ABSTRACT

Title of Thesis: ORTHOGRAPHIC EFFECTS IN L2 ARABIC WORD PROCESSING: A PRIMING STUDY

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Thesis Directed By: Professor, Nan Jiang, Second Language Acquisition

Late Arabic learners seem to process words in a similar manner to native speakers, distinguishing their processing pattern from the commonly held assumption that form-relatedness drives lexical access in L2 learners. The morphologically driven facilitation witnessed in L2 Arabic learners inspired the current study to further investigate if orthographic effects can be obtained within the same population. Therefore, the current study investigated if late Arabic learners process orthographically related prime-target pairs in a similar manner to native speakers. The study measured participants' reaction times during a lexical decision task while being primed by orthographic neighbors *(شاب – باب)* and orthographic embedded words *(أسباب - باب)*. The results contradicted the prediction and challenge the notion that L2 learners are generally primed by form similarities. L2 Arabic learners seem to differ from L2 speakers of concatenative languages. The results also confirmed previous claims suggesting a lack of orthographic priming effects in L2 Arabic learners, indicating that their processing could be morphologically driven.

ORTHOGRAPHIC EFFECTS IN L2 ARABIC WORD PROCESSING: A PRIMING STUDY

By

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Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Masters of Arts
2025

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Acknowledgments

I would like to acknowledge and thank my advisor, Dr. Jiang. His guidance and support greatly motivated me throughout the writing process. Thank you to the committee members, Dr. Hui and Dr. Sudina, for their endless support and insightful comments. Last but not least, I would like to thank my family for their unwavering support throughout my academic journey.

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Chapter 1: Introduction

Research on second language word processing considers the various ways in which lexical properties can affect visual word recognition. One commonly used method for examining the influence of lexical properties, such as orthography and morphology, on language processing is by conducting priming experiments (Diependaele et al., 2011, Foote et al, 2020; Forster & Davis, 1984; Forster & Taft, 1994; Silva & Clahsen, 2008). Moreover, the results of priming studies conducted on Semitic languages raises questions about the universality of orthographic processing, mainly whether the early stages of lexical processing are consistent across different writing systems (Boudelaa et al., 2024; Velan & Frost, 2011).

Although research examining lexical processing has consistently shown a difference between native and non-native speakers, it has predominantly focused on Indo-European languages as the target language (Diependaele et al., 2011; Heyer & Clahsen, 2015; Silva & Clahsen, 2008). Specifically, L1 speakers reliably produce a masked priming effect for word pairs that are morphologically related (view–viewer) but not for those that are only orthographically related (freeze–free) (Diependaele et al., 2011). Meanwhile, L2 speakers demonstrate a masked priming effect for both morphologically and orthographically related word pairs (Diependaele et al., 2011; Heyer & Clahsen, 2015; Jiang & Wu, 2022; J. Li et al., 2017; M. Li et al., 2017; Li & Taft, 2020; Qiao & Forster, 2017; Viviani & Crepaldi, 2022). These findings suggest that orthographic similarities can facilitate early stages of lexical processing for non-native speakers, which has been consistent across second language learners with Spanish or Dutch L1 (Diependaele et al., 2011), German L1 (Heyer & Clahsen, 2015), and Chinese L1 (Jiang & Wu, 2022; J. Li et al., 2017; M. Li et al., 2017; Li & Taft, 2020).

An interesting finding emerged from studies examining Semitic language learners, suggesting that L2 Arabic speakers rely heavily on morphology, processing words in a manner similar to native speakers (Foote et al., 2020; Foot & Saadah, 2021; Freynik et al, 2017). This diverging result seen in Arabic L2 learners was attributed to fundamental differences in lexical organization between Semitic and Indo-European languages (Velan & Frost, 2011). Whereas Indo-European lexicons depend on orthographic similarity (e.g., letter sequences), Semitic lexicons prioritize morphological components, particularly the root (Velan & Frost, 2011).

Arabic processing uniqueness might stem from its distinct morphological system. Almost every Arabic word is formed by combining two integral morphemes, a root and a word pattern, to create the final word form (Holes, 1995; Versteegh, 1997, as cited in Boudelaa & Marslen-Wilson, 2001). For example, the root *r-s-l*, associated with the concept of sending, can be combined with a variety of word patterns to create different derived words such as *resalah* “message,” *yarsel* “sending,” and *arsala* “he sent.” Therefore, morphological decomposition in Arabic involves extracting three consonantal roots from a word pattern, which serves as an underlying template. This contrasts with the linear morphological systems of Indo-European languages such as the previous example (e.g., *view–viewer*) in English.

The root and pattern morphological structure might obscure cases where orthographic priming is obtained even among native speakers of the language such as in transposed letter priming. For instance, letter transpositions facilitate recognition in Indo-European languages (e.g. English: *garden* facilitate*s GARDEN*) (Perea et al, 2010) or (e.g. Spanish: *relovución* facilitates *REVOLUCIÓN)* (Perea & Carreiras, 2006). Conversely, in Semitic languages, transpositions might introduce new roots (e.g., k-l-m "to talk," m-l-k "to own," l-k-m "to hit," k-m-l "to complete"), which disrupt lexical access (Perea et al., 2010). The sensitivity to the root morpheme reflects the critical role of morphological decomposition in Arabic and Hebrew readers (Velan & Frost, 2011).

The distinctive features that set Semitic languages apart from Indo-European languages raise the question of whether second language processing of Semitic languages might differ significantly from that of Indo-European languages. Moreover, limited research on L2 Arabic learners and the unique features of Arabic provide the foundation for the current study. The native-like processing patterns reported in Arabic L2 learners (Foote et al., 2020; Foote & Saadah, 2021; Freynik et al., 2017) distinguish their processing from that observed in extensively studied Indo-European languages. This divergence between the two linguistic systems hinders the development of a unified theory of second language processing.

In a recent study, Boudelaa et al. (2024) examined the orthographic processing universality and found that the early stages are similar between Semitic and Indo-European languages. This finding clarifies that orthographic effects are not impossible in Semitic language in spite of the morphological complexities. However, most of the research conducted on the processing of Semitic languages is concerned with native speakers. And the few studies conducted on L2 Arabic learners have not reached a definitive conclusion that would explain the processing of second language learners' processing of a Semitic language, namely Arabic. Thus, the current study examines whether orthographic priming occurs among L2 Arabic speakers in a similar manner to Indo-European language learners.

Chapter 2: Literature Review

The literature review covers the relevant research that situates the current study and builds the case for its necessity. This section is divided into four subsections: (a) general and common findings in L2 word processing studies, (b) Arabic morphology, (c) L1 Arabic word processing, and (d) L2 Arabic word processing. It concludes with a subsection on the current study, which explains the main aim, hypothesis, and research questions.

