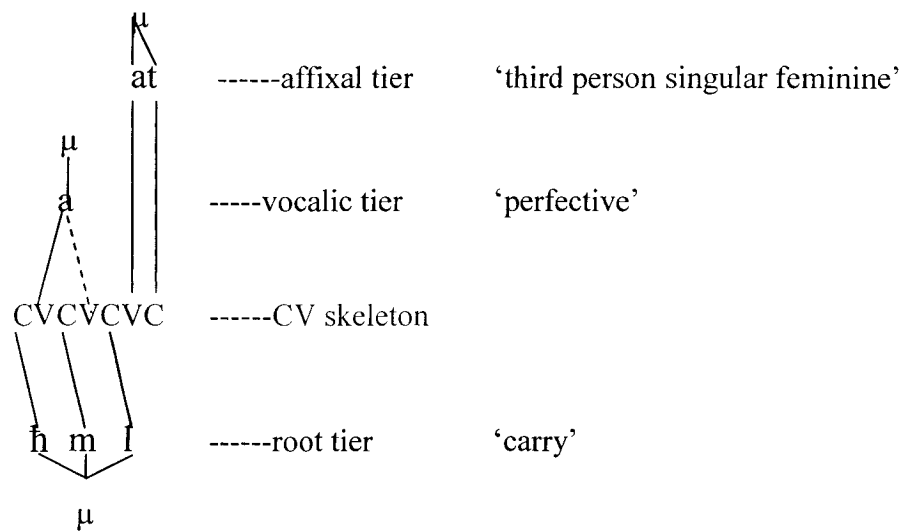
iii. If all melodic elements are associated and if there are one or more unassociated melody-bearing elements, all of the latter are assigned the melody associated with the melody-bearing element on their immediate left if possible [automatic spreading].”

(McCarthy, 1981, p. 382).

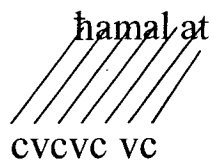
The association of the morphemic tiers is shown in (5a). The figure in (5b) illustrates the linearization of the three morphemic levels before their final convergence on the skeleton.

(5) Derivation of the Arabic word *ḥamalāt* ‘she carried’

a. Association of morpheme levels to CV- skeleton



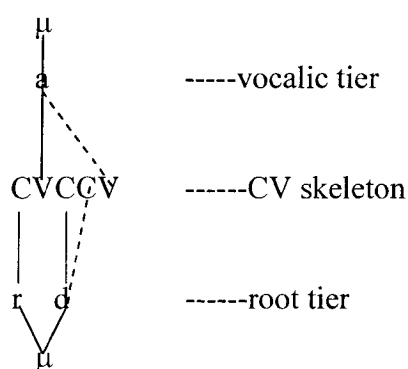
b. Tier conflation



The notion of left to right spreading of association, represented by dashed lines in (5a), is required by the Obligatory Contour Principle that prohibits the existence of

identical adjacent elements “in any autosegmental tier” (McCarthy, 1981, p. 383),¹¹ particularly the case of words with geminate root consonants. According to this analysis, in a word such as *radda* ‘he returned’, only the first consonant of the geminate is underlying and the second is a result of spreading. The left-to-right directionality accounts for the fact that gemination is almost never in the first two consonants of the root. The association of the first *d* (in *radda*) automatically spreads to fill in the empty consonant slot, as dictated by the association conventions, given above. This is illustrated in the following diagram in (6).¹²

(6) Derivation of the Arabic word *radda* ‘he returned’



1.1.1.2.2 Prosodic morphology

The main difference between CV and prosodic morphology is that, whereas the first refers to segments, the second makes use of hierarchically-built prosodic units. The Prosodic Morphology Hypothesis (McCarthy & Prince (M&P), 1990a, 1999) requires that “the templates of reduplicative or templatic morphology are defined in terms of the authentic units of prosody: the mora, the syllable, the foot, and the phonological word” and

¹¹ For a recent discussion of the constraint in Arabic, consult Frisch, Pierrehumbert, and Broe (2004). Greenberg (1978) is a classical reference on the discussion of this issue in Arabic and Semitic languages.

¹² A more accurate representation of this derivation includes two stages. At the underlying representation the consonants and vowels of the verb are mapped onto the skeleton of Form I (third person perfect), CVCVCV, giving the form *radada*. A metathesis (of one root consonant) and syncope (of a vowel) rule then applies on C2V2 (to turn it to V2C2 and then deletes V2) creating a geminate [radda]. Evidence for the proposed underlying form is the existence of similar variants such as [radad-ta] ‘you returned’. This analysis is first formalized in Brame (1970) and adopted by McCarthy (1986) (but apparently not in McCarthy, 1981). A similar analysis is assumed by Bohas (2000) in example (17), below.

relies on “the same vocabulary of prosody in general, including stress, syllabification, epenthesis, compensatory lengthening, rhyme, ‘counting rules’, and poetic meter” (M&P, 1990a, p. 3).

M&P (1990a, pp. 5-6) give four reasons to argue for the superiority of the prosodic analysis over the CV analysis (McCarthy, 1981). First, while the units of Prosodic Morphology are independently motivated, the CV skeleton segments are not. Second, the templates are often connected with other prosodic phenomena of the language. Third, Prosodic Morphology “often forces the correct analysis in cases where CV skeletal theory is confronted with an array of incompatible and inadequate options” (p. 6). Fourth, because it is more restrictive, Prosodic Morphology is more adequate from a learnability perspective.

Examining the basic skeletons of Arabic nouns, M&P (1990a) found that the stem can contain one bimoraic syllable or maximally two syllables either one heavy and one light or both heavy. Independent evidence for this constraint comes from the fact that trisyllabic nouns are very rare and irregular. As for the templatic analysis of verbs, M&P found that all verbs have a light syllable followed by an obligatory final syllable. They have then proposed that all templates are derived by prefixing the light syllable to the monosyllabic base that has either a light or a heavy syllable.

The root-and-pattern theory has recently been challenged by the less common and more recent etymon theory. The challenge is particularly directed at the notion of the root.

1.1.1.3 The etymon and matrix theory

1.1.1.3.1 The etymon

The etymon theory seems to remedy some of the problems of the root and pattern theory. The data in (7) and (8), below, show that an explanation in terms of the root “ne permet pas de rendre compte des relations phonétiques et sémantiques entre les mots, qu’elle ne permet même pas de les observer” (Bohas, 2000, p. 11). First, the words in (7) (from Bohas, 2000, p. 13) share the same root (in bold) but have very little semantic similarity.¹³

¹³ The glosses for the examples in this section are originally in French and are translated by the present author.

(7) Arabic words with the same root but with different meanings

	Word	Gloss
a.	s ^ʕ abara	‘tie, attach something or somebody to something’
b.	s ^ʕ ubratun	‘a heap of grain’
c.	s ^ʕ abiiraturun	‘a rocky hill, a mountain’
d.	mus ^ʕ tabirun	‘a heap of meat’

Second, in (8) (from Bohas, 2000, p. 15), there is semantic similarity between words that do not share the same root, but only two consonants (in bold).

(8) Arabic words sharing two root consonants

a.	b atta	‘to cut (off)’ ¹⁴
b.	b atara	‘to cut the tail of an animal; to cut (off)’
c.	ʔin b ataʕa	‘to be cut off’
d.	b ataka	‘to cut (off); to separate a part from the whole’
e.	b atala	‘to cut (off); separate a part from the whole’
f.	b alata	‘to cut (off)’
g.	b arata	‘to cut’
h.	s abata	‘to cut (off); to shave one’s hair’

Bohas (1997, 2000) calls the two consonants shared by the above words an etymon. He proposes that the etymon is a more abstract and fine-grained construct that links semantically-related words that otherwise have different trilateral or quadrilateral roots. It is, therefore, according to him, a better candidate for the organization of the “lexique” (the lexicon in lexicological sense) and the semantic relationships between lexical items and should replace the root (1997, pp. 10-14). The third consonant of what is traditionally known as the root is considered to be augmented/extended to fill the three-consonantal pattern, a notion also adopted in the etymon theory. The etymon consonants can be non-

¹⁴ Unless otherwise noted, all verbs are in the third person perfect, which is the default form that is often used as entry head in dictionaries.

ordered (e.g. *ʔiʔalla* ‘he/it fell sick’ and *lawwaʕa* ‘he/it tormented’). The etymon itself is the phonemic instantiation of a far more abstract bundle of phonetic features that Bohas calls the phonetic matrix, which we will discuss shortly.

Another reason behind the proposal of the biliteral etymon as a base of lexical relations and derivation is the existence in the lexicon of Arabic (and other Semitic languages) of a large number of words with only two root consonants. These include, in addition to the many words with a geminated second root consonant, words that have both the first and the second root consonants reduplicated, as in *dʒardʒara* ‘to drag’. Work done so far on the etymon could identify at least 200 etymons in Arabic (Bohas, 2000).

Bohas (1997, 2000) proposes that there are five ways by which the etymon develops/is augmented into a root: (i) spreading, (ii) addition, (iii) prefixation, (iv) integration of two etymons, and (v) reduplication.

1. Augmentation by spreading

Bohas (1997, 2000) adopts the multilayered analysis of McCarthy (1981), as well as his notion of spreading of association¹⁵ in the case of words with a geminated second root consonant (see section 2.1.2.1 above for a discussion of these notions). The words in (9) (from Bohas, 1997, p. 167) indicate that the second geminate consonant is the result of the spreading of the second consonant of the etymon {b,dʒ} in (9a) and {b, q} in (9c). Evidence for the spreading analysis is the existence of words as in (9b) and (9d) that share the same meaning and two consonants with the words in (9a) and (9c) respectively.

- (9) Augmentation by spreading of etymons into roots
- | | | |
|----|----------------|--------------------------------|
| a. | badʒdʒa | ‘to pierce (a wound, a tumor)’ |
| b. | badʒasa | ‘to pierce a wound’ |
| c. | baqqa | ‘to disperse’ |
| d. | baqatʔa | ‘to disperse’ |

¹⁵ Whereas McCarthy (1981) argues that association is from left to right, Bohas (2000) contends that it is free.

2. Augmentation by addition

The words in (10a-c) (Bohas, 1997, p. 168) share the etymon {ḥ, d} and the ones in (10d-e) share the etymon {k, b}. While words in (10b), (10c) and (10e) get their third consonant by spreading as argued above, the third consonant in (10a) and (10d) is added or incremented, to use Bohas's exact term.

(10) Augmentation by extension of etymons into roots

- | | | |
|----|------------------|---|
| a. | ḥadad za | ‘to look fixedly at someone or with a penetrating, scrutinizing look’ |
| b. | ḥad da | ‘to look fixedly at something’ |
| c. | ʔa ḥad da | ‘to look fixedly at something’ |
| d. | kab ata | ‘to throw someone down’ |
| e. | kab ba | ‘to throw someone down, face against the ground’ |

The added consonants in (10a and 10d) are final but they can be initial or medial as in (8h) and (8f-g), respectively.

3. Augmentation by prefixation

Bohas (2000, pp. 37-38) cites examples from Saguer (as cited in Bohas, 2000) of how the *n* can be a prefix in many Arabic verbs with several meanings. Bohas argues that since the verb *nakafa* in (11a) and its derivative *ʔinkaffa* in (11c) are semantically related to the forms in (11b, d, e) with which they share the phonemes /k/ and /f/, it can be concluded that they have the etymon {k, f} and the *n* is a prefix bearing a reflexive meaning, a prefix that is attested in other unrelated forms.

(11) Augmentation by prefixation of etymons into roots

- a. **nakafa** 'to recoil from something; to move off'
- b. **kaffa** 'to get someone out of the way'
- c. **?inkaffa** 'to move off'
- d. **kafaʔa** 'to be chased'
- e. **kafaha** 'to drive away'

4. Integration of two etymons

In this process two etymons are integrated to derive another etymon that shares a phoneme or two with each original etymon/word. The evidence of integration is the fact that the two words from which the new word is presumably derived share meaning (partially) with the derived word. The following two examples, in (12), are from Bohas (2000, p. 50).

(12) Augmentation of etymons into roots by integration of two etymons

- a. **razaba** 'to stay in place without moving' from *razza* 'fix solidly' and *rabba* 'to stay in one place'.
- b. **zakaba** 'to fill in' from *zakka* 'to fill' and *zabba* 'to fill'.

5. Reduplication

In reduplication, the whole original word with a bi-consonantal etymon (i.e. the first word in each pair) is reduplicated, as in the following examples from Bohas (2000, p. 58).

(13) Augmentation by reduplication of etymons into roots

- a. **bas^ʕs^ʕa** 'to shine'
- bas^ʕbas^ʕa** 'to shine'
- b. **t^ʕadʒdʒa** 'to flow slowly'
- t^ʕadʒt^ʕadʒa** 'to flow (of water)'

Bohas (1997, pp. 186-187), however, admits that there are trilateral roots, as in (14), which cannot be traced to etymons due to a lack of other verbs which share phonological and semantic material.

(14) Words with roots that cannot be traced to etymons

- a. baḥuta 'to be pure'
- b. baahata 'to love sincerely'
- c. tʰaqara 'to shake (with fear)'
- d. qanata 'to adore God sincerely; spend a lot of time praying'

The etymon theory is not without its limitations. A major theoretical problem with the etymon is that there are no clear criteria/rules to identify this morpheme in a word (e.g. Bentin & Frost, 2001), especially as its consonants can be non-ordered and the etymon-related words might share little meaning. It is, therefore, not clear how native speakers recognize/extract the etymon consonants.

The phenomenon of phonetic and or segmental overlap exists also in concatenative languages, but is not considered a morphological element. In English, for instance, although some words share one or two phonemes, this relationship is not accepted as a morphological one. Bloomfield (1933, p. 245) gives the examples in (15) that share initial or final phoneme(s) and some general meaning, which he calls 'symbolic roots'.

(15) English words sharing "symbolic roots"

[fl-]	'moving light': <i>flash, flare, flame, flick-er, flimm-er</i>
[fl-]	'movement in the air': <i>fly, flap, flip</i>
[gl-]	'nonmoving light': <i>glow, glare, gloat, gloom, glint</i>
[sl-]	'smoothly wet': <i>slime, slush, slop, slobb-er, slip, slide</i>
[b-]	'dull impact': <i>bang, bash, bounce, biff, bump, bat</i>
[-ejr]	'big light or noise': <i>blare, flare, glare, stare</i>
[-awns]	'violent movement': <i>bounce, jounce, pounce, trounce</i>

1.1.1.3.2 The phonetic matrix

As mentioned earlier, the etymon is a phonemic manifestation of a more fine-grained semantic relationship between words that is based on a bundle of shared phonetic features, which Bohas (1997, 2000) dubs the phonetic matrix.¹⁶

The phonetic matrix (M)¹⁷ is a minimal semantico-phonetic unit that is made of “une combinaison de traits phonétiques et de noyaux sémiques” (Bohas, 2000, p. 64). It relates via a very complex semantic network words sharing two or more unordered phonetic features (e.g. [labial], [coronal]). Included under the same matrix then are words that share either the same etymon¹⁸ (i.e. two phonemes) as in (16a-b) or only place features in two different phonemes (16c-f). The shared meaning of the words in (16) having the same phonetic matrix {[labial], [coronal]} is the act of hitting without specifying the object of the action (Bohas, 2000, pp. 72-73). The etymon is, therefore, a phonological manifestation (in two non-ordered phonemes) of the more abstract notion of the phonetic matrix.

(16) Arabic words sharing the phonetic matrix {[labial], [coronal]}

- | | | |
|----|---------------------------|-----------------------------------|
| a. | ḥabata | ‘to hit’ |
| b. | habata | ‘to hit’ |
| c. | habaʃa | ‘to hit someone and hurt him/her’ |
| d. | d^ʕaraba | ‘to hit; to beat up’ |
| e. | rafaza | ‘to hit; to beat up’ |
| f. | fat^ʕaʔa | ‘to hit (on the back)’ |

¹⁶ It is probably important to reiterate that the phonetic matrix is a morphological notion. Bohas (personal communication, August 4, 2004) clearly explains that «si l'on entend par morphème la plus petite unité phonétique douée de sens, il est clair que cela correspond à la matrice. Mais il est clair que cette forme n'est pas autonome ; elle ne peut apparaître seule. »

¹⁷ The symbol (M) is used instead of (μ) proposed by Bohas (1997) to represent phonetic matrices. The latter notation is used to represent morphemes as originally proposed by McCarthy (1979/1982).

¹⁸ Bohas (2000) is not explicit on whether the more general notion of the phonetic matrix should replace the etymon of which it is a part.

Bohas (2000, p. 31) proposes the following three-level organization of the Arabic lexicon:

- (i) “Matrice: combinaison, non ordonnée linéairement, de traits phonétiques, liée à une *signification commune primordiale*.”
- (ii) Étymon : combinaison, non ordonnée linéairement, de phonèmes comportant ces traits et développant cette *signification commune primordiale*.
- (iii) Radical : étymon développé par diffusion de la dernière consonne, préfixation ou incrémentation (à l’initiale, à l’interne et à la finale) et comportant au moins une voyelle, et développant cette *signification commune primordiale*. »

Bohas (2000, p. 33) thinks that what happens at the level of the “radical”, which is made of an etymon with a prefixed or added consonant and a skeleton with at least one vowel, is morphological. “Dans les deux premiers niveaux [i.e. matrix and etymon], nous nous situons à l’intérieur du lexique, mais ici [au niveau du radical] nous arrivons au moment où intervient la morphologie. La morphologie est organisée sur des schèmes triconsonantiques et le problème posé à ce niveau est donc d’apparier des étymons biconsonantiques avec des schèmes triconsonantiques. C’est à ce niveau que l’étymon biconsonantique est développé pour cadrer avec le schème.»

Thus, etymons develop into stems as a morphological process¹⁹ and therefore the added consonant is at the morphological level. When it is a glide, however, it is more

¹⁹ Idrissi and Kehayia (2004) argue that Bohas’ enterprise is only diachronic. Bohas (2000, p. 125), however, insists that these morpho-semantic processes “ne sont pas seulement des processus attestés il y a quelques millénaires, ou postulés dans le lexique, mais qu’ils sont toujours à l’œuvre dans la morphologie et la phonologie des langues sémitiques d’aujourd’hui.” The following are examples of these processes from (Bohas, 2000).

(i) Reduplication of the etymon in Damasene Arabic (p. 128)

fakk	‘disassemble/dismantle’
fakkak	‘(make s.o) disassemble/dismantle’
fakfak	‘dismantle, undo one or many things many times’

(ii) Prefixation of *m* in Modern Assyrian (pp. 129-130)

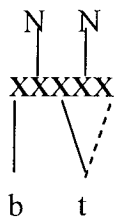
The factitive is derived from the form /CaaCəC/ ‘pull, third person singular in the present tense by prefixing an *m*.

Factitive	Gloss	Third person present
[matxər] /madxər/	‘make think, remind’	daaxər
maxdər	‘make walk’	xaadər

likely to be a phonological process, as glides are often epenthesized in Arabic in plural and adjective formation to fill an empty consonant-slot in the pattern (cf. Bohas, 1997, p. 20).

As in prosodic morphology, the development of etymons into ‘radicals’/stems is multi-linear. The first example in (17) (Bohas, 2000, p. 66) illustrates the development by spreading.

(17) /batata/ [batta] ‘to cut’²⁰



In (18) there is an example of the development by adding a consonant (from Bohas, 2000, p. 67). The added consonant either in the beginning, the middle, or the end is also represented on a separate tier à la McCarthy.

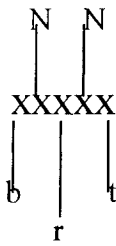
masyəm	‘place, establish’	saayəm
--------	--------------------	--------

(iii) Non-ordered etymons in Moroccan Arabic (pp. 136-137):

{r, f}	
rəfrəf	‘flap wings’
fərfər	‘flap wings’
{s, h}	
səhsəh	‘tell lies’
həssəs	‘make noise’

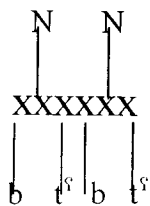
²⁰ Note that in his representation, Bohas is examining stems with no complete inflection of the third person singular perfect, that is without the final vowel affix *a*.

(18) *barata* ‘to cut’



In the case of reduplication, however, the two copies of the etymon are represented on the same tier and the association is free (the following example is from Bohas, 2000, p. 67).

(19) *bat* ^ʃ*bat* ‘disperse (of dust)’



Although it adopts a multilinear approach to morphological representation, the etymon/matrix theory is different from prosodic morphology in at least two ways. Instead of the root, this theory proposes the etymon/the matrix as an abstract non-autonomous morpheme. The etymon/matrix then develops within the skeleton that already has a vowel attached to it to become a “radical”/stem, which is the basis of morphological processes. Whether it is essential for further derivation or not, the etymon is proposed as a separate unit in the lexicon. The present study examines the cognitive validity of such a construct. Phonetic matrices will be discussed in detail in section 1.2, below.

As the reader might have noticed, the discussed morphemes are all abstract unpronounceable units. Their abstractness is graded ranging from the three consonant construct, to the two ordered or non-ordered consonant construct, to the partly specified

partly unspecified pattern to the very abstract notion of the phonetic matrix. One of the objectives of this work is to examine how lexical processing handles this abstractness.

1.1.2 The stem-based theory

Morpheme-based theory in general (i.e. the classical root-pattern hypothesis, the prosodic morphology hypothesis, and the etymon hypothesis) has been under criticism from proponents of the stem-based theory, the other major theory of Arabic morphology. The stem-based theory claims that the process of word formation is based on the stem. The root in these theories is considered a part of a paradigmatic relation between words (Bat-El, 1994 and Ussishkin, 1999 for Hebrew and Ratcliffe, 1997 and Benmamoun, 1999 for Arabic). The main argument in support of the word-based analysis is that certain features (e.g. consonant clusters) in a word are carried over to the derived word. We will examine the arguments put forward in the case of Hebrew first.

Bat-El (1994) argues that denominal verb formation in Hebrew is an output-to-output process that does not rely in any way on the consonantal root. She instead proposes the stem as the basis of the derivation for Hebrew morphology in general. One of the main arguments against the extraction of the root consonants and their association with a pattern in the process of output-to-output derivation is that it does not account for consonant cluster and vowel transfer and instead stipulates a rather arbitrary pattern. In (20) below are examples from Bat-El (1994, p. 578) of cases where the preservation of the consonant clusters cannot be explained by any phonological constraint. The consonant clusters, within the same syllable or in adjacent syllables, are underlined in (20).

(20) Output-to-output derivation in Hebrew denominative verbs

	Base	Gloss	Derived verb	Gloss
a.	<u>pr</u> <u>ak</u> lit	'lawyer'	<u>pri</u> <u>k</u> let	'to practice law'
	<u>tr</u> <u>ak</u> lin	'salon, parlour'	<u>tri</u> <u>k</u> len	'to make something neat'
b.	<u>gus</u> <u>pan</u> ka	'approval, seal'	<u>gis</u> <u>pen</u> k	'to approve, seal'
	<u>nos</u> <u>tal</u> gia	'nostalgia'	<u>nis</u> <u>tel</u> g	'to be nostalgic'

In (20a), the expected shape of the derived verb, based on other verbs in Hebrew, is CVCCVC (i.e. **pir.klet*, **tir.klen*). In the examples above, the verbs have the same shape as the base form: CCVCCVC. In (20b), despite the fact that they are not common in final position in Hebrew, consonant clusters appear in the derived verbs.

A very similar view is found in Ussishkin (1999), who provides an optimality-theoretic analysis of the same phenomenon. Ussishkin argues that not only is information about the consonants of the base available for the derived denominal verbs but so is information about the vowels. The latter determines the appearance of some sounds in the derived form. For instance, the quality of the vowel will determine the appearance of either [j] or [v], which Ussishkin argues are both glides, as shown in (21a) (from Ussishkin, 1999, p. 405):

(21) Output-to-output derivation in Hebrew denominative verbs

	Base	Related denominal verb
a.	[j]-forms	
	tik ‘file’	tijek ‘to file’
	bul ‘stamp’	bijel ‘to stamp’
	ʕir ‘city’	ʕijer ‘to urbanise’
	kis ‘pocket’	kijes ‘to pickpocket’
	buʕa ‘shame’	bijeʃ ‘to put to shame’
b.	[v]-forms	
	sug ‘kind, type’	siveg ‘to classify, to sort’
	ʃuk ‘market’	ʃivek ‘to market’
	hon ‘capital, wealth’	hiven ‘to capitalise’
	tox ‘inside, midst’	tivex ‘to mediate, to arbitrate’
	luax ‘table’	liveax ‘to tabulate’

The examples in the bases in (21a) have a high vowel (either [i] or [u]) and their corresponding denominal verbs have a [j]. In (21b), by contrast, the bases have a round vowel (either [u] or [o]) and the corresponding derived verbs have a [v]. Thus, words with

[u] can have derivatives with either [j] or [v], as is the case with the words *bul* and *fuk*, above.

As for Arabic, Benmamoun (1999, p. 197), for instance, points out that the root-and-pattern theory cannot account for the persistence of vowel length in the derivation of the broken plural in Arabic in (22).

(22) Arabic broken plural formation

	Singular	Plural	Gloss
a.	dʒund ub	dʒanaad ib	locusts
b.	qind iil	qanaad iil	lamps

Benmamoun argues that the root plays little role in Arabic morphology. He proposes that, syntactically, the imperfective stem carries no tense and is therefore the default form from which imperatives (23 a) and nominals (23b) are derived in an output to output process.

(23) Arabic imperatives and nominals derived from the imperfective

a. Imperfective	Imperative
ta-drus	ʔudrus
1S-study	
‘you study’	
ta-qraʔ	ʔi-qraʔ
1S-read	
b. Imperfective	Nominal
yu-ʕallim	mu-ʕallim
3S-teach	nom-teach
‘he teaches’	‘teacher’
yu-saaʕid	mu-saaʕid
3S-assist	nom-assist
‘he assists’	‘assistant’

To account for the inadequacy of the root analysis, Ratcliffe (1997, p. 151) gives examples of underived nouns and verbs in (24) where the stem is not divisible into morphemes. In a word like (24c), once the affixes *ya* and *u* are stripped, the stem cannot be decomposed into morphemes. For one thing, if we consider the consonants a separate morpheme (a root), the vowel also has to be a morpheme. But, as shown in (24), this vowel can be “any of the three short vowels in the language” and is not “predictable on semantic or grammatical grounds”. Furthermore, each word has to be derived from its ostensible root by a nonce rule.” (Ratcliffe, 1997, p. 151).

(24) Underived words in Arabic

	Word	Gloss
a.	qird-un	‘a monkey Nom’
b.	rumḥ-un	‘a spear Nom’
c.	ya-d ^ʕ rib-u	‘he hits’
d.	ya-ktub-u	‘he writes’

Similar suggestions have been made for other Semitic languages. In their analysis of Maltese, Hoberman and Aronoff (2003) argue that the verbal morphology of Maltese is based on affixation and that the root and pattern in this language and other Semitic languages are only diachronic features that attest to the common origin of these languages. The authors cite examples (e.g. 25) in which derivations of verbs do not depend on the pattern, but rather on the base from which they are derived (p. 68).

(25) Some derivations in Maltese

a.	i>i (no change)		
	kiser ‘break’	kisser	‘smash’
b.	e>e		
	xemex ‘sun’	xemmex	‘expose to sun’
c.	a>a		
	sabar ‘bear with patience’	sabbar	‘console’

Moreover, Maltese words borrowed from Romance (mainly Italian) do not respect the Semitic Maltese patterns and other phonological constraints such as initial clusters and geminates, which do not exist in Semitic Maltese.

On the whole, the main conclusion from these stem-based approaches is that words are represented as stems or whole units on which morphological processes apply. The consonantal root has no importance in the morphological derivation. Furthermore, the meaning that is often associated with the root is sometimes unpredictable in the derived form.

To sum up, I have so far discussed two major theories of Arabic morphology, the morpheme-based theory and the word-based theory. The morpheme-based theory comprises two main sub-theories, the root and pattern theory and the etymon theory. Let us now turn to Arabic phonemes, an issue related to Arabic morphology, namely the notion of etymon and phonetic matrix.

1.2 Phonemes and phonetic features in Arabic

This section provides a brief description of consonants in Modern Standard Arabic, with focus on the phonetic matrices as described in Bohas's work (1997, 2000) (see discussion in section 1.1.1.3.2 above). Since Bohas's work focused on Classical Arabic and this work is on Standard Arabic, only the phonetic matrices that still exist in Modern Standard Arabic will be examined. Also taken into account is the fact that the Standard Arabic used in Tunis, the variety examined in our experiments, is affected by the regional dialect (i.e. Tunisian colloquial Arabic).

The Modern Standard Arabic spoken in Tunis has twenty seven consonants. It contains all the consonants in the table below except for /dʕ/. The grapheme <ض> should be pronounced as /dʕ/ [a voiced pharyngealized dental stop] according to the prescribed norms but is usually pronounced as /ðʕ/ [a pharyngealized dental fricative], thus making no distinction between it and the grapheme <ظ>. The phoneme /dʒ/, which corresponds to the grapheme <ج>, is pronounced /ʒ/ [palato-alveolar fricative] in the Standard Arabic variety used in Tunis. This variation, however, has no effect on our choice of the stimuli. Both variants in each of the cases discussed here belong to the same phonetic matrices.

Table 1

Arabic Consonants

(based on Al-Ani, 1970 and Watson, 2002)²¹

	Bi-labial	Labio-dental	Inter-dental	alveolar	Pharyngeal ized dentals	Palatal(al veolar)	Velar	Uvular	Phary-ngeal	Glottal
Stops	b ب			t d ت د	t ^ʕ ط d ^ʕ ض		k ك	q ق		ʔ ء
Fricative		f ف	θ ð ث ذ	s z س ز	s ^ʕ ص ð ^ʕ ظ	ʃ ش	x ɣ خ غ		ħ ʕ ح ع	h هـ
Affricate						dʒ ج				
Trill				r ر						
Lateral				l ل						
Nasal	m م			n ن						
Glides	w و					j ي				

In Modern Standard Arabic, there are three short vowels /i/ /a/ /u/ and their equivalent long vowels. But since vowels in Arabic are not considered in the phonetic matrices (Bohas, 1997, 2000), (Table 2, below) only the features of the consonants are presented here. In fact, only the features that will be used in the definition of the phonetic matrices that are believed to underlie the Arabic lexicon are included. Notice also that Bohas (2000) excluded glides from his phonetic features making up matrices.

²¹ When two phonemes appear in the same cell one following the other, the first is voiceless and the second is voiced.

Phonetic matrices in Arabic and the phonemes belonging to them

The following is a list of the different phonetic matrices proposed for Arabic and the (etymon) phonemes that correspond to them. For a word to be part of a phonetic matrix, it has to have two phonemes with each having one place feature of the two main features of the matrix. For instance, for an Arabic word to be within the phonetic matrix {[labial], [coronal]} in (26a), it needs to have one phoneme that has the feature [labial] and another phoneme with the feature [coronal]. In other words, it has to have either an /m/, a /b/, or an /f/ and one of the following phonemes: /s/, /θ/, /ð/, /t/, /d/, /z/, /ʃ/, /ʕ/, /tʰ/, /dʰ/, /ðʰ/, /sʰ/, /l/, /n/, /r/. I also included the very general meaning (signification commune primordiale) corresponding to each phonetic matrix.

(26) Phonetic Matrices in Arabic and the Phonemes Corresponding to Them (Bohas, 1997, 2000)

a. {[labial], [coronal]}: ‘porter un coup ou des coups (sans spécifier l’objet)’ (Bohas, 2000, p. 69).

[labial]: /m/, /b/, /f/

[coronal]: /s/, /θ/, /ð/, /t/, /d/, /z/, /ʃ/, /ʕ/, /tʰ/, /dʰ/, /ðʰ/, /sʰ/, /l/, /n/, /r/

b. {[+consonantal, labial] [+consonantal, -voiced, +continuous]}: ‘mouvement de l’air: vent, soufflé; expulsion de l’air chez l’homme ou l’animal’ (Bohas, 2000, p. 82).

[labial]: /m/, /b/, /f/

[-voiced, + continuous]: /f/, /θ/, /s/, /ʃ/, /sʰ/, /h/, /x/, /ħ/

c. {[labial, -sonorant], [pharyngeal]}: ‘lier’ (Bohas, 2000, p. 85)

[labial, -sonorant]: /b/, /f/

[pharyngeal]: /tʰ/, /dʰ/, /sʰ/, /ðʰ/, /h/, /ʕ/, /ħ/, /x/, /q/

d. {[coronal], [pharyngeal, -dorsal, -voiced]}: ‘produire un bruit sourd, rauque’ (Bohas, 2000, p. 89).

[coronal]: /z/, /d/, /t/, /ð/, /θ/, /s/, /ðˤ/, /dˤ/, /tˤ/, /ʕ/, /sˤ/, /l/, /n/, /r/

[pharyngeal, -dorsal, -voiced]: /ħ/, /ʕ/, /ħ/

e. {[coronal], [dorsal]}: ‘couper’ (Bohas, 2000, p. 117).

[coronal]: /z/, /d/, /t/, /ð/, /θ/, /s/, /ðˤ/, /dˤ/, /tˤ/, /ʕ/, /sˤ/, /l/, /n/, /r/

[dorsal]: /k/, /sˤ/, /ðˤ/, /dˤ/, /tˤ/, /ɣ/, /x/, /q/

f. {[labial, -sonorant], [dorsal]}: meanings related to ‘la forme ∩ disposée de diverses manières, ce que Nicolai a appelé la courbure’ (Bohas, 2000, pp-90-91).

[labial, -sonorant]: /f/, /b/

[dorsal]: /k/, /sˤ/, /ðˤ/, /dˤ/, /tˤ/, /ɣ/, /x/, /q/

1.3 Arabic orthography

The following discussion of the characteristics of Arabic orthography is motivated by the fact that orthography affects word recognition in at least one way. Since Arabic is written in two versions, either vowelised or unvowelised, the importance of phonology in lexical processing may vary depending on which version is being used. While in the vowelised version, short vowels, represented by diacritics, are added, they are not used in the unvowelised version. In this work, phonology will be held constant, as words will be presented in their unvowelised version, the way adult readers of Arabic normally read. But, I propose that because they are always represented in orthography, consonants might be more salient in reading Arabic. This hypothesis is tested in Study 5 (chapter 4). Furthermore, this section provides an idea about orthography, which is necessary to understand the experiments, i.e. how orthography/phonology and morphology are manipulated.

Arabic, like Hebrew, is written from right to left and is mainly consonantal. The orthography is made of 28 consonants, including three glides (see Table 2 above for a phonetic description of Arabic consonants). The three glides: *ʔalif* <ا>, *waaw* <و> and *yaa* <ي>

<ي> serve as long vowels as well, pronounced as /a:/, /u:/ and /i:/ respectively. The three short vowels are represented by diacritics (in vowelised representation only).

Though letters have no capital versions, they have slightly different shapes depending on their position in the word, as shown in Table 3. Initially and finally, letters have to be connected to the following or the preceding letter respectively. Medially, on the other hand, letters have to be connected to the preceding and following ones. For instance the letter /b/ has the following shape when it is separate (i.e. not attached to any letter) <ب>, but the following shapes <ب>, <ب>, <ب>, in initial, final, and medial positions when attached to other letters, respectively. The following words illustrate the shape of the letter in the four mentioned positions: أصاب [ʔasʔaaba] ‘he/it hit the target’; بان [baana] ‘he/it became clear’; تغلب [tayallaba] ‘he/it triumphed’; تجبر [tadzabbara] ‘he became a despot’.

There are some letters that are referred to as one-sided connectors (see e.g. Azzam, 1989). These are connected by a small stroke to only the preceding letter in medial and final position and are left unconnected in initial position (i.e. in the shape they have when separate). One-sided connectors are the letters *ʔalif* <ا>, which represents the phoneme /ʔ/, *daal* <د> /d/, <ذ> *ḏaaʔ* /ð/, *raaʔ* <ر> /r/, *zaaʔ* <ز> /z/, *waaw* (و) representing /w/when a glide and /u:/ when a vowel. When connected to preceding letters with an extra stroke, these letters look like this: <ح> <د> <ذ> <ر> <ز> <و>. The letters that follow one sided letters are left unconnected from the right hand side, the side adjacent to the one sided letter.

In addition to its variation due to position in the word (as shown above for the letter *baaʔ*, /b/), the spelling of the *hamza* <ء> /ʔ/ depends on the type of the vowels/diacritics preceding and following it. Depending on the preceding vowel, *hamza* can be represented either on a seat <أ>, a *waaw* <ؤ>, an *ʔalif* <إ>, a *yaaʔ* <ئ> or without anything beneath it <ء>. The final /t/ of the feminine in nouns and adjectives can be represented as either attached <ة> or detached <ه> depending on whether the letter that precedes it is one-sided or regular, that is a double-sided connector, as in أرجوحة [ʔurdʒuuħa] ‘a swing’ and فتاة [fataat] ‘a girl’.

