# A META-SYNTHESIS ON THE IMPORTANCE OF DIACRITICAL MARKS IN ARABIC WORD RECOGNITION FOR TYPICALLY DEVELOPED ARABIC READERS: TOWARD A COMPREHENSIVE THEORY

A Dissertation

by

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# ABSTRACT

The purpose of this meta-synthesis is to formulate a hypothesis concerning the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers. I propose that the importance of diacritical marks in Arabic word recognition varies as a function of grade level, stimuli frequency, and text affiliation. Stimuli commonly affiliated with narrative and informational texts are more easily read with diacritical marks in lower primary grades, where phonological recoding is the dominant reading strategy for accessing phonologically and semantically unfamiliar words. Four years of systematic exposure to standard Arabic can increase knowledge of morphology, vocabulary, and orthography to the point of developing a visual reading strategy that dominates word recognition. Thus, in the upper school grades, diacritical marks lose their supportive function for accessing stimuli commonly affiliated with narrative and informational texts; they eventually become a visual burden that compromises the direct visual access of words/texts, causing delayed semantic access and errors in accuracy. However, diacritical marks regain their supportive function when Arabic readers in the upper grades encounter stimuli that are more commonly affiliated with Quranic, literary, and poetic classical texts. These stimuli are known to have a low frequency of the derivatives, roots, and morphemic patterns with which readers are unfamiliar. Encountering these stimuli forces Arabic students to re-adopt a phonological recoding reading strategy. This meta-synthesis includes nine studies published between 1995 and

2020. The results reported in this meta-synthesis substantiate my hypothesis. The results reported in seven studies align with my hypothesis. The results reported in two studies that reported contradictory findings do not discredit my hypothesis, but rather contribute two additional variables that further refine my hypothesis. Overall, sufficient evidence supports the conclusion that the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation. Developing a comprehensive theory concerning the importance of diacritical marks in Arabic word recognition would provide research-based evidence for purely anecdotal policies regarding the transition from vowelized to unvowelized script that have been used in Arabic educational systems for more than 70 years.

# DEDICATION

To Mohammad Al Mahdi and Professor Ali Al Jafar.

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## Contributors

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# CHAPTER I

## INTRODUCTION

Diacritical marks in Arabic orthography are a combination of written symbols onto which consonants are mapped. These symbols contribute phonological, as well as morpho-syntactic, information. Representing these diacritical marks remains optional, which results in two Arabic scripts: a phonologically transparent vowelized script and an unvowelized script that maps only consonants and long vowel sounds, leaving other phonological information to be inferred where necessary. Traditionally, across the Arab world, textbooks in primary education are vowelized. However, a common policy is to transition to unvowelized textbooks from middle school onwards. Although this transition policy has no scientific grounding, educators and policymakers have advocated it for almost 70 years.

The importance of diacritical marks in Arabic word recognition has attracted scholars' attention since 1995, with three perspectives offered. Proponents of diacritical marks believe that they reduce phonological ambiguity, whereas opponents consider them to be a perceptual and visual burden that further complicates Arabic literacy acquisition. However, some scholars argue a more nuanced position: diacritical marks support word recognition only in early grades, whereas more advanced readers in upper grades benefit more from the unvowelized script. Results reported by studies published over the past 25 years have often been contradictory.

A typical approach among scholars who have investigated the importance of diacritical marks in Arabic word recognition is to attribute contradictory findings to

methodological differences and to generalize findings conducted at specific grade levels with particular stimuli. This meta-synthesis argues that all three perspectives regarding diacritical marks are valid assumptions. Generalizing these assumptions, however, is the only invalid assumption. The findings published over the past 25 years are not as explicitly contradictory as they first appear. Instead, these findings suggest a reliable pattern that connects all three assumptions if a variable that is often neglected is considered. Stimuli frequency and text affiliation help resolve discrepancies in the reported findings; their consideration can promote the development of a comprehensive theory to guide related research inquiries. My hypothesis is grounded in theoretical arguments about the sociolinguistic context of Arabic literacy acquisition and the association between word recognition and reading comprehension. My theoretical arguments, in turn, are based on a comprehensive literature review of studies on Arabic orthography published over the past 30 years.

I hypothesize that the importance of diacritical marks for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation. In early grades, Arabic readers rely predominantly on a phonological recoding reading strategy to access phonologically and semantically unfamiliar words. Thus, word/text reading benefits from the vowelized condition. Four years of systematic exposure to standard Arabic allows readers to develop sufficient morphological, orthographic, and lexical knowledge, which in turn promotes a shift to a reading strategy based on visual access. Thereafter, diacritical marks become a visual burden when processing phonologically and semantically familiar words that are typically affiliated with narrative

and informational texts. This can cause latency in lexical access, as well as accuracy errors resulting from processing irrelevant phonological information. Hence, word/text reading is better facilitated by the unvowelized condition. However, even advanced Arabic readers are forced to rely on a phonological recoding reading strategy when encountering unfamiliar words typically affiliated with religious and literary classical texts, which are traditionally introduced in upper grades. Hence, the importance of diacritical marks is restored and the vowelized condition is more conducive to word/text reading.