2.1. Second Language Word Processing

Empirical evidence shows that L2 learners treat morphologically complex words like *neatness* or *prayed* as whole forms, whereas native speakers subconsciously decompose these words into their constituent parts (Silva & Clahsen, 2008). A large body of priming research has consistently shown a processing difference between L1 and L2 speakers. Whereas native speakers typically process words based on their morphological structure, L2 learners tend to rely on form-based processing (Diependaele et al., 2011; Heyer & Clahsen, 2015; Jiang & Wu, 2022; Li et al., 2017; Li & Taft, 2020). These recurring findings suggest that late L2 learners develop a different lexical representation, one that does not resemble native speakers' processing strategies.

Diependaele et al. (2011) presented one of the first pieces of evidence for the difference between L1 and L2 processing by conducting a priming experiment on Spanish-English and Dutch-English bilinguals. Their study consisted of three critical conditions: morphologically and semantically related pairs *viewer – VIEW*, morphologically decomposable but semantically unrelated pairs *corner – corn*, and orthographically similar but morphologically and semantically unrelated pairs *freeze – FREE*. They reported a facilitation in all conditions, including the orthographic condition, among non-native speakers; however, native speakers were primed by all conditions except the orthographically-related one.

Diependaele et al.'s (2011) study was one of the many that attributed the facilitation to be morphological and orthographic in non-native speakers. To determine the underlying cause of priming facilitation observed in non-native speakers, Heyer and Clahsen's (2015) directly compared purely orthographically related prime-target pairs (e.g., *country – COUNT)* with derived items that shared orthography, morphology, and semantics (e.g., *darkness – DARK.)* This approach allowed them to disentangle the effects of orthography from morphology, which had been conflated in earlier studies. Heyer and Clahsen (2015) investigated whether non-native speakers process morphologically complex words using the same mechanisms as native speakers. Using a masked priming paradigm, they compared facilitation effects for two types of prime-target pairs: those that were orthographically, morphologically, and semantically related (e.g., *greatness-GREAT)* and those that were purely orthographically related (e.g., *season-SEA.)* Their findings revealed that non-native speakers showed priming in both conditions, suggesting that their processing may be influenced by surface-level orthographic similarities rather than morphological structure. These findings challenged the assumption that non-native speakers process morphology in a native-like manner and emphasized the role of orthography in non-native language processing.

Other L2 priming studies have reported evidence for orthographic effects in bilinguals with items like "*stranger–ANGER"* (Li & Taft, 2020). Facilitation was observed with real prefixed words (e.g., *sabagree–DISAGREE*) and with nonprefixed words (e.g., *plerough–THOROUGH*) (Taft & Li, 2021). Furthermore, some researchers have explained the observed orthographic influence in relation to participants' L1. For example, in the data from Chinese-English bilinguals, the authors suggested that facilitation could be due to the lack of affixes in the participants' L1 or the differences between logographic and alphabetic reading systems (Taft & Li, 2021).

Another orthographic priming study by Jiang and Wu (2022) compared the performance of English native speakers and non-native speakers in a lexical decision task. Their aim was to see the distinction in their processing patterns with items that present an orthographical overlap at the initial and final positions but no semantic or morphological relatedness. The findings reaffirmed that an orthographic priming effect existed in non-native speakers, but not in the native ones.

Additionally, Viviani and Crepaldi (2022) examined bilinguals' form-meaning mapping using a masked morphological priming paradigm. The findings supported the earlier documented patterns observed in L1 word processing, in which target words are facilitated by the prime if it is semantically transparent (e.g., *dealer–DEAL*) or semantically opaque (e.g., *corner–CORN,*) but no priming effect is observed in the orthographic-only condition where there is no morphological relation (e.g., *public–PUB.*) However, for L2 learners, the prime facilitated the target in all categories.

Priming experiments have consistently demonstrated a clear distinction between the processing patterns of native and non-native speakers, attributing these differences to how they access and organize their mental lexicon. Native speakers rely heavily on morphological structure for lexical access. They decompose words into their constituent parts, as these parts contribute meaningfully to word recognition. For example, native speakers did not exhibit an orthographic priming effect when presented with items like "public–PUB" (Viviani & Crepaldi, 2022), as their processing was arguably driven by morphological and semantic relationships rather than orthographic overlap.

In contrast, non-native speakers tend to demonstrate broader and more inclusive processing patterns. Priming experiments frequently report facilitative effects for both morphological and orthographic similarity in L2 speakers. For example, word recognition is facilitated with purely orthographically related items such as *"stranger–ANGER"* (Viviani & Crepaldi, 2022) or "*stage-AGE"* (Jiang and Wu, 2022). It later became evident that what drives non-native speakers' lexical access is pure orthography, as the surface form is a common feature between the morphological and orthographic conditions. This led researchers to conclude that "the observed facilitation in the morphologically related word pairs might be due to the shared letters between the two words" (Heyer & Clahsen, 2015, p. 544). Moreover, the orthographic facilitation observed in non-native speakers may stem from less automatic access to the L2 mental lexicon. As a result, L2 speakers tend to rely more on orthographic cues to access the L2 mental lexicon.

It should be noted that all these studies involved a target language that is alphabetic and concatenative in its morphological structure—i.e., English. In such languages, word formation typically involves adding affixes to a stem in a linear manner (e.g., help – helper). There are several lexical features that differentiate Arabic apart from English and Indo-European languages. Some of these features is the distinct morphological system and the prioritization of morphological components in areas where orthographic similarity would be prioritized in English or other languages. Though these differences do not show an extremely divergent processing pattern between L1 Arabic speakers and L1 speakers of other languages, it does show some discrepancies between L2 Arabic speakers and L2 speakers of other languages.

2.2. Arabic Morphology

Before reviewing relevant research on Arabic processing, it is important to know the morphological structure of Modern Standard Arabic (MSA). MSA is a non-concatenative Semitic language in which words are constructed from two discontinuous morphemes, a root and a word pattern (Holes, 1995; Versteegh, 1997; Wright,1995, as cited in Boudelaa & Marslen-Wilson, 2000; 2005; 2011). The root consists of three consonants that carry semantic information, and the word pattern provides syntactic and phonological structure (Wright, 1995, as cited in Boudelaa & Marslen-Wilson, 2005; 2011; Boudelaa & Marslen-Wilson 2000; 2004; Freynik et al., 2017). The template structure is best illustrated in the (faʕala) example where the three consonant root letters substitute the place of f-ʕ-l in the template (Boudelaa & Marslen-Wilson, 2001). For example, the root *k-t-b*, associated with the broad meaning of "writing," combines with the word pattern *faʕil* (فاعل), which denotes an agent actively performing the action, to form *kateb* (كاتب) "writer." Another pattern, *mafʕul* (مفعول), often indicates a passive participle or the object of an action, as in *maktub* (مكتوب) "written" or "something that has been written." It is also the base root for other derived words such as kia:b (كتاب) “book,” maktab (مكتب) “desk or office,” and maktaba (مكتبة) “library” (Holes, 2004, p. 99).

