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Masked cognate translation priming with Arabic-English bilinguals: Further support for the morphological account

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Abstract. The aim of this study is to test the two accounts that have been posited as how cognates are represented in the bilingual mind: the mophological account and the phonological account. More specifically, this study exploits the uique feature of pluralization in Arabic (i.e., concatenative vs. non-concatenative process of pluralization) to invetigate how cognates are represented in the bilingual mind of different-script bilinguals (Arabic-English bilinguals) using the masked priming technique. Two types of cognates were used: cognates that are pluralized concatenatively and cognates that pluralized non-concatenatively in Arabic. In concatenative pluralization, the phonology of the singualr form is intact such as هرمون /hormōn/ (hormone in English), which is pluralized as هرموناتhormōnat/ (hormones in English). On the other hand, in non-concatenative pluralization, the phonology of the singular form is broken when a word is plualized non-concatenatively as in ترم /tirm/ (term in English) and أترام atrām/ (terms in English). The results show a comparable priming effect for both types of pluralizations indicating that cognates in Arabic-English bilinguals may have a shared morphological representation since the magnitude of priming was not affected by the type of pluralization. This similar priming effect for concatenative and non-concatenative pluralization indicates that cognates may share a special kind of morphological representation as suggested by the morphological account.

Keywords: *cognates, non-concatenative, morphology, bilinguals.*

Алзахрані Алхасан. Маскований переклад когнатів з арабсько-англійськими білінгвами: Додаткове свідчення на користь морфологічного підходу.

Анотація. Мета цього дослідження – дослідити за допомогою техніки маскованого праймінгу, як свідомість білінгвів репрезентує слова-когнати. Було використано два типи когнатів: ті слова, які в арабській мові утворюють множину шляхом конкатенації, або «зрощування», та слова, які не утворюють множину за допомогою конкатенації. У випадку утворення множини шляхом конкатенації фонологічна форма однини залишається незмінною, наприклад, هرمون /hormōn/ (гормон в англійській мові), яка у множині має форму هرموناتhormōnat/ (гормони в англійській мові). З іншого боку, у разі неконкатенативного способу утворення множини фонологічну форму однини порушено, як, наприклад, у ترم /tirm/

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(термін в англійській мові) та أترام /atrām/ (терміни в англійській мові). Результати показують зіставний ефект праймінгу для обох типів утворення множини, що вказує на те, що когнати в арабсько-англійських білінгвів можуть мати спільну морфологічну репрезентацію, оскільки на величину праймінгу не впливав тип утворення множини. Подібний ефект праймінгу для конкатенативної та неконкатенативної множини вказує на те, що когнати здатні мати особливий тип морфологічної репрезентації, як це передбачає морфологічний підхід.

Ключові слова: *когнати, неконкатенативний, морфологія, білінгви.*

Introduction

One of the important topics in bilingual research is how multiple languages are processed and represented in the bilingual mind. A key issue that has been of great interest to language researchers is how cognates are represented in the bilingual mind (e.g., Ferré, Sánchez-Casas, Comesaña, & Demestre, 2017; Nakayama, Sears, Hino, & Lupker, 2013; Poort & Rodd, 2017; Sánchez-Casas & García-Albea, 2005; Vanlangendonck et al., 2020; Voga & Grainger, 2007). One of the widely used techniques to investigate lexical representation and lexical processing is the masked priming technique (Forster & Davis 1984), which involves presenting a prime word rapidly so that it is perceived unconsciously affecting the participant's recognition of the target word. Previous masked priming studies (e.g., Voga & Grainger 2007) have found that lexical decision responses to L2 targets that are preceded by their L1 cognate translation equivalents (i.e., words that have a high level of phonological, semantic, and/or orthographic overlap between two languages) are faster and more accurate compared to those preceded by unrelated words. This priming advantage was observed for same-script bilinguals in which cognates share orthography, phonology, and semantics (e.g., Davis et al., 2010; De Groot & Nas 1991) and for different script bilinguals whose cognates share phonology and semantics only with no orthographic similarity (e.g., Gollan et al., 1997; Voga & Grainger 2007). This differential sensitivity to related and unrelated primes is assumed to reflect either the shared representation or connectivity of prime-target pairs with related words having a shared representation while unrelated words do not (Sanchez-Casas et al., 1992), which seems to be the case even with bilingual children (see e.g., Koutamanis et al., 2024, for a review). The present study investigates the representation of cognate translation equivalents for different-script bilinguals (Arabic-English bilinguals) using the masked priming paradigm.