Table 3

Arabic Graphemes and Their Shapes in Different Positions

Letter	Phoneme	Beginning	Middle	End	Separate
ʔalif	a:	أ	ا	ا	ا
baaʔ	b	ب	ب	ب	ب
taaʔ	t	ت	ت	ت	ت
θaaʔ	θ	ث	ث	ث	ث
ziim	dʒ	ج	ج	ج	ج
haaʔ	h	ح	ح	ح	ح
χaaʔ	x	خ	خ	خ	خ
daal	d	د	د	د	د
ðaal	ð	ذ	ذ	ذ	ذ
raaʔ	r	ر	ر	ر	ر
zaay	z	ز	ز	ز	ز
siin	s	س	س	س	س
ʃiin	ʃ	ش	ش	ش	ش
s ^ʕ aad	s ^ʕ	ص	ص	ص	ص
d ^ʕ aad	d ^ʕ	ض	ض	ض	ض
t ^ʕ aaʔ	t ^ʕ	ط	ط	ط	ط
ð ^ʕ aaʔ	ð ^ʕ	ظ	ظ	ظ	ظ
ʕayn	ʕ	ع	ع	ع	ع
ʕayn	ʕ	غ	غ	غ	غ
faaʔ	f	ف	ف	ف	ف
qaaf	q	ق	ق	ق	ق
kaaf	k	ك	ك	ك	ك
laam	l	ل	ل	ل	ل
miim	m	م	م	م	م
nuun	n	ن	ن	ن	ن
haaʔ	h	ه	ه	ه	ه
waaw	w	و	و	و	و
yaaʔ	j	ي	ي	ي	ي
hamza	ʔ	أ	ا	ا	ء

Fifteen letters are dotted. They have either one, two or three dots either above or below. The dots are used to differentiate between a set of consonants that have the same shape. Diacritics represent the short vowels. In Arabic, vowels always follow consonants. The vowel /a/ is represented by a stroke (), called *fatḥa*, above the consonant letter that the vowel follows, /u/ is represented by this symbol (), called *ḍamma*, over the consonant letter and /i/ as a stroke under the letter (), called *kasra*. A symbol similar to a miniature zero is represented over a consonant letter when there is no vowel after the consonant (). Gemination is also represented by a diacritic over the geminated consonant letter ().

Diacritics represent grammatical functions and occasionally lexical functions. Grammatical functions include tense, voice and mood, as in: مَزَجَ [mazaʒa] ‘he mixed’ vs. مُزِجَ [muziʒa] ‘it was mixed.’ The lexical function of diacritics refers to their use to distinguish two otherwise graphemically identical words, as in: قَسَمَ [qasam] ‘an oath’ vs. قِسْمَ [qism] ‘a part, a department’.

Diacritics are rarely represented in writing, except in elementary school texts (for grades 1-3) or in readers for children and in religious texts. They might also be included in otherwise ambiguous words. Arabic orthography, therefore, has two versions: the vowelled version (with short vowel diacritics) and the unvowelled version. Long vowels, however, are represented by consonants as mentioned above. Thus, many unvowelled words that share the same root or have a homographic root look exactly the same in reading. But on the whole, Arabic has a relatively transparent orthography, with a one-to-one correspondence between graphemes and phonemes. The vowelled version is more transparent since it contains almost all the phonological information of spoken words.

In the review of the studies on lexical processing in the following chapter, studies done on Hebrew are also included because Hebrew has a similar morphology and orthography to Arabic. The results for Hebrew should, however, not be generalized to Arabic, and vice versa, without replication. Arabic orthography is more complex than Hebrew orthography (e.g. Ibrahim, Eviatar, & Aharon-Peretz, 2002). While the dots are relied on in Hebrew as diacritics only to indicate short vowels, Arabic relies on them to distinguish phonemes/letters that are otherwise identical. Diacritics, different from dots,

are used in Arabic to indicate short vowels. Besides, while only a few letters in Hebrew change their shape at the end of a word, most letters in Arabic have initial, middle and final-position shapes. Furthermore, Arabic letters are attached to each other in words. This complexity of Arabic orthography makes it difficult to process. Ibrahim, Eviatar, and Aharon-Peretz (2002) found that the orthography of Arabic as a first language was significantly slower to process than Hebrew as a second language in the visual form of a Trail Making Test, in which participants serially ordered letters while matching them with numbers. There was no difference in the auditory version of the test. Roman and Pavard (1987), who examined the reading processes of Arabic-French bilinguals, found that eye fixation per word in reading Arabic text was significantly longer than in French.

1.4 Summary and implications

The discussion in this chapter has focused on the status of roots, patterns, and etymons within two main theories of Arabic (and Semitic) morphology: the morpheme-based theory and the word-based theory. The major difference between these theories is that while the former considers the root and/or the etymon and pattern as the basis of derivation, the latter contends that derivation is based on the stem.

This controversy has implications for the mental representation and processing of lexical items. These theories of morphology have inspired theories of lexical processing, discussed in the following chapter. Like the morpheme-based theory, some theories of lexical processing, namely the decompositional hypothesis and the dual access hypothesis, rely on morphemes in representation and processing. Inspired by the word-based theory of morphology, the word-based hypothesis of lexical processing suggests that sub-word units (the root, the pattern and/or the etymon) have no cognitive relevance and therefore no effect in lexical processing.

Despite the merits of the word-based theory, most psychological evidence supports the morpheme-based theory (the existence of the root and pattern). This evidence is presented in the following chapter. The present study will attempt to provide further evidence for the morpheme-based theory. It will test the validity of various morpheme-based theories by examining the cognitive relevance of the root, pattern and etymon and matrix in lexical processing.

The present study will examine a newly revived controversy as to whether the root or the etymon is the basic unit of representation in the Arabic (and by extension Semitic) lexicon. The study will also go further to examine the experimentally unexplored notion of the phonetic matrix as a unifying representational factor in the Arabic mental lexicon. The experiments will, therefore, assist in deciding which (if any) of the morpheme-based theories is cognitively valid.

Two other questions related to the processing of morphological units are (i) whether there is a gradation in priming effects that correlates with semantic and/or orthographic overlap between primes and targets and (ii) the extent of abstractness lexical processing can reach.

The study also tests the hypothesis, based on the morpheme-based theory of morphology, that root consonants are more salient than other consonants. Due to the reduced importance of the pattern (as found in some lexical decision tasks in both Arabic and Hebrew) and because of the lesser importance given to vowels in Arabic orthography, the hypothesis that vowels are less salient than consonants is also tested.

The following chapter deals with the cognitive facets of these issues. It discusses theories of mental representation and processing of lexical items and their relation to the theoretical controversy discussed in this chapter. It also reviews previous studies on the cognitive relevance of the morphemes and phonemes discussed with a focus on their role in lexical processing in Arabic.

Chapter Two

Review of Theories of Lexical Processing and Previous Relevant Empirical Studies

2.0 Introduction

While the first chapter provided a theoretical background to some questions in Arabic morphology and phonology, the present chapter will address the psycholinguistic side of these issues. It discusses the cognitive relevance of the selected morphemes and phonemes, focusing mainly on their role, if any, in lexical representation and processing. The first part (section 2.1) presents a general background to theories of lexical representation and processing, with a focus on morphology. These theories include the word-based hypothesis, the morpheme-based hypothesis, the dual-access hypothesis, and the connectionist hypothesis. The second part (section 2.2) discusses the role of other factors, besides morphemes, that have an effect on lexical representation and processing. The third section (2.3) reviews previous research on the cognitive relevance of roots, etymons, and patterns, as well the relative cognitive status of vowels and consonants in the Arabic lexicon. Finally, implications are drawn for the present work (in section 2.4).

2.1 Theories of lexical representation and lexical processing

2.1.0 Introduction

The aim of the following overview of the major hypotheses on lexical representation and processing is to relate the controversy within theories of morphology to theories of lexical representation and processing and provide a background against which the results of this study will be interpreted. The discussion of these theories will be centered on the role of morphology in lexical representation and processing.

But before embarking on a discussion of these hypotheses, a brief definition of the two often vaguely used terms *representation* and *access* is necessary. I adopt the distinction between *lexical entry* and *access representation* proposed by Marslen-Wilson, Tyler, Waksler, and Older (1994, p. 4). According to these authors, the term ‘lexical entry’ refers to “the modality-independent core representation of a word’s syntactic and semantic

attributes as well as its abstract phonological properties.” Access representation, on the other hand, is the “modality-specific” representation “which provides the perceptual target for lexical access, defining the route whereby information in the sensory input is linked to a given lexical entry.” (p. 4).

A similar definition is given by Taft (1988) who distinguishes representations in the input systems that are used as access codes from representations in the modality-free central system.²² While the first representations are physical and can be either visual or auditory depending on the incoming stimulus, the representations in the central system include pronunciation, spelling, meaning, and syntactic properties. Yet, as will be shown below, such a distinction is considered unnecessary in connectionist models (e.g. Seidenberg & McClelland, 1989).

2.1.1 The whole-word/full-listing hypothesis

The proponents of this hypothesis think that words are fully listed together with related words in long term memory. Morphological relations/rules are not represented and therefore not used in lexical access and production (see Butterworth, 1983 for a review of related studies). Taking this assumption as a starting point may be problematic when accounting for the production and recognition of novel words (see discussion in Chialant & Caramazza, 1995). Butterworth (1983), however, argues that the full listing hypothesis may rely on “fall-back procedures” that are in the form of general meta-rules based on existing exemplars to understand or produce a novel word.

Henderson, Wallis, and Knight (1984) do not exclude decomposition in morphologically complex words, but argue that it is post-lexical. While they found that priming with a stem was distinct from semantic similarity, Henderson et al. (1984) argue that there was no evidence that decomposition was pre-lexical. In a second experiment using pseudo-affixed (prefixes and suffixes) words and non-words, they found no significant time cost that might suggest pre-lexical affix stripping. Similarly, Manelis and Tharp (1977) found no difference in lexical decision time between suffixed and pseudo-suffixed words.

²² The existence of a modality-free central system remains controversial. Butterworth (1983) argues on the basis of many studies that although there is evidence for a separation between graphemic and phonemic lexical representations, there is little evidence for modality-neutral lexical representations.

Thus, according to this hypothesis, all words, simple or complex, are fully and separately represented. Rules apply to words and not morphemes. What follows from this view is that access to lexical representation, either phonological or orthographic, occurs in a direct matching fashion.

Word-based theories of Arabic morphology would fit within this conception of lexical representation and processing. There are, however, few findings that support this theory in Arabic (or any other Semitic language for that matter), as will be discussed in section 2.3.

2.1.2 The decompositional/morpheme-based hypothesis

According to the decompositional hypothesis, only morphemes are represented and used to recognize words. Complex words are, therefore, decomposed before any access takes place. This hypothesis was first proposed in the pioneering work of Taft and Forster (1975). They found that nonword roots that were part of prefixed stems (such as *vive* in *revive*) took more time to reject than those that were not (such as *depertoire*). They also found that it took longer to reject an illegal combination of a prefix and a root than a nonword made of a prefix and a non-existing root. Their explanation is that words are decomposed before being recognized. According to this interpretation, while the real roots are taken to the central system after being stripped of their prefixes before they are rejected, the others are rejected at the first stage (i.e. in the input system).

The study discussed above (Taft and Forster, 1975) was later formulated in what has become to be known as the affix-stripping hypothesis (although most work was on prefixes). Under this hypothesis (e.g. Taft, 1981, 1988), sensory input (visual or auditory) is mapped onto an access lexical representation in the input system. This access unit, which is the stem after prefix stripping, is used to retrieve information from the central system. This information will finally be checked against the visual or auditory stimulus. In what follows are listed some more results that are often brought forward in support of this hypothesis are listed.

(i) Prefix stripping in complex words is time costly and therefore recognizing non-prefixed words takes less time. Taft (1981),²³ for instance, found that pseudo-affixed words (*precipice*) took longer to recognize/reject than prefixed words (*replica*). A similar result was found in a naming task, where pseudo-prefixed words took longer to name than prefixed words and pseudo-prefixed (*unique*) words took longer to name than non-prefixed words (*create*). Rubin, Becker, and Freeman (1979) also found that pseudo-prefixed words were more difficult to recognize than non-prefixed words.

(ii) The conclusion that words are accessed only after affix stripping was also supported in a study on English by Taft, Hambly, and Kinoshita (1986) using both an auditory and a visual lexical decision task. In both tasks, Taft et al. (1986) found that prefixed nonwords (*invape*) took longer than nonwords that had no prefixes (*ibvape*). The difference between prefixed and non-prefixed nonwords was much larger in nonwords that had a real root (*dejoice* vs. *tejoice*) than in ones that did not (*dejouse* vs. *tejouse*). They explain this result by proposing that the root is represented in the mental lexicon. The recognition process starts by checking the root, after stripping, in the central system and if found the process continues to check if the root and prefix could be combined to form a word. They, however, found no difference in processing time between non-prefixed nonwords that had real roots (e.g. *ibvive*) and those that did not (*ibvape*). In the nonprefixed nonwords, the cluster *bv* never occur in English, a fact that Taft does not seem to have controlled.²⁴ The explanation that Taft (1988) gives for this seeming contradiction of results is that only prefixed words are stripped of their affixes, suffixed words can still be accessed through their stems even if they have an illegal suffix.

(iii) Derived suffixed words are claimed to be accessed in a left to right parsing fashion (e.g. Taft, 1979a, 1986). In this view, different attempts of access are made with different chunks until a successful access is achieved. Taft (1986), for instance, found that while the code of access was the first few phonemes in spoken words, in line with the

²³ Taft (1979a, 1979b, 1981) uses stem to mean root. In this dissertation, unless otherwise indicated *root* refers to any non-inflected word whose derivational affixes are stripped off and *stem* refers to the word with derivational but not inflectional affixes.

²⁴ I owe this remark to Eta Schneiderman.

Cohort Model²⁵ (e.g. Marslen-Wilson, 1989), it was the morpho-orthographic syllable (Taft, 1979a, 1986) in printed words.

(iv) Another major source of evidence in favour of this model is the effect of root frequency. Taft (1979b), for instance, found that it was faster to recognize prefixed and inflected words with frequent roots than words with less frequent roots despite the fact that both whole words were of similar frequency.

In his 1988 paper, Taft adopts a weaker version of this hypothesis. He proposes, on the basis of evidence from an auditory lexical decision experiment, that both prefixes and stems might be used together in accessing lexical entries in the central system. In this experiment, contrary to the prediction of the decomposition hypothesis, prefixed words and non-words were recognized faster than non-prefixed words (e.g. *impurity* vs. *purity*) and non-words (e.g. *enrapsify* vs. *rapsify*) with the same root.

More recently, Taft (1994) calls for a reinterpretation of all the evidence for the morpheme-based hypothesis in terms of an interactive activation model (e.g. McClelland & Rumelhart, 1981), discussed below (section 3.1.6). Two major limitations of his morpheme-based hypothesis prompted this revision. First, the morpheme-based hypothesis cannot explain the effect of semantic priming since words are presumably accessed through their stems regardless of any semantic information. Second, the claim that words are stripped of their prefixes presupposes the existence of a store for prefixes that are used in such a process, which is unlikely, since in some cases people are unaware of prefixes. Another reason behind this change is that there is evidence that phonology/orthography plays a role in lexical processing, something which an interactive activation model such as the one proposed by McClelland and Rumelhart (1981) handles very well. To account for morphological priming effects, Taft (1994) proposes the addition of a morpheme level that is above the rhyme and below the word level to any interactive activation model. Thus, words are represented in separate units but accessed together directly in an interactive fashion.

²⁵ The Cohort Model of spoken word recognition (e.g. Marslen-Wilson, 1989) suggests that when a word is heard it activates a number of related words with similar pronunciation. As the word is fully heard only one candidate is finally mapped onto and the others are deactivated.

As we will see in section 2.3 below, there is evidence of word decomposition in Arabic lexical processing. This hypothesis will be tested in the experiments of the present work, reported on in chapters 3 and 4.

2.1.3 The dual-access hypothesis

In recent years, more evidence has been reported in favor of the hypothesis that some words are decomposed and some are not and in both cases whole words are activated. A representation of this view in concatenative languages is the frequently discussed Augmented Addressed Morphology hypothesis (AAM).

The main assumption of the AAM hypothesis (e.g. Caramazza, Laudanna, & Romani, 1988; Laudanna, Badecker, & Caramazza, 1989) is that words are accessed in a parallel manner through whole access units and the decomposed units of complex words. Whole word access is the default and is faster in known words, but decomposing is more efficient and more common in unfamiliar words and non-words. While access units include both whole units and separate morphemes, words are represented as separate stems and affixes in the mental lexicon. It is important to mention that the AAM hypothesis also suggests that orthographically similar words are also activated.

The main evidence for the AAM hypothesis and against the word-based hypothesis and the morpheme-based hypothesis comes from the results of a study by Caramazza et al. (1988). These three theories have different explanations of how words are accessed and therefore different predictions about response time in identifying different types of words. Caramazza et al. (1988), using three lexical decision tasks in Italian, tested the predictions of these hypotheses with respect to partially decomposable non-words. In the first experiment, they tested the predictions of the whole word hypothesis and the AAM (and the decompositional hypothesis), by comparing the response time to decomposable non-words (e.g. *cant-evi*: *cant* is the stem which means ‘sing’ and *evi* is the 2nd person singular past morpheme of verbs of the second conjugation) compared with non-decomposable non-words (*canzovi*: *canz* is not an existing stem and *ovi* is not an existing suffix). The AAM and the morpheme-based hypothesis predict that non-decomposable non-words will be rejected faster while the whole word hypothesis predicts no difference. Their results supported the prediction of the AAM and morpheme-based hypothesis.

To test the predictions of the AAM and the morpheme-based hypothesis, Caramazza et al. (1988) included in the first experiment, in addition to decomposable non-words with legal affixes and stems (*cant-evi*), non-decomposable non-words (*canzovi*), non-words with partial morphological structure, namely words with either only a legal stem (*cant-ovi*: *cant* is legal stem which means ‘sing’, but *-ovi* is a nonsense affix) or only a legal affix (*canz-evi*: *canz* is a nonsense stem, but *-evi* is a legal affix). The morpheme-based hypothesis predicts a delay in lexical decision only of decomposable non-words (*cant-evi*) since it would take time to decompose the nonword and check whether the stem exists in the lexicon and whether it could be combined with the affix at hand. But it does not predict delay in non-words with illegal stems and no apparent affixes (*canz-ovi*), as these non-decomposable non-words are rejected at the lexical access stage. As for the non-words with partial morphological structure, the morpheme-based hypothesis predicts that those that have a legal stem but no affix (e.g. *cant-ovi*) will be rejected as early as the affix-stripping stage, very much like non-decomposable non-words (with neither legal affixes nor legal stems, e.g. *canzovi*). The morpheme-based hypothesis also predicts that non-words with an illegal combination of an affix and nonsense stem (*canz-evi*) will take longer to reject than non-words of the *cant-ovi* type, since in this case the target undergoes affix stripping followed by a search with the combination of the stem and the affix. Thus, although they undergo affix stripping, non-words with legal affixes (*canz-evi*) are rejected faster than non-words with legal stems and affixes. This is because in the latter case there is no search with a stem. The order of the time of recognition of these four types of non-words is predicted to be as follows: *cant-evi* > *canz-evi* > *cant-ovi* = *canzovi*, the last being the quickest to be rejected.

The AAM, on the other hand, predicts the following order: *cant-evi* > *canz-evi* = *cant-ovi* > *canzovi*. This model, as discussed above, relies on a parallel activation process with both whole words and stems/roots as access units for familiar words and orthographically similar morphemes or words for unfamiliar words. Thus, in the recognition process of a word such as *cant-evi*, similar words such as *canzoni* or *calzoni* are activated in addition to the morpheme *cant* and *evi*, an activation that will eventually die out because the combination is illegal. Thus, the rejection of *cant-evi* is slower than *canz-ovi*, which will not activate any morphemes. The AAM predicts that there will be a similarity in response

time between non-words with partial morphological structure (either legal affix *canz-evi* or legal stem *cant-ovi*) and the time for these will be half way between the non-decomposable non-words (*canz-ovi*) and the decomposable non-words with both a legal stem and a legal affix (*cant-evi*). In both cases, the non-words will activate an access unit (*-evi* or *cant-*) but the rest of these stimuli will not activate any unit and therefore no lexical item will be activated. Caramazza et al.'s (1988) results confirmed all the predictions of the AAM. The morpheme-based hypothesis correctly predicted that decomposable non-words with legal stems and affixes are rejected more slowly than non-decomposable non-words but was not right about the non-words with partial morphological structure.

The proponents of the AAM hypothesis also argue that familiar complex words are accessed as whole units and unfamiliar regular complex words are decomposed, provided that the morphological complexity is orthographically transparent (e.g. Caramazza, Laudanna, & Romani, 1988; also Bradley, 1980 for English). It is noteworthy, however, that for known transparent complex words, both whole units and decomposed units are activated in parallel, although whole access is faster.

Though not typically associated with the AAM hypothesis, Laine, Seppo, and Hyoenae (1999) also found that lexical access in Finnish is mediated by either stems or full words. They found a time cost for words with case inflection (Experiments 1, 2, and 3) as well as for morphologically ambiguous nouns that could be one word or a stem and an affix (Experiment 5), as well as pseudo-ambiguous nouns (e.g. the verb *pun/ish* in English) (Experiment 6). There was, however, no evidence of delay in pseudo-inflected nouns (Experiment 2) or nouns with pseudo-stems like *bar* in *barley* (Experiment 4).

There are some empirical findings that the AAM cannot account for. Contrary to what the AAM predicts based on the whole word default activation in frequent words, Niemi, Laine, and Tuominen (1994) found that frequent case-inflected Finnish words took longer to recognize than monomorphemic words matched for frequency and length.

A dual access hypothesis for Arabic

Although all three hypotheses discussed above were based on results from a few concatenative languages, they are often presented as universal. In this section, I review a proposal for Arabic that is in line with the dual access hypothesis.²⁶

On the basis of a study on both regular (suffixed) and irregular plurals in Arabic carried out with both normal and aphasic participants, Mimouni, Kehayia, and Jarema (1998) have proposed a dual model of access and representation in line with the model of representation proposed by McCarthy (1979/1982).

McCarthy (1979/1982) suggests that the Arabic lexicon includes roots, stems, words, and rules. Regular words are related to the consonantal root from which they are derived and accessed. The lexical entry is an n-ary branching tree with the root as the highest dominating node, the only node in the tree that could have idiosyncratic information. If an item *a* is dominated by an item *b*, then *a* is derived from *b* and *a* should have the sum of the meaning of *b* plus whatever the derivational rule adds. However, irregular words (one that require idiosyncratic information) such as broken plurals, are listed separately, in addition to being listed under the root entry. The broken plural form is dominated by the singular in a family fashion, in the same way as morphologically related words are dominated by the root. These irregular words are derived by an idiosyncratic rule and they do not have a compositional meaning like the ones that are derived by regular rules.

The findings of Mimouni, Kehayia, and Jarema (1998) support some of these hypotheses. Mimouni et al. examined both regular and irregular singular and plural nouns in an auditory priming lexical decision task with both aphasic patients and normals. In both cases they included either the singular or the plural form as the prime. The delay between primes and targets was 250 ms. They found that morphologically related primes, sharing the same root, led to faster recognition in all conditions. The pattern did not lead to priming.

²⁶ On the basis of a number of studies (discussed in detail in section 3.3.2 below), Frost and his colleagues (Frost, Forster, & Deutsch, 1997; Deutsch, Frost, & Forster, 1998; and Frost, Deutsch, & Forster, 2000) have proposed that the Hebrew lexicon has two levels (lexical and morphemic) and that words are accessed in a parallel way making reference to both levels but only in verbal forms because nominal forms were primed with roots but not with patterns.

The major interesting finding that supports McCarthy's (1979/1982) distinction between regular and irregular words is that response time (RT) was significantly faster for the singular and broken plural forms than the suffixed regular plurals. The authors attribute this to the fact that, in the case of the regular plural, the time cost is due to the decomposition of the words into stems and affixes before access. They also found that singulars are always accessed faster than their broken plural counterparts. This supports the hypothesis that the broken form is dominated by its corresponding singular form in a separate entry. The authors suggest, as a result, that the plural is accessed through the singular. They are, however, unclear about the role of the root and the pattern and what rules are applied to form words.

Despite their different conceptions of how language is stored in the mind, all the hypotheses/models discussed above, generative in essence, share their conception of language as human-specific faculty that is made of two separate modules: the mental lexicon and the mental grammar (e.g. Pinker, 1999). The first is where units/symbols are stored with their phonology and meaning and the second is responsible for the computation of any relationship between them as variables rather than instances (e.g. noun vs. dog). Symbolic models are generally dual systems; they rely both on rules and storage in an associative memory of irregular forms (e.g. Pinker, 1991, 1999), (for a review of symbolic models see Ullman, 2001).

2.1.4 The connectionist hypothesis

The main assumption of most connectionist models (e.g. McClelland & Rumelhart, 1981, 1982; Seidenberg & McClelland, 1989) is that morphology and language in general are stored and accessed like other general cognition activities. A word is perceived as a result of the activation of nodes, which mimic but are not equivalent to neurons. Nodes can be fixed and independent in localist models (e.g. McClelland & Rumelhart, 1981, 1982) or functionally non-specified and dependent on other nodes in distributed models²⁷ (e.g. Seidenberg & McClelland, 1989).

²⁷ There is more evidence in the field of brain research for a distributed activation in cognitive processes (e.g. Thorne, 1995/1998).

In (distributed) connectionist models, therefore, there is no morphological decomposing; priming effects are obtained because of the recurrence of certain visual (e.g. McClelland & Rumelhart, 1982) or auditory clusters (e.g. McClelland & Elman, 1986). Besides, there is no lexicon and therefore no lexical entries.

The spellings, pronunciations, and meanings of words are not listed in separate stores; hence, lexical processing does not involve accessing these stored codes. Rather, lexical information is computed on the basis of the input string in conjunction with the knowledge stored in the network structure, resulting in the activation of distributed representations.... [Lexical access is] a partial or graded activation of representations (Seidenberg & McClelland, 1989, p. 560).

Unlike the decompositional hypothesis, connectionism deals with both regular and irregular words in the same way and does not differentiate between language types. In both cases morphological effects are obtained as the result of the recurrent interactions between the units on the basis of orthography/phonology and semantics. As certain clusters of form map regularly to certain meanings, the system will treat them as patterns and give them a componential treatment. Form and meaning are the result of certain types of interacting activity between units. Interactions between units are based on excitatory and inhibitory connections. The system learns to assign a value to any stimulus (e.g. Plaut & Gonnerman, 2000). For instance, Seidenberg (1987) showed in a series of experiments that frequency of orthographic clusters explains better the effect often associated with morphemes (e.g. BOSS in Taft's (1979a) work)²⁸. Since both meaning and form are believed to contribute separately to lexical processing, connectionism predicts and accounts for graded "morphological" effects of facilitation between related words that mirror their differential relatedness in form and meaning (e.g. Gonnerman, 1999; Gonnerman, Seidenberg, & Andersen, 2004). Morphological effect without semantic similarity was often considered incompatible with distributed connectionist models, but Plaut and Gonnerman (2000) could produce similar effects (i.e. priming effects between primes and targets sharing a morpheme but only an opaque semantic relationship) by simulating a morphology-rich

²⁸ BOSS is defined on page 56.

system and a morphology impoverished system. They obtained priming with primes that shared morphemes and an opaque semantic relationship with targets in the language with rich morphology and not in the morphologically-impooverished language.

Although connectionist models are numerous and differ on whether they are localist or distributed and whether they manipulate variables or not, most of these models involve multilayer perceptrons. “A multilayer perceptron consists of a set of *input nodes*, one or more sets of *hidden nodes*, and a set of *output nodes*. These nodes are attached to each other through *weighted connections*; the weights of these connections are generally adjusted by some sort of *learning algorithm*. *Nodes* are *units* that have activation values, which in turn are simply numbers like 1.0 or 0.5. *Input* and *output nodes* also have *meanings* or *labels* that are assigned by an external programmer” (Marcus, 2001, p. 7).

Activation values are set beforehand and are then multiplied by the values of the connections to other nodes. The multiplied value serves as the input to the output node mediated by a rule that might or might not change this input value (see Marcus, 2001 for a detailed explanation). Perceptron models can be localist or distributed. In localist models (McClelland & Rumelhart, 1981, 1982) single input units correspond to a letter, a word, or a concept. In distributed models, input is the result of the activation of a number of units that may represent certain features (phonetic features in Plunkett & Marchman, 1993).

Hidden nodes are used to mediate functions/relationships between input and output units that are difficult to encode by direct connections between inputs and outputs. Hidden units represent the values of inputs via their weighted connections with output units. The connection weights between units are learned as data are fed into the system. The learning process is guided by a learning algorithm.

Marcus (2001) argues that the discussion over the representation of symbols is often fraught with confusion, because if we define symbols as context independent mental representations, even connectionist models use them (for instance the word *door* always activates a certain node or a number of nodes). Marcus (p.34) adds that the real difference between symbolic and connectionist models is “whether the mind is a system that represents variables, operations over variables, structured representations, and a distinction between kinds and individuals.” One type of operations on variables is the concatenation function $f(x, y)=xy$. Marcus provides many examples of how people can presumably

generalize a function such as $f(x, y)=xy$, for instance, in the case of plural formation stem+s, *wug-wugs*. Marcus argues that connectionist models are unable to generalize abstract relations of this kind. Multilayer perceptrons are also incapable of differentiating between individuals (Max) and kinds (a man). They represent all individuals in the same way.

A connectionist model for Arabic

Boudelaa and Marslen-Wilson (2004a) propose, but do not actually implement, a distributed connectionist model similar to the one proposed by Plaut and Gonnerman (2000) to account for the results found in relation to Arabic morphology. In their work on Arabic lexical processing, Boudelaa and Marslen-Wilson (2001a, 2001b, and 2004a) have found evidence for roots, patterns, etymons, and CV skeletons. They suggest that morphological priming/activation in any of these constructs is a distributed activation. Because of their similarity, roots and etymons are suggested to be activated through almost the same nodes/units. The authors also argue that the same thing happens with the similar constructs, that is, the pattern and the CV skeleton.

2.2 Other factors included in lexical processing

The aim of this section is to review the literature on access codes other than morphological codes that also affect lexical processing and that should be taken into consideration when controlling variables in experiments. Morphological priming is based on the assumption that the presentation of a morphologically-related prime will activate a related word and when that word is presented it is recognized fast. However, there is a strong possibility that this facilitation could be at least partly due to the composite effect of meaning and form (orthography and phonology) that are repeated in the morphological relationship between the target and the prime.

2.2.1 Phonological mediation

There are three major hypotheses on the importance of phonology in lexical processing: (i) the direct access hypothesis, (ii) the strong phonological hypothesis, and (iii) the two-way access hypothesis. The direct access hypothesis suggests that phonology

is not accessed before meaning (e.g. Patterson & Coltheart, 1987; Jared & Seidenberg, 1991; Coltheart, Curtis, Atkins, & Haller, 1993). Instead, phonology is activated only later when a lexical entry is accessed/opened. The strong phonological hypothesis (Frost, 1998 and Frost, Ahissar, Gottesman, & Tayeb, 2003 and references therein) claims that phonology is used even in the very early milliseconds of word-processing. The two-way access model is middle-of-the road compared to the other two. Scholars defending this view (e.g. Frost, Katz, & Bentin, 1987) claim that depending on whether the orthography of a certain language is shallow or deep, the lexical access can rely on either orthography (the addressed routine) or phonology (the assembled routine). In the assembled routine, the phonological representation is accessed after being assembled from print. In the addressed routine, the phonological entry of the word is accessed as a whole via its orthographic representation. In Arabic and Hebrew, the assembled routine is often associated with the vowelised orthographic version and the addressed routine is associated with the unvowelised version. A similar opinion is expressed in the parallel model (e.g. Carr & Pollatsek, 1985) and in the interactive activation models (e.g. McClelland & Rumelhart, 1981) that assume that both phonology and orthography are used simultaneously.

Because of their availability and relevance to the present work, the discussion of phonological mediation is limited to studies on Arabic and Hebrew. Despite the abundance of studies, the results are inconclusive. Some researchers, who examined the vowelising (adding of the short vowels to orthography) in Hebrew, found facilitation of speed in naming tasks (Navon & Shimron, 1981; Shimron & Navon, 1982; Koriat, 1984) but not in lexical decision tasks (Koriat, 1984; Bentin & Frost, 1987). Vowelising (i.e. phonology) helped more in less frequent words (Koriat, 1985). Ravid (1996) found that advanced readers did better at retrieving the uninflected forms in the unvowelised version of a text in oral reading, suggesting that skilled readers may use a different strategy of reading. Shimron and Sivan (1994), by contrast, found that vowelised Hebrew texts were read faster and understood better than the unvowelised texts by advanced native speakers.

Studies on Arabic have found that phonology is used in word recognition. Bentin and Ibrahim (1996), using both written words from Modern Standard Arabic and transliterated words from a Palestinian spoken-variety, tested whether visual word recognition includes phonology. Their hypothesis was that if lexical decision was based on

orthography and not on phonology, transliterated spoken Arabic words would seem very unfamiliar and would, therefore, be rejected faster than, or as fast as, legal non-words in MSA. The results showed that the transliterations took longer to reject than legal non-words.

Abu-Rabia (1998) found that vowelising helped increase reading accuracy for both poor and skilled readers in Arabic narrative, informative, poetic and Koranic texts. As for reading comprehension, Abu-Rabia (1999) found that vowelising improved the reading comprehension of Arabic-speaking children (two age groups: 7-8 and 12-12; 6).

Robertson (1990) examined the effect of vowelising on speed and pronunciation in a naming task. The participants were American students of Arabic as a foreign language. In a second task, the effect of vowelising was examined at the text level and its effect on speed and comprehension. In both tasks, two instruction methods (the second independent variable in addition to vowelising) were evaluated: the phonics method and the whole word method. The results of the first task showed that students taught in the phonics method had significantly better accuracy. But there was no difference between the groups in latency; unvowelled words were recognized significantly faster. In the second experiment, there was no significant difference due to either orthography or instruction.

Despite their inconclusiveness, the results in Hebrew and Arabic show that phonology/vowelising is used in naming and helps accuracy in reading aloud. In comprehension, there is some evidence that vowels help, but more research is needed, especially with proficient participants. In the present study, all stimuli will be unvoweled. Other aspects of phonology, mainly the shared phonemes between a prime and a target, will be controlled for.

2.2.2 Orthography

As is the case for phonology, there is a disagreement on the role of orthography in lexical processing, mainly as to whether it is distinct from morphology. There is some evidence that morphological priming is different from orthographic priming in both concatenative and non-concatenative languages. Forster and Azuma (2000) used three lexical decision experiments with masked priming (Forster & Davis, 1984) to test morphological priming in prefixed English words that shared a bound stem and little

meaning, as in *submit-permit*, and in prefixed words with transparent semantic relationships, such as *fold-unfold*. In the first experiment, they found priming with both morphologically-related prime-target pairs at a stimulus onset asynchrony (SOA, i.e. the delay between the presentation of primes and targets) of 50 ms., contrary to the results found by Marslen-Wilson et al. (1994) with a crossmodal priming paradigm. This priming was found to be no different from orthographic primes introduced in their second experiment. In their third experiment, the exposure time was raised to 68 ms. and the orthographic priming disappeared.

In a work on Arabic using lexical decision tasks with masked priming, Boudelaa and Marslen-Wilson (2001b) found that orthographic effect emerged at a different SOA than for morphology and semantics. The same authors (2001a, 2001b) also found that priming by morphological units was significantly different from the orthographic/phonological controls. Similar results have been found in Hebrew (e.g. Feldman & Bentin, 1994; Feldman, Frost, & Pnini, 1995; Frost, Deutsch, & Forster, 2000). These studies on Arabic and Hebrew are discussed in detail in section 2.3.2, below.

2.2.3 The syllable as an access code

Studies on the importance of the (first) syllable in lexical processing have been conducted mainly by Taft and his colleagues on English. Taft and Forster (1976), for instance, found that it took more time to decide on nonword compounds whose first part (also a syllable) is a word than those whose first part is not. They also found that, unlike non-syllables, first syllables in non-words show interference effects. Furthermore, frequency of the first constituent in a compound had an effect on lexical decision. The last syllables, by contrast, had no effect.

Taft (1986), using both auditory and visual priming, found that while the first phonemes, regardless of their syllable structure, were used to recognize spoken words, the first syllable was used as an access code in printed words. Because of problems associated with the definition of the syllable as a pronunciation unit, namely in relation to the discrepancy between the stem (first syllable) and the syllable in certain words such as *ac.tor*. On the basis of his work on English (1979a, 1985, 1986), Taft proposes the notion of the basic orthographic syllabic structure (BOSS). He defines BOSS as “all consonants

following the first vowel group of the stem morpheme, unless principles of orthographic co-occurrence are violated (e.g. *tl*). Thus, the BOSS of both *gentle* and *gently* is *gent*, and the BOSS of both *nature* and *natural* is *nat*.” (1985, p. 112). Taft (1979a), for instance, found that division of words (either by a gap or changing case) according to their morpho-orthographic syllable was more helpful than division based on the phonological syllable in lexical decision. However, Taft (1979a) found that parsing of words showed no use of the BOSS but rather a left-to-right parsing technique and suggested that words are only represented (and not parsed) on the basis of their BOSSes. Words like *meath* that had a word-like beginning showed interference effect. If they were accessed through the BOSS, they would not show any time cost since such syllable words do not exist. The notion of the BOSS was, however, challenged. Seidenberg (1987), for instance, showed that frequency of orthographic groupings were more important than BOSSes or affixes.