While some root-pattern combinations, such as those derived from *k-t-b*, demonstrate a clear semantic relationship, this is not always the case. For example, the root *ɣ-r-b* "west" combines with *mafʕEl* (مفعل) to form *maɣrEb* (مغرب) "sunset," with *fa:ʕil* (فعيل) to create *ɣari:b* (غريب) "stranger," and with another pattern to produce ɣurba (غربة) "exile" (Freynik et al., 2017). The exampls provided above shows that semantic transparency varies in Arabic, even with words derived from the same root.

The root-and-pattern system is integral to Arabic morphology, unlike concatenative languages where morphology is not as complex. This integral feature may have contributions on lexical processing for both native and non-native speakers. For example, in a concatenative language, decomposition is more straightforward because suffixes are added to a stem in a linear, transparent manner. For instance, morphologically related English words are also semantically related (Boudelaa & Marslen-Wilson, 2000). A straightforward example of the linearity of concatenative languages is morphologically related words like “happy-happily” even in allomorphic variations like “decide-decision” the linear form overlap is still fairly noticeable (Boudelaa & Marslen-Wilson, 2000). However, the non-concatenative language Arabic relies on intertwining two morphemes—the root and the word pattern—in a nonlinear, discontinuous, and templatic process (Holes, 1995; Wright,1995, as cited in Boudelaa & Marslen-Wilson, 2000; Holes, 2004).

Boudelaa & Marslen-Wilson (2000) argued that the root-and-pattern system serves as an effective framework for examining morphological structure in the mental lexicon separately, given that both the root and pattern function as bound morphemes, and their discontinuous nature affects the surface form. As a result, morphologically related surface forms do not necessarily exhibit a left-to-right form overlap, as seen in concatenative languages (e.g., *happy – happily*) (Boudelaa & Marslen-Wilson, 2000). This structure suggests that Arabic word decomposition involves a deeper level of morphological processing. Decomposition requires locating and extracting the discontinuous root letters from the word pattern, making the process fully reliant on morphology. The following subsections cover the relevant findings about Arabic L1 word processing and what it might explain about native speakers’ lexical representation.

2.3. L1 Arabic Word Processing

Sami Boudelaa and William D. Marslen-Wilson are prominent figures in Arabic processing literature. They conducted multiple priming experiments to clarify whether native speakers of Arabic decompose words into root and pattern during lexical access. Their research consistently examined the critical role of morphological structure in L1 Arabic word recognition.

One of the earliest pieces of evidence for Arabic word processing came from a cross-modal priming experiment, where a target word was preceded by an auditory prime. Boudelaa and Marslen-Wilson (2000) found that priming occurs when prime-target pairs share a root, regardless of whether the relationship is transparent or opaque. However, priming for word pattern sharing pairs occurred only when the pattern conveyed the same syntactic meaning.

In another study, Boudelaa and Marslen-Wilson (2001) examined whether roots serve as a primary organizing unit during lexical access. Through cross-modal repetition priming and masked priming experiments, they tested the impact of morphological, orthographic, and semantic relationships on word recognition. Their findings revealed that morphologically related pairs sharing a root showed strong priming effect, regardless of semantic transparency. For example, pairs like *mubtallun–waabilum* (مبتلٌ - وابلٌ), which share etymons—a finer-grained version of the root, and semantics, were facilitated as much as pairs like *eiqtifaaun–tawfiiqun* (اتفاقٌ - توفيقٌ), which share an etymon but lack a semantic relationship. However, orthographically related pairs, which share surface-level letter patterns without morphological connections, did not facilitate priming.

Another study by Boudelaa and Marslen-Wilson (2005) revealed that word patterns produced only transient priming effects. In a series of incremental masked priming studies, the researchers gradually increased prime exposure time and found that word patterns exhibited short-lived priming, whereas roots consistently facilitated recognition across all stimulus onset asynchronies. According to Boudelaa and Marslen-Wilson (2005), the transient nature of word pattern priming may stem from the fact that these patterns become available only after root processing. Additionally, word pattern activation requires some degree of phonological mediation because word patterns in Arabic orthography are only partially represented because vowels, which are part of the pattern, are not fully specified. In contrast, roots are entirely consonantal and fully represented, allowing them to be accessed more readily during lexical processing.

In yet another priming study, Boudelaa and Marslen-Wilson (2011) further solidified the importance of roots in Arabic word recognition by examining if native speakers' automatically decomposed words into their constituent morphemes during lexical access. Using both masked and cross-modal priming experiments, they showed that roots played a dominant role in driving morphological priming effects. Most importantly, these effects were independent of semantic transparency, indicating that roots are recognized and processed earlier than word patterns.

Overall, these studies demonstrated the complex nature of Arabic processing. As in many Indo-European languages, Arabic L1 speakers seem to rely on morphological information and access the mental lexicon through decomposition. Root priming demonstrates a clear advantage, emerging earlier than word pattern priming. Word patterns are not fully orthographic, making its effect less evident and is reliant on the availability on the root (Boudelaa & Marslen-Wilson, 2000, 2001, 2005, 2011). These findings provide adequate evidence for the significant role of morphology in Arabic word processing.

However, form-relatedness seem to be challenging to obtain in Semitic languages (Frost, 2012). It is suggested that, unlike speakers of Indo-European languages, speakers of Semitic languages focus primarily on letters that carry morphological information during lexical access (Frost, 2012). While these claims hold true for real words, experiments with nonword primes found an interesting orthographic priming effect when Arabic learners were primed by nonwords (Boudelaa et al., 2024; Perea et al., 2014). In a masked form-priming study, Perea et al. (2014) investigated related nonword-word pairs that only differed by one letter (e.g., *kxtabh* priming *ktabh* كخابة – كتابة) and unrelated nonword-word pairs (e.g., *davly* priming *ktabh* داثلي – كتابة). The authors reported a priming effect in the related nonword condition. Similarly, Boudelaa et al. (2024) found an orthographic priming effect when the root and word pattern were absent, which was achieved by using nonwords as primes. The authors suggested that the orthographic facilitation served as evidence of quantitative rather than qualitative differences between the processing of Semitic and Indo-European languages (Boudelaa et al., 2024; Perea et al., 2014).