Two accounts have been proposed to explain the cognate translation priming effect found in lexical decision tasks (LDT). The first one, *The Morphological Account*, that has been proposed by some researchers (e.g., García-Albea et al., 1998; Sánchez-Casas & García-Albea, 2005) assumes that the priming effect for cognate pairs is attributed to a language-independent morphemic representation shared by the prime-target pairs. This morphemic unit is captured by a general learning mechanism that detects form (phonology and/or orthography) and meaning similarity within and across languages in which the priming effect size is not expected to vary as a function of form overlap. Based on this account, the priming effect produced by cognate pairs should not differ significantly from morphologically related words within the same language that share form and meaning as well. Incorporating into the BIA model, cognates across languages

are activated in the retrieval of these morphological units in related words from the lexicon at the intermediary level between form and meaning (Sánchez-Casas & García-Albea, 2005, p. 244). Sánchez-Casas and García-Albea (2005) stated that the possibility that priming effects of cognate translations occur at a morphological level that is intermediary between form and meaning. At the intermediary level between form and meaning, a convergence of phonological representations from bottom-up and semantic meaning from top-down occurs. Bilingual speakers use a lexicon where words (i.e., cognates) are retrieved and related by reference to morphological units, not by phonology or semantics alone. Sánchez-Casas and García-Albea (2005) claim that this occurs across all languages whether speakers are monolingual or bilingual. In other words, this is a language-independent process that speakers retrieve words by morphological units of a general learning mechanism whether it is their first or second language. Sánchez-Casas and García-Albea (2005) based this idea on the finding that a priming effect was only found when stimulus onset asynchrony (SOA) was set at 30 ms for false friends; 30 ms, 60 ms, and 250 ms for cognates; and 250 ms for non-cognates (p. 234 and 238). False friends share only similar phonology that is only found to prime among least proficient bilinguals set at 30 ms, and, crucially, bilinguals lacking a particular level of proficiency will not be found to exhibit priming effects set at 60 ms and 250 ms for cognates because they have not reached a level of proficiency to process shared morphological units set at 60 ms and 250 ms and can only process shared phonological representations set at 30 ms. Therefore, the phonological account does not seem plausible to explicate priming effects when the SOA is set at 60 ms and 250 ms. Furthermore, non-cognates are found to have priming effects set at 250 ms because they require more time for semantic representations that are only shared among words to show priming effects at 250 ms in which non-cognates do not show to occur otherwise when set at 60 ms and 30 ms (Sánchez-Casas & García-Albea, 2005, p. 245-6). Cognates share these morphological units and, therefore, are represented in the mind of bilinguals because of a convergence between phonological and/or orthographic representations from a bottom-up processing and semantic representations from a top-down processing that creates shared morphological representations that all words share, refuting that phonological representations alone are responsible for cognate priming found among bilinguals. It is therefore possible that "Words that share form and meaning will undergo conjoint learning, such that when a word becomes more fluent because of practice, other related words will also benefit," (Kroll & De Groot 2005, p. 236). Further research for cognate priming among bilinguals was conducted within and across languages providing clear evidence that the priming effect for morphologically related words within the same language is similar to that produced by cognate translation equivalents across languages (Davis et al., 2010; Sánchez-Casas & García-Albea, 2005). In their third experiment, Davis et al., (2010) with same-script bilinguals (Spanish-English bilinguals) have shown that reaction times to targets were almost identical when these targets were preceded by either their cognate translation equivalents or identity primes (570 ms vs 566 ms). Despite the phonological and orthographic differences between Spanish-English cognate pairs, the facilitation observed for identity priming was almost the same as that for cognate primes. Taken together, the results of these studies support the claim that cognate translations across languages are considered a

special kind of morphological relations since they are assumed to be represented in much the same way morphologically related words within the same language are represented. Even though this account has received some empirical evidence from masked priming studies with bilinguals whose languages use the same script, it might be difficult to use it to account for the findings from different-script bilinguals (Nakayama et al., 2014; Voga & Grainger 2007). Nakayama et al. (2014) pointed out that this difficulty could imply that cognate translation equivalents are represented differently for different-script bilinguals compared to same-script bilinguals. The present experiment has been designed to investigate the underlying representation of cognate translation equivalents, and whether this account can be extended to include different-script bilinguals (Arabic-English bilinguals).

An alternative account, *The Phonological Account*, has been proposed by other researchers to explain the cognate priming advantage for translation equivalents (e.g., Nakayama et al. 2014; Voga & Grainger 2007). This account assumes that cognate priming advantage of cognates can be attributed to two separate effects: conceptual similarity and phonological similarity. Employing the masked priming paradigm, Voga and Grainger (2007) provided empirical support for the phonological account using different-script languages (French and Greek). In their experiment 1, each French target word was primed by either a cognate word (e.g., *κανόνι—canon*), which means cannon in English, a morphologically related word to the Greek cognate prime (e.g., *κανονιά—canon*), which means cannon-shot, or an unrelated word (*κανόνας-canon*), which means rule. Two prime durations were used in this experiment: 50 ms and 66 ms, and each subject was tested at both durations. With the 50 ms prime duration, a significant priming effect was obtained for cognate translation equivalents (36 ms), but no priming effect was produced for morphologically related words to the cognate primes. On the other hand, with the 66 ms prime duration, both prime types produced a significant priming effect, but the priming effect for cognates (50 ms) was significantly larger than that for morphologically related primes (34 ms). This experiment was designed with the aim of testing the morphological account that attributes the priming advantage for cognates to the shared language-independent morphemic representation. Based on this account, no difference in the priming advantage was expected from both cognates and morphologically related cognates, which was not supported by the results of this experiment. Therefore, an alternative account was proposed by Voga and Grainger (2007) that can better explain the priming observed for their bilinguals, the phonological account. This priming effect according to this account, as Voga and Grainger (2007) stated, is composed of two additive effects: phonological and conceptual similarity. The stronger priming effect observed for cognates compared to non-cognates was due to the fact that cognate translations share both components (semantic and phonological similarity) while non-cognates share one component (semantics). This study has been criticized by later researchers (e.g., Nakayama et al., 2014; Zhang et al., 2018) because Greek and French have some orthographic overlap. For instance, the πιάνο–piano cognate pairs share one phoneme /o/, which makes it difficult to distinguish the role of orthography on the cognate facilitation effect. Therefore, the results, as Zhang et al. (2018) indicated, do not fully support the phonological account. The present study will

further examine the cognate priming effect for Arabic-English bilinguals using languages that use completely different orthographies.

