ABSTRACT
Two cross-modal priming experiments focussed on the use of word patterns and roots as morphemic units in deverbal nouns in Modern Standard Arabic. In the first experiment, prime and target pairs sharing a word-pattern yield cross-modal priming only if their overlap is both at the level of the phonological structure and the syntactic meaning of the word pattern. In Experiment 2, primes and targets sharing a root but co-variating in terms of their semantic relationship were used. Significant cross-modal priming occurs not only when prime and target share a root and a transparent semantic relationship but also, and more importantly when they share a root and an opaque semantic relationship. These results point clearly to word-patterns and roots being lexical units in MSA. They indicate that the language processor picks up on highly abstract morphological units, which never surface on their own.

1. INTRODUCTION
Morphology, the structure of words, has been argued to be a crucial determinant of the organisation of the mental lexicon [1, 2]. Most of what we know about morphological processing and representation relates to Indo-European languages in which morphemes are concatenated in a linear way such that the same form is usually, if not always, a phonetic word and a free morpheme at the same time. Consequently, morphologically related words like the English “ear, cars, happy-happily” are also semantically and phonologically related. Furthermore, even in cases of allomorphic variations as in “sane-sanity, decide-decision”, which are historical relics, the form overlap is still relatively conspicuous [3]. The very nature of concatenative morphology makes it difficult to clearly tease apart effects of morphology from those of semantics and phonology and/or orthography. Semitic languages, by contrast to Indo-European ones, draw on a non-concatenative word building principle whereby morphemic units are not linearly strung one after the other, but intertwined one within the other [4, 5]. In Modern Standard Arabic (MSA), a Semitic language which will be our main focus, surface word are traditionally analysed as comprising two morphemes: A consonantal root that carries semantic information, and a word pattern providing information about the syntactic category and the phonological structure of the surface from. Accordingly, the actual word [katam] is composed of the root morpheme {ktm} with the semantic information “concealment”, and the word pattern {fa’al} with the syntactic meaning “active verb”1. Word patterns and roots are morphemic units by virtue of their productive recurrence in the language. For instance, the syntactic meaning “active participle” carried by the pattern {fa’wil} cuts across the following surface forms: [kaatimun] “someone who conceals”, [kaatibun] “someone who writes” [fa’ithun] “someone who opens”. Similarly the semantic meaning “concealment” conveyed by the root {ktm} recurs in many surface forms containing this root such as the substantive noun [kitmaanun] “concealment”, the active participle [kaatimun] “one who conceals” and the passive participle [maktuุมun] “concealed”.

What makes word patterns and roots a suitable domain for evaluating the extent to which morphology structures the mental lexicon independently of semantic and phonological factors is that they are not only bound morphemes but also and most crucially discontinuous when they appear in a surface form. This means that morphologically related surface forms exhibit no left-to-right form overlap. Furthermore, word patterns convey syntactic rather than semantic information and root morphemes are highly productive, which means that they recur in very many surface forms with relatively strong or weak semantic links.

A genuine contribution of morphemic structure to lexical processing in MSA can be demonstrated if pairs of words sharing a word pattern like [daarisun-kaatimun] “someone who studies-someone who conceals” are found to facilitate each other in a priming paradigm. It will be of interest as well to examine the priming likely to occur not only between prime target pairs sharing a root and a transparent semantic relationship like [kitaaabun-maktabatun] “library-book”, but also and most critically between pairs sharing a root and an opaque semantic relationship as [katibatin-maktabatun] “squadron-book” [6].

In the remaining part of the paper we present two cross-modal priming experiments assessing the status of word patterns and roots as a lexical units. The basis for choosing cross-modal priming is that it has been shown to be highly sensitive to morphological effects while being relatively insensitive to pure form overlap. In addition to this, the absence of a time interval between the offset of the auditory prime and the onset of the visual target in this paradigm allows a close tracking of processing events as they unfold overtime.

1 Here we follow the traditional practice by using the three letters “f,” “i,” “l” to indicate the slots onto which the letters of the root map.
Word patterns provide crucial syntactic information about surface word forms. They also act as a sort of phonological structure [6, 7]. This raises the question of whether the word pattern is used as a meaning-conveying unit or as a phonological structure. To assess these two possibilities we will compare facilitation between items sharing the word pattern both at the level of phonological structure and meaning with that between primes and targets sharing only the phonological structure the word pattern.