2.4. L2 Arabic Word Processing

Research into L2 word processing of Arabic derivational morphology has raised questions about whether non-native speakers organize their lexicons similarly to native speakers. Freynik et al. (2017) addressed this gap in research by investigating whether L2 learners show a root-based priming effect in Arabic, a highly productive templatic morphology.

The authors conducted a cross-modal priming experiment to examined the role of the root (+R) and semantic relatedness (+S) during lexical access in five conditions: (+R+S = mudʒa:mala "مجاملة"- dʒami:l "جميل"), (+R-S = dʒumla "جملة"- dʒami:l "جميل"), (-R+S = wasi:m "وسيم"- dʒami:l "جميل"), (-R-S = sa:ʕa "ساعة" - dʒami:l "جميل"), and (Phon = dʒi:l "جيل"- dʒami:l "جميل"). The phonological is a control condition that was added to ensure that the priming effect was due to shared morphological features rather than phonological overlap. Their results revealed significant priming effects in shared root conditions (+R+S and +R−S) for both native speakers and L2 learners, suggesting that L2 learners develop a root-based lexical organization similar to native speakers. However, while native speakers were sensitive to semantic transparency, L2 learners were not, indicating a reliance on structural properties of morphology over semantic associations. The phonological condition showed no priming, thus further supporting the conclusion that root-based priming was morphological for the non-native speaker group.

These findings align to some extent with findings from other languages, where native speakers produce a robust morphological priming. However, the non-native speaker results reported by Freynik et al. (2017) diverged from previous findings where non-native speakers often show priming based on form overlap (Diependaele et al., 2011; Heyer & Clahsen, 2015; Li & Taft, 2020; Taft & Li, 2021; Jiang & Wu, 2022; Viviani & Crepaldi, 2022).

Another study by Foote et al. (2020) found no facilitation for orthographic neighbors, suggesting that non-native speakers of Arabic process words similarly to native speakers by decomposition. Specifically, the authors examined if non-native Arabic learners organize their L2 mental lexicon in a nativelike pattern, and if proficiency levels play a role in this as well. Following the shallow structure hypothesis (SSH), which suggests that L2 learners are less sensitive to morphological structure than native speakers, Foote et al. (2020) hypothesized that L2 learners are not able to process and produce morphology like native speakers, at least in part because morphemes are not presented in the same way in their mental lexicon. The results showed a morphological priming effect for both advanced learners and native speakers, indicating that morphological processing develops with proficiency, as advanced learners demonstrated native-like patterns. Intermediate learners, on the other hand, struggled with decomposing complex morphological structures. The findings obtained by Foote et al. (2020)

contradict the SSH's claim of a surface-level preference for L2 speakers, which this is not surprising, as the SSH has primarily been tested with concatenative languages.

Additionally, no orthographic priming effect was observed in any of the three groups in Foote et al. (2020). In the orthographic condition, the prime and target were orthographic neighbors (xabar "خبر" 'root = x-b-r' – xubz "خبز" 'root = x-b-z'), differing by one letter but sharing the same word pattern. The orthographic neighbor condition eliminated the possibility of morphological relation because prime-target pairs had two different roots. This finding also challenged previous studies conducted on other languages, supporting Freynik et al.'s (2017) findings that L2 learners of a Semitic language are capable of adapting a native-like processing pattern.

In another masked priming study, Foote and Saadah (2021) examined processing of regularly inflected adjective forms in Arabic. The two critical conditions were (a) a morphologically related-root conditions, that is, the prime-target pairs shared a root but differed in gender alone (waasiʕ "واسع" 'spacious' - waasiʕa "واسعة" 'spacious +fem'), or both gender and number (naðiːf "نظيف" 'clean' – naðiːfaat "نظيفات" 'clean +fem +pl) and (b) an orthographic neighbor condition that shared a word pattern (waasiʕ- spacious "واسع" - taasiʕ -ninth "تاسع"). The results showed priming with a morphologically-related root that agreed in gender only but not in the gender-and-number agreement condition, indicating that morphological decomposition may be partial in non-native speakers. The delay in the gender-and-number condition was explained as a result of an overload of inflectional features, which led to the observed delay in stripping the affixes to access the stem form, as it is expected that a decomposition process is occurring in this context. As for the orthographic neighbors category (i.e., a shared word pattern and a difference in one root letter), no significant priming effect was observed for learners of

Arabic. This was attributed to their greater sensitivity to morphological structure than to surface form (Foote & Saadah, 2021).

The unique characteristics of Semitic languages may have contributed to the differences observed in L2 research, diverging from the commonly reported form-based priming seen in the Indo-European literature. Moreover, research on Arabic learners reveals a critical point about their L2 processing. Studies consistently showed that Arabic learners produce a priming effect with morphologically related items during word recognition tasks, while form-based priming does not influence their processing (Freynik et al., 2017; Foote et al., 2020; Foote & Saadah, 2021). These findings suggest that L2 Arabic speakers show a different processing pattern in comparison to L2 speakers of other languages. The lack of orthographic priming suggest that L2 Arabic speakers may display a native-like processing behavior. However, to the best of my knowledge, research on L2 Arabic speakers is limited to the three studies reported above, and this population has not been extensively studied. Thus, there is a significant need for more behavioral evidence to further explore L2 Arabic speakers' processing patterns and determine whether these patterns truly diverge from those observed in speakers of other languages.

2.5. The Current Study

The current study examined whether orthographic priming facilitates word recognition for L2 Arabic learners, aiming to align their processing patterns with findings from L2 processing studies on other languages. Unlike previous L2 Arabic research, which compared orthographic and morphological effects, this study focused exclusively on two orthographic conditions: orthographic neighbors and orthographic embeddedness. An identical prime condition was also added to provide a baseline for comparison. To the best of my knowledge, the embedded condition is a novel addition to orthographic testing in L2 Arabic word processing.

By incorporating the embedded condition, this study aims to provide evidence that L2 Arabic processing might resemble the form-based L2 processing observed in priming studies conducted on English as a second language. Moreover, identifying an orthographic priming effect among L2 Arabic speakers would suggest that their processing is not fundamentally different and therefore extends the claims of Perea et al. (2014) and Boudelaa et al. (2024) to L2 learners of Arabic.

Based on previous findings, the current study hypothesizes that native speakers will not be primed by orthographic conditions. Moreover, L2 Arabic learners will not be primed by the neighbor condition, as indicated in previous studies. However, priming should occur in the embedded condition, as embedded prime-target pairs exhibit a complete overlap of the target form in the prime, which is not the case for the neighbor condition. Furthermore, because previous L2 Arabic studies have found a similar processing pattern between native and non-native speakers, this study's hypothesis predicts that their priming will differ, as captured in the embedded condition. The study aims to answer the following research questions:

1. Is there an orthographic priming effect for L2 Arabic learners in both the embedded and neighbor conditions? And to what extent is the size of the priming effect greater in one condition than in the other?
2. To what extent do Arabic native speakers and L2 Arabic learners differ in their processing patterns?