This meta-synthesis consists of five chapters. Chapter II presents a literature review of the major topics related to Arabic literacy acquisition. The literature is further divided into two major sections: background and a relevant literature review. The background section lays the foundation—the sociolinguistic context of Arabic literacy acquisition, including the structure of Arabic orthography, the reading and spelling processes, reading and spelling disabilities, reading comprehension, the association between oral reading fluency and silent reading comprehension, the visual complexity of Arabic orthography, and diglossia in the Arab world. In the background section, I synthesize the literature published on Arabic orthography over the past 30 years, connecting it with major reading theories and models originating in Latin-based orthographies and drawing critical conclusions.

In the review of relevant literature, I present studies investigating the importance of diacritical marks in Arabic word recognition, critically discuss previous attempts to resolve discrepancies in the findings reported over the past 25 years, and highlight the research problem. The subsections that follow lay out the foundational theoretical

argument for this meta-synthesis, the operational definitions, and the proposed hypothesis. Chapter II concludes by discussing the potential implications for developing a comprehensive theory concerning the importance of diacritical marks in Arabic word recognition.

Chapter III presents the methodology for this meta-synthesis, including search procedures, inclusion/exclusion criteria, an overview of the included studies, and data analysis protocols. A major section in Chapter III considers the stimuli used in the included studies. I have used the ARALEX database to analyze the frequency of derivatives, roots, and morphemic patterns. Analyzing these stimuli was a necessary step to further confirm claims reported in the included studies regarding the frequency of derivatives, as well as to expand the analysis to include other morphological and lexical items such as roots and morphemic patterns.

Chapter IV is divided into two major sections: the results of this meta-synthesis and a discussion section. Available evidence published over the past 25 years supports my conclusion that the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation. Finally, in Chapter V, I report on limitations, directions for future research, and my study's implications.

# CHAPTER II

# LITERATURE REVIEW

## Background

### *Structure of Standard Arabic Orthography*

#### Phonological and Syllabic Structure

Arabic has a total of 37 phonemes, consisting of 28 consonant sounds, three long vowel sounds, three short vowel sounds, and three nunation sounds that serve as case endings for indefinite nouns in a non-pausal continuous speech (Appendix D). In terms of syllabic structure, Arabic has six types of syllables: CV, CVV, CVC, CVVC, CVCC, and CVVCC. A consonant sound (C) is mapped either onto a short vowel sound (V), creating a CV structure, or onto a long vowel sound (VV), creating a CVV structure. The syllable division pattern in Arabic is at the boundary of body-coda, rather than onset-rime. Vowel teams are not permissible in Arabic. Finally, the initial consonant cluster is not a permissible pattern in Arabic, in contrast to a final consonant cluster (Saiegh-Haddad & Henkin-Roitfarb, 2014).

#### Writing System

Arabic uses a Semitic orthography that is written from right to left. It has 28 alphabetic letters, 25 of which represent consonants and three of which represent both consonant and long vowel sounds. Short vowel sounds are not part of the alphabet and are represented as strokes above (◌َ ◌ُ) or under (◌ِ) consonants. Similarly, nunation sounds are also represented as strokes above (◌ً ◌ٌ) or under (◌ٍ) consonants.

Arabic has two other written marks—pronounceable consonants that do not map onto short vowel sounds are represented by a silence mark (ْ); a doubled consonant is represented by a germination mark (ّ) to indicate a stressed syllable. Together, short vowel marks, nunation marks, silence mark, and germination mark are known as *diacritical marks*. The fact that Arabic can be written with or without the diacritical marks results in two types of orthography: the vowelized script in which phonology is completely represented and the unvowelized script, in which some aspects of phonology must be inferred. Unvowelized scripts are consistent in terms of Grapheme-to-Phoneme Mapping (GPM). They also map consonants and long vowel sounds. However, the diacritical marks are inferred, if needed, through lexical, morpho-syntactic, and contextual knowledge (Abu-Rabia, 2002). Eye-tracking studies have shown that Arabic readers demonstrate a longer gaze duration per word compared to readers of Latin-based orthographies, despite a similar number of fixations when interacting with the unvowelized script to infer phonological and contextual information to support reading (Roman & Pavard, 1987).