2.1. Method

Participants: A group of 40 volunteers, aged 16 to 20 took part in the experiment. They were pupils at the High School of Tataouine in the Southern part of Tunisia and used MSA on regular basis.

Material: The material consisted of 24 target nominal forms which were 4 to 5 letters long and contained 3 syllables on average. These targets were paired with 96 primes to construct four priming conditions (Table 1).

<table>
<thead>
<tr>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>+[WP]+[F]+[M]:</td>
<td>جدين</td>
</tr>
<tr>
<td>(submission)</td>
<td>/خديع/</td>
</tr>
<tr>
<td>[+WP]+[F]−[M]:</td>
<td>جدين</td>
</tr>
<tr>
<td>(prisons)</td>
<td>/خديع/</td>
</tr>
<tr>
<td>[+Phonology]:</td>
<td>جدين</td>
</tr>
<tr>
<td>(union)</td>
<td>/خديع/</td>
</tr>
<tr>
<td>[Unrelated]:</td>
<td>أستاذ</td>
</tr>
<tr>
<td>(teacher)</td>
<td>/خديع/</td>
</tr>
</tbody>
</table>

Table (1): Design and sample stimuli for Experiment 1 with Arabic script, IPA transcription and English glosses.

In the first condition, labelled [+]WP+[F]+[M] the prime and target share the phonological structure and the syntactic meaning of the word pattern. In Condition 2, [+]WP+[F]−[M] refers to pairs sharing a word pattern at the level of phonological structure but not at the level of syntactic meaning. The third condition, [+Phonology] is one in which prime and target share phonological overlap in the sense of having two consonants in common. Although cross-modal priming is relatively insensitive to pure form overlap, condition 3 was included in order to assess the possibility that any priming effects in condition 2 could be due to pure form overlap. In the fourth condition, labelled as [Unrelated], primes and targets share no relationship whatsoever.

A further 46 fillers were used to dilute the proportion of related pairs and to construct four experimental lists containing the same number of word targets and non-presented at its offset. All the target words were orthographically unambiguous.

2.2 Results and discussion

Figure 1, displays the net priming effects obtained for each of the experimental conditions.

![Figure (1): Priming effects for Experiment 1, showing the test-baseline difference for the conditions [+]WP+[F]+[M], [+]WP+[F]−[M] and [+Phonology].](image)

Error analysis did not reach statistical significance and will not be reported. An analysis of Variance across subjects (F1) and across items (F2) was performed on the RTs with Prime Type as a within subjects factor and List as a between subjects factor. There is a significant main effect of prime type [F1 (1,39) = 9 p < .05, F2 (1, 23) = 5, p < .05]. The interaction between Conditions and List [F1<1, F2<1] is not significant. Planned comparisons using a paired sample t-test revealed a significant 64 ms facilitation when primes and targets share the phonological structure and the meaning of a word pattern. When they share only the phonological structure there is a non-significant tendency towards inhibition. Phonological overlap (i.e. the sharing of two consonants in Condition 3) results in significant ~25 ms of inhibition. Also, word pairs sharing only the phonological structure of the word pattern are not different from those overlapping phonologically.

These results show that the word pattern is used as a meaning-conveying unit during the processing of MSA nominal morphology. The phonological structure of the word pattern alone is not enough to give rise to facilitation. It needs to be backed up by the syntactic meaning component. The sharing of the phonological structure of the word pattern is processed in much the same way as the sharing of phonological overlap. Nevertheless, only pure form overlap (our Condition 3) gives rise to inhibitory effects while the sharing of the phonological structure of the word pattern does not. The inhibition observed in the former case is probably due to competition arising between sub-lexical units, but this needs to be further explored. What is most critical for our present purposes is that word patterns, which do not convey semantic meaning, do give rise to significant priming effects. This speaks in favour of morphological
structure being important independently of semantics and indeed of phonology. This result is crucially important for our understanding of how morphological effects affect the mental lexicon. Furthermore it is a novel finding from the perspective of Semitic languages because previous research on Hebrew nominal morphology failed to find word pattern effects [7, 8], although these authors do report significant effects for the verbal morphology.