Emmorey (1989), who examined auditory priming with English roots, suffixes (e.g. *smiling* and *barking*) and last syllables in lexical decision found that while roots had a priming effect, suffixes did not. The shared last syllable (*poking* and *winking*) led to priming. The last syllable, however, also contained a shared suffix.

In the online experiments of the present work, reported in the following chapter, the first letters/phonemes as well as the number of syllables in the different priming conditions were controlled.

2.2.4 Word extremities as access codes

To my knowledge, this factor has not been particularly examined in Semitic languages. Besides, the results on concatenative languages briefly reviewed below are inconclusive. Stanners, Forbach, and Headley (1971) manipulated the first and the last phonemes of both words and non-words to see whether these phonemes as well as the lexical status of a word (i.e. a word or a nonword) have an effect on word recognition. The participants took part in a lexical decision task with three types of stimuli: CVC non-words, CVC words and CCC non-words. The first and the last consonants in these categories were the same. The responses were fastest for CCCs non-words, followed by the words and finally the CVC non-words. The frequency of the letters had no effect in the case of CCCs. The authors concluded that decoding, at least in the early stage, was purely

phonological. The CVC non-words took longer to recognize because, unlike in the case of words, the search for meaning that follows the phonological evaluation could not lead to an entry.

McCusker, Gough, and Bias (1981) tested the speed of the naming of the letters of four-letter words in three online experiments. Either the two inside letters (the second and the third) or the two outside letters (the first and last) were presented first for 50 ms. before the whole word was presented and participants were asked to name all four letters. In the control condition, a word was presented without priming. McCusker et al. (1981) found that letters were not decoded in a serial fashion and that outside letters led to significantly faster lexical decisions than inside letters in four-letter words. These results seem to corroborate those found by Stanners et al. (1971).

Taft (1979a), however, suggested that English words were parsed from left to right. This conclusion was based on the finding that words contained in non-words caused parsing time cost only when they were inserted in the beginning of the word. Taft and Forster (1976) also found that last syllable words in nonword compounds did not create interference effects.

The discrepancy in the results may be due to the length of words. The first two studies found word extremities to be important in short words. The serial left to right hypothesis, by contrast, has been proposed on the basis of results on long words.

Although word extremities were not examined in the experiments of the present work, it was made sure that initial overlap between targets and primes was identical in all experimental conditions.

2.2.5 Semantics

In addition to form (orthography/phonology), the other main question in studying morphological processing is to find out whether morphological priming is distinct from priming due to shared meaning. This question has been addressed from at least two related angles, first in terms of the effect of semantic transparency in the morphological decomposition and second in terms of the time course of morphological and semantic priming. I will start first with a review of the effect of semantic transparency in morphological processing.

As for the other factors, there is little agreement on the effect of semantic transparency on priming and decomposition of words. For English, Marslen-Wilson, Tyler, Waksler, and Older (1994), using a cross-modal priming paradigm, found that priming between root and derived words was obtained between pairs that were semantically related (*friend/friendly*), but not between pairs that shared only an opaque semantic relationship (*department/depart*). There was, however, no priming when primes and targets shared a semantic relationship and a root, but had different suffixes.

Feldman, Soltano, Pastizzo, and Francis (2004) also found no semantic effects in a cross-modal priming at SOA 250 ms. with suffixed prime-target pairs compared to unrelated controls (Experiment 1a). However, they, found a graded effect, that is, the semantically and morphologically-related primes helped more than opaque ones. At SOA 250 ms., using a masked visual lexical decision task, they found an effect of transparency (Experiment 1b), where the transparent primes were different both from the opaque and the control primes. At shorter SOA (48 ms.) (Experiment 2), in a visual priming task with no mask, they found no difference between semantically transparent and semantically opaque prime-target pairs on the one hand, and between the morphological pairs (transparent and opaque) combined and the unrelated controls. In Experiment 3, they used visual masked priming at SOA 83 ms. and found no priming effect of either type of morphologically related primes and no difference between them.

Slightly different results were found in French. Longtin, Segui, and Hallé (2003) reported priming effects occurred only between morphological relatives that shared a transparent semantic relationship in the cross-modal lexical decision task, but there was decomposition even in words that shared pseudo morphemes in the visual masked priming task. Evidence from Hebrew (Frost, Deutsch, Gilboa, Tannenbaum, & Marslen-Wilson, 2000) and Arabic (Boudelaa & Marslen-Wilson, 2001a) with cross-modal priming shows that decomposition occurs even if the target and the prime share little meaning.

Studies that manipulated semantic transparency across time have found some evidence that morphological priming is different from semantic priming. Rastle, Davis, Marslen-Wilson, and Tyler (2000) examined semantic and morphological effects in English, using a lexical decision task with masked priming. They found priming effects for both semantically opaque and semantically transparent morphologically-related words

(derivation) at SOA 43 ms. But, only semantically transparent primes led to facilitation in target word recognition at SOAs 72 and 230 ms. They also found priming facilitation between orthographically/phonologically and semantically related words such as *glisten* and *glitter* only at SOA 230 ms. These findings suggest that morphological priming is different from both meaning and form (phonology and orthography) priming. In a study on Arabic, Boudelaa and Marslen-Wilson (2001b), found morphological priming at SOAs 32, 48 and 64 ms. Semantic relatedness had an effect only at SOA 80 ms.

There is, however, evidence that formal and semantic priming are related and thus obviating the need to postulate a separate role for morphology in lexical processing. In a study on Chinese integrated and compound characters using the masked priming paradigm with three SOAs (30, 50, and 80 ms), Weekes, Chen, and Lin (1998) found that phonological and semantic priming were coincidental. Chinese characters can be simple (integrated) or compound. Compound characters are made of radicals (sub-lexical units) that can correspond to phonology and meaning. Phonology in integrated characters, by contrast, has to be learned and not decoded. In fact, Weekes et al. found phonological priming with compound targets at 50 and 80 ms. exposure durations, but not with integrated characters. They also found semantic priming with both types of characters at SOAs 50 and 80 ms.

In the experiments of the present work, semantic effects were examined in the constructs where meaning could have an effect, namely in sound and weak roots.

2.3 Morphological units in the Arabic mental lexicon: Previous studies

Having reviewed the major hypotheses on lexical representation and processing, as well as some factors other than morphology that could be involved in lexical processing, I will now review the major research findings on the cognitive relevance of roots, patterns, etymons and phonetic matrices in Arabic. The review draws on evidence from the analysis of speech errors in both normals and aphasic patients, the analysis of first language data, well-formedness judgment tasks, paper-and-pencil tasks, word naming tasks, and lexical decision tasks. The focus will, however, be on the role of these morphemes in Arabic lexical processing. While there is work on roots and patterns using different research

methods, there is no research at all on the phonetic matrix and only two studies on etymons with contradictory conclusions.

2.3.1 Evidence for the cognitive relevance of roots and patterns

Evidence for both roots and patterns is presented in the same section because both types of morphemes are closely associated. Most studies, however, have focused on the root.

2.3.1.1 Evidence from slips of the tongue

Berg and Abd-El-Jawad (1996) found that Jordanian Arabic (JA) differs from German and English in single segment and metathesis slips of the tongue. JA errors display almost unconstrained metatheses between initial and final consonants within the word domain, thus targeting all root consonants. Errors in German and English, by contrast, tend to occur more often in initial position and respect the parallel syllable structure constraint. The latter constraint requires that a constituent exchanges places with a similar constituent. Thus, a coda should exchange positions with a coda. Similar evidence is found in the rather artificial task of word games. Prunet, Béland, and Idrissi (2000) cite examples of word games where all consonants of the root undergo metathesis but not affixal consonants.

The special separate status of the root is also apparent in the derivation of hypocoristics²⁹ (Zawaydeh & Davis, 1999 and Davis & Zawaydeh, 2001). In this process, only root consonants are transferred from name to hypocoristic. The affixal *m* in the following example from Davis and Zawaydeh (2001) fails to appear.

(27) Derivation of hypocoristics in Arabic

Name	Hypocoristic	Root	Gloss
<u>mu</u> hammed	hammuud	h, m, d	‘thank’

Abd-El-Jawad and Abu-Salim (1987, p. 154) give evidence from speech errors showing that not only the root but also the pattern is extracted separately. The errors in

²⁹ A hypocoristic is an endearment nickname that is derived from a full name. In the case of Arabic, hypocoristics have several fixed templates that are different from those of the full names from which they are derived.

(28) show that both the root and the pattern are exchanged between the target and the “erroneous” words without changing either the consonants of the root or the vowels of the pattern. Notice also that the exchange does not target the clitic pronoun *ha* ‘her’.

(28) Errors in Arabic including exchange of both root and pattern

	Target	Gloss	Error
a.	kalaam-ha s^ʕahiih		s ^ʕ ahaaḥ-ha kaliim
	speech her right	‘she is right’	
b.	nabiil u kamaal		kamiil u nabaal
	Nabiil and Kamaal	(proper names)	

2.3.1.2 Evidence from well-formedness judgment studies

Berent and Shimron (1997) used well-formedness judgments to study the tacit knowledge of the obligatory contour principle (OCP) in Hebrew. They found that non-words with no OCP violation were significantly preferred over ones that violate it (i.e. those that contain gemination of the first consonant of the root).

Frisch and Zawaydeh (2001) did a similar study on Arabic while taking into consideration analogy to existing words and phonotactic probability, two factors overlooked in Berent and Shimron’s (1997) study. Frisch and Zawaydeh (2001) also found that native speakers showed a “dispreference for roots containing repeated homorganic consonants” in novel verbs (p. 103). Frequency and similarity to existing roots were not significant factors. Gradiency/degree of violation was, however, important in the acceptance or rejection of a word. OCP-place (non)violation was of three degrees: (i) no OCP-place violation, (ii) one OCP-place violation, and (iii) identical root consonants (C1 and C2).

2.3.1.3 Evidence from aphasia studies

Prunet, Béland, and Idrissi (2000) who studied the speech of an aphasic Arabic-French bilingual, adult patient found similar results to the ones related to slips of the tongue reviewed above. They found that in the Arabic metathesis errors, the linear order of the consonants of the roots change but “patterns and vowels remain intact” (p. 613).

Besides, “metatheses target the consonants of the root only. Affixal consonants (in prefixes, suffixes, and infixes) are never involved” (p. 614). Unlike in Arabic, the patient’s metatheses in French are much less frequent and include not only reversal of adjacent and nonadjacent consonants, but metathesis of a consonant and a vowel or syllables, as well as metathesis of vowels only. The authors demonstrate that the phonetic, the graphemic, or the semantic accounts are untenable. They argue that the patient “singles out Arabic consonants because they form a unit in his mental lexicon. That unit is not phonetic/phonological, since he leaves affixal consonants in place.” (p. 619).

In a follow-up on this study, Idrissi, Prunet, and Béland (2002) found that metatheses affected even the underlying glides of weak roots, that is glides that do not surface in the stimuli. This result is counterevidence for the proposal by Davis and Zawaydeh (2001) that output-output derivations such as in hypocoristics are based on a surface root.

Further evidence for the multi-tier analysis of Semitic words comes from templatic errors. In Barkai’s study of a Hebrew-speaking aphasic (as cited in Prunet, Béland, & Idrissi, 2000), the patient made errors in the selection of the appropriate template. The data in (29) show verbs with an inappropriate template/pattern.

(29) Template mis-selection in Hebrew: Data from the speech of an aphasic patient.

Target form	Target pattern	Gloss	Output	Pattern
yisog	nifʔal (2)	‘he will retreat’	yasug	paʔal(1)
higdil	hifʔil (5)	‘they enlarged’	gadlu	paʔal

While the first mis-selected pattern leads to a nonexistent word, the second leads to an occurring but contextually inappropriate verb.

2.3.1.4 Evidence from language acquisition studies

Because the few studies done on Arabic (e.g. Omar, 1973) did not focus on the root and pattern, studies on Hebrew are instead reviewed. Berman (1981), who studied the speech of Hebrew-speaking children aged between 2 and 4, found that children tended to regularize verbs with defective roots. As discussed earlier, Semitic words are usually made

of three consonant roots. In defective roots, one of the consonants does not appear in some of the words that are derived from it. The following example from Berman (1981, p. 611) will illustrate the point.

(30) Regularization of pattern I Hebrew verbs with a defective root-final

Root	Present tense		Past tense	
	Infinitive	3 rd fem.sg.	1 st sg.	3 rd fem.sg.
Full	li-CCoC	CoCéC-et	CaCáC-ti	CaCC-a
s-x-v 'pull'				
Adult and child:	li-sxov	soxév-et	saxáv-ti	saxv-a
Final h= /y/:				
s-x-y 'swim':	i-sxot	soxa	saxíy-ti	sax-ta
Children:	li-sxot	*soxét-et	*saxá-ti	sax-ta
			*saxát-eti	

As shown in the asterisked words, children treat the defective {s, x, y} as a full paradigm substituting the missing root consonant with the /t/ of the infinitive and the /t/ of the past tense feminine of the target adult forms. They, therefore, consider the /t/ the third consonant of the root {s, x, y}.

Berman (1997), who reviewed a number of studies of her own as well as those of other researchers on the development of the pattern and root system, reported the following order in the development of the pattern/root. Between the age of 2 and 3 years, the child learned a pattern as a formulaic expression and used it for more than one function (for instance for both intransitive and transitive). Between 3 and 4 years, children started varying the pattern of the same root of common verbs to convey different meanings. Around 4-5 years, children started varying patterns with many roots. Between the age of 5 and 6, children showed an almost complete mastery of the system of root and pattern morphology.

Another source of evidence for learners' tacit knowledge of morphology is their error-free ability to recognize that a metathesis of the prefixal /t/ with the initial sibilant consonant was triggered only in conjugation with the *hitpaʔel* verb pattern:

(31)	Root	Verb	Gloss
	s-r-k	mi-s-t-arek	‘combs’
	c-l-m	ni-c-t-alem	‘we’ll photograph’ (Berman, 1997, p. 312).

Ravid (2003) reported on a few studies on the development of the root in Hebrew and Palestinian Arabic. The results of these studies indicated that as early as kindergarten native speakers of Hebrew and Palestinian Arabic showed awareness of the root in root relatedness task (telling relation between words having the same root) and analogy test (using the same root to create another word). This awareness increased with age, which was very likely due to linguistic development and literacy.

2.3.2 Roots, patterns, etymons, and phonetic matrices in lexical processing

Lexical processing studies in both Arabic and Hebrew have focused on the root and the pattern and have found that these two morphemes affect, though differently, lexical processing. The etymon, however, is very little studied and to my knowledge, there is no previous research on the phonetic matrix. Roots and patterns are discussed separately, because they are tested separately in priming experiments.

2.3.2.1 Roots

Studies on Hebrew have found that priming with the root significantly facilitates word recognition in lexical decision tasks (e.g. Bentin & Feldman, 1990; Feldman & Bentin, 1994; Frost, Forster, & Deutsch, 1997) and word naming (Feldman, Frost, & Pnini, 1995; Frost, Forster, & Deutsch, 1997). Root priming effects have been found to be distinct from the effects of orthographic and phonological similarity (Feldman & Bentin, 1994; Frost, Deutsch, & Forster, 2000; Feldman, Frost, & Pnini, 1995) and semantic relatedness (Frost, Deutsch, Gilboa et al., 2000; Bentin & Feldman, 1990). Native speakers also showed processing of the root by rejecting pseudo-words with existing roots more slowly than pseudo-words with nonexistent roots (Goral & Obler, 2003).

Frost, Deutsch, and Forster (2000) found that the notion of the root as a three consonantal unit was an abstract constraint that was relied on in lexical processing. They actually found no priming with verbal patterns combined with weak roots (where one of

the consonants did not surface in some derivatives) either as target and/or prime but, when a random consonant was added, thus creating pseudo-words, morphological priming was obtained.

The results in Arabic are similar to those found in Hebrew, especially in relation to the distinct effect of morphology compared with phonology and semantics. Mimouni, Kehayia, and Jarema (1998) used an auditory priming paradigm to examine morphological priming in Algerian Arabic-speaking non-brain-damaged and aphasic participants at SOA of 250 ms. They found facilitation in word recognition when either regular or irregular plural nouns primed were primed by their singular counterparts.

Boudelaa and Marslen-Wilson (2001b) examined the effect of both root and pattern as well as semantic and orthographic factors in different stages of the recognition process using two masked priming lexical decision experiments. The first experiment examined deverbal nouns and the second studied verbs. The authors varied the display time over four conditions: 32, 48, 64, and 80 ms. The other independent variable was the type of relationship between primes and targets: morphological, orthographic, or semantic. These were further divided into six conditions. In condition 1, the prime and the target shared a word pattern. In condition 2, primes and targets shared some orthographic similarity in vowels. In condition 3, primes and targets shared both the root and a very transparent semantic relationship. In condition 4, by contrast, the semantic relationship between primes and targets that shared the same root was rather opaque. In condition 5, another orthographic control was designed to control for the similarity in the root; in this case primes and targets shared consonants. In condition 6, primes and targets shared meaning but not roots.

The results of both experiments showed that morphological priming was distinct from orthographic and semantic factors. While the root was found to have a stable effect in four display conditions, the word pattern had an effect only at 48 and 64 ms. The orthographic effect was in the case of vowel sharing at 32 ms. and in the case of consonant sharing at 80 ms. Semantic relatedness (without morphology) had an effect only at SOA 80 ms. In a more recent study, however, Abu-Rabia and Awwad (2004) examined the effect of both roots and word patterns in nominals in both lexical decisions and naming using a

masked priming paradigm. They found no priming effect either for roots or word patterns in both tasks.

Boudelaa and Marslen-Wilson (2004b) examined whether allomorphs of roots (that undergo assimilation) prime sound roots in a lexical decision task with immediate cross-modal priming. They found that there was priming effect in the condition where there is only a morphological relation between the prime with the allomorph (a noun) and the target (a verb with a sound root), as well as with primes that shared meaning in addition to the abstract root. In both cases the priming was similar to that of the primes (nouns) and targets (verbs) that shared the same sound root. This is similar to the results reported for Hebrew, suggesting that processing seems to depend on the three root consonants even if one of its segments is different from that of the abstract underlying root. The explanation given by Boudelaa and Marslen-Wilson is very plausible: that weak roots (with glides) are underspecified, with the glide slot being specified only for [-syllabic]. Thus, any consonant will do the job in the activation process.

To sum up, unlike in concatenative languages,³⁰ where shared bases of words are not fragmented, the orthographic and phonological explanations of morphological priming cannot be extended to Semitic languages. Likewise, meaning has been found to play a minor role in comparison with pure morphological priming in both Hebrew and Arabic. The results in Arabic are inconclusive.

2.3.2.2 Patterns

Studies on Hebrew showed that pattern priming depended on task and word class. While Frost, Forster, and Deutsch (1997) found that the pattern, unlike the root, had no effect in naming and lexical decision tasks using a masked priming paradigm at an SOA of 43 ms, Deutsch, Frost, and Forster (1998), using the same methodology, found that the pattern had a facilitation effect in verbal forms at SOA 42 ms both when primes were legal and when they were illegal combinations of existing roots and patterns. Since no nominal forms were examined in the previous study, Frost, Deutsch, Gilboa, Tannenbaum, and Marslen-Wilson (2000) replicated this study using a cross-modal task (auditory-visual).

³⁰ For studies on the facilitating effect of visually presented morphologically-related words in priming in concatenative languages, consult for instance Stanners, Neiser, Herson, and Hall (1979), Fowler, Napps, and Feldman (1985), and Feldman (1992).

They found that verbal word patterns, but not nominal word patterns, had a significant facilitatory effect. However, Frost, Deutsch, and Forster (2000), using a masked priming paradigm, found that verbal patterns had no effect when either or both prime and target forms missed a root consonant.

Unlike in Hebrew, there was some evidence of priming with patterns for both verbs and deverbal nouns in Arabic. Boudelaa and Marslen-Wilson (2001b) found priming effects of the pattern at display time 48 and 64 ms. in deverbal nouns and only at SOA 48 for verbs. In both experiments, the orthographic effect was in the case of vowel sharing at 32 ms. and in the case of consonant sharing at 80. The difference in priming with Hebrew was, according to Boudelaa and Marslen-Wilson, due to their definition of word pattern. Boudelaa and Marslen-Wilson defined a word pattern as not only a phonological formal similarity but also a word class category. Mimouni, Kehayia, and Jarema (1998) found no priming effect of patterns of Algerian Arabic plural and singular irregular and regular nouns in an auditory priming lexical decision task with both normals and aphasic patients at SOA 250 ms and found no priming effect of patterns. Abu-Rabia and Awwad (2004) also found no priming of patterns in derived Modern Standard Arabic nouns at an SOA of 50 ms using masked priming and naming.

In a later study, Boudelaa and Marslen-Wilson (2004a) went further and tested the CV-skeleton and the vocalic melody (see discussion of these separate tiers above, or refer to McCarthy, 1981) in three lexical decision experiments using visual masked, auditory-visual, and auditory-auditory priming paradigms respectively. The stimuli included verb forms. They compared pairs of words that shared a vocalic melody, a CV-skeleton, or both. While they did not find any priming with the vocalic melody in three experiments, they found a consistent priming effect with the skeleton that was comparable to the priming of the pattern, which contains both the CV-tier and the vowels. There was, however, a slight advantage for the pattern over the CV-skeleton. They therefore proposed that CV-skeletons are morphological units alongside patterns which have specified vocalic slots and occasional C slots.

Boudelaa and Marslen-Wilson (2004b) tested whether disrupted pattern allomorphs prime words with corresponding undisrupted patterns in cross-modal priming lexical decision task. In the first condition, the prime and the target shared the same pattern with

sound roots in both. In the second condition, although the pattern was also not disrupted, in the prime the pattern was combined with a weak root that had undergone assimilation so that an underlying glide changed to a consonant. In the third condition, the pattern of the prime and the target was disrupted; that is, one of the consonants of the root (a glide) did not surface. The fourth condition included primes and targets that shared form and served as controls. Priming facilitation was significant only in the two first conditions with no significant difference between them. The authors concluded that allomorphic units that did not affect the CV-structure still primed their related targets, but they failed to do so as soon as the CV skeleton of the morpheme (the word pattern in this case) occurred. It is not, however, possible to make a definite claim that the lack of priming in the third condition was due to lack of access to the pattern. The third condition actually included the disruption of both the root and the pattern.

2.3.2.3 Etymons and phonetic matrices

There is no previous research on the phonetic matrix and evidence for the etymon is both scarce and controversial. Evidence for the etymon comes from a lexical decision experiment on Arabic by Boudelaa and Marslen-Wilson (2001a). They used two paradigms, cross-modal priming and masked priming, with the same stimuli. In addition to the control condition (i.e. a word totally unrelated to the target), three conditions were tested in the first experiment: (i) [+Etymon, +Sem] the prime was both semantically and morphologically related to the target; (ii) [+Etymon, -Sem] the prime and the target shared the etymon but were semantically unrelated (that is the semantic relationship was diachronic but not synchronic); and (iii) [-Etymon, +Phon] the prime shared the same amount of phonological overlap (which is not linear as in concatenative languages) with the target as in the case where they shared the same etymon (i.e. condition 1).

There was a significant effect of both the morphologically-related and the both semantically and morphologically-related primes. This means that there was no significant effect of the semantic transparency. This is similar to the results obtained in priming for roots in Arabic (Boudelaa & Marslen-Wilson, 2001b) and in Hebrew (Frost, Forster, & Deutsch, 1997).

In the second experiment where they used masked priming, Boudelaa and Marslen-Wilson (2001a) focused on the difference between “the morphologically-related conditions [+Etymon, +Sem] and [+Etymon, -Sem]” and “the phonological condition” (p. 78). The results showed significant differences between the morphological condition in comparison with both the phonological and the unrelated conditions. As in the first experiment, there was no significant difference between the semantically transparent and the semantically opaque morphological conditions.

Yet, Bentin and Frost (2001) cast doubt on these results. They designed a paper-and-pencil task to test whether native speakers of Arabic consciously knew the etymon. Twenty university students were asked to extract etymons from words after being told what an etymon was. The stimuli, which were taken from the data used in Boudelaa and Marslen-Wilson (2001a), included 20 pairs of words, one from the prime and one from the target. The students “correctly identified the etymon of only 27.2 words (68%) out of the 40 words in the list” (p. 115). The authors considered this percentage too low to reflect knowledge of the etymon. Their claim was, however, not statistically tested. More importantly, they found that in “only 50% of the pairs (10.1 out of 20) was the same etymon correctly identified for *both* the prime and the target.” (p. 115). This latter finding undermines the conclusion that the priming effects obtained in Boudelaa and Marslen-Wilson’s study are morphological. Bentin and Frost also questioned the size of the priming effect obtained by Boudelaa and Marslen-Wilson, which they considered too large. They also questioned the fact that priming was almost the same in both the [+Etym, +Sem] and [+Etym, -Sem] conditions.

Other counterevidence against the cognitive relevance of the etymon comes from the speech of an aphasic patient (ZT). Idrissi and Kehayia (2004) examined the patient’s metathesis errors on words that had potential etymons and found that only a few could be considered etymon-related. In fact among the 64 metathesis-errors made, only (17) 26.6% involved the etymon but 73.4% involved the metathesis of the extender (third consonant of the root in addition to the two of the etymon) and another consonant of the root/etymon (37), or the extender and both consonants of the etymon (11).

The results are not very convincing, though. It is true that the fact that the extender was metathesized is incompatible with the etymon theory, but the fact that there were

26.6% of the errors involved the etymon cannot be interpreted as evidence against the etymon. Given the number of errors and the number of consonant mutation possibilities of the root and the etymon, we expect the number of the mutations of root consonants to be three times as many as those involving the etymon, which was born out by the results, with a slight advantage for the etymon (73.4% against 26.6%). What casts doubt on the relevance of the etymon as a morphological unit is the fact that the bipartite metathesis errors involving the extender and another root/etymon consonant were significantly more frequent than those involving only the two etymon consonants ($\chi^2=15.17$, $p < .001$).

Given the inconclusiveness of these results, further research is necessary. The present work will further examine the etymon using a lexical decision task with masked priming.

2.4 Phonological/orthographic units in the Arabic mental lexicon: Previous studies

While the focus in this review will be on Arabic and Hebrew, reference is also made to evidence from work done on concatenative languages. Previous studies that went below the level of the morpheme examined the order of the letters/phonemes, the importance of syllables, as well as vowels and consonants. The focus here will be on whether vowels and consonants are perceived/processed and therefore represented differently from one another. I believe the study of single phonemes will provide interesting insights into the representation of words and help refine theories of lexical processing.

2.4.1 Consonants vs. vowels

The lexical processing studies reviewed below were primarily intended to test the use of phonology in lexical “access”. They are on both Arabic and Hebrew.³¹

2.4.1.1 Evidence from aphasic speech

There seems to be no reported evidence from aphasic patients speaking a Semitic language that supports differentiating vowels and consonants. In concatenative languages, Caramazza, Chialant, Capasso, and Miceli (2000) who studied the speech errors of two Italian-speaking aphasic women reported that one patient produced three times as many

³¹ For a more detailed review of studies on Hebrew, consult Shimron (1993) who reinterpreted these studies from the perspective of the role of vowels/diacritics in lexical processing.

errors on vowels as on consonants and the other made five times as many errors on consonants as on vowels. The authors verified that this discrepancy could not be explained in terms of a breakdown in either a feature-based system or a sonority-based system. There was no correlation between error rates and certain vowel and consonant features nor between error rates and consonant sonority. The authors suggested that at some level vowels and consonants are represented and therefore processed separately.

This interpretation has been challenged by Monaghan and Shillcock (2003) who have modelled two feature-based systems that could reproduce similar effects of error rate as found in Caramazza et al.'s study, but without the need to postulate separate category status for vowels and consonants. To produce these effects, their model required the creation of two sets of hidden units. Damage to one set produced a high error rate on vowels and damage to the other produced a high error rate on consonants. The authors plausibly suggested that vowels and consonants could be processed differently in different areas of the brain, without necessarily being represented as two different categories. The difference simply arose from the distribution of bundles of features.

2.4.1.2 Visual lexical processing

There has been no actual contrast between vowels and consonants in lexical processing studies in Arabic and Hebrew, but some hypotheses could be formulated on the basis of the study of these units within morphemes or separately (in the case of short vowels in orthography). Most studies in Arabic and Hebrew suggest that while they help in accuracy in reading aloud and recognition of low frequency words, vowels have little role in lexical processing, especially when context is provided. In fact, vowelising was not found helpful in lexical decision of words given in context (Abu-Rabia & Siegel, 1995 for Arabic) and without context (Koriat, 1984; Bentin & Frost, 1987 for Hebrew). The ability to do without the diacritics develops with reading proficiency (Ravid, 1996; Abu-Rabia & Siegel, 1995 for Arabic). Vowelising was, however, found helpful in naming (Koriat, 1984; Shimron & Navon, 1982) and lexical decision with low frequency Hebrew words (Koriat, 1985) and in reading aloud accuracy for Arabic (Abu-Rabia, 1997, 1998).

Boudelaa and Marslen-Wilson (2004a) examined whether vowels had a priming role and therefore a morphemic status as proposed in McCarthy's (1981) prosodic

morphology. They tested these assumptions in three lexical decision experiments using masked, cross-modal and auditory-auditory priming paradigms respectively. They did not find any facilitation of word recognition due to vocalic overlap between primes and targets.

The relatively more important role of consonants in word recognition was also found in English, which suggests that this bias to consonants might not be restricted to languages written in mainly consonantal scripts. Lee, Rayner, and Pollatsek (2001) examined the relative importance of vowels and consonants in English using a delayed letter paradigm, in which either a vowel or a consonant of the target word was delayed for 30 ms. They found that the delay of consonants led to more fixation time than the delay of vowels. A 60-ms-delay had the same effect for both consonants and vowels. These results suggest that consonantal information is processed/accessed earlier than vowels.

In another study, Lee, Rayner, and Pollatsek (2002) replicated the same results using the fast priming paradigm to evaluate the role of vowels and consonants on gaze duration. High or low frequency primes that shared either consonants or vowels with targets were presented for either 30 or 45 ms. and were followed by targets embedded in sentences. Targets stayed on the screen until the sentences were read. They found that primes with the same consonants as targets led to shorter gazes only at 30 ms. and only with high frequency primes. At 45 ms. duration, frequency had no effect and both primes with the same consonants and primes with the same vowels as targets were equally shorter than controls.

Berent and Perfetti (1995) examined the role of vowels and consonants in reading using a nonword backward masking paradigm, which involved the presentation of a target word immediately followed by a nonword mask. Participants had to write down what the word they saw on the screen was. Berent and Perfetti found that a backward mask that preserved some consonants of the word had a better effect in the identification accuracy in short target and mask target exposure (15-30 and 30-30 ms respectively), an advantage that disappeared at exposure time of 45-30 and 45-60 ms for mask and target word respectively.

Yet, the results reported in Berent and Perfetti (1995) were not replicated in a study on Italian by Colombo, Cubelli, Zorzi, and Caporali (as cited in Lee, Rayner, & Pollatsek, 2001) using the same methodology. Colombo et al. actually found that when the durations

of nonword primes and the word targets were short (16-33ms and 33-33ms), vowel-preserving primes helped more in the identification of words than did consonant-preserving primes. There are also no universal results with respect to the ease or difficulty in the detection of vowels versus consonants in different languages (see discussion in Cutler, 1997).

2.4.1.3 Comprehension

Studies comparing the effects of vowels and consonants on reading comprehension are scarce, probably because of the methodological difficulties associated with such a task. One way of examining the issue in Arabic and Hebrew is to evaluate the added benefit of short vowels in reading in the vowelised version of orthography. Vowelling (i.e. adding the short vowels/diacritics to the usual mainly consonantal orthography) was found to increase reading comprehension of Arabic-speaking children (two age groups: 7-8 and 12-12; 6) in comparison with unvowelised texts (Abu-Rabia, 1999). Abu-Rabia (2001) also found a positive effect for vowelling in comprehension with skilled adult readers of Arabic as their first language and Hebrew as their second language. Evidence from Hebrew shows that vowelling helps skilled readers in better recall and comprehension of texts (Shimron & Sivan, 1994). In a later study with third and sixth graders, Shimron (1999) found that vowels helped recognition recall and free recall of words (where lists of words were recalled and written down) and in the recall and comprehension of some texts.

2.4.1.4 Perception

There is indirect evidence from two studies (one offline and one online) on Arabic-speaking learners of English (Ryan & Meara, 1991) indicating that they have some bias for consonants. In the offline task, a group of Arabic speakers and another control group of ESL learners were given a list of English words lacking vowels and were asked to reproduce the target word. Arabic speakers produced twice as many errors that involved providing a totally different word as the control group. In the main online study, 10 Arabic speakers and two control groups (10 non-Arabic speakers and 10 English native speakers) were presented with one hundred ten-letter words on a computer screen. First a word appeared for about a second and then reappeared with the same spelling or lacking a

vowel. The misspelled words ($n=60$) had a missing vowel in the second position (15 words), in the fourth position (15), in the sixth position (15) or in the eighth position (15). The participants were asked to indicate if the presented words were identical by pressing a button. Error analysis showed that Arabic speakers did significantly worse than the two other groups (native speakers did best). An analysis of the reaction times responses also showed that Arabic speakers were significantly slower than the two control groups. The authors interpreted that as a result of interference from their first language where short vowels are not orthographically represented.

2.4.2 (Root) consonants vs. (affixal) consonants

2.4.2.1 Lexical processing

The studies reviewed below were originally designed to examine the role of the root and pattern morphemes in lexical processing; none of them contrasted the role of different types of consonants.

Although both the root and the pattern have been found to play a role in lexical processing, there is some evidence from studies on Arabic and Hebrew pointing to the priority of the root, consisting of three consonants, over the pattern, consisting of affixal consonants and vowels. In Arabic, Boudelaa and Marslen-Wilson (2001b) found a priming effect of the verbal pattern only at SOA 48 ms. In Hebrew, Frost, Deutsch, Gilboa et al. (2000) found that unlike the root, the pattern had a facilitation effect in verbal forms but not in nominal forms. Besides, verbal patterns had no effect when either or both prime and target forms missed a root consonant (Frost, Deutsch, and Forster, 2000). In Arabic, Boudelaa & Marslen-Wilson (2001b) found that the pattern had a rather inconsistent facilitatory effect in lexical decision with both verbal and nominal forms, compared with roots. Neither Mimouni, Kehayia and Jarema (1998) nor Abu-Rabia and Awwad (2004) obtained priming with patterns.

2.4.2.2 Perception

Studies on visual perception that examined the difference between letters are lacking. Ephratt (1997) studied the psychological status of the root in Modern Hebrew by means of a letter-coloring task to test whether the root is psychologically real. The results

showed that native speakers of Hebrew (both children and adults) colored the root significantly more than other letters. The purpose of Ephratt's study was to find evidence for the "psychological reality" of the root.

2.5 Summary and implications

The results surveyed above in relation to the cognitive relevance of the root, the pattern and the etymon, suggest that the root and to a lesser extent the pattern have cognitive relevance and therefore support the morpheme-based theory for Semitic morphology. There is, however, little empirical evidence for the etymon and no studies on the phonetic matrix in either Arabic or any other Semitic language. Thus, further research is needed to explore the notions of the etymon and matrix and their relation to the root in any Semitic language. The relative importance of vowels and consonants in the Arabic mental lexicon have also been very little researched.

The present work uses online experiments to provide further evidence from Arabic to validate previous results concerning the cognitive relevance of the root and the pattern in lexical processing. It also examines the cognitive relevance of the less studied etymon and matrix and their role in lexical processing, as well as the relative importance of vowels and consonants in the Arabic mental lexicon. The morphological units (root, etymon, pattern, and phonetic matrix) will be examined by use of lexical decision tasks with a masked priming paradigm. The phonological units (vowels and consonants) will be examined by means of an offline paper-and-pencil task. The implications of the results of these experiments for theories of Arabic morphology and theories of lexical representation and processing will be discussed.

Another major objective of this work is to examine whether there is gradation in priming during the activation of words that results from the correlation of semantic and/or form overlap between primes and targets. This will test the predictions of distributed connectionist models, compared to those of theories that adopt an entry-opening metaphor of the lexicon. The gradation of priming will be tested by examining whether meaning and/or form overlap correlates with the amount of priming within and across similar morphemes. The compared morphemes are sound roots and weak roots (with or without

transparent semantic relationship between primes and targets), ordered etymons, nonordered etymons, and phonetic matrices.

Another objective of this work is to examine how abstract lexical processing can be. Arabic morphemes are all abstract, but some are more abstract than others. As is the case in the examination of gradation of priming, the priming effect of the following similar morphemes will be compared: sound roots, weak roots, ordered etymons, nonordered etymons and phonetic matrices. This comparison will also allow us to examine the relationship between morphological theory and psycholinguistic theory.

The above general questions/objectives were broken down into the following research questions.