Additional support for the phonological account was provided by a masked priming study with different-script bilinguals (Japanese-English bilinguals) in Nakayama et al. (2014). In this study, Nakayama et al. (2014) examined Japanese-English bilinguals using cognate and non-cognate translation equivalents. In their study, Nakayama et al. (2014) had English targets that were primed by two types of primes conditions: high and low similarity prime conditions with Katakana words being used as cognate primes and Kanji words being used as non-cognate primes. Since the phonological account assumes that cognate priming effect consists of two additive effects (phonological and conceptual facilitation), it was predicted that the magnitude of priming will be affected by the degree of phonological similarity between primes and targets. Therefore, the goal of this study was to examine this prediction using cognates with high and low phonological similarity. This study found that the cognate priming advantage was significantly larger for high-phonologically similar primes than for low-phonologically similar primes supporting the existence of two additive effects in the cognate priming advantage. Even though this study clearly supports the phonological account, other researchers (e.g., Zhang et al., 2018) found it problematic to use two different scripts for Japanese-English cognates and non-cognates (Katakana and Kanji respectively). One of the differences between these writing systems is that Katakana is a shallow writing system with a clear correspondence between orthography and phonology, while the correspondence between orthography and phonology is less transparent for Kanji words (Zhang et al., 2018). This, as Zhang et al. (2018) indicated, is considered a violation of the homogeneity of cognate and noncognate primes. As a result, this study could not sufficiently provide clear evidence to support the phonological account. Taken together, this study tests the magnitude of priming for phonologically similar cognate pairs (i.e., cognates that are pluralized concatenatively) compared to phonologically less similar cognates pairs (i.e., cognates that are pluralized non-concatenatively). We will begin by laying out the morphological system of Modern Standard Arabic (MSA), which consists of two derivations comprising its morphology (concatenative and non-concatenative derivation). Then we will demonstrate how these two types of derivations apply to the Arabic plural system.

Arabic Morphology in MSA: Concatenative vs. Non-concatenative Derivation

The Arabic morphology is known for its richness and complexity. Words in Arabic can be derived in two different ways. First, words are derived by attaching suffixes to the base form linearly with no change in the phonological properties of the base, which is known as the concatenative derivation. For instance, the formation of the possessive form in (1) is realized by the suffixation of *-i* to the base form, while the phonology of the nominal base is intact.

1. kitab-i
   book-my
   "My book"

The second method of derivation does not employ the simple suffixation process that is used in the concatenative derivation. Instead, it is done through the mapping of a consonantal root onto a template (as shown in 2), which is referred to as the non-concatenative derivation (McCarthy, 1979).

2. Kaatib
   CaaCiC
   "writer"

The word *kaatib* 'writer' is derived from the verbal base *katab* 'wrote'. The consonantal roots are mapped onto the template CaaCiC in which the vowels (i.e., –aa–i–) are already determined by the template and cannot be changed without changing the meaning entirely (i.e., thus resulting in unrelated words).

The pluralization process in Arabic utilizes both methods of derivations, (McCarthy, 1979). In the concatenative method of pluralization, apart from case, the suffix *–un*, *–in* or *-at* is appended directly to the base form as shown in (3).

3. *muʔallim-un*
   teacher-masc.pl
   'teachers'

In the case of feminine plural as Holes (1995) stated, the feminine plural marker *–at* is suffixed to the base form. If the noun has a feminine plural marker as in *muʔallim-a* 'female teacher' that is pluralized as *muʔallim**at*** 'female teachers', the feminine plural marker is suffixed to the base form after removing the feminine plural marker *–a*. Traditional grammarians refer to this type of pluralization as the *sound plural*, (McCarthy & Prince, 1990). The reason for calling the first type "sound plural", as Boudelaa and Gaskell (2002) indicated, is not because it does not involve any modification of the singular form, but because the inflectional process involves very little (as in feminine plural) or no change to the stem word. In the present study, only the feminine plural suffix *-at* was used to generate the feminine sound plural.

Unlike concatenative pluralization which involves almost no change to the base form, in the case of non-concatenative pluralization, which is traditionally known as the broken pluralization (McCarthy & Prince, 1990), the pattern of the singular form is broken down through morphological processes within the base form. In the non-concatenative pluralization, the only shared elements between the base form and its plural counterpart are the consonantal roots. The root is defined as a consonantal unit that denotes the abstract meaning of all possible derivations of that root (McCarthy & Prince, 1990). The pattern or the vocalic melody of the base form, often changes partially or completely as in (4).

4. kitaab 'book' → kutub 'books'

Example (4) shows that the vocalic pattern of the singular form was changed from *i-a* to *u-u*, but the consonantal root *k t b* remained intact in the base and the derived form.