3. EXPERIMENT 2

Experiment 2 is designed to assess the status of root morphemes as lexical units. A genuine role of roots as morphemic units can be demonstrated if word pairs sharing a root are found to facilitate each other. The status of the root as a processing and a representational unit will be established on even firmer grounds, if pairs of words sharing a root but no semantic relationship are found to facilitate each other.

3.1. Method

Subjects: A group of 40 volunteers from the same age group and background as in Experiment 1, took part in the experiment.

Material: Thirty two nominal forms which were 3 to 5 letters long and containing 3 syllables on average served as targets. They were paired with 128 filler primes in order to dilute the proportion of related pairs and to construct four experimental conditions as shown in Table 2.

<table>
<thead>
<tr>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. [+R+S]:</td>
<td>إدخال /hídaxáalun/ (inserting)</td>
</tr>
<tr>
<td>2. [+R-S]:</td>
<td>مداخلة /múdáaxalátun/ (conference)</td>
</tr>
<tr>
<td>3. [-R+S]:</td>
<td>صفقة /mánfúqun/ (outlet)</td>
</tr>
<tr>
<td>4. [Unrelated]:</td>
<td>الورقة /qáwwáthun/ (coffee)</td>
</tr>
</tbody>
</table>

Table (2): Design and sample stimuli for Experiment 2 with Arabic script, IPA transcription and English glosses.

The label [+R +S] in Condition 1 refers to primes and targets sharing a root and a transparent semantic relationship as determined in a pre-test. This contrasts with the condition [+R -S] in which the prime and target share a root but their semantic relationship is opaque. In Condition 3, [-R +S] indicates that the prime and target are semantically related but morphologically unrelated in that they do not share a root. The fourth condition sets the baseline against which priming effects will be assessed. Seventy filler pairs were further selected and used to construct four lists containing the same number of word targets and non-word targets with about 30% of related pairs. The subjects had to perform the same task as in the previous experiment.

3.2. Results and discussion

The net priming effects are displayed in figure 2.

Figure (2): Priming effects for Experiment 2, showing the test-baseline difference for the conditions [+R+S], [+R, -S] and [-R+S].

Statistical analysis using ANOVA with two four level factors: “Prime Type” as a within subject factor and List as a between subjects factor. There was a significant main effect of relation [F1 (1, 39) = 10 p < .001, F2(1, 23) = 7, p < .001]. The interaction between Relation and List was not significant [F1<1, F2<1]. Pair wise comparisons further revealed that the amount of facilitation in the +R+S (+50 ms), the +R-S (+49 ms) and the −R+S (+19 ms) conditions was significant. There was a significant difference however between the +R+S and −R+S on the one hand and the +R-S and the −R+S on the other, revealing thus that morphological relatedness (i.e. sharing a root) is significantly different from semantic relatedness.

The results of Experiment 2 demonstrate clearly that morphological facilitation cannot be attributed to semantic relatedness. Words sharing morphology and semantics are processed differently from words sharing semantics only, and morphological priming is obtained in the absence of semantic support. Moreover, the primes and targets do not share a left-to-right form overlap. Indeed the three root segments which morphologically

2 Fifteen judges used a 1-to-9 point scale, with 9 being semantically related and 1 unrelated, to rate pairs of words for semantic relatedness. Pairs rated 6.5 or more were considered as semantically related whilst those rated 3.5 or less were considered as semantically unrelated.
related have in common are not the same position across primes and targets, which makes a form based account difficult to maintain.

4. CONCLUSION

The purpose of this study was to assess the effects of morphological structure on the processing and representation of MSA deverbal nouns. At least three key outcomes emerge from the experiments reported above: First word patterns and roots are clearly lexical units playing a crucial role in the processing and representation of MSA. Second, the priming results observed reflect genuine morphological effects which cannot be attributed either to form overlap or to meaning overlap. Third, morphological structure affects the mental lexicon even when all the morphemes of the language are not only bound but also discontinuous when they surface. From the perspective of a general theory of the mental lexicon these results demonstrate that morphological structure is an important determinant of lexical processing and representation that is independent of both form and meaning. It remains to be seen however if the same pattern of results can be obtained with MSA verbs and primitive nouns and if it can be replicated using other experimental paradigms.

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6. REFERENCES