Research questions

1. What is the role of the root in Arabic lexical processing and is it distinct from the effect of orthography and semantics (Study 1)?
2. What is the role of (ordered and non-ordered) etymons compared to orthographic overlap in Arabic lexical processing (Study 2)?
3. What is the role of the phonetic matrix in Arabic lexical processing compared to similar phonological overlap (Study 3)?
4. What is the role of sound and weak patterns in Arabic lexical processing (Study 4A-B)?
5. What is the role of weak roots in Arabic lexical processing and is it distinct from that of orthography and semantics (Study 4C)?
6. Are there graded priming effects that correspond to the gradation in the formal overlap in and across roots (form and meaning vs. form; sound root vs. weak root) and etymons (ordered vs. non-ordered) (Studies 1, 2, and 4C)?
7. How abstract can morphological processing be (Studies 1, 2, 3, and 4)?
8. What is the status of root consonants in relation to affixal consonants in the Arabic mental lexicon (Study 5)?
9. What is the status of vowels in relation to consonants in the Arabic mental lexicon (Study 5)?

The following two chapters will present the methodology as well as the results of the experiments that were undertaken to answer these research questions.

Chapter Three

Studies Part I: Morphological Units

3.0 Introduction

This chapter outlines the methodology employed to collect and analyze the data and presents the results of four studies that focused on morphological units in the Arabic mental lexicon. These four studies, which included six experiments, used lexical decision with priming to examine the role of the root (section 3.2), the etymon (section 3.3), the phonological matrix (section 3.4) and the pattern and the weak root (section 3.5) in Arabic lexical processing.

3.1 Lexical decision tasks with priming: An overview

All experiments reported below were lexical decision tasks with masked visual priming. In lexical decision, participants see linguistic items and decide whether they are words or non-words. In the *masked priming paradigm*, the prime is preceded by some pattern and/or other stimuli. The stimulus onset asynchrony (SOA) time is kept very short so that participants will not notice the prime. Masking is meant to eliminate any effect of episodic memory traces on repetition priming (cf. Evett & Humphreys, 1981; Forster & Davis, 1984). Masked priming has been found to be very sensitive to morphological priming, especially at short SOAs (Frost, Deutsch, & Forster, 2000; Feldman & Bentin, 1994), as well as to formal priming (orthography and phonology) (Forster & Taft, 1994; Forster, 1999).

The assumption behind repetition priming in general is that the target benefits from the preceding activation of a related prime. The facilitating relationship between the prime and the target can be orthographic, phonological, semantic or morphological. The purpose of the experiments in this dissertation is to see if the effect of morphology (experimental variable) on lexical processing is significantly different from the effects of semantics and phonology and orthography (control variables).

To allow comparability, all experiments in this work used the masked priming paradigm with the same SOA, which was about 50 milliseconds (3 ticks with a refresh

time of 16.75 ms), and verbal forms as stimuli. Keeping the same SOA also allowed the comparison of the results of these studies to those of other studies that used a similar exposure time.

I conducted four studies that included six online experiments (Study 4 comprised 3 separate experiments). The main objective of these four studies was to test whether the root, the etymon, the matrix and the pattern morphemes are used in word recognition (verbal forms). If they are, we can claim that they have a separate cognitive status in the Arabic mental lexicon. These studies examined the first five major research questions on page 77.

In addition to testing whether the above morphological units have a cognitive relevance in the Arabic mental lexicon, one of the objectives underlying the design of all these studies was to examine whether there was a fine-tuning in lexical processing (Research Question 6) in a connectionist fashion (see section 3.1.6 on Connectionism) or in the manner proposed in the strong phonological hypothesis, which assumes that phonology is essential at least in the early stages of lexical processing (e.g. Frost, 1998; Frost, Ahissar, Gotesman, and Tayeb, 2003). The gradation was examined within the same morpheme/experiment and across morphemes/experiments. The within-construct comparison concerned the effect of the overlap of morphology and meaning in sound and weak roots (in Study 1 and Study 4C, respectively). If there is a gradation of priming effects as predicted by the distributed connectionist hypothesis, sound or weak roots with a transparent semantic relationship will facilitate word recognition more than sound or weak roots with an opaque semantic relationship. Across experiments, I compared the correlation between form overlap and amount of priming across the following similar morphemes: sound roots (Study 1), weak roots (Study 4C), and etymons (Study 2). The comparison included the correlation of overlap in the number of morpheme consonants and priming effect, as well as the correlation between form and priming time in the orthographic conditions.

The other main objective behind the examination of these abstract morphemes, roots, etymons (ordered and non-ordered), and phonetic matrices is to see how abstract lexical processing might be (Research Question 7).

The studies in this chapter deal directly with research questions 1-5. Although based on the results of the online studies reported in this chapter, Research Questions 6 and 7 are discussed in chapter 5, because they are more related to the global interpretation of the results.

3.2 Study 1: Priming with roots

3.2.1 Objectives

Previous studies in Arabic are inconclusive. Whereas Boudelaa and Marslen-Wilson (2001b), using a between items design, found a rather persistent priming effect of the root in lexical decision masked priming in verbal nouns and verbs at SOAs of 32, 48, 64 and 80 ms., Abu-Rabia and Awwad (2004) did not find any facilitatory effect at SOA of 50 ms. in nouns using a masked priming paradigm. The present study tried to validate previous findings and allow for comparability with the other experiments on the etymon and the phonetic matrix discussed below. The purpose of the study was to make sure that morphological effects were/are different from phonological and semantic effects.

This experiment examined the role of roots in a visual lexical decision task with verbal forms. It tested whether a masked word prime would facilitate the recognition of a target word having the same root. Given some evidence for the importance of the root in lexical processing in Arabic (Boudelaa & Marslen-Wilson, 2001b) and Hebrew (Feldman & Bentin, 1994; Frost, Forster, & Deutsch, 1997), I expected to find a priming effect of the root.

The assumption behind priming is that a significant facilitation effect is evidence that the shared morpheme is being decomposed from a complex word and used to activate the target word stored in the mental lexicon/long term memory. To ascertain that any potential facilitatory effect is morphological and not due to semantic or orthographic/phonological similarity between primes and targets, both a semantic and a orthographic/phonological condition, as well as an unrelated condition, were included. Because it was very difficult to find good primes that had the same root and were either related to the target by both the root and meaning or only the root, I resorted to dividing the targets in the first condition into two sets. The choice is also theoretically motivated since morphemes are defined as meaning units, whose derivatives can have an opaque or transparent

relationship. The first set included 24 targets and was paired with primes that belonged to one of the following three experimental conditions: (i) +Root +Semantics (Experimental condition), (ii) +Orthography/ +Phonology (Control condition 1), and (iii) Unrelated (Control condition 2). In the first condition, primes and targets had the same root as well as a transparent semantic relationship.³² In the second condition, primes shared with targets roughly the same number of letters/phonemes in the same order as the related conditions, but not the same root. The third condition included primes that had no semantic or formal relation with their targets. The second set of targets were paired with primes that belonged to one of the following three conditions: (i)+Root-Semantics (Experimental condition), (ii)+Orthography/+Phonology (Control condition 1), and (iii) Unrelated (Control condition 2) (see Figure 1, below). In the first condition, primes and targets shared the same root but very little meaning. The primes in the second condition shared the same number of letters/phonemes with the targets, as did the morphological primes. In the third condition, the primes had almost the same number of letters/syllables as the targets, but shared no morphological or orthographic/phonological relationship. The unrelated condition in both target sets served as the baseline against which the two other conditions were measured to decide if there was any facilitation effect. There were occasional cases where a letter/phoneme in the unrelated condition overlapped with the target. These instances in this experiment and the following experiments could not be avoided because they were part of the patterns (prefixes or infixes), which I tried to keep constant across all prime conditions.

3.2.2 Participants

The participants were 36 Arabic-speaking students from Tunisia, where all the experiments were conducted. They were aged between 22 and 27 and all had at least 12 years of formal education in Arabic. They all had some knowledge of French as a second language. They had normal or corrected to normal vision. The participants in all experiments were volunteers. They were contacted on an individual basis in two university libraries (Faculté des Sciences Humaines et Sociales de Tunis and Institut Supérieur des

³² Whether the root was disrupted by infixed vowels and/or consonants was not considered an issue, since previous research (Feldman & Bentin, 1994) found (dis)continuity of the root to have no effect on priming.

Langues de Tunis). The same recruitment procedure was used in all the online experiments.

3.2.3 Stimuli and Design

The targets were 48 trilateral Arabic verbs in the third person singular perfective past, a rather neutral form. They had a mean letter length of 4.42 letters and a mean syllable length of 3.65 syllables. As indicated above, the targets were divided into two sets each containing 24 words. Each target of the first half was paired with three primes, one from each of the first three experimental conditions mentioned above: (i) the morphologically and semantically related, (ii) the orthographically/phonologically related, and (iii) the unrelated conditions. The second set of targets were also paired with three types of primes: (i) the morphologically related (+Root-Semantics), (ii) the orthographically/phonologically related, and (iii) the unrelated. Figure 1 below displays examples of the stimuli used. The letter and syllable lengths of the primes were kept very similar. The primes in the morphologically and semantically related condition had an average of 3.83 letters and 3.38 syllables. The mean length of letters and syllables in the morphological condition was 4.17 and 3.55, respectively. In the orthographically/phonologically related condition, the mean length of letters and syllables was 4.19 and 3.56, respectively. The primes in the unrelated condition had a mean length of letters of 3.81 and a mean length of syllables of 3.37. For the list of experimental items in the three conditions, see Appendix A.

The number, position, order, and continuity of the overlapping letters in the orthographic/ phonological control condition mimicked as much as possible those in the related conditions. Because of their importance in lexical processing, the overlapping initial letters in the control and the related conditions were identical. The average amount of prime-target overlap was 3.13 letters and 3.13 phonemes in the morphologically and semantically related condition; 3.13 letters and 3.13 phonemes in the morphologically related condition; and 2.87 letters and 3.02 phonemes in the orthographically/phonologically related condition. Caution was taken to keep a roughly equal number of pattern types across all the experimental conditions, especially patterns that have pseudo-

prefixes and that might be harder to process. None of the primes in the four experimental conditions shared a word pattern with the target.

The semantic relatedness between both morphologically related primes and their targets was based on the judgment of twenty native speakers of Arabic on a seven-point relatedness scale, with 1 being ‘unrelated’ and 7 being ‘very much related’. The semantically related set included items whose mean rating was 4 or more, with an overall mean of 5.03. The semantically unrelated set included items whose mean ranking was less than 4 (the criterion was less than 4, but they were all actually less than 3.5), with an overall mean of 2.47.

The final selection of the 48 target words and all primes was based on a judgment of familiarity,³³ which, like the semantic relatedness test, consisted of ranking words on a seven-point familiarity scale by 30 native speakers, 1 being ‘unfamiliar’ and 7 ‘very familiar’. This procedure was followed in all the following experiments. Only words that had a familiarity mean score between 4 and 6 were finally included. The targets had an overall mean familiarity score of 5.16. The unrelated primes were given an average score of 4.87. The overall mean was 4.88 in the orthographically related condition and 5.09 in the morphologically related condition (5.20 in the [+Semantic +Root] condition and 4.97 in the [-Semantic +Root] condition).

In addition to the 48 words and their corresponding primes in every condition, 48 unrelated word-word fillers were selected. Another 96 word-nonword filler pairs were added, 48 of which were formally related, while the other 48 pairs were unrelated. To familiarize the participants with the task, 34 practice trials were also included. These were 17 word-word pairs and 17 word-nonword pairs. The overlap in the related word-nonword filler pairs was morpho-phonological. Obviously, the semantic condition could not be included in the word-nonword pairs. The unrelated condition was not included since there were already 48 word-nonword unrelated pairs. The morphological overlap could not be complete because that meant giving existing roots. The overlap was, therefore, at the level of the consonants of the roots and, to a lesser extent, the affixes. The non-words in all

³³ Familiarity was controlled despite the fact that previous research has found similar priming with low and high familiarity primes in masked priming even with low short SOA (Forster & Davis, 1984; Rajaram & Neely, 1992).

experiments were created by mixing legal non-existing roots with existing word patterns. The pseudo-roots were constructed by changing one or two root consonants of existing roots. From the word *dafaʕa*, for instance, the nonword *fadaʕa* was created. The pattern (CaCaCa) is legitimate but the root {f, d, ʕ} does not exist in Modern Standard Arabic. Because pseudo-word and word fillers were included only as distracters, I opted for a between items design rather than a within items design as in the experimental words in all the online experiments.

All the stimuli were divided into three lists, each containing a total of 226 pairs (half of them were words and half were non-words). The stimuli were rotated within the four conditions in a Latin-square design in such a way that each participant was assigned the same number and type of conditions, i.e. prime-target pairs. The Latin Square design was done in the following way. I created three lists with the same targets and then randomly divided each list into three subgroups of words. All the items in the first subgroup in the first list were assigned the morphological items (+Morpho), the items in the second subgroup were assigned the ortho-phonological primes (+Orthophono), and the items in the third subgroup were matched with the unrelated primes (Unrelated). In the second list, I assigned ortho-phonological primes to the first subgroup, the unrelated primes to the second subgroup, and the morphological primes to the third subgroup. In the third list, the assignment of primes was in the following order: Unrelated, +Morphology and +Orthophonology. The rotation of the items in this way ensured that no participant saw the same target or prime more than once. To make sure that no participant got three consecutive YES or NO responses, I also rotated the fillers in a Latin Square fashion. The same procedure was followed in the following experiments. The stimuli in this and other experiments were presented in the unvowelled version of Arabic orthography, but caution was taken to include words that had only one reading.

Figure 1. Examples of Prime-target Pairs Used in Study 1, with Arabic Script, Phonetic Transcription, and Gloss (continued on the next page)

Words	Prime	Target
1. +Root+Sem	تَقَسَّم [taqassama] 'was divided'	قاسَم ³⁴ [qaasama] 'shared'
2. +Orthog/+Phono	تَقَاعَسَ [taqaaʕasa] 'was uninterested'	قاسَم [qaasama] 'shared'
3. Unrelated	تَصَدَّرَ [tasʕaddara] 'occupied the leading position'	قاسَم [qaasama] 'shared'
Set 2		
1. +Root–Sem	احْتَرَمَ [ʔihtarama] 'respected'	حَرَّمَ [harrama] 'forbid'
2.+Orthog/+Phono	تَكَرَّمَ [takarrama] 'showed one's generosity'	حَرَّمَ [harrama] 'forbid'
3. Unrelated	تَوَطَّدَ [tawatʕtʕada] 'was strengthened'	حَرَّمَ [harrama] 'forbid'

³⁴ All stimuli in all online experiments are verbs in the third person singular in the past/perfective form.

Non-words (primed by words)

1. Related: (prime shares the pseudo-root of the target)	التجأ [ʔiltazaʔa] 'resorted'	لتج [lataza] ³⁵
3. Related: +orthog/+phono	تفرّد [tafarrada] 'was unique'	استفرّث [ʔistafraθa]
4. Unrelated	بزغ [bazaxa] 'broke forth'	أجدن [ʔazdana]

Note: The root and the pseudo-root are in bold and the rest of the phonemes make up the pattern/template.

3.2.4 Procedure and apparatus

One third of the 36 participants were arbitrarily assigned to each of the three lists. They were tested individually in a quiet room. The participants were instructed to respond as quickly and as accurately as possible by pressing the *Yes* key for a word response and the *No* key for a nonword response. The dominant hand was used for word (Yes) responses and the non-dominant hand for the nonword (No) responses. The experiment lasted about 15 minutes. A training session with 34 practice items preceded the experiment. When felt necessary the practice session was repeated twice.

This experiment and all the following experiments were conducted on an HP portable Computer (Pentium (R) 4 CPU 2.66 GHz) running the display system DMDX.³⁶ Each trial consisted of three events. The first event was a mask of 28 vertical lines that was displayed for 500 ms. The second event that immediately followed was a prime word that

³⁵ As mentioned in the first chapter, the grapheme/phoneme <ج> is pronounced /ɟ/ in the standard variety of Arabic spoken in Tunisia and not as a /dʒ/ as prescribed. The grapheme <ض> is a /dʕ/ in the prescribed pronunciation but is pronounced /ðʕ/ in Tunisian Modern Standard Arabic, thus making no distinction between the graphemes <ض> and <ظ>. In the transcription of all experimental stimuli, a Tunisian Arabic pronunciation (the variety of the participants) is assumed.

³⁶ The DMDX software was developed by J. C. Forster at the University of Arizona. This program is a member of the DMASTR family developed at Monash University and the University of Arizona by K.I. Forster and J.C. Forster. For more information on DMDX check the following website: <http://www.u.arizona.edu/~kforster/dmdx/dmdx.htm>.

appeared for 50.25 ms (three ticks of 16.75 ms. each). The last event that immediately followed the prime was a target word, which remained on the screen for 2000 ms. or until a response was provided by pressing a button on a USB joystick. The mask was presented in 30-point Traditional Arabic font size, the prime in 24-point font size and the target in 34-point font size.

3.2.5 Results

The averages of correct response times (RT) and mean error frequencies were obtained for both participants and items. Both types of data were analyzed using separate analyses of variance (ANOVAs). For correct responses, outliers that were two standard deviations above or below the mean were eliminated without being replaced. Participants who had more than 20 % error on the experimental words were excluded and replaced. The same procedure of data cleaning and analysis (i.e. two-way ANOVAs by subjects and items) for both response time and error was followed in all of the following online experiments. The effect of priming in the related conditions was evaluated against the baseline orthographic/phonological condition. The means, standard deviations, and error rates for all experimental conditions are presented in Table 4.

Three sets of two-way ANOVAs were run for subjects (F_1) and items (F_2). The two independent variables were prime condition and list, with each containing three levels. However, the effect of list will not be reported because this between subjects factor was introduced to reduce variance.

To check whether the root had a special priming effect, I ran a set of ANOVAs on the first three conditions, (1) +Root (either semantically related or not), (2) +Orthography/+Phonology and (3) Unrelated. Prime condition (main effect) was significant only in subject analysis, $F_1(2, 66)=5.82, p<.005$ (alpha was set at .05 in all the experiments in this study). Planned comparisons (contrasts between the experimental conditions) revealed a significant difference between the morphological condition (+Root) and the unrelated condition: $F_1(1, 33)=10.65, p<.005$ and more important between the morphological condition and the form condition (+Orthography/Phonology), $F_1(1, 33)=7.24, p<.05$. The form condition, by contrast, was not different from the unrelated condition: $F_1(1, 33)=.50, p>.05$.

Error analysis also showed a significant effect of priming condition in subject analysis, $F_1(2, 66)=3.98, p <.05$. Planned comparisons revealed a marginal significant difference only between the morphological condition and the unrelated condition, $F_1(1, 33)=3.62, p <.06$.

Table 4

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 1

Condition	RT(ms)	SD	% error
1. +Root+/-Sem	716	86	6.5
2. +Orthog/+Phono	735	94	10.9
3. Unrelated	744	92	9.7
1a.+Root+Sem	761	113	5.6
2a. +Orthog/+Phono	766	101	7.9
3a. Unrelated	765	95	6.5
1b.+Root-Sem	700	79	6.4
2b. +Orthog/+Phono	721	98	11.1
3b. Unrelated	743	110	8.5

To test whether semantics had a priming effect in the morphological condition, I further ran two other sets of ANOVAs. The first set of these two-way ANOVAs included these three conditions: +Root, +Semantics, +Orthography/+Phonology, and Unrelated. Here I included half of the data: the items that were both semantically and morphologically related and their equivalents in the other conditions. The analysis did not yield a main effect of prime condition in either subject or item analysis, $F_1(2, 56)=.14, p >.05$ and $F_2(2, 63)=.02, p >.05$.

The third set of ANOVAs included the (i) +Root, -Semantics, (ii)+Orthography/+Phonology, and (iii) Unrelated conditions. Interestingly enough, the prime condition

variable was significant in subject analysis, $F_1(2, 60) = 6.73, p < .005$ and very marginally significant in item analysis, $F_2(2, 63) = 2.6, p = .08$. To determine the effect of morphology compared to orthography/phonology, I used a deviation planned comparison test. The result of these planned comparisons revealed that only the contribution of the morphological condition was significant, $F_1(2, 60) = 8.62, p < .01$.

3.2.6 Discussion

The results of this experiment support the hypothesis, based on previous work done on Arabic (Boudelaa & Marslen-Wilson, 2001b), that the root has a priming effect and therefore has a cognitive validity in the Arabic mental lexicon. The priming effect of the root is different from the formal effect of orthography/phonology since the amount of priming in the morphological condition (+Root) was significantly different from that of the orthographic/phonological condition (a difference of 19 ms.).

The results also show that morphological priming is not dependent on the semantic relationship that often accompanies a morphological relationship. In fact, I found in the separate treatment of the semantically-related prime-target pairs and the less semantically-related pairs a rather interesting tendency; the less semantically-related are the ones that have a significant priming effect. While previous studies on Arabic (Boudelaa & Marslen-Wilson, 2001b) and Hebrew (Frost, Forster, & Deutsch, 1997) also found that priming occurred regardless of whether the prime had a close semantic relationship with the prime or not, no study on Semitic languages reported a similarly large advantage for the less semantically related primes. We will return to this result later in the discussion of Study 4 C, where a similar effect is also found.

3.3 Study 2: Priming with etymons

3.3.1 Objectives

This study aimed first to revisit the question of whether the etymon, a two-consonant root-like morpheme, has a cognitive role in Arabic lexical representation and processing. The only study on this issue to date was by Boudelaa and Marslen-Wilson (2001a). Their results were, however, met with much scepticism (e.g. Bentin & Frost, 2001). In addition to attempting to replicate Boudelaa's and Marslen-Wilson's (2001a)

findings, the present study examined whether the order of the consonants of the etymon had an effect on the degree of priming, an issue that was not examined in Boudelaa and Marslen-Wilson (2001a). The results will also be compared to those of the previous study (Study 1) to see if more overlap in roots led to more priming.

If the etymon had a cognitive validity, we would expect a priming effect in the conditions where primes and targets share the same etymon.

The experiment comprised three main conditions: (i) +Etymon (ordered or not) (Experimental condition), (ii) +Orthography/Phonology (Control condition 1), and (iii) Unrelated (Control condition 1), with 48 targets each. But to allow for an evaluation of the priming effect of ordered etymons in comparison to non-ordered etymons (in the first general condition), the target words were divided into two sets of three experimental conditions with 26 words with ordered etymons and 22 words with non-ordered etymons (see Figure 2, below).

The first set included the following three conditions: (i) +Ordered Etymon, (ii) +Orthography/+Phonology, and (iii) Unrelated. In the first condition, primes and targets shared an ordered etymon. In the second condition (+Orthography/+Phonology), primes and targets shared two consonants (orthography/phonology) such that it mimicked the prime-target overlap in the morphological condition both in the number and the position of the shared consonants. In the third condition (Unrelated), primes and targets had roughly the same number of different letters (i.e. with no form or meaning similarity). A semantic condition was not included because words with the same etymon were found, on the basis of a semantic relatedness judgment test administered to 20 native speakers, to have very little semantic relationship. In fact, they all had a mean score of less than 3 on a seven-point scale. The overall mean for all the prime-target pairs was 1.77. The second set included, in addition to the +Orthography/+Phonology and Unrelated conditions, the +Non-ordered Etymon condition in which primes and targets shared non-ordered etymons.

3.3.2 Participants

Thirty-six Arabic-speaking students participated as volunteers in the experiment. None had participated in Experiment 1. However, participants in Experiment 1 and 2 were

comparable in terms of factors such as age and education, so that they could be considered to have been drawn from the same population.

3.3.3 Stimuli and Design

The targets were 48 trilateral Arabic verbs in the past tense third person singular form with a mean letter length of 4.25 and a mean syllable length of 3.52. Each of these words was paired with three primes, one from each of the experimental conditions described above (see Figure 2 for a sample of the stimuli). The mean letter and syllable length of the primes that shared an ordered etymon with the targets was 3.52 and 3.01 respectively, and 3.36 and 2.82 respectively for the primes that shared a non-ordered etymon with the targets. In the orthographically/phonologically related condition, the primes were of a mean letter length of 3.59 and a mean syllable length of 3. In the unrelated condition, the mean letter and syllable length were 3.42 and 3.08, respectively. A list of all the experimental items is provided in Appendix B.

The number, position, order, and continuity of the overlapping letters in the orthographic/phonological control condition mimicked as much as possible those in the morphological condition. In the morphological condition, primes and targets shared an etymon that was either ordered or non-ordered, a fact that was coded and tested (that is whether the order of the shared etymon matters). The primes in the three experimental conditions had the same word patterns and therefore roughly the same number of letters and the same syllable structure. The average amount of prime-target overlap was 2.40 letters and 2.42 phonemes in the morphological condition (2.39 letters and 2.43 phonemes in the ordered etymon condition and 2.41 letters and 2.41 phonemes in the unordered etymon condition). The primes in the orthographically/phonologically-related condition shared an average of 2.17 letters and 2.27 phonemes with the targets.

The verbs included mostly forms that have three consonants, two of which are believed to constitute the etymon, based on the work of Bohas (1997, 2000). Only a few weak verbs (verbs with a deleted underlying glide) that are believed to share an etymon with other verbs were included. Weak verbs are examined separately in Study 5.

The 96 verbs selected in this study were of the following types: 19 verbs whose third consonant is a result of spreading/gemination, 22 verbs with an added consonant in

initial (root-consonant) position, 22 verbs with an added consonant in second position, and 33 verbs with an added consonant in third position. The added consonant could be either a consonant or a glide (42 verbs had an added consonant and 35 had an added glide).

The stimuli had to have a familiarity score that ranged between 3 and 5 (on a seven-point scale). The overall mean scores within the different item types were as follows: 4.08 for the targets, 4.30 for the unrelated primes, 4.27 for the orthographically-related primes, and 4.13 for the items that share an etymon with the targets.

In addition to the 48 words and their corresponding primes in every condition, 144 fillers were selected. The fillers included 48 unrelated word-word fillers and 96 word-nonword pairs. Half of these pairs (48) were formally related whereas the other 48 pairs were unrelated and served as a control for the filler pairs. Each item file/list also contained 34 practice trials: 17 words and 17 non-words. The overlap in the related condition of the nonword-word pairs was morpho-phonological. The overlap in this condition, as in the experimental condition, included two ordered or non-ordered consonants of the root (a pseudo-etymon) and/or consonants from the affixes. Three lists were finally created; each containing a total of 226 pairs.

Figure 2. Examples of Prime-target Pairs Used in Study 2, with Arabic Script, Phonetic Transcription, and Gloss (continued on the next page)

<u>Words</u>	Prime	Target
1. +Ordered Etymon, -Sem	قضم [qað ^ʕ ama] 'gnawed'	انقرض [ʔin-qarað ^ʕ a] 'became extinct'
2. +Orthog/+Phono	رفض [rafad ^ʕ a] 'refused'	انقرض [ʔin-qarað ^ʕ a] 'became extinct'
3. Unrelated	سلك [salaka] 'followed'	انقرض [ʔin-qarað ^ʕ a] 'became extinct'

Set 2

1. +Non-ordered Etymon, -Sem	موّه [mawwaha] 'feigned'	اهتمّ [ʔihtamma] 'was interested'
2. +Orthog/+Phono	متع [mattaʔa] 'made enjoy'	اهتمّ [ʔihtamma] 'was interested'
3. Unrelated	عطل [ʔatʔʔala] 'obstructed'	اهتمّ [ʔihtamma] 'was interested'
<u>Non-words</u>		
1. +Pseudo-etymon	قفز [qafaza] 'jumped'	أعفز [ʔaʔfaza]
2. +Orthog/+Phono	انشقّ [ʔinʃaqqɑ] 'was split'	تشنّس [taʃannasa] ³⁷
3. Unrelated	أطنب [ʔatʔnaba] 'overdid'	توضّر [tawaðʔðʔara]

3.3.4 Procedure and apparatus

This was the same as in the previous experiment.

3.3.5 Results

Means for both correct response times and error frequencies were obtained for both participants and items. As in Study 1, any correct response that was two standard deviations above or below the mean of each participant was eliminated without being replaced. This eliminated 3.46% of the data. The overall error rate was 12.7. The effect of priming in the related condition was evaluated against the baseline orthographic/

³⁷ The three phonemes that could make an etymon are in bold.

phonological condition. The means, standard deviations, and error rates for all experimental conditions are presented in Table 5.

Because the etymon is theoretically conceived of as an overlap in two radical consonants that may or may not be ordered, I ran a first set of ANOVAs in which the morphologically-related condition included a balanced number of ordered and non-ordered etymons. The conditions were therefore the following: +Etymon (ordered or non-ordered), +Orthography/ Phonology, and Unrelated. The prime condition was significant by subjects, $F_1(2, 66)=8.66, p <.001$. Planned comparisons revealed a significant difference between the +Etymon condition and the unrelated condition, $F_1(1, 33)=18.98, p <.001$ as well as between the +Etymon condition and the form condition (+Orthography/Phonology), $F_1(1, 33)=7.74, p <.01$. The form condition did not differ from the unrelated condition, $F_1(1, 33)=2.45, p >.05$. Error analysis did not show any significant differences between the conditions.

To see whether the order of the etymon consonants had an effect on priming, I further ran two sets of ANOVAs. The first included the +Ordered Etymon, +Orthography/ Phonology, and Unrelated conditions. Prime condition was significant, $F_1(2, 66)=4.56, p <.01$. Planned comparisons, using the deviation contrast, showed that only the morphological condition had a significant effect, $F_1(1, 33)=6.92, p <.01$.

In the other set of ANOVAs the +Non-ordered Etymon condition, the form condition, and the control condition were compared. The prime condition was not significant either by subjects ($F_1(2, 64)=.55, p >.05$) or by items ($F_2(2, 57)=.07, p >.05$).

Table 5

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 2

Condition	RT(ms)	SD	% error
1.+Etymon+/-ordered	800	113	10.9
2. +Orthog/+Phono	816	118	12.4
3. Unrelated	828	120	14.9
1a.+Ordered etymon	774	115	12.4
2a. +Orthog/+Phono	781	118	14.2
3a. Unrelated	800	123	12.4
1b.+Non-ordered etym	832	134	10.7
2b. +Orthog/+Phono	842	132	9.1
3b. Unrelated	840	130	14.3

3.3.6 Discussion

The results partly replicate what has previously been reported about the priming effect of etymons in Arabic by Boudelaa and Marslen-Wilson (2001a). Despite the fact that the present experiment included both ordered and non-ordered etymons, I found a significant effect in the morphological (+Etymon) condition. Boudelaa and Marslen-Wilson, who used mostly ordered etymons, suggested on the basis of their findings that the etymon is used in lexical processing.

What is new in the present experiment is the fact that priming occurs only when the primes and targets share an ordered etymon. This result casts some doubt on this construct.

Yet, we cannot conclude that the effect is due to orthographic/phonological overlap because the effect of the etymon consonants is largely significantly different from the effect of orthography/phonology (a difference of 16 ms.). I might, however, tentatively suggest that the construct used in the activation of lexical representations is not as abstract as the theoretical construct proposed in morphological theory. The cognitive construct is very likely a formal (orthographic) ordered unit that might be related to the root. Primes fail to activate target words with which they share a non-ordered etymon probably because the activation process is linear/ordered.

3.4 Study 3: Priming with phonetic matrices

3.4.1 Objectives

The phonetic matrix has not been examined in previous research. Boudelaa and Marslen-Wilson (2001a) mentioned the notion of the matrix as the underlying unifying unit of etymons, but actually used mostly etymons that shared two phonemes. The purpose of the present experiment was to investigate whether a prime would facilitate the recognition of a target word with which it shared the phonetic features assumed to be unifying etymons (see section 1.1.1.3 for a detailed discussion of the notions of phonetic matrix and etymon). Since I did not find any priming with non-ordered etymons, I did not expect to find priming with the very abstract notion/construct of phonetic matrix.

Three conditions were studied. In the *morphological condition* (+Phonetic Matrix - Semantics) (Experimental condition), primes and targets shared a phonetic matrix, namely two place features that related etymons share (see Figure 3 for examples of the different prime-target pairs in the different conditions). Primes in the *phonological condition* (+Phonology -Semantics) (Control condition 1), as in the related condition, were related to the target by sharing roughly the same number and order of features/phonemes. The only difference was that in the phonological condition the primes shared only one feature of the matrix features with the targets. In cases where a morphologically related prime and a target shared an additional letter in addition to the shared matrix, it was repeated in the phonological condition. In the *unrelated condition* (Control condition 2), primes and targets shared one or no phonetic feature. The shared feature had to be other than the two place features making the matrix in the morphological condition or any other matrix. There

were a few cases where an extra overlap was found in the affixes of the unrelated condition. These were theoretically irrelevant and could not be avoided when the patterns of the primes had to be as similar as possible.

In all conditions, the short vowels were not considered in the overlap. First, vowels are not part of the root/etymon and belong to a separate morpheme. Second, vowels do not show in the orthographic transcription. To assure an optimal control over the variation, there were two cases in which all primes including the unrelated primes shared the word pattern with the targets (the focus was on the variation of the matrix features). The three experimental primes had in most cases the same pattern and the same number of letters/phonemes.

If the phonetic matrix had an effect in lexical processing primes in the matrix-related condition should prime their targets significantly more than the phonological controls. As mentioned earlier, I predicted no priming effect.

3.4.2 Participants

The participants were another 36 Arabic-speaking students from the same population as in the previous experiments. None of them participated in the previous experiments.

3.4.3 Stimuli and design

The choice of the words was based on the work of Bohas (1997, 2000). The words belonged to one of the following seven matrix-based groups:

- (i) {[labial], [coronal]}
- (ii) {[+consonantal, labial] [+consonantal, -voiced, +continuous]}
- (iii) {[labial, -sonorant], [pharyngeal]}
- (iv) {[coronal], [pharyngeal, -dorsal, -voiced]}
- (v) {[coronal], [dorsal]}
- (vi) {[labial, -sonorant], [dorsal]}

(see Table 2 above for a feature-based description of Arabic consonants and (26) for the consonants associated with each of the above mentioned matrices). A matrix also includes

words that share the same etymon/two phonemes, but these were paired with words with which they shared only the specified phonetic features, not whole phonemes.

The stimuli included trilateral Arabic verbs. The targets were 36 words/verbs whose mean letter length was 4.17 and mean syllable length was 3.53. Each of the target words was paired with three primes, one from each of the experimental conditions: (i) the [+Matrix -Semantics] condition, (ii) the [+Phonology -Semantics] condition, and (iii) the Unrelated condition. The primes that shared a phonetic matrix with the targets (morphological condition) were, on average, 3.31 letters long and had an average of 2.97 syllables. The phonological primes also had an average of 3.31 letters and 2.97 syllables. The mean letter and syllable length of the unrelated primes were 3.28 and 2.86, respectively (see Appendix C for a complete list of the experimental items).

In most cases, primes in the three conditions had the same word patterns, which were, in every case, different from those of the targets. The overlap between primes and targets was in terms of phonetic features as well as whole phonemes. Only the segmental overlap is reported here. The primes in the matrix-related (morphological) condition shared with the targets an average of 0.92 letters and 0.97 phonemes. In the phonological condition, primes and targets shared an average of 0.89 letters and 0.92 phonemes.

As in the other experiments discussed above, the items were selected on the basis of a familiarity judgement made by 30 native speakers. The criterion of selection was a mean familiarity score that ranged between 3.5 and 5.5. The overall mean scores were distributed as follows: 4.02 for the targets, 4.05 for the unrelated items, 4.30 for the phonologically related items and 3.98 for the primes that shared a phonetic matrix with the targets. Because the non-words were not examined, the strict criterion of selection of words was not observed. The word-nonword pairs that served as controls for the matrix related words did not share any phonemes, very much like the unrelated word-nonword pairs. No attention was paid to the features of the phonetic matrices studied, because these were not included in the analysis.

Figure 3. Examples of Prime-target Pairs Used in Study 3, with Arabic Script, Phonetic Transcription, and Gloss

	Prime	Target
1. +Matrix, -Semantics	لفح [lafaha] '(a hot wind) blew'	نفس [naffasa] 'relieved'
2. +Phonology	فرض [farað'a] 'imposed'	نفس [naffasa] 'relieved'
3. Unrelated	علق [ʔaliqa] 'stuck'	نفس [naffasa] 'relieved'
<u>Non-words</u>		
1. No phonology	كظم [kað'aama] 'suppressed'	تخائل [taxaaθala]
2. +Phonology	تلاءم [talaaʔama] 'fit'	اقتظر [ʔiqtað'ara]
3. Unrelated	لحن [lahhana] 'composed'	تكارف [takaarafa]

Three lists were created. Each list contained, in addition to the 36 experimental pairs, 111 filler pairs, 36 of which were word-word pairs, and 72 word-nonword pairs. A total of 34 practice pairs were also included. Thus, each list contained a total of 178 pairs.

3.4.4 Procedure and apparatus

This was the same as in the previous experiments.

3.4.5 Results

The RT and error data were cleaned as in the previous experiments, which resulted in the elimination without replacement of a small part of the data (4.2%). The effect of priming in the related conditions was compared to the phonological condition. The means, standard deviations, and error rates for all experimental conditions are presented in Table 6.

The prime condition variable was not significant either in the response time analysis ($F_1(2, 66)=3.09, p > .05$ and $F_2(2, 99)=.21, p > .05$) or in the error analysis ($F_1(2, 66)=1.86, p > .05$ and $F_2(2, 99)=.88, p > .05$).