The Goal of the Study

The goal of the present study is to investigate cross-language translation priming effect in Arabic-English bilinguals. The current research is another examination of the phonological and the morphological account. According to the morphological account, the priming effect for cognate translations across languages is linked to a special kind of morphological representational status in bilingual language processing. This account proposes that the general learning mechanism that is responsible for detecting morphemically related words that share form and meaning within a given language is the same learning mechanism that is responsible for identifying form and meaning similarity across languages (i.e., cognate translation equivalents across languages). According to this view, priming based on morphological relations is not assumed to be sensitive to the degree of phonological similarity of cognate translation pairs. On the other hand, according to the phonological account, the cognate priming effect is attributed to the additive effects of phonology and semantics of the cognate pairs. This account predicts that the priming effect will be modulated by the degree of phonological similarity between prime-target pairs. This prediction was tested in this experiment by using Arabic-English cognate translation equivalents that are highly phonologically similar to their targets (i.e., pluralized concatenatively) compared to Arabic-English cognate translation equivalents that are less phonologically similar to their targets (i.e., pluralized non-concatenatively). Arabic is an ideal language allowing a better test for these two accounts since morphologically complex words in Arabic are formed by either: (i) constructing a linear sequence of morphemes (sequential concatenation of morphemic units) in which the phonology of the stem is intact when a word is pluralized concatenatively, (ii) constructing a non-linear sequence in which root letters are intertwined with the pattern of the word. This contrasts with English, and other Indo-European languages. The non-concatenative pluralization found in Semitic languages such as Arabic provides valuable cross-linguistic contrast and offers an opportunity to assess these two accounts in a more clear-cut manner since the two morphemes of a complex word in Arabic is appended in a different way than concatenative languages.

Considering previous evidence from bilingual lexical decision studies with cognate translations, we predicted that if the advantage of processing cognates is due to the sum of phonology and semantics between cognate pairs, then greater priming effect is expected for morphologically complex cognates that are pluralized concatenatively since the phonology of the base form is preserved when a word is pluralized concatenatively in Arabic. By contrast, less priming effect for those that are pluralized non-concatenatively is expected because the internal structure of the base form is modified when a word is pluralized in a non-concatenative manner. On the other hand, if the cognate advantage in masked priming is due to a language-independent morphemic representation shared by the prime and target in English and Arabic, then a comparable priming effect for complex words that are pluralized concatenatively and non-concatenatively is expected. If this is indeed the case, then there should be a shared morpheme between English and Arabic creating this priming

effect regardless of how the prime is pluralized in Arabic, concatenatively or non-concatenatively, providing strong evidence that morphology is the critical principle of bilingual lexical organization as suggested by Sánchez-Casas and García Albea (2005). The ultimate goal of this study is to address the question of how cognates are stored and represented in the bilingual mind.

Method

Participants

A total of 54 male Arabic-English bilinguals with normal to corrected-to-normal vision participated voluntarily in this experiment. All the participants were either graduate or undergraduate students in Dallas-Fortworth area, Texas, USA. Ten of the participants were excluded due to their high error rates (>20%). The participants completed a language-background questionnaire in which they stated their native language (Arabic), self-reported their dominant language (Arabic), their age (18- 38 years old), and their latest language proficiency tests such as TOEFL or IELTS (average 80/120 for TOEFL test and 6.5/9 for IELTS test). All the participants had reported studying English for an average of 12 years. The participants' L2 proficiency was also measured using the Lextale test (Lemhöfer & Broersma, 2012), which is a 5-minute vocabulary proficiency test. Due to the lack of a widely accepted standardized vocabulary-size test, the Lextale test was chosen specifically because it has been proven to correlate well with general English proficiency and experimental word recognition data but not self-ratings. The scores of the participants ranged between 63 and 80 with an average of 71 out of 100. In their study, Lemhöfer and Broersma (2012) have shown that the average score for proficient bilinguals is 70.5 out of 100, which is very close to the average score obtained by the participants in the current study.

Materials

The experiment consisted of 160 target items, 80 Arabic-English cognate translation equivalents and 80 pronounceable nonword targets. The targets were presented in English (L2) and primes were presented in Arabic (L1). Each English word target was primed by four Arabic prime types: (i) its cognate translation equivalent in Arabic such as computer-كمبيوتر /kombūtar/, (ii) its cognate translation equivalent in Arabic that was morphologically complex (i.e., pluralized either concatenatively using the Arabic feminine plural marker -*at* or non-concatenatively) such as computer-كمبيوترات /kombūtarat/ or filter-فلاتر /falātır/ respectively, (iii) simple unrelated word such as plastic-التزام /iltizām/ meaning obligation, (iv) unrelated word that was morphologically complex (i.e., pluralized either concatenatively or non-concatenatively) such as computer-مقاسات /maqāsat/ or filter-كتب /kutub/ respectively (see Table 1 and 2 for more examples of all prime types). The English targets were selected to form two sets: The first set (40 English word

targets) were paired with morphologically complex primes that can only be pluralized concatenatively in Arabic; and the second set (40 English word targets) were paired with morphologically complex primes that can only be pluralized non-concatenatively in Arabic. Primes that are pluralized concatenatively had phonological and semantic overlap with their targets since the base form is intact when a word is pluralized concatenatively in Arabic while the primes that are pluralized non-concatenatively had less phonological similarity with their targets due to the internal modification of the stem.