Chapter 3: Method

3.1. Participants

Thirty native Arabic speakers and thirty late L2 Arabic learners were recruited to participate in the priming experiment. Participants were recruited in-person and online via emailing Arabic programs to share the experiment with their eligible students. All participants were based in the U.S. during the time of the experiment and were compensated for their participation with an e-gift card (native speakers = \$6 per person, non-native speakers = \$10 per person). Some participants decided to volunteer without compensation. The native speakers' average age was 28.35 (SD = 7.39) and the non-native speakers' average age was 22.8 (SD= 3.67).

One Arabic learner was excluded during the trial phase due to hesitations about their own abilities to perform as fast and as accurately as possible. All participants in native speakers group were from an Arabic-speaking country, and have obtained their K-12 education in Arabic. As for the Arabic learners group, they were all L1 English speakers and late Arabic learners. The average number of years spent learning Arabic was M = 3.06 (SD = 2.17) with the majority rating their proficiency as advanced or intermediate (advanced: n = 11, intermediate: n = 9, beginner: n = 9). The proficiency was determined based on their level in the language program and their self-rating. The primary investigator was present with the participants during the lexical decision task either in-person or online to ensure participants' adherence to the experiment instructions.

3.2. Materials and Design

3.2.1. The Selection of Test Materials

Six priming conditions were created as follows: identical prime, orthographic neighbor prime, and orthographic embedded prime, each of these critical conditions had a corresponding control condition that resembled the lexical properties of its respective condition. Nonwords for the lexical decision task were adapted from Perea et al. (2014). The nonwords resemble legal Arabic words in terms of length and word pattern.

Neighbor primes differed from the target by only one letter, whereas the embedded prime contained the target's form intact, either in the initial or final position of the prime, with a different semantic root for the prime-target pairs to eliminate morphological effects. The overlap in initial and final forms ensures that the overlap was purely orthographic because Arabic morphology is non-linear. Table 1 shows a sample of the final 72 items and their primes for each condition.

Table 1. Sample set of stimuli for the priming task

	Prime Conditions					
Target	Identical prime	Identical control	Neighbor prime	Neighbor control	Embedded prime	Embedded control
باب **/baab/** **(door)**	/baab/	ثوب /thoub/ (gown)	شاب /shaab/ (young man)	ممل /mumel/ (boring)	أسباب /asbaab/ (reasons)	اخلاق /axlaaq/ (morals)
ليل **/layl/** **(night)**	/layl/	خسر /xasar/ (lost)	ليس /lays/ (not)	ثقل /thuqul/ (weight)	قليل /qaleel/ (few)	مكان /makan/ (place)

3.2.2. Lexical Properties of Materials

The stimuli were verified for frequency and word length using the ARALEX database (Boudelaa & Marslen-Wilson, 2010). The embedded and neighbor primes were revised to align with their respective control conditions in terms of lexical properties. Additionally, three advanced Arabic learners assessed the familiarity of the selected items. Stimuli that did not meet the required criteria were removed during this process, resulting in a final set of 72 target words, each paired with six primes (identical, neighbor, embedded, and their matched controls). See Table 2 for stimuli frequency and length details.

Table 2. Stimuli characteristics—Priming task

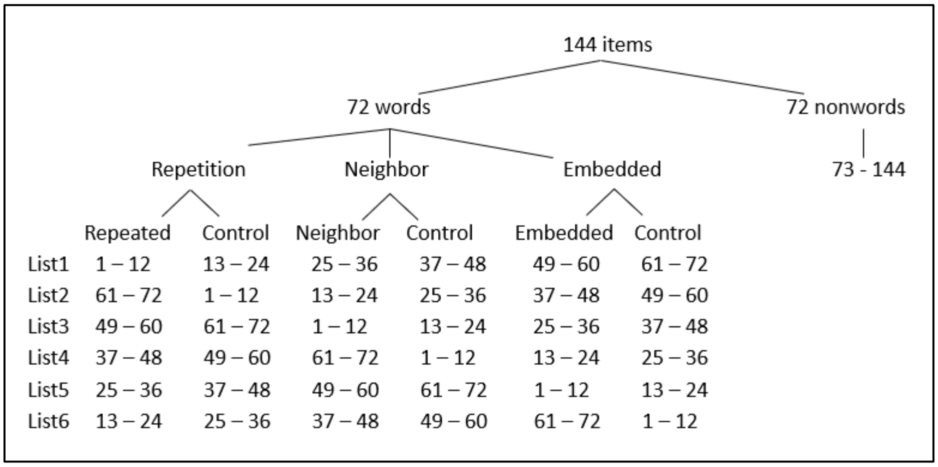
Prime Type	**Identical**	**Identical Control**	**Neighbor**	**Neighbor Control**	**Embedded**	**Embedded Control**
Length	2 – 4	2 – 4	2 – 4	2 – 4	3 – 7	3 – 7
Frequency	75.3	84.4	87.7	77.7	41.5	39.8

Note. Frequency: the orthographic frequency as indicated in the ARALEX database. Length: letter counts.

3.2.3. Presentation Lists

Each of the 72 items had 6 primes, so in order to ensure the items were only displayed once for each participant, six counterbalanced presentation lists were constructed in a Latin square design. Each list consists of 144 items of which are 72 real words and 72 nonwords. The 72 items were randomized with the nonwords to ensure that the participants tap into their mental lexicon during the task and avoid forming an automated response due to the constant display of only real words. The 72 real word items consist of 12 items in each of the six conditions: identical and control, embedded and control, and neighbor and control. The items were displayed such that they never appeared twice on the same list, and each target appeared in a different condition across the six lists, as illustrated below in Figure 1.

Figure 1. Counterbalanced Presentation Lists



3.3. Task and Procedure

The experiment was created and hosted on the Gorilla Experiment Builder platform (www.gorilla.sc). After reading the consent form, the participants were presented with a demographic and language background survey. The experiment took place in a quiet room either in-person or online. After completing the survey, the online participants were asked to share their screen with the PI to ensure that they fully understand the instructions and do not get distracted during the task.

3.3.1. Lexical Decision Task

The lexical decision task (LDT) was used to measure the effect of the independent variables (condition and language group) on the dependent variables (RT and accuracy). This task involved displaying a sequence of letters on a computer monitor, consisting of an equal number of real words and nonwords presented in random order (Jiang, 2018). Participants were instructed to decide whether each displayed item was a real Arabic word.