Table 6

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 3

Condition	RT(ms)	SD	% error
1. +Matrix	791	131	13.1
2. +Phono	776	128	9.6
3. Unrelated	780	128	13.7

3.4.6 Discussion

The results clearly show that the phonetic matrix has no priming effect. As discussed above (see chapter 1), the phonetic matrix is the very abstract and general construct that underlies etymons that share the same matrix of phonetic features. The lack of priming by the phonetic matrix was expected, especially that no priming was found with the non-ordered etymon, which is a much less abstract manifestation of the phonetic matrix.

Both results of the non-ordered etymon and the phonetic matrix suggest that the processor or the activation process is not very abstract. It rather relies on visually and linearly parsable units, very likely graphemes, to activate related words in visual lexical processing. Abstractness in lexical processing will be discussed more in chapter 5.

3.5 Study 4: Priming with sound and weak patterns and weak roots

3.5.1 Objectives

The present study tried to examine whether patterns, sound or weak, have a priming effect. Weak patterns are patterns that are intertwined with weak roots to make words. Because the focus in all the following experiments is on weak roots and their effect on the pattern and morphological priming/processing, a brief definition of weak roots is in order. Weak verbs are verbs that have lost an underlying glide, ending with only two root consonants in the surface form. The deleted glide, a /w /or a /j /, could be the first (initial), the second (medial) or the third (final) consonant of the root.³⁸ Only verbs with medial and final deleted glides were included in the stimuli because verbs with initial weakness are rare and result from assimilation, which is not the case with the other weak verbs. An example of a verb with an initial glide is *wasala* ‘he arrived’. The glide of this verb is lost in form VIII (perfective) (ʔiftaʕala) in contact with affixal /t/, as in: /ʔiwtasʕala/---[ʔittasʕala]. Forms of this kind were not selected because they include assimilation rather than deletion, and therefore the verb still has three consonants. Verbs with initial glides undergo glide deletion in the imperfective as in *waqaʕa* ‘he fell’ *ya-qaʕu* ‘he falls/he is falling’. However, only the perfective was used because it is the most neutral form in Arabic and has no person marker prefixes. While glide deletion is more common in weak verbs with medial or final glides, it does not involve all paradigm forms. Verbs lose their medial glide in the following paradigm forms: Form I (faʕala), Form IV (ʔafʕala), Form VII (ʔinfaʕala), Form VIII (ʔiftaʕala), and Form X (ʔistaʕala). The forms in which verbs delete their final glide include: Form I (faʕala), Form II (faʔʕala), Form III (faaʕala), Form

³⁸ The two sound consonants of weak verbs (i.e. the ones that do not change) are potential etymons (Bohas, 1997, pp. 19-25).

IV (ʔaffʔala), Form V (tafaʔʔala), Form VI (tafaaʔala), Form VII (ʔinfaʔala), Form VIII (ʔiftaʔala), Form X (ʔistaʔʔala).

3.5.2 Study 4A

This experiment tested whether patterns conjugated with weak roots primed words with similar patterns that were conjugated with sound roots. These were compared to primes conjugated with different sound roots in order to control items that shared the same number of letters with the targets but had different patterns and different roots. There were, therefore, three conditions: (i) +Pattern with Sound Root, (ii) +Pattern with Weak Root, and (iii) +Phonology/Orthography (control condition). In the first condition, primes shared the same patterns with targets but had different sound roots and different meanings. However, in the second condition, the roots of the primes were weak, that is, they lacked one consonant. The root weakness affects the pattern by changing its syllabic structure. The site of the weakness could be medial or final. The stimuli included an equal number of each type of weak verbs to examine if the position of weakness played any role. In the third condition, primes and targets shared the same number of letters as in the related conditions. The shared letters/phonemes could be either consonants or long vowels. Short vowels, represented by diacritics, were not used, as the stimuli were presented in the unvowelled version of Arabic orthography.

3.5.2.1 Participants

The volunteer participants were a different group of 36 Arabic-speaking students. None of them participated in the previous experiments from the same population as in the previous experiments.

3.5.2.2 Stimuli and Design

The targets were 48 verbs that were derived from the following patterns: **faʔala** (11 verbs/items), **ʔaffʔala** (11), **tafaʔʔala** (5), **ʔiftaʔala** (8), **ʔistaʔʔala** (3), **tafaaʔala** (3), **ʔinfaʔala** (4), **faaʔala** (2), **faʔʔala** (1). The targets were 4.19 letters long and 3.5 syllables long, on average. Each target word was paired with three primes, one from each of the three

conditions mentioned above: (i) +Pattern with Sound Root, (ii) +Pattern with Weak Root, and (iii) +Orthography/Phonology. The mean length of the primes was 4.17 letters and 3.5 syllables in the pattern with sound root; 4.19 letters and 2.73 syllables in the pattern with a weak root condition; and 4.17 letters and 3.40 syllables in the +orthography/phonology condition.

The number, position, order, and continuity of the overlapping letters in the control condition mimicked as much as possible those in the related conditions. In fact, the amount of overlap was almost identical. It was, however, very difficult to keep the same amount of overlap in the same order in the control condition. Some patterns in the targets had up to three consecutive affixal letters in the beginning of the word (e.g. *ʔistaffala*). The average amount of prime-target overlap was 1.31 letters and 1.31 phonemes in the pattern with sound root condition; 1.34 letters and 1.34 phonemes in the pattern with weak root condition; and 1.34 letters and 1.34 phonemes in the +orthography/phonology condition. Unlike in the related conditions, primes in the control condition had different patterns from those of the targets. The control primes, however, had roughly the same number of ‘prefixed’ patterns as the related primes and always mimicked the initial letter overlap between related primes and targets. A sample of the stimuli is given below in Figure 4 (for the complete list of items, see Appendix D).

For an item to be included, it had to have a mean familiarity score between 4 and 6 on a seven-point scale. The overall mean score for the targets was 5.07. The overall mean score for the primes in the orthographically-related condition was 5.00. The overall mean score for the primes that shared “weak” patterns with the targets was 4.86. The overall mean score for the primes that share “sound” patterns with the targets was 5.05.

In addition to the 48 target words, 48 unrelated word-word fillers were selected. Another 96 word-nonword pairs were added, 48 of which were formally related, whereas the other 48 pairs were unrelated. The overlap in the related word-nonword pairs was morpho-phonological. As in the experimental word-word pairs, the overlap between primes and targets was in the word patterns. Primes shared with non-word targets ‘weak’ patterns (i.e. patterns with weak roots), ‘sound’ patterns, or only consonants of both the root and the affixes. The primes in the related word-nonword pairs were mostly with sound roots, because weak roots are not frequent in the language.

The stimuli were finally divided into three lists. One third of the 36 participants were tested on each of the three lists.

Figure 4. Examples of Prime-target Pairs Used in Study 4A, with Arabic Script, Phonetic Transcription, and Gloss

	Prime	Target
<u>Words</u>		
1. +Pattern with sound root	استعمر [ʔistaʕmara] 'colonized'	استقبل [ʔistaqbala] 'welcomed'
2. +Pattern with weak root	استغنى [ʔistaynaa] 'was able to dispense with'	استقبل [ʔistaqbala] 'welcomed'
3. Control: +Orthog/Phono	أسقط [ʔasʕatʕa] 'made fall'	استقبل [ʔistaqbala] 'welcomed'
<u>Non-words</u>		
1. +Pattern with sound root	تكرم [takarrama] 'was generous'	تحسف [taħassafa]
2. +Pattern with weak root	استغاث [ʔistayaaθa] 'asked for help'	استماش [ʔistamaafa]
3. Control: +Orthog/Phono	أطفأ [ʔatfaʔa] 'put out'	تطفأ [tatʕaffaka]

3.5.2.3 Procedure and apparatus

This was the same as in the previous experiments.

3.5.2.4 Results

RT and error data were gleaned and cleaned following the same procedure as in the previous experiments. A small part of the data fell outside the two-standard deviation cutoffs (4.73%). The effect of priming in the related conditions was compared to the orthographic/ phonological condition. The means, standard deviations, and error rates for all experimental conditions are presented in Table 7.

The prime condition variable was not significant in either RT analysis ($F_1(2, 66)=.30, p > .05$ and $F_2(2, 135)=.05, p > .05$) or error analysis ($F_1(2, 66)=1.36, p > .05$ and $F_2(2, 135)=.64, p > .05$).

Table 7

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 4A

Condition	RT(ms)	SD	% error
1.+Sound Pattern	727	90	7.2
2. +Weak Pattern	730	90	5.3
3. +Orthography	729	89	5.9

3.5.2.5 Discussion

The results show that there is no difference at all between the two related conditions and the control condition. The lack of priming with a sound pattern (only 2 ms more than the control) suggests that, unlike the root, the pattern does not play a role at this stage of lexical processing (50 ms). One possible explanation for the lack of priming with patterns could be the fact that the short vowels of the pattern are not orthographically represented.

This result does not support the results on Arabic reported by Boudelaa and Marslen-Wilson (2001b). They found priming effects of the pattern at display time 48 and 64 ms. in deverbal nouns and only at SOA 48 for verbs. As Boudelaa and Marslen-Wilson's stimuli have not been published, I cannot compare their stimuli to mine. The results in Hebrew are equally intriguing. Studies on Hebrew showed that pattern priming had a priming effect at SOA of 42-43 ms in verbs and not in nouns (Frost, Forster, & Deutsch, 1997; Deutsch, Frost, & Forster, 1998), which is different from the pattern for Arabic reported by Boudelaa and Marslen-Wilson.

Because I found no priming in either sound or weak patterns, I could not make any speculation. I, however, proceeded to test weak patterns that shared both consonants and vowels with their primes. Long vowels, which are frequent in weak patterns, are represented orthographically.

3.5.3 Study 4B

Although I found no priming with sound patterns, I wanted to test if there was no priming with exact weak patterns. That is, I tested the condition in which both the prime and the target are weak and share orthographic vowels and consonants. I also included a condition where primes and targets share a weak pattern with a different site of weakness. Two slightly different morphological conditions were, therefore, included in addition to the control condition (see Figure 5, below). In the first related condition, both primes and targets shared the same patterns with the same site of disruption (weakness) and therefore had very similar prosodic templates (i.e. similar syllabic structure). In the second condition, primes and targets shared the same patterns but differed as to the site of the disruption. The dissimilarity in the site of the weakness also affected the orthography. The site of the weakness is a long/orthographic vowel, particularly a long *aa* which is written in two different ways: as an *ʔalif* <ا> in the middle of the word and as *yaaʔ* <يا> at the end. This discrepancy in orthography was, however, controlled in the three conditions by selecting half of the primes with an *ʔalif* and the other half with a *yaaʔ*. In the control condition (+orthography/phonology), primes shared the same number of letters with targets. The overlap was both in consonants and long vowels (24 verbs overlapped in long vowels and consonants and 24 in consonants).

3.5.3.1 Participants

Another 36 Arabic-speaking students from the same population as in the previous experiments volunteered to take part in this experiment.

3.5.3.2 Stimuli and Design

The target words were 48 verbs that were derived from the following patterns: *faʕala* (24), *ʔafʕala* (11), *ʔiflaʕala* (9), *ʔistafʕala* (2), *ʔinfaʕala* (2).³⁹ They had a mean letter length of 3.81 and a mean syllable length of 2.5. Each target word was paired with three primes, one from each of the three experimental conditions: (i) same pattern, with a weak root (ii) slightly different pattern, with a weak root and (iii) +orthography/phonology. The primes that shared the same patterns with targets were, on average, 3.81 letters long and 2.50 syllables long. The mean letter and syllable length of the primes that shared slightly different patterns with targets were 3.81 and 2.35, respectively. In the +orthography/phonology condition, primes had a mean letter length of 3.92 and a mean syllable length of 2.94.

The number, position, order, and continuity of the overlapping letters in the control condition mimicked as much as possible those in the morphological conditions. Despite the fact that the control primes had patterns different from other primes and targets, they nonetheless had the same initial overlap with the targets as in the related conditions, as well as roughly the same number of prefixed patterns. The average amount of prime target overlap was 1.32 letters and 1.81 phonemes in the same pattern condition; 1.31 letters and 1.81 phonemes in the slightly different pattern condition; and 1.35 letters and 1.82 phonemes in the orthography/phonology condition (Figure 5, below, contains examples of the different prime-target pairs and Appendix E has the complete list of items). The amount of overlap was kept similar to the one in the previous experiment.

The familiarity score of the selected items ranged between 3.75 and 5.75 over a seven-point scale. The overall means of the targets and the primes in the different conditions were as follows: 4.16 for the targets; 4.59 for the orthographically/phonologically-related primes; 4.50 for the primes that shared a slightly

³⁹ The wazn (pattern) *faʕala* could not be included simply because in verbs with middle glide that glide surfaces.

different pattern with the targets; and 4.36 for the primes that shared the same pattern with the targets. The familiarity scores of the stimuli in this experiment were very close to those in the previous one (Study 4A).

As in the previous experiments, 48 unrelated word-word fillers were selected. Another 96 word-nonword filler pairs were added, 48 of which were formally related while the other 48 pairs were unrelated. There were also 34 practice pairs. The overlap in the related nonword-word pairs/fillers was either morphological or phonological. As in the experimental word-word pairs, the morphological overlap in these word-nonword fillers was in the shared word patterns. The phonological overlap (in one third of the prime-target pairs) was in some of the root consonants and affix consonants.

The stimuli were finally divided into three lists. Each list was presented to a different group of twelve participants.

Figure 5. Examples of Prime-target Pairs Used in Study 4B, with Arabic Script, Phonetic Transcription, and Gloss (continued on the next page)

	Prime	Target
<u>Words</u>		
1. Same pattern with weak root	ارتمى [ʔirtamaa] 'threw oneself'	انتقى [ʔintaqaa] 'selected'
2. Slightly different pattern with weak root	احتاط [ʔihtaat ^ʕ a] 'was cautious'	انتقى [ʔintaqaa] 'selected'
3. Control: +orthog/ phono	أتقن [ʔatqana] 'mastered'	انتقى [ʔintaqaa] 'selected'

Non-words

1. Same pattern with weak root	هاج [haaʒa] 'became agitated'	زاق [zaaqa]
2. Slightly different pattern with weak root	شاب [ʃaaba] 'aged'	ضجى [ðʕaʒaa]
3. Control: +orthog/phono	عانق [ʕaanaqa] 'embraced'	تناوذ [tanaawaða]

3.5.3.3 Procedure and apparatus

The procedure was the same as in the previous experiments.

3.5.3.4 Results

The data cleaning led to the elimination of 4% of the data. The effect of priming in the related conditions was compared to the orthographic/phonological condition. The means, standard deviations, and error rates for all experimental conditions are presented in Table 8.

The analysis of RT data showed a significant effect of the prime condition variable, $F_1(2, 66)=4.20, p < .05$. This significance was not due to a priming difference between the +Same Pattern condition and the control condition, but rather to the inhibitory effect of the second condition (+slightly different pattern). Planned comparisons showed a significant difference between the +Slightly different pattern condition and the control condition (+Orthography/Phonology), $F_1(1, 33)=8.78, p < .01$. Error analysis did not reveal any difference between conditions.

I also ran a t-test to see if the items that shared both orthographic vowels and consonants in the first condition were different from the control condition. The test revealed no significant difference between the two conditions, $t(35)=.64, p > .05$. A similar test between the items that shared the same weak pattern but a different orthographic

representation of the long vowels in the first condition and the control condition also revealed, an expected nonsignificant difference, $t(35)=-.40, p>.05$.

Table 8

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 4B

Condition	RT(ms)	SD	% error
1.+Same Weak Pattern	689	96	7.5
2.+Slightly different Weak Pattern	699	80	7.4
3. Unrelated	680	73	5.4

3.5.3.5 Discussion

The results of this experiment clearly show that weak patterns do not prime each other, even if they share the same orthographic representation of both the consonants and the long vowels of the pattern. The results of this experiment and the previous one show that patterns, either sound or weak, do not activate lexical representations at this stage of lexical processing (i.e. at SOA of 50 ms). Comparing the results of Study 4A and Study 4B to those of Study 1 and Study 2, we can conclude that roots and etymons have an active role in lexical processing but patterns do not. This conclusion is further tested in the following study.

3.5.4 Study 4C

In this experiment, I tested whether I could demonstrate priming with weak roots; that is, when both primes and targets shared the same weak root. Because I found priming with etymons where only two consonants were shared, I thought that I could find priming with weak roots as well. There is, however, a difference between etymons and weak roots. Etymons, unlike weak roots, make up stems that have three “root” consonants. Having a sound pattern in a word seems to be obligatory for decomposition in Hebrew. Frost,

Deutsch, and Forster (2000), using a masked priming paradigm, found that verbal patterns had no effect when either or both prime and target forms missed a root consonant. Yet, once they added an arbitrary consonant to the weak root of the prime coupled with a target that had both a sound root and pattern, the pattern effect appeared. The authors concluded that for decomposition to occur the system should detect both an existing pattern and three consonants.

Although I am examining Arabic and not Hebrew, I propose an alternative hypothesis to the one proposed in Frost et al. (2000). I suggest that the lack of priming found in Frost et al. (2000) could be due to the disruption of the pattern/CV skeleton and not to the root. Keeping the same weak root in primes and targets, but varying the (weak) patterns would very likely lead to priming. This hypothesis is based on the results from Arabic and Hebrew, which suggest that the root is more important and stable in priming than the pattern, as well as on the results found in Arabic in relation to the etymon.

The experiment comprised three conditions with two sets of targets, 24 items in each set (Figure 6, below). The first set included the following three conditions: (1a) +Weak Root, +Semantics (Experimental condition), (2a) the form (orthography/phonology) related (Control condition 1), and (3a) the unrelated (Control condition 2). In the second set there were these three conditions: (1b) +Weak Root, -Semantics (Experimental condition), (2b) the form-related (Control condition 1), and (3b) the unrelated condition (Control condition 2). In the first/morphological condition, in both sets, the prime and the target shared a weak root. While the first set included items that shared morphological as well semantic relationship with targets, the second set included primes that shared weak roots and a vague semantic relationship with targets. In the form-related condition, primes and targets shared the same number of phonemes as in the morphological condition.

If we find that it is the pattern that matters, it would mean that the pattern includes the root in the processing. That is, both the root and the pattern are complementary and the existence of both units is necessary in the decomposition. The putative priming effect between weak primes and weak targets would also support the etymon hypothesis, because words with weak roots are considered etymons (Bohas, 1997, 2000).

3.5.4.1 Participants

The participants were another 36 Arabic-speaking students from the same population as in the other experiments.

3.5.4.2 Stimuli and Design

The targets were 48 weak verbs whose mean letter length was 4.94 and mean syllable length was 3.19. They had one of the following patterns: *ʔiftaʔala* (9), *ʔistaffʔala* (14), *tafaaʔala* (6), *tafaʔʔala* (4), *ʔinfaʔala* (5), *faʔala* (3), *ʔafʔala* (5), *faaʔala* (2).⁴⁰ Half of the targets were paired with primes in the following three conditions: (a) +Weak Root, +Semantics, (b) form-related (+Orthography/Phonology), and (c) Unrelated. The second half of the targets were paired with primes in the following three conditions: (a) +Weak Root, -Semantics, (b) form-related (+Orthography/Phonology), and (c) Unrelated. The mean letter and syllable length of primes in the ‘+Weak Root+Semantics’ condition were 3.63 and 2.38, respectively. The primes in the ‘Orthography/Phonology’ condition were, on average, 4.23 letters long and 3.23 syllables long. The primes in the unrelated condition had a mean letter length of 3.56 and a mean syllable length of 3.34. The primes that shared weak roots but no meaning with the targets had a mean letter length of 3.50 and a mean syllable length of 2.25 (see Figure 6 for examples of prime-target pairs in the different conditions and Appendix F for a complete list of the experimental items).

The overlap was both in the number and the position of the shared phonemes. Because of the importance of first phonemes/letters in processing, whenever the target and the morphological prime shared one or more initial letters the overlap was reproduced in the phonological/orthographic condition. In the unrelated condition, primes and targets had roughly the same number of letters, but no form or meaning similarity. Unlike in the morphologically related condition, in both the phonological and the unrelated conditions, the verbs had sound roots. The same rigorous control for the number of letters and word pattern (syllabic structure) used in the other experiments was adopted. In most cases, the primes in the three experimental conditions shared the same patterns, which differed from those of the targets. In a few instances, the unrelated prime had to have a different pattern

⁴⁰ As discussed in the previous experiment, verbs can have the same pattern but a different weakness site.

to avoid the overlap in the first letter with the target. In cases where such changes were necessary, it was made sure that if the shared pattern between a related prime and a target had a prefix, the control had to have a prefixed pattern as well. For instance, the particle in “ʔi” in form VIII (*ʔiftaʔala*) is epenthetic, but it might be considered a (pseudo)prefix because it is orthographically/visually represented. Thus, it might be stripped during processing or at least cause prefix-like effects.

In the ‘+Weak Root +Semantics’ condition, primes and targets shared an average of 3.29 letters and 3.38 phonemes. In the +Orthography/Phonology condition, the prime-target overlap was 3.03 letters and 3.27 phonemes, on average. In the ‘+Weak Root, -Semantics’ condition, the average overlap in letters and phonemes was 2.96 and 3, respectively.

Semantic similarity was determined by randomly presenting word-pairs sharing the same root to 20 native speakers to judge their semantic relatedness on a 7-point scale. For the low-relatedness pairs, the ranking ranged between 1.35 and 3 (the criterion was less than 4), with a general mean of 2.35 and it ranged between 4 and 6.3 for the high-relatedness pairs, with a general mean of 4.75.

The selection of the stimuli was also based on a familiarity score on a seven-point scale obtained from 30 native speakers of Arabic. The selected items had to have a mean score above 4. The overall means of targets and primes in the different conditions were as follows: 4.56 for the targets, 4.48 for the unrelated primes, 4.47 for the primes in the orthographic/phonological condition, and 4.48 for the primes in the morphological condition (4.59 in [+root, +semantics] condition and 4.37 in [+root, -semantics] condition).

In addition to the 48 words and their corresponding primes in every condition, 48 unrelated word-word fillers were selected. Another 96 word-nonword pairs were added, 48 of these were formally related and the other 48 pairs were unrelated. The overlap in the related nonword-word pairs was morphological and phonological and mimicked the overlap in the related experimental conditions. The morphological overlap included the consonants of the root, which, unlike in the experimental words, were not all weak. The phonological overlap involved a mixture of root and affix consonants.

Figure 6. Examples of Prime-target Pairs Used in Study 4C, with Arabic Script, Phonetic Transcription, and Gloss (continued on the next page)

Set 1

<u>Words</u>	Prime	Target
1a: +Weak Root +Sem	ضاع [ðʕaaʕa] 'got lost'	أضاع [ʔa-ðʕaaʕa] 'lost'
2a: +Phono/Ortho	ضاعف [ðʕaaʕafa] 'multiplied'	أضاع [ʔa-ðʕaaʕa] 'lost'
3a: Unrelated	هرب [hariba] 'run away'	أضاع [ʔa-ðʕaaʕa] 'lost'

Set 2

1b: +Weak Root-Sem	جاز [ʒaaza] 'was allowed'	اجتاز [ʔi-ʒtaaza] 'passed'
2b: -Weak Root +Phono/Ortho	جازف [ʒaazafa] 'ventured'	اجتاز [ʔi-ʒtaaza] 'passed'
3b: Unrelated	وشح [waʃʃaha] 'adorned'	اجتاز [ʔi-ʒtaaza] 'passed'

Non-words

1. +Weak pseudo-root ⁴¹	ارتشى [ʔirtaʃaa] 'accepted to bribe'	راش [raaʃa]
2. +Phono/Ortho	هاجم [haaʒama] 'attacked'	انهمق [ʔinhamaqa]
3. Unrelated	نادى [naadaa] 'called'	استنغد [ʔistanyada]

3.5.4.3 Procedure and apparatus

This was the same as in the other experiments.

3.5.4.4 Results

Correct response times (RT) and mean error frequencies were averaged across participants and items. As in the other experiments, outliers were eliminated without replacement. This led to the elimination of 4.23% of the data. Both types of data were analyzed using separate analyses of variance (ANOVAs). The means, standard deviations, and error rates for all experimental conditions are presented in Table 9.

Three sets of two-way ANOVAs were run across subjects and items. The two independent variables were prime condition and list, each containing three levels. The first set of ANOVAs was run on the following three conditions: +Weak Root (either semantically-related or not), +Orthography/+Phonology, and Unrelated. The prime condition variable was not significant by subjects, $F_1(2, 66)=1.37, p>.05$ but was close to significance by items, $F_2(2, 135)=1.27, p=.09$. Error analysis also did not reveal any difference between conditions in all the ANOVAs run in this experiment.

Since I found a rather interesting effect of the morphology with opaque semantic overlap in the first experiment, I wanted to check if there was a similar tendency in this

⁴¹ Only a small number of weak verbs were included as primes to non-words first because they are not frequent in the language and second because including weak verbs in both targets and fillers might bias the responses.

experiment. I therefore ran another two sets of ANOVAs. In the first set of these tests I examined these conditions: +Weak Root+Semantics, +Orthography/+Phonology, and the Unrelated. Prime condition was not significant either by subjects ($F_1(2, 62)=.70, p>.05$) or items ($F_2(2, 63)=.18, p>.05$).

Table 9

Lexical Decision Reaction Times (RTs), Standard Deviations (SD), and Percentage Error Rates (% error) in Study 4C

Condition	RT(ms)	SD	% error
1. +Weak Root+/-Sem	739	88	6.7
2. +Orthog/+Phono	753	105	9
3. Unrelated	754	97	9.1
1a.+Weak Root+Sem	745	103	5.7
2a. +Orthog/+Phono	750	109	5.8
3a. Unrelated	738	96	7.7
1b.+Weak Root-Sem	732	82	5.5
2b. +Orthog/+Phono	742	111	9.8
3b. Unrelated	763	109	7.3

The other set of two-way ANOVAs included the other three conditions (+Weak Root-Semantics, +Orthography/+Phonology, The Unrelated) and interestingly yielded a main effect of prime condition: $F_1(2, 64)=3.34, p<.05$. Planned comparisons, using the deviation contrast test, revealed a marginally significant effect of only the morphological condition, $F_1(1, 32)=3.79, p=.06$.

3.5.4.5 Discussion

The results of this study are far from straightforward. Unlike in Study 1, where sound roots facilitated word recognition, weak roots did not lead to a clear priming effect. Responses in the morphological condition were nonetheless faster, even if they did not reach statistical significance; the morphological condition was 14 ms faster than the unrelated condition and 13 ms faster than the orthographic condition. I also found a significant priming effect of the morphological condition when I compared the items that shared only a weak root with targets to their equivalents in the orthographic and unrelated conditions. Given these results, we cannot draw any firm conclusion in favor or against the lexical status and role of weak roots. More experiments are definitely needed to clarify this issue. Possible approaches would be to replicate the present experiment using a greater number of experimental stimuli and to test the effect of adding an arbitrary consonant to the prime, as done by Frost et al. (1997).

An interesting result found in Study 1 and this study (4C) is that both weak and sound roots demonstrate significant priming mainly when they share morphemes and have very opaque semantic relationships with their targets. This evidence suggests that priming with the root is probably formal. The process of decomposition seems not to require a semantic relationship to activate words sharing the same root. It is, however, difficult to explain why there is little or no priming when primes share both a root and a semantic relationship with the target. One possible explanation that bears further investigation is that semantics somehow slows down the activation process.

The results of all these studies will be discussed in the light of theories of Arabic (and Semitic) morphology and theories of lexical processing in chapter 5. The following chapter reports on an empirical study of the status of consonants and vowels in the Arabic mental lexicon, which builds on the results reported on in this chapter.

Chapter Four

Studies Part II: Phonological Units

4.0 Introduction

This chapter, like the previous one, is empirical. It reports on an experiment that examined the cognitive validity of some phonological units in Arabic. Based on the root and pattern theory of Arabic morphology and the nature of Arabic orthography, as well as the results of the first online experiment, this study used a letter-circling task to test the status of consonants in relation to vowels and the status of root consonants in relation to affixal consonants. The general discussion of the results of this study and the studies presented in the previous chapter and their interpretation within the different theories of morphology and lexical processing are presented in the following chapter.

4.1 Study 5: The status of different letters/phonemes: An offline letter-circling task

We have seen the interaction of phonology and morphology when examining the phonetic matrix as a morphological unit. Another interaction between morphology and phonology is the perception and probably the representation of different phonemes in the Arabic lexicon.

This experiment advanced and tried to test two major hypotheses in relation to lexical processing/reading Arabic and by extension other Semitic languages⁴² that rely on a mainly consonantal orthography. The first hypothesis is related to the unique nature of the morphology of Semitic languages. If we adopt the traditional theory of Semitic morphology, which is supported by previous studies, as well as the results of Study 1 in this work, the consonantal root is taken to be the backbone of any derived word. The root carries the core meaning of all words from which they are derived after being intercalated with different templates. The second hypothesis is that because of the consonantal nature of the script of Semitic languages, readers of these languages might develop a bias towards consonants as more “important” than vowels.

⁴² The discussion is limited to Arabic and Hebrew because they are the most researched among Semitic languages especially from a psycholinguistic perspective.

I tested these two hypotheses by means of an offline letter-circling task that was administered to both native and nonnative speakers of Arabic to examine two major research questions (Research Questions 8 and 9):

8. What is the status of root consonants in relation to affixal consonants in the Arabic mental lexicon?

9. What is the status of vowels in relation to consonants in the Arabic mental lexicon?

The study also examined other satellite questions, namely whether the circling of letters is affected by the following independent variables: (i) native language (ii) age, (iii) explicit training, (iv) (non)productivity and (v) (dis)continuity of roots, and (vi) (in)frequency of words. The above major research questions and the related minor questions were broken down to several research questions and hypotheses, given in section 4.1.5.

4.1.1 Objectives

The main objective of this task was then to test whether pre-adolescent (grades 4 and 5), adolescent (grades 9 and 10) and adult Arabic speakers and adult non-native speakers perceive root consonants differently than other letters and whether that perception and the possible tacit knowledge underlying it develop with age and training. The independent variables were of two types: stimulus-related and participant-related. Participant-related variables included age, formal training, and first language background, while stimulus-related variables included root-productivity, root continuity, and word familiarity. The dependent variable was circling (root) letters.

4.1.2 Participants

The study included 220 participants who belonged to one of the following six groups. Group 1 included forty Arabic-speaking fourth graders and Group 2 included forty Arabic-speaking fifth graders. Group 3 included thirty Arabic-speaking 9th graders and Group 4 comprised thirty Arabic-speaking 10th graders. Forty Arabic-speaking university students made up Group 5 and forty adult students of Arabic as a Foreign Language made

up Group 6. The non-native speakers had a Romance (French, Spanish, Italian or Romanian) or a Germanic (English or German) first language. Their proficiency in Arabic was judged 'advanced' on the basis of a placement test designed and administered by the Bourguiba Institute of Modern Languages where they were enrolled for a summer course.

The first and second groups were treated as one group when their performance was compared with that of the adults to see whether there was an effect of cognitive maturation or training. Group 1 and Group 2 converged on two criteria. They were both in the same age range (9-12) and received no explicit training on the root. Such training is normally introduced in grade 6 and reinforced in grade 7. Younger students were not recruited because it was feared that the task would be very demanding for them. Likewise, Groups 3 and Group 4, who shared formal knowledge of the root and fell in the same age range (14-17), were blended when compared to younger students and adults. While they were taught the root extensively in grades 7 and 8, by grades 9 and 10 pedagogical attention moves to other areas of grammar. Thus, they were not very conscious of the root. The adult non-native advanced learners of Arabic, however, had just received extensive training in the root the previous year/level. An after-task discussion with some of them revealed that they were conscious of the root despite the teacher's and researcher's insistence that the task had nothing to do with their class. The adult native speakers, by contrast, were taught in a period when school programs did not focus on the root explicitly. They were taught that mainly verbs could be trilateral or quadrilateral, but they were not given explicit explanation and practice (including extraction) of the root as is current practice. To sum up, at the time when the experiment was done, only adolescent native speakers (grades 9 and 10) and adult non-native speakers were having or had just had an explicit training about roots and patterns.

Both preadolescents (4th graders and 5th graders) and teenagers (9th graders and 10th graders) were recruited in schools in (lower) middle class areas in the towns of Le kef and Bizerta, Tunisia. The native adults were second-year students of English at the Institut Supérieur des Sciences Humaines et Sociales, Tunis and the L2 adults were participating in a summer school at the Institut Bourguiba des Langues Vivantes, Tunis.

4.1.3 Stimuli

The stimuli consisted of thirty-four words, divided into two sets on the basis of familiarity (17 familiar and 17 less familiar words) and productivity (13 productive and 21 less productive) (see Appendix G). The words included a balanced number of nouns, verbs and adjectives. They contained either continuous or discontinuous root-consonants (16 continuous vs. 19 discontinuous). Continuous roots made an orthographic unit in words, but discontinuous roots were disrupted by other letters that were not root consonants/letters. The words also contained both sound and weak roots. Weak roots were, however, few in number (one word with a deleted underlying glide and two with a geminated second consonant). There was also one word with a quadrilateral root. To adequately mask the root, most words (32 out of 34) had at least as many affixal and cliticized consonants and vowels as root consonants (see Appendix H). Most words contained at least one orthographic vowel. The clitics were mainly prepositions and pronouns. To further mask the root, I included some words that contained two similar consecutive letters, one being a root consonant and the second an affixal consonant or a long vowel. All words were presented without the diacritics (representing the short vowels).

The stimuli were taken from Wehr's (1979) Arabic-English dictionary. First, 69 words were chosen on the basis of their productivity. Names of places (e.g. Nabataya) were not included. To avoid ambiguity, homonymous words were not selected. Productivity was defined as the number of all derivatives (including plurals) in the dictionary entries related to the same root of a selected word. On the basis of an examination of the dictionary entries, a criterion was set as to whether a word was of high or low productivity. It was found that the most productive words had around 35 derivatives. The least productive roots had one derivative. These extreme case root types were few in number. To obtain a clear-cut distinction between the high and low productivity roots, a rather conservative criterion was opted for. Only words that had ten derivatives or less were considered of low productivity. Likewise, only words that had 15 derivatives or more were considered of high productivity. Moreover, most words chosen had a productivity score higher than 15 in the case of the high productivity set and lower than 10 in the case of the low productivity set. This productivity-based distinction was

meant to test a hypothesis, associated with connectionism (e.g. McClelland and Rumelhart, 1981), which suggests that roots are abstracted as a result of familiar exposure, or according to network theorists as a result of abstraction from many morphologically-related words.

The selected 69 words were then given to 20 Arabic-speaking university students to be ranked in terms of familiarity on a 7-point scale where 1 meant very unfamiliar and 7 meant very familiar (see Appendix G). The verbs were presented in their common citation form of third person (either perfective or imperfective) and the nouns and the adjectives were given in either their singular or plural and feminine or masculine forms. A word was considered familiar only if it was given a score equal to or higher than 4 by at least 85% of the judges. A word was counted unfamiliar if it was given a score lower than 4 by at least 60% of the judges. On the basis of this familiarity-judgment test, 34 words out of the 69 were selected: 17 familiar and 17 unfamiliar. This final selection took into consideration, in addition to familiarity scores, two other factors. First, the chosen words had to have a very low or a very high productivity score to clearly fit into the high productivity or the low productivity set. Second, a balanced number of verbs, adjectives and nouns was included. There were 14 verbs, 10 nouns and 10 adjectives.⁴³ A correlation between familiarity and productivity scores was obtained to ascertain that these two notions were separate.⁴⁴ Such correlation showed that there is almost no relation between productivity and familiarity ($r = 0.06$). The words had also a balanced number of continuous (17) and discontinuous (17) roots.

4.1.4 Procedure

The procedure for this task was based on a study on Hebrew by Ephratt (1997), in which participants were asked to color letters. Instead of coloring letters in words, the participants in this study were asked to circle at most three letters of their choice in every word. Coloring was judged inappropriate for adults, as it is often associated with young learners. Besides, coloring was feared to be inconvenient in at least two ways. First, it could distract the young participants. Second, it could lead to incomplete coloring of

⁴³ Adjectives in Arabic are similar to nouns. This explains the fact that Arab grammarians did not classify adjectives as separate categories.

⁴⁴ Ohlander (1976, chapter 7) thinks that statistical frequency is distinct from productivity.

certain letters, which would cause ambiguity when coding, especially as Arabic letters, unlike in Hebrew, are attached in writing. Circling was opted for instead, not only because it had less risk of inconvenience, but also because it was/is a common technique in language, science, or math exercises.

Ephratt (1997) based his coloring task on the Maluma Takete Test (Köhler, 1947, pp. 224-227), which claimed that people perceive things and give them names and associations that are built on subjective experience. The hypothesis in this study is that if root consonants were essential in reading, they would unconsciously be perceived differently in “arbitrary” letter circling.

The words were typed in bold in 16 point letters and randomly presented in the same order for all participants. Before distributing the sheets, the participants were informed that the task had nothing to do with their course; would not be graded; and its use was for research purposes only. In the case of school children, caution was taken not to administer the task in/after a grammar class. There was no time limit on the completion of the task, which participants completed easily and quickly.