English targets that were paired with Arabic primes that are pluralized concatenatively were 3-10 letters in length (M= 6.5 letters) and had a mean written Celex frequency of 34.22 per million. Whereas English targets that were paired with Arabic primes that are pluralized non-concatenatively were 3-9 letters in length (M= 5.4 letters) and had a mean written Celex frequency of 31.87 per million. The prime and target frequencies were accessed using the N-Watch database (Davis, 2005). Four experimental lists were created in which the targets were rotated across these four conditions so that each target cannot appear more than once for each subject. The targets were presented in bold capital letters using Courier New font of size 14, and the primes were presented in bold using the Courier New font of size 12. The font size for both the hash marks and the target words was a bit larger than that of the primes to make sure that the diacritical dots of the Arabic primes are completely masked. The nonword targets were created using the ARC database (Rastle, Harrington, & Coltheart, 2002) while respecting the phonotactic constraints of English. The nonword primes were created to mimic the word primes in terms of concatenativeness and phonological overlap with their targets. The nonword targets that were paired with nonword primes that are pluralized either concatenatively or non-concatenatively were very similar to the word targets in terms of the length of letter strings: nonword targets in the concatenative condition were 4-8 letters in length (M= 5.17), and nonword targets in the non-concatenative condition were 4- 7 letters in length (M= 5.42).

Table 1
Sample Stimuli of All Priming Conditions For Cognates That Are Pluralized Concatenatively

	Arabic Primes			
English Targets	**Simple translation**	**Complex translation**	**Simple control**	**Complex control**
HORMONE	هرمون /hormōn/ (hormone)	هرمونات /hormōnat/ (hormones)	مهرجان /mahrajān/ (festival)	مهرجانات /mahrajānat/ (festivals)
PLASTIC	بلاستيك /blāstik/ (plastic)	بلاستيكات /blāstikat/ (plastics)	إلهام /ilhām/ (inspiration)	إلهامات /ilhāmat/ (inspirations)

Table 2
Sample Stimuli of All Priming Conditions For Cognates That Are Pluralized Nonconcatenatively

	Arabic Primes			
English Targets	**Simple translation**	**Complex translation**	**Simple control**	**Complex control**
BANK	بنك /baŋk/ (bank)	بنوك /bunuuk/ (banks)	جبل /jabal/ (mountain)	جبال /jibāl/)mountains(
TERM	ترم /tirm/ (term)	أترام /atrām/ (terms)	محبس /maḥbas/ (prison)	محابس /maḥbis/ (prisons)

Procedure

Each participant was tested individually. The software that was used for presenting the stimuli and measuring the reaction times (RTs) is the DMDX (Forster & Forster, 2003). Three-field masked priming paradigm was used in which, first, eleven hash marks appeared for 500 ms. Then, the mask was immediately followed by the L1 prime with an exposure duration of 50 ms., which was followed by an upper-case L2 target that was presented for 500 ms. The subjects completed 8 practice items before the experimental items to familiarize themselves with the task. The subjects were instructed to make lexical decisions on the targets as quickly as possible by pressing a response key using the right hand when the letter string they saw is a word and pressing another response key using the left hand when the letter string they saw is not a word in English. Their responses were immediately followed by feedback, printed on the screen. The feedback indicates whether the response is right or wrong and it also includes the latency of the response. The participants were also asked to take a short vocabulary knowledge test known as the Lextale test, which is available at http://www.lextale.com/takethetest.html. The purpose of this test was to measure their L2 proficiency as noted earlier.

Results

Word Analysis

Reaction times for correct responses were averaged across subjects and items. To minimize the effect of outliers, reaction times that were outside a range of two standard deviations above or below the subject's mean were replaced with the appropriate cutoff value. All response latencies beyond the range of 300 ms -1500 ms were discarded and excluded from the analysis. In addition, all responses on which an

error occurred were discarded. The treatments were applied to 11.8 % of the data (averaged across files). All participants whose error rates were greater than 20% (n = 10) were replaced.

Separate analyses of variance (ANOVAs) were calculated, one by subjects (F1) and one by items (F2). The data were analyzed using a 2 x 2 x 2 x 4 ANOVA with RT as the dependent variable and morphological complexity (morphologically-simple vs. morphologically-complex), relatedness (related vs. unrelated), concatenativeness (concatenative vs. non-concatenative), and 4 lists/item groups as the independent variables. Morphological complexity and relatedness were repeated measures for both subject and item analyses, while concatenativeness was a repeated measure for subject analysis but non-repeated for item analysis since an item can be pluralized either concatenatively or non-concatenatively. Lists/item groups was non-repeated for both subject and item analyses. Table 3 shows the mean reactions times and error rates from the subject analysis.