The LDT is commonly used in priming studies, where stimuli are composed of two integral parts: the prime and the target. The time from the prime's presentation to the target's appearance was set to 50 milliseconds to achieve the desired priming effect as used by previous priming studies in Arabic (Boudelaa, 2024; Perea et al, 2014) and to ensure the prime is only processed subconsciously (Forster and Davis, 1984). All primes were displayed in the same position as the target word as there was no other way to manipulate the physical overlap in Arabic as used in English with upper or lower case variations (Foote et al., 2020). The prime text size was set to 24, and the target size to 36 (Boudelaa et al., 2024). Participants pressed ‘1’ if the displayed item was a real word and ‘0’ if it was not; they were instructed to do so as quickly and as accurately as possible. The target words remained on the screen until the decision was made. The first step was a practice session with 12 items to familiarize the participants with the task. The six presentation lists were randomized to have each list to be displayed to 5 participants in each group.

3.3.2. Vocabulary Familiarity Test

The L2 learners group completed a familiarity test in which they identified unfamiliar words from those presented in the LDT. This test included both prime and target words, resulting in a longer participation time for this section of the experiment. To streamline the process, the familiarity test was designed according to the six presentation lists, with each participant receiving the version corresponding to the list they were randomly assigned in the first task.

The familiarity test was scored based on the familiarity ratings for both the prime and target words within each item and condition. If either or both words were marked as unfamiliar, the item was assigned a score of zero. Conversely, if both words were deemed familiar, the item received a score of one. This coding approach allowed the familiarity test to serve as a covariate in the statistical models. Specifically, familiarity was included as a covariate for the L2 group to control for its potential influence on the RT.

3.4. Data Analysis

All analyses were conducted in R Statistical Software (v4.4.3; R Core Team, 2025). Before fitting the models, participants with a 30% or higher error rate (ER) and any items with 40% or higher ER were excluded. This step led to the removal of two participants and four items from the Arabic learners' data, allowing data from 30 native speakers, and 27 non-native speakers to move on to the cleaning phase.

Responses that were less than 300 ms or longer than 2000 ms were trimmed, which affected 0.7% of the native speaker data and 0.9% of the non-native speaker data. Before the analysis, inaccurate responses were removed for the RT analysis but retained for ER analysis. The accuracy filter affected 5.9% and 18.4% of the native and non-native speaker data, respectively. Using the *psych* library in R (Revelle, 2024), descriptive statistics for RT and ER were examined separately for each group (see Table 3). A follow-up pairwise comparison was computed using the *emmeans* library to inspect the priming effect between each priming condition and its control (Lenth, 2025).

The following step was to check the RT's distribution by conducting a Shapiro-Wilk normality test for both native and non-native speaker groups. The native speaker data illustrated a right skew that deviated from the normal distribution ($p < .001$). The L2 learners' RT's were also right-skewed ($p < .001$). Log-transforming the native speakers' RT data reduced the skewness, though not significantly ($p < .001$). However, log-transforming L2 learners' RT data helped reduce the skewness to an approximately normal distribution ($p = .085$).

After ensuring that the data were properly cleaned, the mixed effects models were fitted. Using the *lme4* package (Bates et al., 2015), the first linear mixed-effects model (LMM) was fitted to examine the overall effects of all predictors, which included the speaker group (native and non-native speakers), prime condition (identity, neighbor, embedded), and relatedness (related prime and unrelated control prime) as fixed effects, and a three-way interaction term between the main predictors. The random effects were the item and participants (see Table 4). Before fitting the model, the categorical predictor variables were sum-coded to compare the effect of different levels of each factor.

To answer the research questions, a linear mixed-effects between-subjects analysis was performed. It involved fitting three models, one for each condition and its corresponding control, with condition and group as fixed effects, and items and participants as random effects (see Table 5). This step was to ensure that the results are consistent with the omnibus model. Additionally, six LMMs were fitted separately for each group to examine RTs. In the L2 group models, familiarity test scores were included as a covariate to control for potential influences unrelated to the primary effect. The final within-group analysis models were omitted from the results section due to redundancy, as they resembled the patterns already observed in Tables 4 and 5.

Chapter 4: Results

To inspect the data, descriptives statistics were calculated for both the RT and ER across groups and conditions. The descriptives showed the difference in RT and ER and for either priming condition when compared with its corresponding control condition. Table 3 presents the mean and standard deviations for RTs and ERs for both native and non-native speaker groups.

Table 3. Descriptive statistics of RT and ER

Condition	**NS**		**NNS**	
	RT	**ER**	**RT**	**ER**
		Mean (SD)		
I	743(207)	4.5 (20.7)	854 (240)	16.7(37.4)
IC	797(218)	5.3 (22.5)	886 (234)	22.1(41.5)
Priming effect	54*	.01	32*	.05
N	773 (210)	5.9 (23.6)	883(235)	19.1(39.4)
NC	768(199)	7.2 (25.9)	892(246)	17.9(38.4)
Priming effect	-5	.01	9	-.01
Em	770(201)	7.5 (26.4)	870(253)	17.8(38.1)
EC	779(205)	5.3 (22.5)	880(253)	17.5(38.1)
Priming effect	9	.02	10	0

Note. I = identity condition; IC = identity control condition; N = neighbor condition; NC = Neighbor control condition; Em = embedded condition; EC= embedded control condition. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

As shown in Table 3, both groups responded faster in the identity condition compared to the control one, and this response acceleration was significant for both groups. However, there was no priming effect for both orthographic conditions when compared to their control conditions for both groups. The following step was to model all predictors in one statistical model to see the overall effects. Table 4 displays the summary of the omnibus LMM using the maximum likelihood estimation.