For calibration, the task was pre-tested on 5 fifth graders to both ensure that they understood the instructions and the stimuli and to assess the time necessary to complete the task. The informants were told to circle a maximum of three letters in each of the given words. No additional information was provided. Thus, they were not told to “circle the most important letters in each of the following words”, because such information might have revealed the linguistic nature of the task.

4.1.5 Research questions and hypotheses

(1) Do native speakers of Arabic circle root consonants more than affixal and cliticized letters?

H₀: There is no significant difference between the circling of root consonants and affixal and cliticized letters.

In addition to comparing root consonants to other affixal and cliticized letters, other criteria, namely consonants vs. vowels, and odd letters vs. even letters, were examined (Research Questions 5 and 6 respectively). In a similar study on Hebrew using a similar task, Ephratt (1997) reported that both young and adult native speakers of Hebrew selected

root consonants significantly more than affixal letters. Thus, I predict that the null hypothesis will be rejected.

(2) Do young (preadolescents and teenagers) and adult native speakers who had no explicit training regarding the root differ in the circling of root consonants?

H_0 : There is no significant difference in the circling of root consonants between teenagers and adult speakers of Arabic.

H_0 : There is no significant difference in the circling of root consonants between preadolescents and adult speakers of Arabic.

Teenagers had just had formal training and adults had been exposed more to the language. I expect that formal training and long exposure to the language will cancel each other's effect. I anticipate that the first null hypothesis will not be rejected. However, I expect the rejection of the second null hypothesis, because adults had been exposed more to the language, in addition to the obvious cognitive differences.

(3) Is there a difference in the circling of root consonants between native speakers who have had a formal training regarding the root (9th and 10th graders) and those who have not (4th and 5th graders)?

H_0 : There is no significant difference in the circling of root consonants between native speakers who have had a formal training regarding the root and those who have not.

Given the fact that training often helps in morphological awareness (e.g. Carlisle, 1995), I predict the rejection of the null hypothesis.

(4) Is there a difference in the circling of root consonants between non-native and native speakers matched for age (i.e. adult non-native vs. adult native speakers)?

H_0 : There is no significant difference in the circling of root consonants between non-native and native speakers matched for age.

If we assume that native speakers have tacit knowledge of the root, we might expect it to balance out the explicit knowledge of the non-native speakers and therefore predict no difference between the two groups.

(5) Do native speakers of Arabic circle non-root consonants more than vowels?

H_0 : There is no significant difference between the circling of non-root consonants and vowels.

Because Arabic, like most Semitic languages, has a mainly consonantal orthography, readers are likely to develop a bias towards consonants and therefore give them more attention than vowels. In fact, studies in languages such as English, whose orthography relies on both consonants and vowels, suggest that vowels may be dispensable (e.g. Shimron, 1993). Thus, I predict the rejection of the null hypothesis.

(6) Do native speakers of Arabic circle odd and even letters differently?

H_0 : There is no significant difference between the circling of odd and even letters.

I predict no difference between odd and even letters, since this is a nonlinguistic factor.

(7) Is there a significant difference between productive and non-productive words?

H_0 : There is no significant difference in the circling of root consonants between productive and non-productive words.

If we follow a morpheme-based theory as well as results of priming, all words are represented as and/or related to roots, but certain roots and patterns are more used than others. Feldman, Frost, and Pnini (1995) found that it was easier to extract a word pattern conjugated with a productive root than with one conjugated with a non-productive root. Since this was only a matter of ease, I predict the rejection of the null hypothesis.

(8) Is there a significant difference for native speakers in the circling of root consonants in familiar versus unfamiliar words?

H_0 : There is no significant difference in the circling of root consonants in familiar versus unfamiliar words.

Since this task is offline (does not test real time performance) and is assumed to test perception, I expect that the null hypothesis will not be rejected.

(9) Is there a significant difference between the circling of continuous and discontinuous root consonants?

H_0 : There is no significant difference between the circling of continuous and discontinuous root consonants.

Lexical decision studies (e.g. Feldman & Bentin, 1994) have reported no difference between disrupted and non-disrupted roots. Thus, I predict that the null hypothesis will not be rejected.

4.1.6 Results

The circled letters were tallied in each category: root consonants vs. other letters, vowels vs. non-root consonants, and even vs. odd letters by item and participant. Some letters were, therefore, coded under more than one category. The number of circled letters for each category was counted as a percentage of the actual number of the existing letters of that category in a word. For instance, the number of circled root consonants for each participant was counted as a percentage of the actual number of root consonants in all experimental words. The raw scores for each group of informants were used to answer the questions and the hypotheses related to them.

Question 1:

To test the hypothesis and answer the first and main question regarding the difference in the selection of roots versus other letters (including affixes and clitics, both consonants and orthographic vowels), an ANOVA was run to test root vs. other letter selection as well as the effect of age among native speakers. The results revealed a significant main effect of age: $F(1, 177)=174.31, p<0.001$ as well as an interaction between age and type of letter (root vs. affix): $F(2, 177)=8.38, p<0.001$. Planned comparisons (Tests of simple effect) showed that all three groups (preadolescents, teenagers and adults) selected root-consonants significantly more than other letters. The results of the tests of simple effect were as follows: $F(1,177)=58.42, p<0.001$; $F(1,177)=30.11, p<0.001$ and

$F(1,177)=91.18, p<0.001$, for the preadolescents, the teenagers and the adults respectively. The results are therefore as we expected, that the null hypothesis would be rejected. Means of selected root-consonants vs. other letters are given in Table 10.

Table 10

Means of Root and Other Letter-selection by Preadolescence, Teenage, and Adult Native Speakers⁴⁵

	Preadolescents	Teenagers	Adults
Root	46%	41%	59%
Non-root letters	29%	27%	29%

Questions 2 and 3

As for the effect of age, planned comparisons showed that adults selected root consonants significantly more than preadolescents ($F(1,177)=11.40, p<0.001$). This is in line with my first hypothesis related to Research Question 2. In contrast, the second hypothesis is not borne out by the results as adults did better than teenagers ($F(1,177)=18.74, p<0.001$). The null hypothesis related to Question 3 was also maintained, which I did not expect. In fact, there was no significant difference between the teenagers and the preadolescents.⁴⁶ Since there was no significant difference in root selection between trained teenagers and untrained preadolescents, we may conclude that training has no effect among native speakers.

The same results were found when I further examined whether there was a more fine-grained difference in terms of age and training (Research Questions 2 and 3), by means of another ANOVA with five groups. Both the group of the preadolescents and the group of the teenagers were divided into two groups, fourth and fifth graders for the first

⁴⁵ Note that the percentages are of the actual number of the corresponding category. That is, 60% of non-root consonants refers to the percentage of circled non-root consonants out of the total of non-root consonants and not the total of all letters.

⁴⁶ Only significant results are reported. The ANOVA of odd vs. even letters revealed non-significant main effect of letter type: $F(1, 177)=0.92, p>0.34$

and ninth and tenth graders for the second. The results revealed an interaction between type of letter and grade/age: $F(4, 175)=4.25, p<0.005$. Apart from the difference between the adults and both the preadolescents and the teenagers reported above, planned comparisons between the five groups showed a difference between 9th and 10th graders. Grade 9 students selected the root significantly more than grade 10 students: $F(1, 175)=5.68, p<0.05$. The difference, however, was not as robust as in the other comparisons.

The planned comparisons of the relation between age and letter type revealed that all participants, even the fourth graders, selected root consonants significantly more than non-root letters. There was a significant difference in the root vs. non-root selection for fourth graders: $F(1,175)=33.85, p<0,001$, fifth graders: $F(1,175)=24.42, p<0.001$, ninth graders: $F(1,175)=14.80, p<0.001$, and tenth graders: $F(1,175)=15.03, p<0.001$. The means for root and non-root selection are shown in Table 11.

Table 11

Means of Root and Other Letter Selection by 4th Graders, 5th Graders, 9th Graders, 10th Graders, and Adult Native Speakers

	4 th graders	5 th graders	9 th graders	10 th graders	Adults
Root	47%	44%	45%	37%	59%
Non-root	29%	29%	31%	23%	29%

Question 4:

Another ANOVA was run to test whether there was a difference in letter selection between the very-well trained non-native speakers and native speakers matched for age (Research Question 4). The analysis revealed an interaction between letter selection and language background (native vs. non-native): $F(1,78)=8.39, p<0.005$. Planned comparisons showed that both native and non-native speakers selected root consonants significantly more than other letters ($F(1, 78)=35.79, p<0.001$ for native speakers and $F(1, 78)=101.60, p<0.001$). Non-native speakers, however, did so significantly more than native speakers

($F(1,78)=4.34$, $p<0.05$). This also did not support my hypothesis, that there would be no difference. The means of letter selection are displayed in Table 12.

Table 12

Means of Root and Non-root Letter Selection by Native and Non-native Adult Speakers

	Native adults	Non-native adults
Root consonants	59%	69%
Non-root letters	29%	19%

Questions 5 and 6

In addition to examining the root vs. non-root letter selection, I also examined whether there was a difference in the selection of non-root consonants vs. vowels (Research Question 5), as well as the selection of odd vs. even letters (Research Question 6) by native speakers. Only the effect of non-root consonants vs. vowels was found to be significant: $F(1,177)=614.11$, $p<0.001$), which supports my two hypotheses related to Questions 5 and 6.

There was, however, no interaction between age and letter selection. Therefore, t-tests were opted for to examine whether there was a difference between consonant and vowel selection among native speakers. The means for non-root consonant and vowel selection are shown in Table 13, below. The t-tests revealed that preadolescence, teenage and adult native speakers all selected non-root consonants significantly more than vowels. The t values were $t(79)=18.70$, $p<0.001$; $t(59)=12.67$, $p<0.001$ and $t(39)=13.44$ $p<0.001$, for the young, the teenagers and the adults respectively. Non-native speakers also selected non-root consonants significantly more than vowels: $t(39)=16.19$, $p<0.001$. However, a learner of Arabic as a second language⁴⁷, who did not take part in the study, pointed to me that she did not consider the glides/long vowels as letters but rather as a lengthening

⁴⁷ The nonnative speaker who made these comments is actually Pr. M-H. Côté.

markers. This is could have been a strategy that some nonnative speakers used. Thus, I should be cautious not to draw a strong conclusion from this result as to the relative salience of consonants versus vowels.

Table 13

Means of Non-root Consonant and Vowel Selection by Native Speakers

	Young	Teenagers	Adults
Non-root consonants	60%	57%	65%
Vowels	14%	13%	17%

Questions 7, 8 and 9

As expected (in my hypotheses), a by-item-analysis of variance (ANOVA) for all groups (native speakers) showed that all three null hypotheses related to (i) frequency of words (Research Question 7), (ii) productivity (Research Question 8) and (iii) continuity of roots (Research Question 9) could not be rejected. There was no significant difference for frequency of words ($F(1, 32)=0.013, p>0.911$), productivity ($F(1, 32)= 0.53, p>0.819$) and continuity of the root ($F(1, 32)=0.50, p>0.485$). The means for each test are presented in Tables 14, 15, and 16.

Table 14

Percentage of Root-selection in Familiar and
Less Familiar Words by Native Speakers

Familiar words	Less familiar words
51%	52%

Table 15
Percentage of Root-selection in Words with Productive
and Less Productive Roots by Native Speakers

Words with productive roots	Words with less productive roots
52%	51%

Table 16
Percentage of Root-selection in Words with Continuous and
Non-continuous Roots by Native Speakers

Words with continuous roots	Words with non-continuous roots
54%	49%

4.1.7 Discussion

The results have revealed that Arabic speakers, both young and old, trained and untrained, circled root consonants significantly more than other letters and non-root consonants more than vowels. These findings support our hypothesis that certain letters are perceived differently than others. Root consonants seem to be more salient and therefore more important for them. This could be interpreted as evidence for the morpheme-based theory of Arabic morphology, which gives roots a separate status. Likewise, the fact that native speakers circled non-root consonants significantly more than vowels meets our prediction that because Arabic orthography is mainly consonantal, consonants are likely to be more prominent than vowels. The fact that non-native speakers also selected non-root consonants more than vowels has two possible explanations. First, these advanced learners have developed the same bias to consonants as their native counterparts. Second, learners of languages like English whose orthography is both vocalic and consonantal have a similar bias as they could dispense with vowels in reading (Shimron, 1993, Lee, Rayner, &

Pollatsek, 2001). Yet, as I mentioned above and in the light with the comments of a non-native who did not take part in the study, glides used after short vowels could be interpreted as lengthening markers and not as letters. Further research is needed to further test the hypothesis that consonants are more salient than vowels.

Contrary to my hypothesis related to Research Question 4, however, there was no difference between untrained and trained participants, which suggests that explicit training seems to have little effect on native readers' perception of root consonants, at least in this task. This should not exclude the importance of training, which apparently had a major effect on non-native speakers. Given their high awareness of the importance of the root in their learning of Arabic as a Foreign Language and because of the immediate effect of their training non-native speakers, in contrast to native speakers, might have approached the task with a conscious awareness that the goal of the task might be related to the root. There seems also to be an effect of cognitive maturity, because adult native speakers selected root consonants more than both the young and the teenagers.

That the frequency of words and the productivity and continuity of roots in words had no effect on the selection of root consonants is an expected result. For one thing, previous results of online experiments showed that the discontinuity of roots had no effect (e.g. Feldman & Bentin, 1994). Productivity of roots and frequency of words were found to affect only the ease of processing words in online experiments (e.g. Feldman et al., 1995).

Overall, the findings of this study validate the results reported by Ephratt (1997) for Hebrew in relation to the saliency of root consonants in comparison to other letters. My finding that (non-root) consonants are more "prominent" than vowels appears to support my hypothesis related to the unequal status of different letters in Arabic, and potentially other Semitic languages. Further research using different methodology is, however, necessary to ascertain that root consonants and consonants in general are more salient and more important to readers of Arabic and other Semitic languages. Possible directions for future research include eye-movement and lexical processing experiments.

Chapter Five

General Discussion and Conclusions

5.0 Introduction

This chapter sums up the results reached in the study and proposes their implications for theories of morphology and theories of lexical processing and representation as well as future research. The first section provides a summary and a general discussion of the results obtained in the present study in the light of theories of Arabic (and Semitic) morphology. The second section outlines the major implications of the results for theories of lexical representation and processing. The third section provides some recommendations for future research.

5.1 Summary of results and implications for theories of morphology

This study examined the cognitive relevance of morphological and phonological units in the Arabic mental lexicon. The morphological units included the root, the etymon, the phonetic matrix, and the pattern. The phonological units were root consonants, affixal consonants, and vowels. The morphological units were examined in lexical processing by means of a lexical decision task with masked priming and an SOA of 50 ms. The phonological units were examined by means of an offline pencil-and-paper task.

This work examined the following research questions:

1. What is the role of the root in Arabic lexical processing and is it distinct from the effect of orthography and semantics (Study 1)?
2. What is the role of (ordered and non-ordered) etymons compared to orthographic overlap in Arabic lexical processing (Study 2)?
3. What is the role of the phonetic matrix in Arabic lexical processing compared to similar phonological overlap (Study 3)?
4. What is the role of sound and weak patterns in Arabic lexical processing (Study 4A-B)?
5. What is the role of weak roots in Arabic lexical processing and is it distinct from orthography and semantics (Study 4C)?

6. Are there graded priming effects that correspond to the gradation in the formal overlap in and across roots (form and meaning vs. form; sound root vs. weak root) and etymons (ordered vs. non-ordered)?
7. How abstract can morphological processing be (Studies 1, 2, 3, and 4)?
8. What is the status of root consonants in relation to affixal consonants in the Arabic mental lexicon (Study 5)?
9. What is the status of vowels in relation to consonants in the Arabic mental lexicon (Study 5)?

The first seven questions focused on the morphological units and the last two examined the phonological units. I will discuss the results related to the morphological units first. In doing so, I will present the three major theories of Arabic morphology and then discuss their theoretical tenets in light of the empirical results.

The three major theories of Arabic morphology are the word-based theory, the root and pattern theory, and the etymon theory. The last two could also be called morpheme-based theories. The word-based theory claims that the process of word formation is based on the stem. The root in these theories is considered a part of a paradigmatic relation between words (Bat-El, 1994 and Ussishkin, 1999 for Hebrew and Ratcliffe, 1997 and Benmamoun, 1999 for Arabic). Thus for this theory, the relevant morphemes are stems and concatenative morphemes like the regular plural marker 'at'. Roots and patterns, which are considered the backbone of most derivations in a root and pattern theory, are excluded in this theory.

In contrast with the word-based theory, word-formation in the root and pattern theory, as the name indicates, is based on the mapping of three consonant roots into partly specified patterns. This view is shared by both the structuralists (e.g. Cantineau, 1950) whose work is also inspired by the work of the old Arab grammarians and the proponents of the prosodic theory of morphology (e.g. McCarthy, 1981 and McCarthy & Prince, 1990a, 1990b). There is a small difference between the classical root and pattern theory and the prosodic morphology hypothesis, which will not affect our interpretation of the results. Whereas in the traditional structuralist view the vowels and the affixal consonants

of the patterns are specified, they are represented on separate morphemic tiers in the prosodic morphology hypothesis.

The other morpheme-based hypothesis is the etymon theory. Like the prosodic morphology hypothesis, the etymon theory relies on the interweaving of morphemes represented on separate tiers. The etymon theory differs from other morpheme-based theories in that it proposes a two-consonant morpheme, the etymon, as a substitute for the root. Unlike the root, the consonants of the etymon can be non-ordered. The third consonant of what is traditionally known as the root is considered to be either augmented/extended or spread/geminated and in both cases dictated by the template/pattern, a notion also adopted in this theory. The etymon itself is the phonemic instantiation of a far more abstract bundle of phonetic features that Bohas calls the phonetic matrix.

The first research question examined whether the *root* had a priming effect significantly different from orthography/phonology and semantics and therefore whether it could be represented in the Arabic mental lexicon. This question was examined in Study 1 and the results clearly showed that the priming effect of the root was different from orthography and semantics. This finding corroborates the results of previous studies that examined the priming effect of the root in lexical processing (Mimouni et al., 1998 and Boudelaa & Marslen-Wilson, 2001b) and its manipulation in speech errors of normals (Berg & Abd-El Jawad, 1996) and aphasics (Prunet et al., 2000). The findings of all these studies attribute cognitive validity to the root in Arabic, thus providing external evidence for the morpheme-based theories. These include the classical root and pattern theory, the prosodic morphology hypothesis and the etymon hypothesis. Although the root is different from the etymon, this result is not incongruent with the etymon theory which considers the third consonant a requirement of the pattern. The word-based theory, by contrast, is not supported by this result.

The second research question examined the notion of the *etymon*. Results showed a clear priming effect with a balanced number of ordered and non-ordered etymons. This result replicates a similar study done by Boudelaa and Marslen-Wilson (2001a), who used lexical decision tasks with either a masked or a cross-modal priming paradigm. This finding is in line with the etymon theory, but it is difficult to fit within the root-and-pattern

theory. It is totally incompatible with the word-based theory. It is, however, important to note that priming was not obtained with the non-ordered half of etymon-related primes. Moreover, previous research on the etymon showed that native speakers have no conscious knowledge of the etymon (Bentin & Frost, 2001) and that, unlike the root, it has no trace in the speech errors of an aphasic person (Idrissi & Kehayia, 2004). This lack of evidence for the etymon in a conscious pencil-and-paper task and in aphasic speech errors, as well as the lack of priming with non-ordered etymons, casts some doubt on the cognitive relevance of the etymon.

The cognitive relevance of the *phonetic matrix*, the more abstract morpheme underlying the etymon, was the subject of the third research question and was tested in Study 3. The test revealed no priming effect of the phonetic matrix. This result is predicted by the word-based theory, the root-and-pattern theory and the prosodic morphology hypothesis. This finding cannot be easily accommodated within the etymon theory. But because there was priming with etymons, it could be argued that the lack of priming with matrices is due to a restriction on abstraction in lexical processing.

The role of *sound and weak patterns* in lexical processing was the subject of the fourth research question. The answer to this question was provided by the results of Study 4A and Study 4B. Neither sound nor weak patterns primed targets sharing sound or weak patterns, respectively. Previous studies do not support a stable effect of the pattern in Arabic lexical processing. Boudelaa and Marslen-Wilson (2001b) who used a masked priming paradigm found priming with verbal patterns at SOA 48 ms. but not at SOAs 32, 64 or 80 ms. Using a similar method, Abu-Rabia and Awwad (2004) did not find any priming with patterns at SOA 50 ms. The lack of priming by patterns is seemingly counter to all morpheme-based theories of Arabic morphology, which consider the pattern essential in word-formation. But, it could be that the pattern is used at a later stage of the word recognition process.

The fifth research question tested whether *weak roots* facilitate word recognition. The answer to this question is not definitive. I did find priming (14 ms) in the main condition with primes that were either semantically and morphologically related or only morphologically-related to their targets, but this priming did not reach significance. However, significant priming was found when the +Weak Root-Semantics primes were

compared to their orthographic and unrelated counterparts. Further experiments are needed before any firm conclusion on the role of weak roots in lexical processing in Arabic could be made.

To sum up, the results of this study corroborate previous results on the cognitive validity of the root in Arabic either in production or visual perception. Evidence for the etymon is not straightforward. While etymons did facilitate lexical decision as found in a similar previous study, the priming was mainly due to the overlap in the ordered etymons and not to the overlap in the non-ordered etymons. Moreover, there was no priming with the related notion of the phonetic matrix. Furthermore, two previous studies, one that examined native speakers' conscious knowledge of the etymon and the second the speech errors of an aphasic, did not find any evidence for the etymon. The weak root facilitated lexical decision only when primes and targets shared a weak root and an opaque semantic relationship. As for patterns, they had no priming effect.

On the whole, these results about the role of roots, etymons, matrices, and patterns in Arabic lexical processing provide external evidence for morpheme-based theories of Arabic morphology. Based on the results of this study and previous studies, the root has a cognitive relevance in the Arabic mental lexicon, which is in line with a morpheme-based theory of Arabic morphology that incorporates roots as essential in derivation. The priming effect found in ordered etymons supports the etymon theory and is difficult to interpret within the framework of a theory that relies on roots and patterns such as the classical root and pattern theory or the prosodic morphology hypothesis. But given the lack of priming with phonetic matrices as well as the lack of evidence from previous studies, the etymon needs more investigation.

The results with respect to phonological units have shown that root consonants are more salient than other letters/phonemes (either affixal consonants or (orthographic) long vowels). The latter results provide more evidence for a morpheme-based theory, particularly one based on roots. Yet, they cannot be interpreted against the etymon theory.

Research questions 8 and 9 concerned the cognitive status of *consonants* and *vowels* in the Arabic mental lexicon, respectively. To answer these questions, I tested whether root consonants were more salient (circled more in an offline experiment) than other letters and whether affixal consonants were circled more than orthographic vowels.

The results revealed that root consonants were circled significantly more than other letters and that affixal consonants were circled significantly more than vowels. The first finding supports a morpheme-based theory of Arabic based on roots, but it does not necessarily run against the predictions of an etymon-based theory. The second finding is in line with our hypothesis that partly because of the high importance of consonants in most languages and mainly because of the effect of Arabic orthography, consonants tend to be more salient than vowels. The latter finding is in line with previous results in both Semitic and Indo-European suggesting that consonants are different from vowels. In Semitic languages, there has been evidence that short vowels when added in the vowelised version of orthography do not play a very important role (Abu-Rabia & Siegel, 1995 for Arabic and Koriat, 1984 and Bentin & Frost, 1987 for Hebrew). As for Indo-European languages, Berent and Perfetti (1995) and Lee, Rayner, and Pollatsek (2001) found that consonants had a more important role than vowels in early lexical processing of English. Caramazza et al. (2000) who examined the speech of Italian aphasics found that either consonants or vowels were impaired. Caramazza et al. suggested that vowels and consonants are represented and accessed differently. Yet, it could be that at least nonnative speakers do not consider the long vowel letters but simply lengthening markers, as one nonnative speaker who did not take part in the study pointed out to me. Thus, further research is needed to investigate more the question of the salience of consonants versus vowels.

The sixth and seventh research questions are related to theories of lexical processing and representation and will be discussed in the following section.

5.2 Implications for theories of lexical representation and processing

The discussion of the implications of the empirical findings of this work to theories of lexical processing will address two main issues. The first concerns which theory fares better in interpreting these results and is addressed from the perspective of the gradation of priming effects (Research Question 6). The second issue concerns the degree to which lexical processing can be abstract and what that tells about the relationship between linguistic and psycholinguistic theories (Research Question 7). Before addressing either issue, a general overview of the main theories of lexical processing is in order.

As discussed in the first part of Chapter Two, there are four major theories/hypotheses about how lexical items are processed and represented. The first is the whole word hypothesis. The proponents of this hypothesis suggest that words are fully listed. Morphological relations are not represented and therefore not used in lexical access and production. The second hypothesis, the morpheme-based (decompositional) hypothesis, is in sharp contrast with the first hypothesis. In the morpheme-based hypothesis, words are believed to be accessed in the central system through their decomposed morphemes (bases after being stripped of affixes in concatenative languages). The third hypothesis is a hybrid one and is referred to as the dual access hypothesis. The main tenet of this hypothesis is that words are accessed either as whole units or through decomposed morphemes. This hypothesis was adopted by Mimouni et al. (1998) to account for their results in Arabic. The fourth main hypothesis of lexical processing is the distributed connectionist hypothesis. According to this hypothesis, word recognition occurs through the parallel activation of different units that may represent phonemes/graphemes or even phonetic features as well as semantic features. The Morphological priming effects are the result of the activation of some of the units that are used in the activation pattern of the target word. The distributed connectionist hypothesis predicts a grading of priming effects that correlates with the amount of phonological/orthographic and semantic overlap between primes and targets. Connectionist models can be localist as is the case of any of the other mentioned hypotheses, which adopt an entry-opening metaphor in lexical access. In a localist connectionist model, the units represent morphemes and words instead of phonemes and features. Boudelaa and Marslen-Wilson (2004a) suggested that their findings for Arabic morphological processing could be best accounted for by a distributed connectionist model similar to the one proposed by Plaut and Gonnerman (2000).

In this work, priming was found with sound roots but not with weak roots, although weak roots that shared little meaning with their targets did facilitate word recognition. It was also found that most of the priming effect found in the case of sound roots was between the prime-target pairs that shared a very opaque semantic relationship. There was also priming with ordered etymons but not with non-ordered etymons. Phonetic matrices and word patterns did not facilitate word recognition. These results are not exhaustive enough to support one theory or another, but it would be helpful to discuss them within the

theoretical tenets in each of the theories of lexical representation and processing mentioned above.

Morphological priming, gradation of priming, and theories of lexical processing

The main result of this study that corroborates what has been found in previous studies on Arabic in lexical processing (Mimouni et al., 1998 and Boudelaa & Marslen-Wilson, 2001b) and in speech errors of normals (Berg & Abd-El Jawad, 1996) and aphasics (Prunet et al., 2000) is the cognitive relevance of the root. The root is therefore not only manipulated in production but is very likely used in lexical processing.

This result cannot be explained by the whole word/full-listing hypothesis, which predicts no priming with roots or any other morpheme. The other theories, the decompositional theory, the dual-access theory and the connectionist theory (either localist or distributed) have no problem explaining the priming effect found with roots. Both the morpheme-based/decompositional theory and the dual-access theory postulate a prelexical decomposition process. The fact that there was a priming effect of the root and not of the pattern suggests that decomposition, if we assume it happens in the case of roots, does not depend on the exhaustive decomposition of the word into its two main morphemes, root and pattern. It seems that the root is extracted in a nonlinear way from the word in which it is intercalated. The connectionist theory explains the priming by the root as a result of preactivation of the nodes that are responsible for the recognition of the target sharing that root.

The results concerning the etymon are less straightforward than the ones concerning the root and are therefore more difficult to interpret. This study has replicated the findings of Boudelaa and Marslen-Wilson, (2001a) about the priming effect of the etymon (a two-consonant root/root-like morpheme). If we accept that the etymon is a morpheme,⁴⁸ this result, like the one related to the root, causes a problem only for the whole-word hypothesis. Yet, the new finding about the etymon in this study is that priming does not occur when the shared etymon is non-ordered (i.e. its phonemes do not have the same order in primes and targets). While this result could be handled by a connectionist

⁴⁸ The fact that native speakers have no conscious knowledge of the etymon (Bentin & Frost, 2001) and that there is no evidence of its use in production (Idrissi & Kehayia, 2004) undermines the conclusion that the etymon has a cognitive validity in the Arabic mental lexicon.

model, theories that adopt a lexical-entry-opening metaphor in word recognition (i.e. decompositional and dual-access theories) cannot easily cope with it. Theories that adopt a lexical entry opening process are localist and assume an-all-or-none priming effect of morphemes. If the etymon is a morpheme it should facilitate access regardless of whether it is ordered or non-ordered. Yet, as will be discussed below, the absence of priming with nonordered etymons could be due to limits on abstractness in lexical processing or to the current methodology.

One of the objectives of this work (Research Question 6) was to see if there is a gradation in priming effects that correlates with the amount of formal and semantic overlap between primes and targets, a result predicted by a distributed connectionist hypothesis. The gradation was examined within the same experiment and across experiments. In particular within experiments (in Study 1 and Study 4C), gradation was examined by contrasting prime-target pairs that shared either roots and a transparent semantic relationship or roots and an opaque relationship. Across experiments, the comparison included the following similar morphemes: sound roots (Study 1), weak roots (Study 4C), and etymons (Study 2). The comparison included the correlation of overlap in the number of morpheme consonants and priming effect, as well as the correlation between form and priming time in the orthographic conditions.

Examining whether there is any gradation of priming effects will allow us to compare the predictions of two main types of theories of lexical representation and processing: theories that assume a lexical entry-opening process in word recognition (i.e. the decompositional theory and the dual access theory) and the distributed connectionist theory. The distributed connectionist hypothesis predicts gradient priming effects that correlate with the amount of phonological/orthographic and semantic overlap between primes and targets.⁴⁹ The decompositional and the dual access hypotheses, both localist, perceive the lexicon as a set of interrelated words through their shared morphemes and would expect priming to be either existent or nonexistent depending on whether or not the morpheme used in lexical access has any cognitive validity.

⁴⁹ According to the distributed connectionist hypothesis, the correlation between priming and formal overlap also depends on the frequency of the co-occurrence of the shared phonemes/graphemes. Because there are no statistical counts of letter/phoneme clusters in Arabic, this question could not be examined in this study.

The gradation of form and meaning overlap was examined in Study 1 (priming with sound roots) and Study 4C (priming with weak roots). The amount of priming by primes that shared both a morpheme (a sound root in Study 1 and a weak root in Study 4C) and a transparent semantic relationship with their targets was compared to that of primes that shared a morpheme and an opaque semantic relationship. The amount of priming is evaluated in milliseconds and percentage in relation to the mean response time. For instance in the +Root +Semantics condition in Study 1, the response time was 3 ms. faster than the mean response time; this priming time is equivalent to 0.39% of the mean response time (764 ms.). The percentage of priming in relation to the mean is used to allow comparisons across experiments.

Table 17

Amount of Priming in the Morphological Conditions Relative to the Mean Response Time in Study 1 and Study 4C

	Formal overlap in +Root+Sem	Priming in +Root, +Sem	Formal overlap in +Root-Sem	Priming in +Root, -Sem
Study 1	3.13 letters	+3 ms.	3.13 letters	+21.33 ms.
	3.13 phonemes	0.39 %	3.13 phonemes	2.96%
Study 4C	3.29 letters	-0.67 ms.	2.96 letters	+13.66 ms.
	3.38 phonemes	0.1%	3 phonemes	1.83%

Everything being equal, the added semantic effect in the +Root + Semantics condition will be expected to lead to more priming according to a distributed connectionist hypothesis. The results shown in Table 17 run totally against the hypothesis of gradation of priming effects due to a conspiracy of form and meaning overlap. Not only did the added semantic overlap not lead to any increase in the amount of priming, but priming actually decreased where the morphological overlap between primes and targets was also coupled with a semantic overlap.

Across experiments, I examined whether the priming effects of the following morphemes, sound roots, weak roots and etymons correlated with the amount of form overlap between primes and targets. The form overlap was examined across the morphological conditions (Table 18) and the orthographic conditions (Table 19). The comparison in Table 18 shows some gradation with roots ranking first, etymons second, and weak roots third. This is not what we would expect given the amount of formal overlap, which puts weak and sound roots in the same position and etymons third, especially that about half of the prime/target pairs shared non-ordered etymon consonants in Study 2. The hypothesis of gradation of effects is not supported in the morphological condition.

Table 18

Amount of Overlap and Priming Relative to
the Mean Response Time in the General Morphological
Conditions in Studies 1, 2, and 4C

	Formal overlap	Priming effect
Study 1: +Root, with or without a transparent meaning	2.87 letters 3.02 phonemes	15.66 ms. 2.14 %
Study 2: +Etymon, ordered or non-ordered	2.17 letters 2.27 phonemes	14.66 ms. 1.8%
Study 4C: +Weak root, with or without a transparent meaning	3.03 letters 3.27 phonemes	9.66 1.29 %

If formal overlap correlated with a priming effect, this should be reflected in the orthographic/phonological condition as well. Table 19 shows that there is no priming effect in the orthographic conditions in the three experiments compared to their respective mean

response time. The lack of priming is sufficient to weaken the gradation of priming effects in correlation with the amount of formal overlap. Still the amount of overlap does not correlate with response time in each of these conditions. If there was such a correlation, the orthographic condition in Study 4C should be the fastest relative to its respective mean response time, but it is actually the slowest.

Table 19

Amount of Overlap and Priming Relative to
the Mean Response Time in the Orthographic/Phonological
Condition in Studies 1, 2, and 4C

	Formal overlap	Priming effect
Study 1: +Orthography/Phonology	3.13 letters	-3.33 ms.
	3.13 phonemes	0.46 %
Study 2: +Orthography/Phonology	2.40 letters	-1.33 ms.
	2.42 phonemes	0.16 %
Study 4C: +Orthography/Phonology	3.13 letters	-4.33 ms.
	3.19 phonemes	0.53 %

The examination of whether the semantic and or formal overlap correlated with priming effects has shown that such correlation is dubious. Another problem with a distributed explanation is the fact that roots and patterns for instance do not have the same status (as pointed out in Frost, Forster, & Deutsch, 1997 in relation to Hebrew). If the same nodes are used for all activations, there need to be some special stipulations to derive the difference between roots which have a robust priming effect and patterns which are not so robust.

Thus, the results are more in favour of a localist decompositional/or a parallel dual-access theory for Arabic. But as mentioned above, these theories cannot account for the

lack of priming with non-ordered etymons. One possible explanation would be that the system, at least in the early stage, is not abstract enough to activate the right etymon morpheme. Another explanation, which I believe accounts best for the findings of the present work, would be to argue that the etymon is not a separate morpheme and that the priming obtained was due to the activation of the roots of which these two-consonants are part. Such an explanation requires a localist connectionist model that incorporates a grapheme/phoneme level representation that interacts with a higher morpheme level. This model should also incorporate some way of coding for the position of letters/phonemes in words. The importance of a grapheme/phoneme level is also motivated by the fact that the orthographic condition was faster than the unrelated condition by 9 ms. in Study 1, by 12 ms. in Study 2 and by 1 ms. in Study 3. This could be due to the partial activation of words having the shared letters/phonemes through the grapheme/phoneme level.

Another result of this work that none of the theories of lexical processing seem to provide a satisfactory explanation for is the lack of facilitation with primes that shared both sound or weak roots and a transparent semantic relationship with their targets. Unlike most of previous results either in Semitic languages or non-concatenative languages, semantic relatedness was neither a necessary criterion for decomposition (as found in English Marslen-Wilson et al. 1994) nor did it have the additive effect found in Hebrew (e.g. Bentin & Feldman, 1990; Frost, Deutsch, Gilboa, et al., 2000). On the contrary, the semantic overlap seems to reduce the priming that is due to the mere formal overlap in the root consonants. Although they did not discuss it, Boudelaa and Marslen-Wilson (2001a) found a similar tendency. In fact, the mean response time in the +morphology –semantics condition was faster than the one in the +morphology,-semantics condition (613 and 627ms, respectively). Morphological priming was, however, obtained in both conditions, probably because of the higher statistical power of their data.

It seems that at the early stage of lexical processing in Arabic, the focus is on finding the three discontinuous consonants of the root with little attention to meaning. This is what has been found in Hebrew, a language with a very similar morphology. In fact, Frost, Deutsch, and Forster (2000), who used a masked priming paradigm, found no priming with verbal patterns when either or both prime and target missed a root consonant.

But, when they added an arbitrary consonant to the weak root, thus creating nonsense roots, priming was obtained.

The effect of semantics seems to be independent of morphology because I have found priming with primes and targets that shared a morpheme but had only a very vague semantic relationship. Although independent, semantics is not excluded in word recognition. In the present case, it seems to have a competitive, rather than an additive role. This is not totally odd. Some studies that focused on semantic priming, without morphology, found that when participants were asked to look for a particular letter in a prime before deciding whether the target was a word or a nonword, semantic priming was totally eliminated (e.g. Stolz & Besner, 1996, 1998). A similar process seems to occur when readers of Arabic focus on finding the discontinuous consonants of the root. However, this conclusion is very tentative, as additive effects were found in similar studies (e.g. Bentin & Feldman, 1990).