Table 3
Mean Lexical-Decision Times (In Milliseconds) And Error Rates Obtained with Arabic-English Bilinguals in Cross-Language (LI -12) Priming Lists

	Morphologically-simple				**Morphologically-complex**			
	concatenative		**non-concatenative**		**concatenative**		**non-concatenative**	
	RT	**ER**	**RT**	**ER**	**RT**	**ER**	**RT**	**ER**
Related	821	.12	842	.14	839	.12	840	.13
Control	884	.18	885	.22	874	.15	889	.18
Priming	***63	*.06	**43	***.08	**35	.03	***49	*.05

*** p < .001; ** p < .01; * p < .05
RT= reaction time, ER= error rate

The analysis of reaction times showed a significant effect for relatedness by subjects and by items, $F1(1,40)= 44.54$, $p<.001$, $F2(1,72)= 48.37$, $p<.001$, indicating that related items were generally responded to faster than unrelated items. There was a marginally significant main effect of concatenativeness by subjects only, $F1(1, 40)= 3.45$, $p=.07$, $F2(1,72)= .60$, $p=.44$. The main effect of complexity was not significant, $F1(1,40)= .21$, $p=.65$, $F2(1,72)= .40$, $p=.53$. Most importantly, we expected to get a significant three-way interaction between concatenativeness, complexity and relatedness with concatenative complex words being responded to faster than non-concatenative complex words if the cognate priming advantage was

due to the additive effect of phonology that is available for Arabic-English cognates that are pluralized concatenatively; however, the interaction between them failed to reach significance, $F1(1,40)=1.35$, $p=.25$, $F2\ (1,72)=.27$, $p=.57$. No further interactions were expected or found (all p's$>.05$).

Two two-way ANOVAs were conducted for simple and complex items separately with concatenativeness (concatenative vs. non-concatenative) and relatedness (related vs. unrelated) as the independent variables and the reaction time (RT) as the dependent variable. The two-way ANOVA for simple items revealed a significant main effect of relatedness by subjects and by items, $F1\ (1,40)= 32.45$, $p<.001$, $F2\ (1,72)=25.21$, $p<.001$, indicating that simple related items were responded to faster than their unrelated controls irrespective of how these simple items can be pluralized, concatenatively or non-concatenatively. To determine if the priming effect for each stimulus type in the simple condition (i.e., simple concatenative and simple non-concatenative) was statistically reliable, simple pairwise comparisons were conducted for each stimulus type individually. First, for the simple concatenative condition, related words were responded to faster than unrelated words by subjects and by items, $F1(1,40)=22.71$, $p<.001$, $F2(1,72)=12.08$, $p<.01$. A similar pattern of results was found for the simple non-concatenative condition in which the effect of relatedness was also significant by subjects and by items, $F1(1, 40)=8.50$, $p<.01$, $F2(1,36)=13.21$, $p<.001$. Again, the two-way ANOVA for complex words show a main effect of relatedness by subjects and by items, $F1(1,40)=25.24$, $p<.001$, $F2(1,72)=22.99$, $p<.001$, indicating that related items were responded to faster than their unrelated controls regardless of they are actually pluralized, concatenatively or non-concatenatively. To confirm that the effect of relatedness was statistically reliable for each stimulus type in the complex condition (i.e., complex concatenative and complex non-concatenative), simple pairwise comparisons were conducted for each stimulus type separately. Again, the effect of relatedness was significant by subjects and by items for complex concatenative words, $F1(1,40)=7.68$, $p<.01$, $F2(1,36)=5.95$, $p<.05$. Similarly, the effect of relatedness was significant by subjects and by items for complex non-concatenative words, $F1(1,40)=5.32$, $p<.05$, $F2(1,36)=6.24$, $p<.05$.

The ER analysis revealed a significant main effect of concatenativeness in the by subject analysis only, $F1(1,40)=7.24$, $p<.05$, $F2(1,72)= .47$, $p=.50$. Also, there was a significant main effect of relatedness in the error by subjects and by items, $F1(1,40)=22$, $p<.001$, $F2(1,72)=20.86$, $p<.001$, indicating that related words were responded to more accurately than unrelated words. The main effect of complexity was not significant by subjects and by items, $F1(1,40)=2.48$, $p=.12$, $F2(1,72)=2.42$, $p=.12$. The interaction between complexity and relatedness was marginally significant, $F1(1,40)= 3.25$, $p=.08$, $F2(1,72)=2.38$, $p=.13$. No further interactions were significant, all Fs<1.

Similar to the RT analysis, two two-way ANOVAs were conducted for simple and complex error data separately. The two-way ANOVA for simple items showed a significant main effect of relatedness by subjects and by items for simple, $F1(1,40)=25.53$, $p<.001$, $F2(1,72)=19.31$, $p<0.001$, indicating that simple related

targets that were preceded by their simple translation equivalents had less errors regardless of their concatenativeness status. The main effect of concatenativeness was only marginally significant, $F1(1,40)= 3.58$, $p=.07$, $F2(1,72)=.5$, $p=.48$. No interactions were found, all Fs<1.

Again the two-way ANOVA for complex words revealed a significant main effect of relatedness by subjects and y items, $F1(1,40)=6.50$, $p<.05$, $F2(1,72)=6.25$, $p<.05$, indicating that English targets primed by their complex translation equivalents (whether they were pluralized concatenatively or non-concatenatively) were responded to more accurately than those preceded by unrelated primes. There was a marginally significant main effect of concatenativeness, $F1(1,40)=3.15$, $p=.08$, $F2(1,72) = .35$, $p=.56$. No interactions were found, all Fs<1.