Table 4. Summary of omnibus linear mixed-effects model

Predictor	Estimate	Std. Error	T-value	P-value
(Intercept)	6.616	.025	270.1	< .001 ***
SpeakerNNS	.137	.035	3.9	< .001 ***
N	-.003	.007	-.4	.7
Em	-.002	.007	-.2	.8
Relatedness	-.013	.005	-2.6	.01 *
N × Relatedness	-.022	.007	-3.2	< .001 **
Em × Relatedness	.015	.007	2.2	.03 *
Speaker × N	.001	.011	.1	.9
Speaker × Em	.009	.011	.9	.4
Speaker × Relatedness	.001	.008	.2	.9
Speaker × N × Relatedness	.008	.011	.7	.5
Speaker × Em × Relatedness	-.006	.011	-.6	.6
Random Effects	**Variance**	**SD**		
1| Participants	.017	.13		
1| Items	.001	.03		
Residual	0.05	0.22		
N participants	57			
N items	72			
Observations	3501			

Notes: Reference levels: Speaker = NS, Prime type = Identity, Relatedness = Unrelated. I = identity condition; N = neighbor condition; Em = embedded condition. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

First, the main effect of speaker group was significant (β = .137, $p < .001$ ***), suggesting that the non-native speaker RTs were longer than the native speaker ones. Both neighbor prime (β = -0.003, $p = 0.7$) and embedded prime (β = -0.002, $p = 0.8$) did not significantly affect RTs compared to the identity prime. There was a significant main effect for relatedness (β = -0.013, $p = .01$*). Interestingly, the interaction between prime type and relatedness was significant in both the neighbor (β = -0.022, $p < .001$ **) and embedded (β = 0.015, $p = .03$*) primes. Moreover, no significant interactions were found between the speaker group and neighbor prime type (β = 0.001, $p = .9$) or the embedded one (β = 0.009, $p = .4$). Similarly, the interaction between speaker group × relatedness was not significant either (β = 0.001, $p = .9$), suggesting a similar processing patterns in both speaker groups.

Finally, the three-way interaction (speaker group × prime type × relatedness) also lacked significance (neighbor: β = 0.008, $p = .5$) or (embedded: β = -0.006, $p = .6$), indicating that the effect of prime type and relatedness on RT did not differ significantly between native and non-native speakers.

In short, the omnibus model showed no interaction between the speaker group and prime type, and the speaker group and relatedness, and failed to show a significant three-way interaction between speaker group, prime type, and relatedness. Thus, simplified models were fitted to examine the data further. Three separate models were fitted for a detailed between-group analysis, with each model comparing a priming condition with its corresponding control (Model 1: identity prime vs. identity control; Model 2: neighbor prime vs. neighbor control; Model 3: embedded prime vs. embedded control). The fixed effects are the condition and the speaker group, and the random effects are the participants and items. The results are summarized in Table 5.

Table 5. Between-subjects mixed effects summary of all conditions

	Fixed effects	Estimate	Std. Error	T value	P value
Identity prime	(Intercept)	6.760	.03	230	< .001 ***
	conditionI	-.039	.02	-1.8	.08 .
	GroupNS	-.113	.04	-2.9	.01**
	conditionI:speakerNS	-.030	.03	-1	.29
Neighbor prime	(Intercept)	6.764	.03	222	< .001 ***
	conditionN	-.015	.02	-.7	.51
	GroupNS	-.152	.04	-3.9	< .001 ***
	conditionN:speakerNS	.021	.03	.7	.47
Embedded prime	(Intercept)	6.748	.03	199	< .001***
	conditionEm	-.004	.02	-.2	.87
	speakerNS	-.119	.04	-2.7	.01**
	conditionEm:speakerNS	-.007	.03	-.3	.79

Note. I = identity condition; IC = identity control condition; N = neighbor condition; NC = Neighbor control condition; Em = embedded condition; EC= embedded control condition; NS = native speakers group. Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

As seen in Table 5, the LMMs summary suggests a significant priming effect for the identity condition (β = -0.039, *p* = 0.08*), leading to faster responses compared to the baseline. Moreover, the native speakers group demonstrated a significantly faster RT compared to the non-native speakers (β = -0.113, *p* = 0.01**). However, the interaction between the identity prime and the speaker group was not significant (β = -0.03, *p* = 0.29), meaning that the effect of priming did not differ between groups. For the neighbor prime condition, there was no significant effect for the condition (β = -0.015, *p* = 0.51). However, native speakers responded significantly faster than non-native speakers (β = -0.152, p < .001***). The interaction between the condition and the group was not significant (β = 0.021, p = 0.47). Finally, the embedded condition did not significantly influence RT's either (β = -.004, p = .87). However, there was a significant effect for the group (β = -0.1209, p = .01**), indicating that native speakers responded faster than non-native speakers. The interaction between the condition and the group was not significant (β = -.01, p = .79).

Chapter 5: Discussion

The present study investigated orthographic priming effects in L2 Arabic learners. The results replicated previous findings, revealing that L2 learners showed no sensitivity to orthographic conditions. The findings presented in Table 4 and 5 suggest a similar processing pattern between native and non-native speaker groups, with priming observed only in the identical condition. However, despite these similarities, native speakers were significantly faster than non-native speakers across all conditions. The main conditions of this study were the two orthographically related prime conditions. The addition of the identical condition was to ensure that the method was adequate in producing a priming effect among the L2 speakers. Moreover, the current findings shows the undeniable divergence of the L2 group from the commonly reported processing pattern seen in L2 learners of other languages. L2 speakers of a concatenative language tend to process words as whole forms; learners of a non-concatenative language, in this case Arabic, do not. Not only are L2 Arabic learners not primed by pure orthographic similarity, but there is also a possibility that they resemble L1 speakers of Semitic languages in that they only rely on letters that carry morphological information (Frost, 2012).

To address the first research question, namely if there was a notable orthographic priming effect for the L2 group, the answer is no. The omnibus model summarized in Table 4 indicates a lack of orthographic priming in the L2 group across both orthographic conditions. However, both the neighbor and embedded conditions differed significantly from their respective unrelated controls. Despite these effects, the lack of significant interaction between the speaker group and the prime type, the speaker group and relatedness, and the main three-way interaction suggests that priming effects did not differ significantly between groups.

Table 4 also answered the second research question, which indicates no significant difference between groups due to the prime type or relatedness. Moreover, the identical condition showed that not only L2 speaker are not primed by the two orthographic conditions, they might also be relying on morphology in a way that resembles native speakers processing. Additionally, the neighbor condition did not produce a priming effect among the L2 speakers group, which was expected as seen in previous studies (Foote et al., 2020; Foote and Saadah, 2021). However, the lack of priming in the embedded condition appears to contradicts the hypothesis and provide additional support for earlier claims about the morphologically driven mental lexicon among L2 Arabic speakers.

Another phase of statistical modeling was conducted using three models for each prime type separately. The purpose of this step was to validate the findings and confirm that the absence of orthographic priming was not due to overparameterization in the omnibus model. As seen in Table 5, the between-subject LMM revealed a significant difference in word processing between groups across all conditions. However, the group differences is similar to the omnibus model; non-native speakers exhibited processing patterns similar to those of native speakers. The similar pattern is indicated by the significant priming effect observed in the identical condition, whereas no orthographic priming was observed in either the neighbor condition or the embedded condition. Thus, although group differences in processing exist, they do not follow patterns reported in L2 speakers of Indo-European languages.