Abstractness in theories of morphology and theories of lexical processing

The study of Arabic morphology (and the morphology of other Semitic languages) gives us a unique opportunity to examine the morphological processing of abstract morphemes. One of the purposes of this work is to examine just how abstract morphological processing can be (Research Question 7). Although the findings of this study suggest that morphological processing can be very abstract indeed, there are nonetheless some limits to abstractness.

Results of Study 1 show that priming can be obtained with roots, a three-consonant discontinuous morpheme. Roots are abstract unpronounceable morphemes. Priming was obtained even when primes and targets shared roots and only an opaque semantic relationship. The findings of Study 2 have revealed that etymons are also used in word recognition. Etymons are discontinuous two-consonant morphemes that share only little meaning. Priming, although marginal, was also obtained with weak roots. Weak roots, like etymons, are discontinuous two-consonant morphemes. There was, however, no priming with either non-ordered etymons, phonetic matrices, or word patterns. The fact that related morphemes behave differently in lexical processing shows a discrepancy between theories of morphology and theories of lexical processing.

How far should theories of morphology correspond to theories of lexical processing and representation? We have found certain areas where such correspondence is not perfect, but does that mean that any of these theories is wrong? One finding that illustrates this very well is the fact that we found priming with ordered etymons but not with non-ordered etymons. Can this result be interpreted as evidence against the morphological theory of the etymon? Or can it simply mean that the processing is not as abstract as morphological theory conceives them to be and that it relies on ordered graphemes or phonemes to access lexical representations. The results with phonetic matrices also have interesting implications for abstractness. Does our failure to find priming with phonetic matrices require us to abandon this notion and exclude it from any theory of morphology? A reasonable answer would be ‘not necessarily’, especially as we found psycholinguistic evidence for other correlative notions, namely the etymon.

The coda from these results is that morphological theory is not necessarily identical to what is proposed in theories of lexical processing.

5.3 Implications for future research

The suggested implications for future research are based on what this work has not done, as well as the questions that it has triggered. This work has validated previous studies, but it has raised other questions that need to be reexamined. Below is a short list of directions for future research.

- a. The results of Study 1 show that prime words facilitate word recognition of targets with which they share roots. Further research using nonword primes sharing roots with targets is necessary to make sure that roots are used prelexically.
- b. The findings in Study 2 have revealed priming with ordered etymons, but not with non-ordered etymons, which casts doubt about the etymons and calls for the necessity of further research. A study that I am intending to do involves the manipulation of the consonants of roots to see if the etymon effect is actually different from that of the root. One possible way to do that is to prime words with words or nonwords that share only two consonants of the root plus an arbitrary third consonant.

- c. The results of Study 4C have revealed a priming effect with weak roots **only** with prime-target pairs that shared a weak root and a vague semantic relationship. Replication of this experiment with more data is necessary to obtain clearer results.
- d. The question of morphological and semantic overlap should be reexamined with more data in both sound roots (Study 1) and weak roots (Study 4C), especially that the stimuli in both studies were not numerous.
- e. The semantic relatedness measures used in Study 1 and Study 4C are very subjective and do not include a very clear-cut division between the transparent and the opaque pairs. More objective measures such as the Latent Semantic Analysis (Landauer & Dumais, 1997) are necessary to validate the personal judgement measures.
- f. The results of this work were based on a masked priming lexical decision task with a presentation delay of 50 ms. Replicating the same experiments with different methodology and delay times might give different results.
- g. The offline study (Study 5) has suggested that root consonants are perceived differently compared to other letters. This encourages other perception studies to further investigate this point in online experiments. A possible direction is through eye-tracking or lexical decision tasks.

Appendices

Appendix A

The Stimuli from Study 1

+Root, Sem	+Orthophono	Unrelated	Target
اختلف [ʔixtalafa] ⁵⁰ ‘He/it differed’ ⁵¹	أُتلف [ʔatlafa] ‘damaged’	أُسقط [ʔasqatʕa] ‘made fall’	تخالف [taxaalafa] ‘differed’
عرف [ʔarifa] ‘knew’	عارض [ʔaaraðʕa] ‘opposed’	هَدَمَ [haddama] ‘destroyed’	تعارف [taʕaarafa] ‘became acquainted’
أقبل [ʔaqbala] ‘came’	استقل [ʔistaqalla] ‘became independent’	أهدر [ʔahdara] ‘thwarted’	تقبل [taqabbala] ‘accepted’
تقسّم [taqassama] ‘was divided’	تقاعس [taqaaʕasa] ‘was uninterested’	تصدّر [tasʕaddara] ‘occupied the leading position’	قاسم [qaasama] ‘shared’
تحمل [taħammala] ‘endured’	تملّك [tamallaka] ‘possessed’	تفرّع [tafarraʕa] ‘branched out’	احتمل [ʔihtamala] ‘bore’
حدث [ħaadaθa] ‘talked to s.o.’	حدّق [ħaddaqa] ‘looked fixedly’	غطس [ʔatʕasa] ‘dived’	تحدّث [taħaddaθa] ‘talked’
استلم [ʔistalama] ‘received’	استسمح [ʔistasmaħa] ‘asked for permission’	انزعج [ʔinzaʕaza] ‘felt uneasy’	تسلم [tasallama] ‘received’

⁵⁰ The consonants of the roots (sound and weak), etymons, and phonetic matrices are in bold.

⁵¹ All verbs are in the third person masculine in the perfect/past tense, but a few verbs have the reciprocal meaning (e.g. talaamasa ‘touched each other’). All verbs have an active meaning unless otherwise indicated. The perfect is a neutral form and is used as a citation form.

استأذن [ʔistaʔðana] ‘asked for permission’	أذنب [ʔaðnaba] ‘did wrong’	تكاسل [takaasala] ‘was lazy’	أذن [ʔaðana] ‘permitted’
بشّر [baʃʃara] ‘announced as good news’	ستر [satara] ‘covered’	وضّح [waðʔðʔaha] ‘clarified’	استبشّر [ʔistabʃara] ‘rejoiced’
لمس [lamasa] ‘touched’	لام [laama] ‘blamed’	جرب [ʒaraba] ‘experienced’	تلامس [talaamasa] ‘touched each other/one another’
هجم [haʒama] ‘attacked’	هاجر [haaʒara] ‘emigrated’	ذبح [ðabaħa] ‘slaughtered’	تهاجم [tahaaʒama] ‘attacked one another’
ألهم [ʔalhama] ‘inspired’	اتّهم [ʔittahama] ‘accused’	تصنّع [tasʔannaʔa] ‘faked’	استلهم [ʔistalhama] ‘was inspired’
عطف [ʔatʔafa] ‘sympathized with’	لاطف [laatʔafa] ‘treated with kindness’	كرّس [karrasa] ‘established’	تعاطف [taʔaatʔafa] ‘sympathized’
تغزّل [tayazzala] ‘flirted with’	تغامز [taʔaamaza] ‘signaled to one another’	تنصّت [tanasʔsʔata] ‘tried to hear’	غازل [ʔaazala] ‘flirted with’
ركض [rakaðʔa] ‘run’	راوض [raawaðʔa] ‘tamed’	خلع [xalaʔa] ‘took off’	تراكض [taraakaðʔa] ‘run fast’

أخبر [ʔaxbara] ‘informed’	تَجَبَّر [taʒabbara] ‘showed one’s power’	تَقَدَّمَ [taqaddama] ‘advanced’	خَبَّر [xabbara] ‘informed’
اغْتَرَب [ʔiytaraba] ‘emigrated’	اسْتَغْرَق [ʔistayraqa] ‘was absorbed in sth.’	أَعْدَم [ʔaʔdama] ‘executed’	تَغَرَّب [tayarraba] ‘emigrated’
رَفَّقَ [rafaqa] ‘was nice’	رَفَّهَ [raffaha] ‘entertained’	زَهَدَ [zahida] ‘renounced worldly pleasures’	تَرَفَّقَ [taraffaqa] ‘was nice’
عَبَدَ [ʔabada] ‘worshipped’	عَبَّرَ [ʔabbara] ‘expressed’	صَرَخَ [sʔaraxa] ‘screamed’	تَعَبَّدَ [taʔabbada] ‘devoted oneself to the service of God’
كَابَرَ [kaabara] ‘treated s.o. haughtily’	دَبَّرَ [dabbara] ‘made arrangements’	سَانَدَ [saanada] ‘supported’	تَكَبَّرَ [takabbara] ‘was haughty’
اتَّفَقَ [ʔittafaqa] ‘agreed’	اسْتَوْقَفَ [ʔistawqafa] ‘brought to a stop’	أَعْجَبَ [ʔaʔʒaba] ‘pleased’	وَأْفَقَ [waafaqa] ‘agreed’
مَنَعَ [manaʔa] ‘prevented’	مَتَّعَ [mattaʔa] ‘made enjoy’	زَوَّدَ [zawwada] ‘provided with’	امْتَنَعَ [ʔimtanaʔa] ‘abstained’
قَلَعَ [qalaʔa] ‘uprooted’	قَاتَلَ [qaatala] ‘fought’	سَرَدَ [sarada] ‘detailed’	اِقْتَلَعَ [ʔiqtalaʔa] ‘uprooted’
انْفَتَحَ [ʔinfataha] ‘unfolded’	الْتَفَتَ [ʔiltafata] ‘turned around’	أَرَبَكَ [ʔarbaka] ‘confused’	تَفَتَّحَ [tafattaha] ‘opened up’

+Root, -Sem	+Orthophono	Unrelated	Target
تَحَرَّفَ [taħarrafa] ‘turned off’	تَرَفَّعَ [taraffaʕa] ‘was too proud’	تَوَسَّلَ [tawassala] ‘implored’	اِحْتَرَفَ [ʔiħtarafa] ‘practised sth. as a profession’
أَبْلَغَ [ʔablaya] ‘informed’	تَبَادَلَ [tabaadala] ‘exchanged’	تَفَقَّدَ [tafaqqada] ‘examined’	بَالَغَ [baalaya] ‘exaggerated’
اِنْعَقَدَ [ʔinʕaqada] ‘was knotted’	اِسْتَقْدَمَ [ʔistaqdama] ‘summoned’	أَشْرَفَ [ʔaʃrafa] ‘supervised’	تَعَقَّدَ [taʕaqqada] ‘became complicated’
تَنَازَعَ [tanaazaʕa] ‘carried on a dispute’	تَزَعَّمَ [tazaʕʕama] ‘was the leader’	تَحَصَّلَ [taħasʕsʕala] ‘obtained’	اِنْتَزَعَ [ʔintazaʕa] ‘snatched’
أَضْرَبَ [ʔaðʕraba] ‘forsook’	اِنْتَابَ [ʔintaaba] ‘befell’	اِنشَغَلَ [ʔinʃayala] ‘was preoccupied’	تَضَارَبَ [taðʕaaraba] ‘conflicted with each other’
تَحَفَّظَ [taħaffaðʕa] ‘was wary’	تَلَفَّظَ [talaffaðʕa] ‘enunciated’	تَجَوَّلَ [taɟawwala] ‘moved around’	اِحْتَفَظَ [ʔiħtafaðʕa] ‘maintained’
بَرَزَ [baraza] ‘stood out’	بَارَكَ [baaraka] ‘blessed’	جَمَدَ [ɟamada] ‘froze’	تَبَارَزَ [tabaaraza] ‘met in combat’
دَافَعَ [daafaʕa] ‘defended’	نَفَعَ [nafaʕa] ‘was useful’	ذَكَرَ [ðakara] ‘mentioned’	اِنْدَفَعَ [ʔindafaʕa] ‘proceeded rashly’

انتسب [ʔintasaba] ‘was related to’	تناوب [tanaawaba] ‘took turns’	أرهق [ʔarhaqa] ‘exhausted’	ناسب [naasaba] ‘fit’
رابط [raabatʕa] ‘was stationed’	رتّب [rattaba] ‘arranged’	حاول [haawala] ‘tried’	ارتبط [ʔirtabatʕa] ‘committed o.s.’
تصفّح [tasʕaffaḥa] ‘leafed’	تصالح [tasʕaalaha] ‘reconciled’	استجوب [ʔistaʒwaba] ‘questioned’	صافح [sʕaafaḥa] ‘shook hands’
تلازم [talaazama] ‘was constantly around s.o.’	تأزّم [taʔazzama] ‘became critical’	تنشّق [tanaʃʃaqa] ‘inhaled’	ألزم [ʔalzama] ‘enforced’
أظهر [ʔaḏʕhara] ‘showed’	انتظر [ʔintaḏʕara] ‘waited’	أبعد [ʔabʕada] ‘took away’	تظاهر [taḏʕaahara] ‘demonstrated’
اعتصر [ʔiʕtasʕara] ‘squeezed out’	تقاصر [taqaasʕara] ‘shrank’	ألحق [ʔalhaqa] ‘joined’	عاصر [ʕaasʕara] ‘belonged to the same age’
تعقل [taʕaqqala] ‘was reasonable’	تقلّب [taqallaba] ‘was altered’	توازن [tawaazana] ‘was balanced’	اعتقل [ʔiʕtaqala] ‘arrested’
أنزل [ʔanzala] ‘caused to descend’	انزلق [ʔinzalaqa] ‘slided’	أتعب [ʔatʕaba] ‘tired’	نازل [naazala] ‘got into a fight’
تقطّع [taqatʕʕaʕa] ‘was disrupted’	تقاعد [taqaaʕada] ‘retired’	أغضب [ʔayḏʕaba] ‘annoyed’	قاطع [qaatʕaʕa] ‘cut off’

أَعْلَمَ [ʔaʕlama] ‘informed’	تَعَلَّقَ [taʕallaqa] ‘was attached’	أَنْجَحَ [ʔanzaha] ‘rendered successful’	عَلَّمَ [ʕallama] ‘taught’
تَرَاوَعَ [taraaʕaʕa] ‘retreated’	تَأَرْجَحَ [taʔarʕaha] ‘swung’	تَزَيَّنَ [tazajjana] ‘dressed up’	أَرْجَعَ [ʔarʕaʕa] ‘returned’
أَصْدَرَ [ʔasʕdara] ‘published’	تَصَاعَدَ [tasʕaaʕada] ‘went up gradually’	أَخْفَتَ [ʔaxfata] ‘silenced’	صَادَرَ [sʕaadara] ‘confiscated’
نَقَشَ [naqaʕa] ‘carved out’	نَاشَدَ [naaʕada] ‘implored’	بَرَعَ [baraʕa] ‘excelled’	تَنَاقَشَ [tanaaqaʕa] ‘debated’
تَوَصَّلَ [tawasʕsʕala] ‘reached’	تَوَاكَلَ [tawaakala] ‘reacted with indifference’	تَهَكَّمَ [tahakkama] ‘mocked’	وَاصَلَ [waasʕala] ‘continued’
ظَلَمَ [ʔʕalama] ‘treated unjustly’	نَظَّمَ [naʔʕʕama] ‘organized’	طَرَدَ [tʕarada] ‘expelled’	انْظَلَمَ [ʔinʔʕalama] ‘suffered injustice’
أَحْتَرَمَ [ʔihtarama] ‘respected’	تَكَرَّمَ [takarrama] ‘showed one’s generous side’	تَوَطَّدَ [tawatʕtʕada] ‘was strengthened’	حَرَّمَ [harrama] ‘prohibited’

Appendix B

The Stimuli from Study 2

+Etymon	+Orthopho	Unrelated	Target
اصطفّ [ʔisʔtʔaffa] ‘lined up’	ارتجف [ʔirtazafa] ‘trembled’	اكتمل [ʔiktamala] ‘became complete’	رصّف [rasʔafa] ‘arrayed alongside each other’
قضم [qaðʔama] ‘gnawed’	رفض [rafaðʔa] ‘refused’	سلك [salaka] ‘followed’	انقرض [ʔinqaraðʔa] ‘was extinct’
تجزّأ [taʒazzaʔa] ‘was divided’	توجّه [tawazʒaha] ‘headed’	تكفّل [takaffala/ ‘became responsible’	أوجز [ʔawʒaza] ‘was concise’
أضفى [ʔaðʔfaa] ‘granted’	أضعى [ʔaðʔnaa] ‘weakened’	ترصدّ [tarasʔsʔada] ‘observed attentively’	انضاف [ʔinðʔaafa] ‘was added’
كلّل [kallala] ‘crowned’	ولع [walaʔa] ‘was/became enthusiastic about’	هذب [haððaba] ‘refined’	تواكل [tawaakala] ‘was indifferent’
حبك [habaka] ‘devised’	عبس [ʔabasa] ‘frowned’	لطم [latʔama] ‘stroke with the hand’	احتبس [ʔihtabasa] ‘detained’
تعفّف [taʔaffafa] ‘refrained from forbidden or indecent’	تعكّر [taʔakkara] ‘troubled’	تحسّر [taħassara] ‘grieved’	اعتكف [ʔiʔtakafa] ‘devoted o.s. (to the service of God)’

تَجَسَّسَ [taʒassasa] ‘spied’	تَوَهَّجَ [tawahhaʒa] ‘glowed’	أَفْرَزَ [ʔafraza] ‘excreted’	تَوَجَّسَ [tawazʒasa] ‘had presentiments’
مَسَّ [massa] ‘touched’	لَمَّ [lamma] ‘gathered’	صَبَّ [sʕabba] ‘poured’	الْتَمَسَ [ʔiltamasa] ‘solicited’
كَدَحَ [kadaha] ‘toiled’	سَنَدَ [sanada] ‘supported’	حَذَقَ [haðqa] ‘was skilled’	نَكَّدَ [nakkada] ‘made life hard’
تَأَلَّفَ [taʔallafa] ‘was composed of’	تَأَوَّلَ [taʔawwala] ‘was interpreted’	تَرَنَّحَ [tarannaħa] ‘staggered’	الْتَفَّ [ʔiltaffa] ‘turned around’
فَرَّ [farra] ‘escaped’	سَرَّ [sarra] ‘made happy’	هَبَّ [habba] ‘blew’ (of the wind)	اسْتَنْفَرَ [ʔistanfara] ‘called out’
نَاوَشَ [naawafa] ‘skirmished’	نَاوَلَ [naawala] ‘handed’	عَاوَدَ [ʔaawada] ‘resumed’	انْتَشَلَ [ʔintafala] ‘pulled out’
صَفَعَ [sʕafaʕa] ‘slapped’	فَلَحَ [falaħa] ‘cultivated’	لَمَعَ [lamaʕa] ‘sparkled’	تَصَافَحَ [tasʕaafaħa] ‘shook hands’
اعْتَزَّ [ʔiʔtazza] ‘was proud’	اسْتَوَعَبَ [ʔistawʕaba] ‘was able to take in’	تَصَدَّقَ [tasʕaddaqa] ‘donated’	أَوْعَزَ [ʔawʕaza] ‘insinuated’
فَاحَ [faaha] ‘diffused aroma’	لَاحَ [laaha] ‘appeared’	غَارَ [yaara] ‘was jealous’	لَفَحَ [lafaha] ‘scorched’

قطف [qatʕafa] ‘picked’ (esp. flowers)	طعن [tʕaʕana] ‘stabbed’	شمل [ʃamala] ‘included’	تقطّع [taqatʕtʕaʕa] ‘was disrupted’
كابر [kaabara] ‘treated haughtily’	جابه [ʒaabaha] ‘faced’	نادم [naadama] ‘drank with s.o.’	تجبّر [taʒabbara] ‘showed one’s power’
رعى [raʕaa] ‘protected’	وعى [waʕaa] ‘was aware of’	غلى [ɣalaa] ‘boiled’	تورّع [tawarraʕa] ‘abstained’
انتصب [ʔintasʕaba] ‘rose up’	استأصل [ʔistaʕsʕala] ‘uprooted’	اكتسح [ʔiktasaha] ‘took hold’	أصاب [ʔasʕaaba] ‘hit the target’
افترس [ʔiftarasa] ‘devoured’	افترى [ʔiftaraa] ‘invented lyingly’	اكتأب [ʔiktaʕaba] ‘became depressed’	ترافس [taraafasa] ‘kicked one another’
صبرّ [sʕabbara] ‘comforted’	عصّر [ʕasʕsʕara] ‘modernized’	شرّح [ʃarraha] ‘dissected’	تعصّب [taʕasʕsʕaba] ‘clung fanatically to’
أفرج [ʔafraʒa] ‘liberated’	أثحف [ʔathafa] ‘presented with sth.’	ألهم [ʔalhama] ‘inspired’	تفجّج [tafaʒʒaʒa] ‘opened a little and slowly’
رذل [raðala] ‘cast off’	فتل [fatala] ‘twisted together’	غنم [ɣanama] ‘gained’	تذلّل [taðallala] ‘lowered o.s.’
رسب [rasaba] ‘sank to the bottom’	ستر [satara] ‘covered’	لكم [lakama] ‘punched’	تسرّب [tasarraba] ‘broke away’

حابى [haabaa] ‘was partial’	تاب [taaba] ‘repented’	ثنى [θanaa] ‘folded’	تحبَّب [tahabbaba] ‘showed love’
لوع [lawwaʕa] ‘tormented’	عبأ [ʕabbaʔa] ‘filled up’	نقَّب [naqqaba] ‘drilled’	اعتلَّ [ʔiʕtalla] ‘fell ill’
أمكن [ʔamkana] ‘enabled’	أسكن [ʔaskana] ‘lodged’	أفسح [ʔafsaha] ‘made room’	تكمَّن [takammna] ‘lay in wait’
روَّج [rawwaʒa] ‘spread (e.g. news)’	رتَّل [rattala] ‘recited’	دعَّم [daʕʕama] ‘supported’	تاجر [taaʒara] ‘did business’
زها [zahaa] ‘was radiant’	تاه [taaha] ‘got lost’	طوى [tʰawaa] ‘folded’	اهتزَّ [ʔihtazza] ‘was shaken’
تراخى [taraaxaa] ‘slackened’	تراضى [taraaðʕaa] ‘came to terms’	تعدَّى [taʕaddaa] ‘went beyond’	خار [xaara] ‘declined in force’
تدنى [tadannaa] ‘was debased’	تداوى [tadaawaa] ‘treated o.s. (with a medicine)’	تسلَّق [tasallaqa] ‘climbed’	نادى [naadaa] ‘called out’
ترقَّق [taraqqaa] ‘was reduced to fine particles’	تروَّض [tarawwaðʕa] ‘did physical exercise’	تخصَّص [taxasʕsʕasʕa] ‘specialized in’	وقَّر [waqqara] ‘respected’
موَّه [mawwaha] ‘feigned’	متعَّ [mattaʕa] ‘made enjoy’	عطَّل [ʕatʕʕala] ‘obstructed’	اهتمَّ [ʔihtamma] ‘was interested’

تَغَطَّى [tayatʔtʔaa] ‘covered o.s.’	تَغَنَّى [tayannaa] ‘sang’	تَحَلَّقَ [tahallaqa] ‘gathered into a circle’	طَغَى [tʔayaa] ‘exceeded proper bounds’
أَتَمَّ [ʔatamma] ‘finished’	اسْتَلَمَ [ʔistalama] ‘received’	أَشْفَقَ [ʔaʃfaqa] ‘pitied’	تَمَاوَتَ [tamaawata] ‘feigned death’
نَقَّى [naqqaa] ‘purified’	نَتَأَ [nataʔa] ‘protruded’	صَرَاحَ [sʔarraha] ‘declared’	اِقْتَنَى [ʔiqtanaa] ‘got’
دَقَّقَ [daqqaqa] ‘was meticulous’	قَتَلَ [qattala] ‘massacred’	رَمَّمَ [rammama] ‘restored’	اتَّقَدَ [ʔittaqada] ‘burned’
قَاسَ [qaasa] ‘measured’	قَارَنَ [qaarana] ‘compared’	رَدَّدَ [raddada] ‘repeated’	انْسَاقَ [ʔinsaaqa] ‘was driven’
أَطَاعَ [ʔatʔaaʔa] ‘obeyed’	أَطَالَ [ʔatʔaala] ‘made long’	تَمَوَّجَ [tamawwaza] ‘moved in undulations’	أَعْطَى [ʔaʔtʔaa] ‘gave’
نَاحَ [naaha] ‘lamented’	نَتَفَّ [nattafa] ‘plucked out’	مَالَ [maala] ‘bended’	تَحَنَّنَ [tahannana] ‘felt sympathy’
طَفَحَ [tʔafaha] ‘flowed over’	طَرِبَ [tʔariba] ‘was delighted’	كَبَحَ [kabaha] ‘reined in’	انْفَرَطَ [ʔinfaratʔa] ‘became detached’
كَفَّنَ [kaffana] ‘shrouded’	كَبَتَ [kabata] ‘inhibited’	غَمَرَ [yamara] ‘overflowed’	اِفْتَأَكَ [ʔiftakka] ‘snatched away’

ناصف [naas ^ʕ afa] ‘shared equally’	ناصر [naas ^ʕ ara] ‘supported’	جادل [ʒaadala] ‘debated’	انقسم [ʔinfras ^ʕ ama] ‘was split’
رجّ [raʒʒa] ‘shook’	رنّ [ranna] ‘rang’	زفّ [zaffa] ‘was given in marriage’	انجرّ [ʔinʒarra] ‘was carried’
وافق [waafaqa] ‘agreed’	فاتح [faataha] ‘opened the conversation’	نغصّ [nayyas ^ʕ a] ‘to spoil s.o.’s pleasure’	اقتفى [ʔiqtafaa] ‘followed s.o.’s tracks’
فوّت [fawwata] ‘let sth. escape’	فصّل [fas ^ʕ s ^ʕ ala] ‘divided into sections’	مجّد [maʒʒada] ‘glorified’	أتلّف [ʔatlafa] ‘damaged’
ورف [warifa] ‘extended’	وترّ [wattara] ‘tightened’	نقش [naqaʃa] ‘carved out’	توافر [tawaafara] ‘was abundant’

Appendix C

The Stimuli from Study 3

+Phonetic matrix	+Phonology	Unrelated	Target
سَرَّب [sarraʔa] ‘sent in groups or batches’	صَعَد [sʕaʕida] ‘rose’	قَيَّحَ [qajjaħa] ‘festered’	اِنْتَصَبَ [ʔintasʕaba] ‘rose up’ Matrix: [lab][corn] ⁵²
دَافَعَ [daafaʕa] ‘defended’	لَاحَقَ [laaħaqa] ‘followed’	وَأَقَعَ [waaqaʕa] ‘had sexual intercourse’	تَحَفَّظَ [taħaffaðʕa] ‘was cautious’ [lab][corn]
نَشَّبَ [naʃʃaba] ‘stuck on’	سَحَرَ [saħira] ‘bewitched’	وَعَى [waʕaa] ‘became aware’	اِسْتَبَسَلَ [ʔistaʔsala] ‘defied death’ [lab][corn]
تَبَضَّعَ [tabaðʕʕa] ‘cut up’	تَجَسَّدَ [taʒassada] ‘materialized’	تَأَوَّهَ [taʔawwaha] ‘moaned’	فَرَزَ [faʔaza] ‘set apart’ [lab][corn]
اِنْبَثَّتْ [ʔinbaθθa] ‘was spread’	اَنْكَرَ [ʔankara] ‘denied’	اَوْحَى [ʔawħaa] ‘inspired’	تَرَسَّبَ [tarassaba] ‘settled’ [lab][corn]
فَوَّتَ [fawwata] ‘made escape’	مَوَّهَ [mawwaha] ‘feigned’	هَيَّأَ [hajjaʔa] ‘prepared’	تَمَاوَتَ [tamaawata] ‘feigned death’ [lab][corn]

⁵² For Experiment 3, the phonetic matrix of each related prime-target pair is also included.

تَنفَذَ [tanaffaḏa] ‘was carried out’	تَعَقَّلَ [taʕaqqala] ‘was reasonable’	تَوَعَّكَ [tawaʕʕaka] ‘was indisposed’	أَبْرَزَ [ʔabraza] ‘caused to come out’ [lab][corn]
حَذَفَ [ħaḏafa] ‘omitted’	قَلَّصَ [qallasʕa] ‘contracted’	عَوَّقَ [ʕawwaqa] ‘hindered’	أَتْلَفَ [ʔatlafa] ‘damaged’ [+lab][+corn]
بَتَرَ [batara] ‘cut off’	نَحَتَ [nahata] ‘sculptured’	قَوِيَ [qawija] ‘became strong’	انْفَطَرَ [ʔinfatʕara] ‘was split’ [+lab][+corn]
أَنْدَفَنَ [ʔindafana] ‘was buried’	أَنْقَذَ [ʔanqaḏa] ‘saved’	اِكْتَوَى [ʔiktawaa] ‘was burnt’	نَبَشَ [nabaʕa] ‘unearthed’ [+lab][+corn]
فَزَرَ [fazara] ‘tore’	رَسَخَ [rassaxa] ‘established’	حَكَى [ħakaa] ‘told’	اِفْتَرَسَ [ʔiftarasa] ‘devoured’ [lab][corn]
تَرَأَفَسَ [taraafasa] ‘kicked one another’	تَعَاوَدَ [taʕaaḏʕada] ‘helped one another’	تَوَاقَحَ [tawaacaqaha] ‘displayed impudence’	اضْطَرَبَ [ʔiḏʕiʕaraba] ‘was in a state of unrest’ [+lab][+corn]
لَفَحَ [lafaha] ‘scorched’	فَرَضَ [faraḏʕa] ‘imposed’	عَلَقَ [ʕaliqa] ‘stuck’	نَفَّسَ [naffasa] ‘relieved’ [+lab][+con, -voice]

نفخ [nafaxa] ‘blew’	حصر [hasʕara] ‘enclosed’	لقن [laqana] ‘inferred’	فاح [faaħa] ‘diffused an aroma’ [+lab][+con, -voice]
فسى [fasaa] ‘broke wind noiselessly’	رثى [raθaa] ‘elegized’	طوى [tʕawaa] ‘folded up’	صفّر [sʕaffara] ‘whistled’ [+lab][+con, -voice]
انفش [ʔinfafʃa] ‘went down’	انهّد [ʔinhadda] ‘was demolished’	اندكّ [ʔindakka] ‘was crushed’	تبخّر [tabaxxara] ‘evaporated’ [+lab][+con, -voice]
صبرّ [sʕabbara] ‘asked to be patient’	وثب [waθaba] ‘jumped’	سرد [sarada] ‘detailed’	اعتكف [ʔiʔtakafa] ‘secluded oneself’ [+lab, -son][+phary]
ارتبط [ʔirtabatʕa] ‘was attached’	ارتحل [ʔirtaħala] ‘departed’	أسدل [ʔasdala] ‘hung down’	تضافر [taðʕaafara] ‘interwove’ [+lab, -son][+phary]
انحبس [ʔinhabasa] ‘was held up’	انغلق [ʔinyalaqa] ‘was closed’	اندثر [ʔindaθara] ‘became wiped out’	اختبل [ʔixtabala] ‘was disordered’ [lab, -son][+phary]
هرّ [harra] ‘growled’	ظلّ [ðʕalla] ‘remained’	جفّ [ʒaffa] ‘became dry’	تنحّح [tanahnaha] ‘cleared one’s throat’ [+cor][+ph, -dor, - voice]

أَنَّ [ʔanna] ‘groaned’	ظَنَّ [ðʕanna] ‘suspected’	كَفَّ [kaffa] ‘refrained’	تَحَنَّنَ [tahannana] ‘felt sympathy’ [+cor][+ph,-dor,- voice]
عَقَفَ [ʔaqaʔa] ‘crooked’	قَمَعَ [qamaʕa] ‘repressed’	شَمَلَ [ʃamila] ‘comprised’	كَعَبَ [kaʕʕaba] ‘made cubic’ [+lab, -son][+dor]
تَحَدَّبَ [tahaddaba] ‘was bowed upward’	تَوَغَّلَ [tawayɣala] ‘penetrated deeply (e.g. in a forest)’	تَوَرَّمَ [tawarrama] ‘was swollen’	انْعَطَفَ [ʔinʕatʕafa] ‘was inclined’ [+lab][+corn]
نَقَبَ [naqaba] ‘made a hole’	خَلَفَ [xalafa] ‘was the successor’	حَسَدَ [hasada] ‘envied’	كَفَّنَ [kaffana] ‘shrouded’ [+lab, -son][+dor]
فَاضَ [faaðʕa] ‘overflowed’	طَالَ [tʕaala] ‘became/was long’	زَالَ [zaala] ‘vanished’	انْفَرَطَ [ʔinfaratʕa] ‘became detached’ [+lab, -son][+dor]
طَفَحَ [tʕafaħa] ‘flowed over’	هَتَفَ [hatafa] ‘shouted’	هَرَعَ [haraʕa] ‘hastened’	انْصَبَ [ʔinsʕabba] ‘was poured out’ [+lab, -son][+dor]
قَبِرَ [qabara] ‘buried’	غَرِقَ [ɣariqa] ‘was drowned’	زَوَّدَ [zawwada] ‘supplied’	اِكْتَنَفَ [ʔiktanaʔa] ‘enclosed’ [+lab, -son][+dor]
فَكَّ [fakka] ‘disassembled’	هَبَّ [habba] ‘got in motion’	ذَمَّ [ðamma] ‘blamed’	حَبَكَ [habaka] ‘wove well and tight’ [+lab, -son][+dor]

رَصَّفَ [rasʕsʕafa] ‘paved’	حَصَّنَ [hasʕsʕana] ‘fortified’	دَنَسَ [dannasa] ‘stained’	عَصَّبَ [ʕasʕsʕaba] ‘folded around’ [+lab, -son][+dor]
طَافَ [tʕaafa] ‘went about’	فَارَ [faara] ‘boiled over’	سَارَ [saara] ‘moved along’	صَفَّفَ [sʕaffafa] ‘set up in a row or line’ [+lab, -son][+dor]
قَضَمَ [qaðʕama] ‘gnawed’	قَبَحَ [qabuha] ‘was ugly’	وَهَبَ [wahaba] ‘donated’	اِقْتَطَعَ [ʔiqtatʕaʕa] ‘took a part’ [+cor][+dor]
قَصَّ /qasʕsʕa/ ‘cut’	مَلَّ /malla/ ‘was bored’	شَذَّ /ʕaðða/ ‘deviated’	اِنْقَسَمَ /ʔinqasama/ ‘was divided’ [+cor][+dor]
قَرَضَ [qaraðʕa] ‘cut’	عَزَلَ [ʕazala] ‘isolated’	فَهَّمَ [fahhama] ‘made s.o. understand’	تَقَاتَلَ [taqaatala] ‘killed each other’ [+cor][+dor]
قَلَّبَ [qallaba] ‘turned around’	ثَبَّتَ [θabbata] ‘consolidated’	نَوَّهَ [nawwaha] ‘praised’	رَبَضَ [rabaðʕa] ‘lay down’ [+cor][+dor]
قَطَمَ [qatʕama] ‘cut off’	صَدَحَ [sʕadaha] ‘chanted’	جَثَمَ [ʒaθama] ‘lay’	اِقْتَصَرَ [ʔiqtasʕara] ‘was limited’ [+cor][+dor]
أَرْخَى [ʔarxaa] ‘loosened’	أَرْتَابَ [ʔirtaaba] ‘was suspicious’	أَفْحَمَ [ʔafhama] ‘silenced s.o. with arguments’	خَارَ [xaara] ‘declined in force’ [+cor][+dor]

Appendix D

The Stimuli from Study 4A

+Sound Pattern	+Weak Pattern	+Orthophono	Target
أنقذ [ʔanqaða] ‘saved’	أرضى [ʔarðʕaa] ‘satisfied’	افترض [ʔiftaraðʕa] ‘supposed’	أكمل [ʔakmala] ‘finished’
تسلّح [tasallaħa] ‘armed o.s.’	تخلّى [taxallaa] ‘relinquished’	تساءل [tasaaʔala] ‘wondered’	تجملّ [taʒammala] ‘made o.s. pretty’
امتنع [ʔimtaɳaʕa] ‘refused’	اجتاز [ʔiʒtaaza] ‘passed’	أورد [ʔawrada] ‘mentioned’	افتقد [ʔiftaqada] ‘missed’
انتفع [ʔintafaʕa] ‘benefited’	انتاب [ʔintaaba] ‘befell’	أنّج [ʔantaʒa] ‘produced’	انتشر [ʔintaʃara] ‘spread’
أنبت [ʔanbata] ‘grew’	أسال [ʔasaala] ‘made flow’	اجترّ [ʔiʒtarra] ‘ruminated’	أحدث [ʔahdaθa] ‘brought about’
استرجع [ʔistarʒaʕa] ‘regained’	استثنى [ʔistaθnaa] ‘excluded’	استند [ʔistanada] ‘was based’	استوقف [ʔistawqafa] ‘brought to a stop’
أنكر [ʔankara] ‘denied’	أغرى [ʔayraa] ‘tempted’	انكسر [ʔinkasara] ‘broke’	أحضر [ʔahðʕara] ‘brought’
انتسب [ʔintasaba] ‘was related to’	احتاط [ʔihtaatʕa] ‘was cautious’	أُتلف [ʔatlafa] ‘damaged’	اعتمد [ʔiʔtamada] ‘relied on’

نهب [nahaba] ‘plundered’	خان [xaana] ‘was disloyal’	عقد [ʔaqqada] ‘complicated’	لمس [lamasa] ‘touched’
اقترب [ʔiqtaraba] ‘approached’	اختار [ʔixtaara] ‘chose’	أمسك [ʔamsaka] ‘held’	اجتمع [ʔiztamaʔa] ‘met’
وضع [waðʕaʔa] ‘put’	باع [baaʕa] ‘sold’	بادل [baadala] ‘exchanged’	غفر [ʔafara] ‘forgave’
التزم [ʔiltazama] ‘took upon o.s.’	اعتدى [ʔiʔtadaa] ‘aggressed’	أفسد [ʔafsada] ‘spoiled’	اكتسب [ʔiktasaba] ‘acquired’
ألحق [ʔalḥaqa] ‘joined’	أدمى [ʔadmaa] ‘caused to bleed’	اجتهد [ʔiztahada] ‘worked hard’	أعرض [ʔaʕraðʕa] ‘turned away’
تضافر [taðʕaafara] ‘interwove’	تعافى [taʕaafaa] ‘recuperated’	توصل [tawasʕsʕala] ‘reached’	تكاسل [takaasala] ‘was lazy’
عبر [ʔabbara] ‘crossed’	عاد [ʔaada] ‘returned’	عاشر [ʔaafara] ‘was on intimate terms’	طرد [tʕarada] ‘expelled’
استعمر [ʔistaʕmara] ‘colonized’	استغنى [ʔistaynaa] ‘was able to dispense with’	أسقط [ʔasqatʕa] ‘let fall’	استقبل [ʔistaqbala] ‘welcomed’
فرح [fariha] ‘was glad’	فات [faata] ‘passed (away)’	فارق [faaraqa] ‘left’	فهم [fahima] ‘understood’

أَتَقَنَ [ʔatqana] ‘perfected’	أَفَاقَ [ʔafaaqa] ‘woke up’	أَنهَزِمَ [ʔinhazama] ‘was defeated’	أَخْلَصَ [ʔaxlasʔa] ‘was faithful’
رَاقِبَ [raaqaba] ‘supervised’	رَاعَى [raaʔaa] ‘observed’	فَرَشَ [faraʃa] ‘spread out’	شَارَكَ [ʃaaraka] ‘participated’
بَارَزَ [baaraza] ‘met in a combat’	قَاسَى [qaasaa] ‘suffered’	غَفَلَ [ʔafala] ‘neglected’	دَافَعَ [daafaʔa] ‘defended’
أَندمَجَ [ʔindamaʒa] ‘was incorporated’	أَنقَضَى [ʔinqaḏʔaa] ‘was finished’	أَنجَبَ [ʔanzaba] ‘gave birth’	أَنفَتَحَ [ʔinfataħa] ‘opened up’
لَعَبَ [laʃiba] ‘played’	بَاتَ [baata] ‘spent the night’	غَالَطَ [ʔaalatʔa] ‘deceived’	مَزَجَ [mazaʒa] ‘mixed’
خَلَطَ [xalatʔa] ‘mixed’	بَنَى [banaa] ‘built’	حَرَّكَ [harraka] ‘moved’	شَتَمَ [ʃatama] ‘insulted’
أَفْرَزَ [ʔafraza] ‘excreted’	أَفْرَجَ [ʔafraʒa] ‘liberated’	أَفْتَقَرَ [ʔiftaqara] ‘lacked’	أَوَكَلَ [ʔawkala] ‘entrusted’
أَنفَقَ [ʔanfaqa] ‘spent’	أَزَالَ [ʔazaala] ‘eliminated’	أَقْتَرَفَ [ʔiqtarafa] ‘committed’	أَغْضَبَ [ʔaʔḏʔaba] ‘annoyed’
تَثَبَّتَ [taθabbata] ‘ascertained’	تَمَنَّى [tamannaa] ‘wished’	تَقَاتَلَ [taqaatala] ‘killed one other’	تَذَكَّرَ [taḏakkara] ‘remembered’

ابتلع [ʔibtalaʔa] ‘swallowed’	ارتضى [ʔirtamaa] ‘threw oneself’	أنشد [ʔanʃada] ‘sang’	اقتصد [ʔiqtasʕada] ‘became thrifty’
انعطف [ʔinʔatʕafa] ‘was bent’	انحنى [ʔinhanaa] ‘bent’	أنذر [ʔanðara] ‘warned’	انقلب [ʔinqalaba] ‘was turned’
ألبس [ʔalbasa] ‘dressed’	أتاح [ʔataaha] ‘made possible’	أخترع [ʔixtaraʔa] ‘invented’	أغمض [ʔaymaðʕa] ‘closed one’s eyes’
اجتنب [ʔiztanaba] ‘avoided’	انتمى [ʔintamaa] ‘belonged’	أسعد [ʔasʕada] ‘made happy’	اعتكف [ʔiʔtakafa] ‘devoted oneself’
لجأ [laʒaʔa] ‘took refuge’	بان [baana] ‘became clear’	صافح [sʕaafaha] ‘shook hands’	خدم [xadama] ‘served’
استعبد [ʔistaʔbada] ‘enslaved’	استفاد [ʔistafaada] ‘benefited’	أسكر [ʔaskara] ‘made drunk’	استغرق [ʔistayraqa] ‘was immersed’
سرق [sariqa] ‘stole’	مال [maala] ‘bent’	فكر [fakkara] ‘thought’	جذب [ʒaðaba] ‘withdrew’
رسم [rasama] ‘drew’	جابه [ʒaaba] ‘wandered’	عذب [ʕaððaba] ‘tortured’	سبق [sabiqa] ‘preceded’
نهض [nahaðʕa] ‘rose’	هدى [hadaa] ‘guided’	خاطر [xaatʕara] ‘risked’	بلغ [balaya] ‘reached’

انعدم
[ʔinʔadama]
‘was missing’

انزوى
[ʔinzawaa]
‘secluded o.s.’