Discussion and Conclusions

The main goal of this paper was to investigate how cognates with different degrees of form overlap (phonological overlap in this case) are represented in the bilingual mind of different-script bilinguals (Arabic-English bilinguals, given the different scripts). The experiment was designed to test two accounts that have been put forward as an explanation for the cognate priming effects across languages: the phonological account and the morphological account. The first one, the phonological account, assumes that the cognate priming effect is attributed to the combined effects of phonology and semantics that are available for cognate pairs in which the priming effect can be modulated by the degree of phonological overlap with high-phonologically similar cognates producing more statistically reliable priming compared to less-phonologically similar cognates. The second one, the morphological account, assumes that cognate translation priming is due to a language-independent shared morphological representation by cognate pairs in the two languages of a bilingual. According to this account, morphologically related words within the same language that share form and meaning are assumed to create a robust priming effect similar to that produced by words that share form and meaning across languages (i.e., cognates). Therefore, based on this account, it is possible that the general learning mechanism that is responsible for detecting words that share form and meaning within the same language is the same mechanism used to detect form and meaning similarity across languages.

The phonological account predicts that the magnitude of cognate priming will be affected by the degree of phonological similarity between the primes and targets. This prediction was tested in this experiment. In the current study, the priming effect for cognates that are phonologically similar to their L2 cognate translation equivalents (i.e., cognates that are pluralized concatenatively) was compared to the priming effect for cognates that are less phonologically similar to their targets (i.e., cognates that are pluralized non-concatenatively). We found that the magnitude of priming produced by both types of prime conditions (i.e., primes that are pluralized concatenatively and non-concatenatively) did not differ significantly from each other (35 ms vs. 49 ms).

Therefore, the degree of phonological overlap alone may not play an additional role in how cognates are processed by bilingual speakers. In other words, cognates may have a shared morphological representation in both lexicons that can be processed quickly irrespective of the degree of the phonological overlap for cognate translation pairs. A search in either form (i.e., the singular or the plural form in this case) will access that shared representation.

Even though the phonological account has received some empirical support from a number of masked priming studies (e.g., Nakayama et al., 2014), this account has some difficulty explaining why concatenative pluralization in which the base form of the singular and the plural word is always intact, and non-concatenative pluralization in which the internal structure of the plural form is phonologically different from the singular one had a comparable priming effect. One possible difference between Nakayama et al.'s (2014) study and the current study was that in addition to using two different Japanese scripts for cognates and noncognates primes in their study, the rating of phonological similarity adopted in both studies are also different. In Nakayama et al.'s study, different participants were asked to rate the degree of phonological similarity between primes and targets. The current study used improved prime stimuli that can better test the effect of phonological similarity in cognate translation equivalents. High and low phonological similarity of cognate pairs was not based on participants' ratings of phonological similarity but based on the characteristics of the Arabic plural system (the concatenative vs. non- concatenative pluralization) that allows for testing the validity of both accounts (i.e., the phonological and the morphological account) in a perspicuous manner. In the concatenative pluralization, the phonology of the base form for the prime-target pairs is very similar. In contrast, in the non-concatenative condition, the phonology of the base form is always broken due to the internal modification of the base form. The lack of a shared script between Arabic and English and the distinctive properties of the Arabic morphological system make Arabic-English bilinguals an ideal participant group to test the morphological and the phonological account.

The results of our study are in line with previous studies (Boudelaa & Marslen, 2011; Boudelaa & Marslen-Wilson, 2005; Frost, Forster & Deutsch, 1997) that emphasize the importance of the morphological effects in visual word recognition in Semitic languages such as Arabic. In their study, Boudelaa & Marslen- Wilson (2005) suggest that words in Arabic are parsed and processed simultaneously into two identifiable morphemes (roots and patterns) in visual word recognition, and root identification is assumed to win the race. According Boudelaa & Marslen- Wilson, (2005), the earlier priming effect for roots over patterns reflects the nature of accessibility for both morphemes; roots are fully specified and can be accessed directly from the written form, which is not the case with word patterns that are partially specified and require phonological mediation to be accessed (i.e., only long vowels are specified, while the rest of pattern letters are automatically inferred by adult readers of Arabic). In other words, the extractability of roots from the orthographic input in Semitic languages such as Arabic may not be greatly influenced by the properties of the pattern; the root letters will always win the race. The

insensitivity to the phonological difference in the concatenative vs. non-concatenative pluralization in Arabic might be attributed to the earlier priming for root letters resulting in equal priming effect for all English targets irrespective of how primes are pluralized in Arabic. Therefore, the phonological account might not work with Semitic languages that rely heavily on roots that are always fully specified in the orthographic form of visual primes compared to word patterns that are partially specified (i.e, only long vowels are represented as full graphemes).