Given the consistent absence of orthographic priming in the L2 group, familiarity test scores were included as a covariate to ensure that participants had explicit knowledge of the words they were tested on. However, even after accounting for familiarity, non-native speakers did not exhibit a priming effect in either the neighbor or embedded condition. This step was omitted from the results section due to its reiteration of the results obtained in Table 4 and 5.

The processing of native speakers seems to be consistent with previous studies (Boudelaa & Marslen-Wilson, 2000, 2001, 2005, 2011; Freynik et al., 2017; Foote et al., 2020; Foote & Saadah, 2021). As for L2 speakers, the observed native-like processing contradicts the original hypothesis but appears to align with the findings obtained from previous studies on L2 Arabic. Thus, a theoretical explanation is needed to account for the consistent absence of form-based priming in L2 Arabic processing.

Previous studies suggested a few reasons that might have contributed to the similar processing among L1 and L2 speakers of Arabic. For example, since all Arabic words consist of two bound morphemes, the Arabic mental lexicon may be organized in terms of the morphological roots (Foote et al., 2020). Furthermore, questions have been raised about the SSH and its ability to consider diverse morphological systems (Foote et al., 2020). Additionally, the lack of form-based priming was explained in relation to the combinatorial entries that exists in the Arabic morphological system (Frynik et al., 2017). Since all Arabic content words are formed through the combination of two bound morphemes, it seems that learners are unable to disregard this morphological structure. Once an Arabic word is recognized, the reader immediately tries to isolate the root morphemes, access the mental lexicon, and search for words derived from the same root (Freynik et al., 2017). These explanations seems to consider the complex morphology of Arabic that does not apply to languages where form-based priming is observed. Thus, it can be speculated that the diverging processing patterns seen in Arabic learners may stem from the complex morphological system of the language itself. Arabic's internal structure is almost impossible to disregard once it is recognized; hence, orthographic components may be recognized after morphological components.

The unique features of Arabic morphology played a significant role in the design of the embedded condition used in this study. This condition effectively eliminated two critical morphological elements. First, the embedded condition overlapped the prime-target pairs in the initial and final positions, ensuring no morphological ties existed between the prime and target words because all morphologically related words are formed in a discontinuous, bound structure. Second, in the embedded condition, the prime is longer than the target, which further guarantees that the prime and the target do not overlap at the word pattern level. This was an additional precaution, because it was evident that the lack of priming in the neighbor condition, as observed in this study and previous research, suggests that word pattern similarity did not have a significant effect on the L2 group. Nonetheless, despite all the measures taken to create the embedded condition, it failed to facilitate word recognition in the L2 group.

The lack of priming in the embedded condition can be explained in terms of a dual-root activation. As noted earlier, once an Arabic word is encountered, the reader is actively attempting to isolate the root morpheme to tap into the mental lexicon with this morphological information (Freynik et al., 2017). If, for example, readers fixate on locating the root letters, and the prime activates a different root subconsciously, this may be indicative of inhibition on any form-based facilitation, because two roots have been activated in their mental lexicon. Consequently, form-based priming effects in Arabic may be difficult to detect unless the prime and the target overlap at the root level, which is impossible because it would introduce morphological associations (Freynik et al., 2017).

Moreover, the observed native-like processing may explained from a language instructional perspective. Foote et al. (2020) noted that Arabic roots and patterns are taught explicitly in the early stages of language acquisition. This could be one of the reasons why the L2 group did not exhibit form-based priming. L2 Arabic learners may develop a strong understanding of morphology that is integrated into their earlier learning experiences of the language. The absence of form-based priming may also be viewed as a positive indicator of successful language learning, as it suggests that learners are able to recognize and process the two integral morphemic components of Arabic words. Thus, the findings suggest that teaching strategies that emphasize initial attention to root-and-pattern structures can develop a native-like processing pattern. Therefore, if the instructional goal is to develop a native-like proficiency, early morphological awareness appear to be effective.

Another point of interest is the question of processing universality. Given the lack of form priming in the current study, which contradicts previous findings obtained from Indo-European languages (Diependaele et al., 2011; Heyer & Clahsen, 2015; Jiang & Wu, 2022; J. Li et al., 2017; M. Li et al., 2017; Li & Taft, 2020; Qiao & Forster, 2017), it can be inferred that the early stages of word processing may not be the same across different linguistic systems. Arguments about the universality of early stages of word processing across language systems support the claim of a "quantitative rather than qualitative" difference, as seen in L1 nonword priming studies (Perea et al., 2014; Boudelaa et al., 2024). This perspective may also apply to the L2 group, where processing differences between native and non-native speakers appear to be a matter of degree rather than a fundamental shift in processing mechanisms. Extending the quantitative difference perspective to L2 Arabic processing is supported by the observed similarities in processing patterns between L1 and L2 speakers, despite measurable differences in processing duration between the two groups. The observed difference appear to stem from the structural properties of Arabic morphology, rather than reflective a fundamental difference between Arabic learners and learners of other languages. This speculation is supported by previous studies on L1 Arabic speakers, which found that letter transposition did not show any priming effects as witnessed in Indo-European languages (Perea et al., 2010). In other words, the lack of priming in Arabic may be due to the internal morphological structure of the language, a dominant feature that seems to drive lexical access regardless of whether the speaker is a native or non-native.

Finally, although the findings did not align with my expectations, they emphasize the need for further SLA research on orthographic priming in L2 Arabic. Future studies could explore alternative methods for testing orthographic similarities within this uniquely designed linguistic system, where morphology is both complex and nearly inseparable. Replications are also needed given the limited number of studies conducted on this learner group, mainly to address the limitation of existing theories, such as the SSH, in considering complex language systems like Arabic. Consequently, conducting more research on L2 Arabic speakers may help in the development of a more comprehensive theory that takes into account the native-like processing in a morphologically rich language.

Chapter 6: Conclusion

The current study investigated orthographic priming effects in the early stages of word recognition among L2 Arabic learners. The results did not indicate any form-related priming effect, showing a similar pattern across the two orthographic conditions (neighbor and embedded) and between groups (native and non-native speakers). First, learners appear to rely on morphology in early word processing, as evidenced by longer response times compared to the control condition. This reliance on morphology diverges from the commonly reported L2 processing pattern, which is typically driven by form similarities. Second, the primary difference between native and non-native speakers lies in the quantity of response time rather than in fundamental processing mechanisms. In other words, while their processing patterns are similar, native speakers respond more quickly. These findings suggest that a language's morphological structure may play a significant role in affecting how L2 words are represented and accessed. Therefore, theories such as SSH seem to apply only to languages without an internal structure. Thus, a universal model of L2 visual word recognition is questionable. Finally, further research is needed to explore how Arabic learners compare to learners of other languages, as this unique processing pattern challenges the widely held assumption that L2 processing is universally form-based.

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