أنجز
[ʔanzaza]
‘carried out’

انبهر
[ʔinbahara]
‘was dazzled’

غلق
[ʔalaqa]
‘closed’

طوى
[tʔawaa]
‘folded’

مهد
[mahhada]
‘paved’

زرع
[zaraʔa]
‘sowed’

أظهر
[ʔaḏʔhara]
‘showed’

أرسى
[ʔarsaa]
‘established’

انشغل
[ʔinʔayala]
‘was occupied’

أخفت
[ʔaxfata]
‘silenced’

تطاول
[tatʔaawala]
‘stretched up (in defiance)’

تباهى
[tabaahaa]
‘was proud’

تعلق
[taʔallaqa]
‘was attached’

تناقش
[tanaaqaʔa]
‘discussed’

أشرف
[ʔaʃrafa]
‘supervised’

أضاف
[ʔaḏʔaafa]
‘added’

انتقم
[ʔintaqama]
‘avenged’

أبطل
[ʔabtʔala]
‘thwarted’

انسدل
[ʔinsadala]
‘descended (on)’

انساق
[ʔinsaaqa]
‘was led’

أنعم
[ʔinʔadama]
‘bestowed’

انفجر
[ʔinfazara]
‘exploded’

تنفّض
[tanaffaḏʔa]
‘was shaken’

تسلّى
[tasallaa]
‘took pleasure’

تسارع
[tasaaraʔa]
‘hurried’

تكتّم
[takattama]
‘held one’s tongue’

تنهّد
[tanahhada]
‘sighed’

تصدّى
[tasʔaddaa]
‘resisted’

تقاعد
[taqaaʔada]
‘retired’

تسمّر
[tasammara]
‘was nailed down’

تمرّد
[tamarrada]
‘rebelled’

تغطّى
[tayatʔtʔaa]
‘was covered’

تراكم
[taraakama]
‘piled up’

تشبّه
[taʃabbaha]
‘compared o.s. with’

جَرَّبَ [ʒarraba] ‘experienced’	سَمَّى [sammaa] ‘named’	نَدِمَ [nadima] ‘regretted’	كَلَّفَ [kallafa] ‘charged with’
تَرَابَطَ [taraabatʕa] ‘was closely tied’	تَرَخَّى [taraaxaa] ‘slackened’	تَعَقَّلَ [taʕaqqala] ‘was reasonable’	تَصَالَحَ [tasʕaalaħa] ‘became reconciled with one another’
أَدْخَلَ [ʔadxala] ‘made/let enter’	أَبَادَ [ʔabaada] ‘exterminated’	ابْتَعَدَ [ʔibtaʕada] ‘moved away’	أَوْضَحَ [ʔawðʕaħa] ‘explained’
اِقْتَسَمَ [ʔiqtasama] ‘shared’	اِحْتَارَ [ʔihtaara] ‘was bewildered’	أَسْكَنَ [ʔaskana] ‘lodged’	اِكْتَأَبَ [ʔiktaʔaba] ‘was depressed’

Appendix E

The Stimuli from Study 4B

+Pattern	+Slightly different pattern	+Orthophono	Target
نعى [naʕaa] 'announced the death'	مال [maala] 'bent'	والى [waalaa] 'was close (to s.o. or a party) '	سها [sahaa] 'was absent-minded'
وفى [wafaa] 'was loyal'	نال [naala] 'obtained'	منى [mannaa] 'made s.o. hope'	شدا [ʃadaa] 'chanted'
ثنى [θanaa] 'bent'	ثاب [θaaba] 'returned'	طور [tʰawwara] 'developed'	سطا [satʰaa] 'assailed'
أعار [ʔaʕaara] 'lent'	أهدى [ʔahdaa] 'gave as a present'	احتذى [ʔihtaɖaa] 'imitated'	أجاب [ʔaʒaaba] 'answered'
اكتفى [ʔiktafaa] 'was satisfied'	احتال [ʔihtaala] 'resorted to tricks'	أنار [ʔanaara] 'illuminated'	اعتنى [ʔiʕtanaa] 'took care (of)'
احتمى [ʔihtamaa] 'protected o.s.'	اجتاح [ʔiʒtaaha] 'stroke'	أقام [ʔaqaama] 'set up'	ارتقى [ʔirtaqaa] 'ascended'
أمضى [ʔamɖʰaa] 'spent'	أباد [ʔabaada] 'exterminated'	امتاز [ʔimtaaza] 'was distinguished'	أغرى [ʔayraa] 'tempted'
رحى [rahaa] 'ground'	زال [zaala] 'disappeared'	سلى [sallaa] 'entertained'	دعا [daʕaa] 'invited'

رضى [raðʕaa] ‘accepted’	زار [zaara] ‘visited’	هدّم [haddama] ‘demolished’	لها [lahaa] ‘amused o.s.’
ارتمى [ʔirtamaa] ‘threw oneself’	احتاط [ʔihtaatʕa] ‘was cautious’	أتقن [ʔatqana] ‘mastered’	انتقى [ʔintaqaa] ‘selected’
انبنى [ʔinbanaa] ‘was built’	انحاد [ʔinhaada] ‘deviated’	أنزل [ʔanzala] ‘caused to descend’	انجلى [ʔinʒalaa] ‘was removed’
أجال [ʔaʒaala] ‘passed around’	أخفى [ʔaxfaa] ‘hid’	اعتزّ [ʔiʔtazza] ‘was proud’	أذاع [ʔaðaaʕa] ‘disseminated’
حوى [hawaa] ‘comprised’	خاف [xaafa] ‘was afraid’	دمّر [dammara] ‘destroyed’	بدا [badaa] ‘appeared’
بكى [bakaa] ‘wept’	باح [baaha] ‘revealed’	غذى [ʔaððaa] ‘nourished’	دنا [danaa] ‘came near’
اغتال [ʔiytaala] ‘assassinated’	احتفى [ʔihtafaa] ‘received kindly’	أشقى [ʔaʃqaa] ‘made unhappy’	اقتاد [ʔiqtaada] ‘led’
أوحى [ʔawhaa] ‘inspired’	أضاع [ʔaðʕaaʕa] ‘lost’	ارتشى [ʔirtaʃaa] ‘accepted a bribe’	أقصى [ʔaqsʕaa] ‘removed’
اكترى [ʔiktaraa] ‘rented’	ارتاح [ʔirtaaha] ‘rested’	استباح [ʔistabaaħa] ‘regarded as public’	انتهى [ʔintahaa] ‘finished’
أجاد [ʔaʒaada] ‘mastered’	أخلى [ʔaxlaa] ‘emptied’	استحى [ʔistahaa] ‘was ashamed’	أعان [ʔaʕaana] ‘helped’

لوى [lawaa] 'cursed'	جاع [ʒaaʕa] 'became hungry'	فسّر [fassara] 'explained'	طفا [tʕafaa] 'floated'
كوى [kawaa] 'burnt'	طار [tʕaara] 'flew'	كشّر [kaʃʃara] 'grinned'	حشا [ħaʃaa] 'stuffed'
أشاع [ʔaʃaaʕa] 'brought to public notice'	أرسى [ʔarsaa] 'fixed firmly'	انزوى [ʔinzawaa] 'lived in seclusion'	أطاح [ʔatʕaaha] 'caused to fall'
أذاب [ʔaḏaaba] 'caused to melt'	أنجى [ʔanʒaa] 'rescued'	اشتري [ʔiʃtaraa] 'bought'	أفاد [ʔafaada] 'was useful'
بقى [baqaa] 'remained'	صان [sʕaana] 'preserved'	هنأ [hannaʔa] 'congratulated'	طها [tʕahaa] 'cooked'
ارتوى [ʔirtawaa] 'quenched one's thirst'	اجتاز [ʔiʒtaaza] 'passed'	أهان [ʔahaana] 'humiliated'	اشتهى [ʔiʃtahaa] 'desired'
استوى [ʔistawaa] 'was the same level'	احتاج [ʔihtaaza] 'needed'	استغاث [ʔistayaaθa] 'appealed for help'	ابتلى [ʔibtalaa] 'put to the test'
نوى [nawaa] 'intended'	طاف [tʕaafa] 'went about'	جمّع [ʒammaʕa] 'grouped'	رجا [raʒaa] 'aspired'
ابتغى [ʔibtayaa] 'desired'	اغتاظ [ʔiytaaḏʕa] 'became angry'	استنتج [ʔistantaʒa] 'concluded'	اقتنى [ʔiqтанаa] 'acquired'

طلى [tʰalaa] ‘painted’	بات [baata] ‘spent the night’	سخن [saxxana] ‘heated’	قسا [qasaa] ‘was cruel’
عمى [ʕamaa] ‘became blind’	غاص [ʕaasʰa] ‘dived’	عطر [ʕatʰtʰara] ‘perfumed’	خطا [xatʰaa] ‘stepped’
زنى [zanaa] ‘committed adultery’	سال [saala] ‘flowed’	كلف [kallafa] ‘charged (with)’	عفا [ʕafaa] ‘forgave’
انصاع [ʔinsʰaaʕa] ‘gave in’	انطوى [ʔintʰawaa] ‘was folded’	أنسى [ʔansaa] ‘made forget’	انهار [ʔinhaara] ‘collapsed’
مشى [maʕaa] ‘walked’	صاح [sʰaaha] ‘screamed’	صلّى [sʰallaa] ‘prayed’	زها [zahaa] ‘was radiant’
عوى [ʕawaa] ‘howled’	نام [naama] ‘slept’	غنى [ʕannaa] ‘sang’	صفا [sʰafaa] ‘became pure’
أضاف [ʔaðʰaafa] ‘added’	أضنى [ʔaðʰnaa] ‘weakened’	امتطى [ʔimtatʰaa] ‘took a means of transport’	أشاد [ʔaʕaada] ‘praised’
استشار [ʔistaʕaara] ‘asked for advice’	استعصى [ʔistaʕsʰaa] ‘was difficult’	استرق [ʔistaraqa] ‘stole’	استفاق [ʔistaʕaafaqa] ‘woke up’
حكى [hakaa] ‘told’	قاس [qaasa] ‘measured’	حوّل [hawwala] ‘transformed’	علا [ʕalaa] ‘rose’

شفی [ʃafaa] ‘cured’	بان [baana] ‘appeared’	سلّح [sallaḥa] ‘armed’	کسا [kasaa] ‘clothed’
ارتدی [ʔirtadaa] ‘wore’	ارتاد [ʔirtaada] ‘frequented’	انحبس [ʔinhabasa] ‘was held’	احتسی [ʔihtasaa] ‘sipped’
سقی [saqaa] ‘irrigated’	فاض [faaḏʿa] ‘overflowed’	ضمّد [ḏʿamma] ‘bandaged’	محا [maḥaa] ‘wiped off’
رثی [raṭaa] ‘elegized’	جاء [ʒaaʔa] ‘came’	علّم [ʕallama] ‘taught’	سما [samaa] ‘towered up’
استجدی [ʔistaʒdaa] ‘begged’	استقال [ʔistaqaala] ‘resigned’	استند [ʔistanada] ‘was based’	استغنی [ʔistaʕnaa] ‘was able to dispense with’
خشی [xaʃaa] ‘feared’	تاه [taaha] ‘got lost’	فجّر [faʒʒara] ‘exploded’	غفا [ɣafaa] ‘dosed off’
شوی [ʃawaa] ‘grilled’	داس [daasa] ‘stepped on’	کَلَم [kallama] ‘talked to’	نما [namaa] ‘grew’
أصاب [ʔasʿaaba] ‘hit the target’	ألقي [ʔalqaa] ‘threw’	اشتكى [ʔiʃtakaa] ‘complained’	أغار [ʔayaara] ‘raided’
وقی [waqaa] ‘protected’	حام [haama] ‘hovered’	دوی [dawwaa] ‘sounded’	رنا [ranaa] ‘looked intently’

هذى [haðaa] ‘was delirious’	خان [xaana] ‘was disloyal’	موّل [mawwala] ‘financed’	غلا [ɣalaa] ‘became excessive (of prices, ideas)’
أطاع [ʔatʰaaʔa] ‘obeyed’	أعفى [ʔaʕfaa] ‘relieved’	ارتخى [ʔirtaxaa] ‘slackened’	أدام [ʔadaama] ‘made last’
أتاح [ʔataaħa] ‘made possible’	أوصى [ʔawsʕaa] ‘entrusted’	انحنى [ʔinhanaa] ‘bent’	أذاق [ʔaðaaqa] ‘had s.o. taste s.th.’

Appendix F

The Stimuli from Study 4C

+Weak root, + Sem	+Orthophono	Unrelated	Target
أفاق [ʔafaaqa] ‘woke up’	اتَّفَق [ʔittafaqa] ‘agreed’	تَغَلَّب [tayallaba] ‘triumphed’	استَفَاق [ʔistafaaqa] ‘woke up’
أَمَالَ [ʔamaala] ‘inclined’	اِغْتَالَ [ʔiytaala] ‘assassinated’	تَذَكَّر [taðakkara] ‘remembered’	اِسْتَمَالَ [ʔistamaala] ‘became inclined’
غَلَا [yalaa] ‘was excessive’	سَلَّى [sallaa] ‘entertained’	طَرَد [tʰarada] ‘drove away’	اِسْتَغْلَى [ʔistaylaa] ‘found expensive’
أَنَسَى [ʔansaa] ‘caused to forget’	اِسْتَنَسَخ [ʔistansaxa] ‘cloned’	أَكْمَلَ [ʔakmala] ‘finished’	تَنَاسَى [tanaasaa] ‘pretended to have forgotten’
تَشَكَّى [taʃakkaa] ‘complained’	تَكَاثَرَ [takaaθara] ‘became numerous’	تَصَلَّبَ [tasʰallaba] ‘became hard’	اِشْتَكَى [ʔiʃtakaa] ‘complained’
أَقَالَ [ʔaqaala] ‘discharged’	اِنْتَقَلَ [ʔintaqala] ‘moved’	تَكَبَّدَ [takabbada] ‘endured’	اِسْتَقَالَ [ʔistaqaala] ‘resigned’
أَخْفَى [ʔaxfaa] ‘hid’	اِسْتَخَفَّ [ʔistaxaffa] ‘valued lightly’	اِسْتَنْجَدَ [ʔistanʒada] ‘asked for help’	تَخْفَى [taxaffaa] ‘hid’
اِقْتَادَ [ʔiqtaada] ‘led’	اِنْتَقَدَ [ʔintaqada] ‘criticized’	تَسَوَّلَ [tasawwala] ‘begged’	اِنْقَادَ [ʔintaqada] ‘was led’

خاف [xaafa] ‘was scared’	خالف [xaalafa] ‘contradicted’	نصح [nas‘aha] ‘gave advice’	أخاف [ʔaxaafa] ‘scared’
حمى [hamaa] ‘protected’	حتم [hattama] ‘made necessary’	كلّف [kallafa] ‘entrusted’	احتمى [ʔihtamaa] ‘took refuge’
رمى [ramaa] ‘threw’	رام [raama] ‘desired’	حفظ [hafað‘a] ‘preserved’	ارتضى [ʔirtamaa] ‘threw oneself’
أبقى [ʔabqaa] ‘kept’	ارتقى [ʔirtaqaa] ‘ascended’	تحدّث [tahaddaθa] ‘talked’	استبقى [ʔistabqaa] ‘made stay’
خطا [xat‘aa] ‘stepped’	خطّط [xat‘t‘at‘a] ‘worked out plans’	دأب [daʔaba] ‘persevered’	تخطّى [taxat‘t‘aa] ‘overstepped’
حار [haara] ‘was bewildered’	تاجر [taazara] ‘did business’	لصق [las‘aqa] ‘stuck’	احتار [ʔihtaara] ‘was bewildered’
أسال [ʔasaala] ‘made flow’	تساهل [tasaahala] ‘was lenient’	أنصت [ʔans‘ata] ‘listened’	سال [saala] ‘flowed’
سوى [sawaa] ‘was equal’	ساوم [saawama] ‘bargained’	هدّم [haddama] ‘demolished’	تساوى [tasaawaa] ‘was equal’
علا [ʔalaa] ‘rose’	عالج [ʔaalaza] ‘treated (a patient or a matter)’	فضح [fað‘aħa] ‘exposed’	تعالى [taʔaalaa] ‘rose’

أفاد [ʔafaada] ‘benefited’	اكتفى [ʔiktafaa] ‘was content’	تطوّع [tatʔawwaʔa] ‘volunteered’	استفاد [ʔistaʔaada] ‘benefited’
زال [zaala] ‘disappeared’	زامل [zaamala] ‘was a colleague’	متع [mattaʔa] ‘made enjoy’	أزال [ʔazaala] ‘caused to disappear’
اعتدى [ʔiʔtadaa] ‘committed an aggression’	استعدّ [ʔistaʔadda] ‘got ready’	أسرف [ʔasrafa] ‘was extravagant’	تعدّى [taʔaddaa] ‘exceeded’
أرضى [ʔarðʔaa] ‘came to terms’	استعرض [ʔistaʔraðʔa] ‘went through’	أنجز [ʔanzaza] ‘carried out’	تراضى [taraaðʔaa] ‘came to terms’
أعار [ʔaʔaara] ‘lent’	أسعر [ʔasʔara] ‘kindled’	توهمّ [tawahhama] ‘imagined’	استعار [ʔistaʔaara] ‘borrowed’
ضاع [ðʔaaʔa] ‘got lost’	ضاعف [ðʔaaʔafa] ‘multiplied’	هرب [hariba] ‘run away’	أضاع [ʔaðʔaaʔa] ‘lost’
ثار [θaara] ‘was excited’	سأير [saajara] ‘kept up’	لعن [laʔana] ‘cursed’	استثار [ʔistaθaara] ‘stirred up’
Root, -Sem	+Orthophono	Unrelated	Target
جاز [ʒaaza] ‘was allowed’	جازف [ʒaazafa] ‘ventured’	وشّح [waffʃaħa] ‘adorned’	اجتاز [ʔiʒtaaza] ‘passed’

أَثْنَى [ʔaθnaa] ‘praised’	اِقْتَنَى [ʔiqtanaa] ‘acquired’	تَرَكَّبَ [tarakkaba] ‘was composed’	اِسْتَثْنَى [ʔistaθnaa] ‘excepted’
ساق [saaqa] ‘drove’	نَسَّقَ [nassaaq] ‘coordinated’	جَلَبَ [ʒalaba] ‘brought’	اِنْسَاقَ [ʔinsaacaq] ‘was driven’
حَازَ [ħaaza] ‘obtained’	نَازَعَ [naazaʔa] ‘disputed’	لَفَتَ [lafata] ‘turned’	اِنْحَازَ [ʔinhāaza] ‘sided with’
أَنهَى [ʔanhāa] ‘finished’	اِنهَارَ [ʔinhāara] ‘collapsed’	أَوْشَكَ [ʔawʃaka] ‘was about to do s.th.’	نَهَى [nahāa] ‘forbid’
دَنَا [danaa] ‘came near’	دَنَسَ [dannasa] ‘stained’	سَبَّحَ [sabbaha] ‘praised God’	تَدَنَّى [tadannaa] ‘was debased’
أَحَاطَ [ʔahaatʔa] ‘surrounded’	أَحْبَطَ [ʔahbatʔa] ‘thwarted’	تَذَمَّرَ [taðammara] ‘complained’	اِحْتَاطَ [ʔihtaatʔa] ‘was wary’
قَاضَى [qaaðʔaa] ‘brought before a court of justice’	نَاقَضَ [naaqaðʔa] ‘contradicted’	دَاعَبَ [daaʔaba] ‘toyed’	اِنْقَضَى [ʔinqaðʔaa] ‘was completed’
تَلَقَّى [talaqqaa] ‘received’	تَلَّحَقَ [talaahāqa] ‘followed in close succession’	تَكَمَّشَ [takammaʃa] ‘became wrinkled’	لَاقَى [laaqa] ‘met’
عَادَ [ʔaada] ‘returned’	عَادَلَ [ʔaadala] ‘treated as equal’	ضَغَطَ [ðʔayatʔa] ‘pressed’	اِعْتَادَ [ʔiʔtaada] ‘was accustomed’

ناب [naaba] ‘represented’	تابع [taabaʿa] ‘followed’	صدق [sʿadaqa] ‘spoke the truth’	انتاب [ʔintaaba] ‘befell’
وفى [wafaa] ‘was integral’	سوّف [sawwafa] ‘postponed’	بدّل [baddala] ‘changed’	استوفى [ʔistawfaa] ‘completed’
راح [raaha] ‘went away’	ستر [satara] ‘covered’	عبد [ʔabada] ‘worshiped’	استراح [ʔistaraaha] ‘took a rest’
ادّعى [ʔiddaʿaa] ‘claimed’	ابتدع [ʔibtadaʿa] ‘invented’	تهرّم [taharrama] ‘became senile’	استدعى [ʔistadʿaa] ‘invited’
جرّى [zarraa] ‘caused to run’	جاور [zaawara] ‘was the neighbor of s.o.’	عبث [ʔabaṭa] ‘fooled around’	جارى [zaaraa] ‘kept in pace’
أفنى [ʔafnaa] ‘annihilated’	انتفى [ʔintafaa] ‘was denied’	أربك [ʔarbaka] ‘confused’	تفانى [tafaanaa] ‘dedicated o.s. completely’
راق [raaqa] ‘pleased’	راقب [raaqaba] ‘observed’	نهض [nahaḏʿa] ‘rose’	أراق [ʔaraaqa] ‘spilled’
خال [xaala] ‘fancied’	خاتل [xaatala] ‘deceived’	كبر [kabura] ‘grew’	اختال [ʔixtaala] ‘felt self-important’
استاء [ʔistaaʔa] ‘was annoyed’	تساءل [tasaaʔala] ‘wondered’	انعدم [ʔinʔadama] ‘was missing’	ساء [saaʔa] ‘became bad’

انتمى [ʔintamaa] ‘belonged’	أنام [ʔanaama] ‘made sleep’	أفرغ [ʔafraya] ‘emptied’	تنامى [tanaamaa] ‘grew gradually’
عانى [ʔaanaa] ‘suffered’	عاتب [ʔaataba] ‘blamed’	جامل [ʒaamala] ‘was courteous’	اعتنى [ʔiʔtanaa] ‘took care’
أهان [ʔahaana] ‘humiliated’	امتھن [ʔimtahana] ‘practised as a profession’	تبرّع [tabarraʔa] ‘volunteered’	استھان [ʔistahaana] ‘considered easy’
جار [ʒaara] ‘committed an outrage’	جاھر [ʒaahara] ‘declared or said openly’	سكب [sakaba] ‘poured’	أجار [ʔaʒaara] ‘granted asylum’
باح [baaħa] ‘confessed’	سبح [sabaħa] ‘swam’	كشف [kaʃafa] ‘uncovered’	استباح [ʔistabaaha] ‘regarded as public property’

Appendix G

The Stimuli from Study 5 with Productivity and Familiarity Scores

no.	Word	Root	Gloss	Gr. category	Prod. score	Freq. score
1	سَيَصِمْدَان [sa-ja-s ^ʕ mudaani]	s ^ʕ ,m,d	they (dual) will resist	V	6	90
2	الْمَتَمَالِكُون [ʔal-mutamaalikuuna]	m,l,k	those who control themselves	A	31	20
3	كَالْإِنْغَلَاات [kal-ʔinɣilaqaati]	ɣ,l,q	like closures	N	15	85
4	بِالْأَرْجُوْجَة [bil-ʔurɜuɣa ^h]	r,ɜ,h	with the swing	N	9	30
5	يَكْتَنِزُون [ja-ktanizuuna]	k,n,z	they amass (e.g. money)	V	8	25
6	مُتَرَاكِمَة [mutaraakima ^h]	r,k,m	piled up (fm.sg)	A	8	85
7	يَتْعَبَانِكَ [ju-tʔibaanika]	t,ʔ,b	they (dual) tire you	V	8	85
8	عَشْوَانِيَّة [ʔafwaaʔiija ^h]	ʕ,ʃ,w	haphazard (fm.sg)	A	16	90
9	سَيَحْسُون [sa-ju-hissuuna]	h,s	they will feel	V	18	95
10	يَسَقِّفَانِهَا [ju-saqqifaaniha]	s,q,f	they (dual) will roof it	V	7	30
11	يَسْتَقْصِيَان [ja-staqs ^ʕ iyaani]	q,s ^ʕ ,j	they (dual) investigate	V	17	25
12	تَقْلِمْنَاهَا [tu-qallimnaha]	q,l,m	they (fm.) trim it (of a tree)	V	9	40
13	ضَعِيفَات [d ^ʕ aʔiifaatun]	d ^ʕ ,ʔ,f	weak (fm.pl)	A	8	95
14	الْمَخْرِيَّة [ʔas ^ʕ -s ^ʕ axrijja ^h]	s ^ʕ ,x,r	the rocky (fm.)	A	5	40
15	الشَّيْخُوْخَة [ʔaʃ-ʃajxuuxa ^h]	ʃ,j,x	the old age	N	10	85

16	فَلْيَعْبَثْنَ [fal-ja-ʕbaθ-na]	ʕ,b,θ	let them (fm.pl) play	V	5	85
17	يَنْتَهِكُونَهَا [ja-ntahikuunaha]	n,h,k	they abuse it	V	10	85
18	رِخَامِيَّة [ruxaamiiya ^h]	r,x,m	made of marble (fm.sg)	A	7	15
19	يَسْتَحْسِنُونَهُ [ja-stahsinuunahu]	h,s,n	they find it/him good	V	26	35
20	سَيَنْكَسِفُ [sa-jankasifu]	k,s,f	it will be eclipsed	V	6	35
21	الْمُتْرَفُونَ [ʔal-mutrafuun]	t,r,f	the rich	A	7	40
22	الْمَلَامَسَةِ [ʔal-mulaamasa ^h]	l,m,s	the coming in contact	N	19	40
23	يَنْبَلِجُ [janbaliʒu]	b,l,ʒ	it dawns	V	6	10
24	يُكَافِحَانِ [jukaafihaani]	k,f,h	they (dual) will confront	V	5	95
25	الْإِنْسَانِيَّةُ [ʔal-ʔinsaaniijja ^h]	ʔ,n,s	the human kind	N	24	95
26	الْقِرَاصِمَةُ [ʔal-qaraas ^ʕ ina ^h]	q,r,s ^ʕ ,n	the pirates	N	3	35
27	اخْتَرَعُوهَا [ʔixtaraʕuuha]	x,r,ʕ	they invented it	V	8	90
28	الْمُدْمِرُونَ [ʔal-mudammiruuna]	d,m,r	the destroyers	A	7	90
29	الْمَشْرَبَةُ [ʔal-maʃraba ^h]	ʃ,r,b	the drinking place	N	23	35
30	مُتَوَاصِلَاتُ [mutawaas ^ʕ ilaat]	w,s ^ʕ ,l	interconnected (fm.pl)	A	33	90
31	ضَاخَةٌ [d ^ʕ aaʒʒa ^h]	ð ^ʕ ,ʒ	noisy (fm.sg.)	A	5	05
32	يَنْبُوعُهَا [junbuuʕuha]	n,b,ʕ	its spring	N	4	30
33	دِرَوسَكَنْ [d,r,s]	d,r,s	your (fm. Pl) lessons	N	15	100

[duruusakunna]					
34	اليهودية [ʔal-jahuudijja ^h]	h,w,d	the Judaism	N	3
Means				11.5	85
				59.26	

Appendix H

The Stimuli from Study 5 with Morphological Composition⁵³

Phonetic transcription (IPA)	no. letters	no. root consonants	no. non-root letters	no. vowels	no. consonants	no. odd letters	no. even letters
سَيَصِمْدَان [sa-ja-s ^h mudaani] 'they (dual) will resist'	7	3	4	1	6	4	3
الْمُتَمَالِكُون [ʔal-mutamaalikuuna] 'those who control themselves'	10	3	7	2	8	5	5
كَالْإِنْغِلَاقَات [kal-ʔinɣilaqaati] 'like closures'	11	3	8	2	9	6	5
بِالْأَرْجُوْحَة [bil-ʔurzuuha ^h] 'with the swing'	9	3	6	1	8	4	4
يَكْتَنِزُون [ja-ktanizuuna] 'they amass (esp. money)'	7	3	4	1	6	4	3
مُتْرَاكِمَة [mutaraakima ^h] 'piled up (fm.sg)'	7	3	4	1	6	4	3
يَتْعَبَانِكَ [ju-tʔibaanika] 'they (dual) tire you'	7	3	4	1	6	4	3
عَشْوَانِيَة [ʔafwaaʔiija ^h] 'haphazard (fm.sg)'	7	3	4	1	6	4	3
سَيَحْسُون [sa-ju-hissuuna] 'they will feel'	6	2	4	1	5	3	3

⁵³ Root consonants are underlined.

يَسْقِفَانِهَا [ju-saqqifaaniha] 'they (dual) will roof it'	7	3	5	1	6	4	3
يَسْتَقْصِيَانِ [ja-staqs'iyaani] 'they (dual) investigate'	8	3	5	1	7	4	4
تَقْلِمْنَاهَا [tu-qallimnaha] 'they (fm.) trim it (esp. of a tree)'	7	3	4	1	6	4	3
ضَعِيفَات [d'a'iifaatun] 'weak (fm.pl)'	6	3	3	2	4	3	3
الصَّخْرِيَّة [ʔas'-s'axrijja ^h] 'the rocky (fm.)'	7	3	4	0	7	4	3
الشَّيْخُوَّة [ʔaʃ-ʃajxuuxa ^h] 'the old age'	8	3	5	1	7	4	4
فَلْيُعِثَّنِ [fal-ja-ʕbaθ-na] 'let them (fm.pl) play'	7	3	4	0	7	4	3
يَنْتَهِكُونَهَا [ja-ntahikuunaha] 'they abuse it'	9	3	6	2	7	5	4
رِخَامِيَّة [ruxaamiiya ^h] 'made of marble (fm.sg)'	6	3	3	1	5	3	3
يَسْتَحْسِنُونَهُ [ja-stahsinuunahu] 'they find it/him good'	9	3	6	1	8	5	4
سَيَنْكَسِفُ [sa-jankasifu] 'it will be eclipsed'	6	3	3	0	6	3	3
الْمُتْرَفُونَ [ʔal-mutrafuun] 'the rich'	8	3	5	1	7	4	4

الملاَمسة [ʔal-mulaamasa ^h] 'the coming in contact'	8	3	5	1	7	4	4
ينبِلج [janbaliʒu] 'it dawns'	5	3	2	0	5	3	2
يُكافِحان [jukaafihaani] 'they (dual) will confront'	7	3	4	2	5	4	3
الإنسانية [ʔal-ʔinsaaniʒja ^h] 'the human kind'	9	3	6	1	8	5	4
القراصنة [ʔal-qaraas ^ʕ ina ^h] 'the pirates'	8	4	4	1	7	4	4
اخترعوها [ʔixtaraʕuuha] 'they invented it'	7	3	5	1	6	4	3
المدمِّرون [ʔal-mudammiruuna] 'the destroyers'	8	3	5	1	7	4	4
المشربة [ʔal-maʃraba ^h] 'the drinking place'	7	3	4	0	7	4	3
متواصلات [mutawaas ^ʕ ilaat] 'interconnected (fm.pl)'	8	3	5	2	6	4	4
ضاجّة [d ^ʕ aaʒʒa ^h] 'noisy (fm.sg.)'	4	2	2	1	3	2	2
ينبوعها [junbuuʕuha] 'its spring'	7	3	4	2	5	4	3
دروسكن [duruusakunna] 'your (fm. Pl) lessons'	6	3	3	1	5	3	3

اليهودية [ʔal-jahuudiɟɟa ^h] ‘the Judaism’	8	3	5	1	7	4	4
Means	7.38	2.97	4.47	1.06	6.32	3.94	3.41

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