As noted earlier, the results of the current study showed very robust priming effect for both prime conditions (i.e., primes that are pluralized concatenatively and non-concatenatively) when measured against unrelated controls with no significant difference between them (35 ms vs. 49 ms) indicating that cognate translation priming effects do not appear to result merely from form (phonological form in this case) and meaning similarity. These results led us to reject the possible contribution of phonological similarity between cognate pairs and to consider the possibility that cognate translations across languages could be a special kind of morphological relations. This possibility imply that cognates have a representational status similar to morphologically related words within a single language. More interestingly, the above findings are consistent with the view that morphology is the critical principle for lexical organization not only in monolingual lexicons but also in bilingual lexicons as suggested by the morphological account, Sánchez-Casas and García- Albea (2005). Even though previous studies supporting the morphological interpretation of cognate priming effects across languages used same-script languages, this study used different-script languages (Arabic and English). However, the results of the current study suggest that this account may not be restricted to same-script languages as stipulated by Voga and Grainger (2007), but it could be extended to include different-script languages. This, then, reinforces the claim that cognate translations across languages cannot be reduced to from and meaning similarity per se, but the priming should be a consequence of the activation of shared morphological representation shared by the cognate pairs.

One potential way for explaining the insensitivity to the phonological differences in the current study appears to be related to the question of whether cognate translations have special kind of representational status similar to morphologically related words within the same language as suggested by Sánchez-Casas and García-Albea (2005). This account assumes that the basis of learning morphologically related words within the same language which is the similarity in form and meaning could be the same basis that detects how cognates should be related across languages. In other words, bilingual speakers would use the same learning mechanism used for learning morphologically related words within their native languages, and this general learning mechanism is responsible for how cognates are represented in the bilingual mind, which is a language-independent process. According to this model, the priming effect produced by cognates should not be modulated by phonological similarity between cognates because cognates are assumed to be connected to a shared morphological representation.

One way to explain the form of that shared representation across languages would be to assume that there is a share morphological unit that captures the correlation between form the form and meaning across languages. The way the facilitation effect for Arabic-English cognates occur could be as follows. When an Arabic-English cognate word is presented as the prime to an Arabic-English speaker (in this case, it is the word فلم /fɪlm/ in Arabic), he would do a morpho-orthographic decomposition to extract the root *flm*, which is a bound morpheme in Semitic languages and is assumed to have a meaning by itself. Then this root morpheme will send activation to a higher level of representation, which is assumed to be a morphological level of representation at which the shared morphemic unit between cognate pairs is represented. Therefore, when the L2 target word FILM is presented, its corresponding morphemic unit that is represented at the morphological level would already be activated by the prime, which should facilitate lexical decision response to the L2 target word FILM. Based on this analysis, all words that share form and meaning will be activated via the same morphological unit shared between cognate translation pairs. In the case of Arabic-English cognates, the shared morphemic unit mediating priming effects is assumed to be the root letters in the speaker's L1 (Arabic) since these root letters carry the core meaning of a word in Arabic, and they are phonologically shared between the cognate pairs. An alternative proposal regarding the form of the shared morphemic unit between the two languages would be to assume that there is a language-independent simple form (phonological form in this case) of prime-target pairs shared between the two languages of a bilingual (Arabic and English) that is represented at the morphological level. The general learning mechanism that detects form and meaning similarity is assumed to detect all possible forms of the word FILM in both languages as intra-lingual variations within the speaker's L1, which implies that phonological differences between these "morphologically related" forms is not critical for lexical representations. There is some, though indirect evidence, suggesting that cognates can be equated with genuine morphological relationships. Crepaldi et al. (2010) found that irregularly inflected words such as fell-FALL yielded significant priming effects than pseudo-irregular pairs such as tell-TALL and orthographic control pairs such as full-FALL with no effect of subregularities that underly irregularly inflected words even though there is no identifiable morpheme shared between *fell* and *fall*. If the manipulation of orthographic similarity, which, in turn affects their phonology, did not show any pattern, then this indicates that morphological priming cannot be reduced to form and meaning similarity. This seems to be the case even with cognates that involve special kind of morphological relations across languages with no effect of the degree of phonological similarity. Once an Arabic-English cognate word is presented as the prime, it will activate all possible forms of that word in both languages as if it were a genuinely morphologically related within his L1.

If Arabic-English cognate translation equivalents can be equated to morphologically related words within the same language that is assumed be mediated by a shared morphemic representation as suggested by the morphological account, then similar priming effects are expected for cognate translations across languages

and morphologically related words within the same language. In fact, the only factor that was manipulated in this study is the phonological factor, and the findings revealed that the manipulation of phonological overlap does not seem to account for the cognate priming effects. This study provided preliminary support for the morphological account, but further work on different-script languages, especially root-based languages such as Arabic or Hebrew is needed to investigate the nature of representation of cognates and to see whether parallels can be drawn between cognates and morphologically related words in the same language. Based on the results obtained from Arabic-English bilinguals, it seems likely that the morphological account is not only compatible with same-script languages, but also seems to provide a good explanation for the representational status of Arabic-English cognates. As far as we know, there are no reported studies that compared the priming effects for cognate words and morphologically-related words within a single language using different-script languages. The data that are in agreement with the predictions of the morphological account have been conducted using same-script languages (e.g., Spanish-English) showing that cognate representations closely resemble morphologically related words within a given language (see García-Albea et al., 1998 for an extensive review). Future studies should also investigate the degree of semantic overlap with cognates and noncognates across languages (Arabic and English in this case) by selecting cognate and noncognate pairs with complete and partial semantic overlap. In this case, cognates should not be affected by the semantic condition, but noncognates should be affected because they do not have a shared morphemic representation compared to cognates that are assumed to have a morphemic unit shared by the two languages of a bilingual.

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