Diacritical marks serve two purposes. Marks that appear on initial and medial letters of a word have a phono-morphemic function. These marks guide pronunciation and are part of the morphemic pattern of a word. Phono-morphemic marks preserve the phonetic or prosodic nature of the morphemic patterns. Thus, morphemic patterns reliably imply absent diacritical marks. The mark that appears on the final letter of a word has a phono-syntactic function. Aside from guiding pronunciation in a running text, the final diacritical mark signals to readers the grammatical function of words (i.e., the case for nouns and mood and the tense for verbs) when word order is manipulated. Arabic has a

fixable grammatical word order; hence, the object can precede both the verb and subject, and the verb can precede the subject. In classical Arabic literature (e.g., the Quran, poetry), maintaining a rhyming pattern is the commonly adopted writing style (Saiegh-Haddad, 2018). Therefore, the final diacritical marks are placed to denote a word's grammatical function. Individuals who specialize in Arabic language and literature demonstrate the ability to process and infer phono-syntactic marks, whereas typical or even highly skilled readers tend to intentionally ignore these marks because they lack syntactic awareness (Saiegh-Haddad, 2018; Taouk & Coltheart, 2004).

In terms of GPM, 24 letters make one sound each, three letters make two sounds, and one letter makes three sounds (Appendix C). There are reliable rules to guide the pronunciation of irregular GPM. In terms of Phoneme-to-Grapheme mapping (PGM), 35 phonemes have consistent mapping and two phonemes have irregular mapping (Appendix D). There are reliable rules to guide spelling choices for irregular mapping. All Arabic graphemes are single-letter.

Most Arabic letters have visually similar shapes (Appendix C). Similarly shaped letters are distinguished by location and the number of dots that appear above or below the letters (e.g., ب ت ث). Only eight letters have a unique shape. Furthermore, all letters assume different shapes depending on their position in a word, although the core original shape is always maintained. For example, the letter /haːʔ/ is written هـ in the initial position, ـهـ in the medial position, ـه in the final connected position, and ه in the final isolated position, wherein the preceding letter is not connected with the letter. Because Arabic letters connect with each other, the style of Arabic writing is always cursive

(Saiegh-Haddad & Henkin-Roitfarb, 2014). In addition to the letters' connectivity, prepositions and pronouns are often attached to words; hence, Arabic is known to be highly agglutinative.

**Morphological Structure**

Arabic morphology can be divided into derivational and inflectional morphology (Abu-Rabia & Awwad, 2004), although one exploratory factor analysis study reported Arabic morphology to be a unidimensional construct, whereby the single-factor solution explained 40% of the variance (Tibi & Kirby, 2017). Derivational morphology is concerned with generating new words. The basic idea behind derivational morphology is better understood using a simple equation: root + pattern = word. Roots (i.e., lexemes) are composed of three consonants (rarely four or five) that convey the initial lexical access of word meanings. Roots provide the core semantic meaning for all words within a root-related family. These roots are mapped onto morphemic patterns to generate specific semantics. Morphemic patterns are fixed prosodic templates (i.e., phonological patterns assigned to letter strings) and are constituted by a combination of consonants, long and/or short vowel sounds, and occasionally prefixes and suffixes. For example, the root ك ت ب is related to writing. When applied to the morphemic patterns CaCaC, Ca:CiC, ma-CCu:C, ma-CCaCa-h, the results would be *he wrote*, *a writer*, *was written*, and *library*, respectively. Another example is the root د خ ل, which is related to entering. When this root is applied to the same patterns described above, the results would be *he entered*, *the person who enters*, *was entered*, and *entrance*, respectively.

Morphemic patterns are categorized according to the semantic functions of words; thus, they denote agents, places, adjectives, objects, time, and instruments (Brosh & Attili, 2009). For example, to describe a machine (e.g., car, refrigerator, water cooler) the pattern CaC'a:Ca-h is used. To describe a place (e.g., laundry, school, farm) the pattern ma-CCaCa-h is used. To describe something in relation to something else (e.g., larger than, smaller than) the pattern a-CCaC is used. Roots are mapped onto morphemic patterns in both a linear and or a non-linear fashion (Tibi, Tock, & Kirby, 2019). In some morphemic patterns, the sequence of the tri-literal root is not broken (e.g., CaCaC). Short vowels do not break the sequence of the root as they are not displayed in unvowelized script. Oftentimes, however, the sequence of a root is broken when the phonological/prosodic pattern of the morphemic pattern entails an infix (i.e., a long vowel sound) such as the pattern ma-CCu:C. Morphemic patterns are phonologically sensitive; manipulating the diacritical marks within a morphemic pattern leads to a different morphemic pattern, and therefore, a different lexical meaning. An example is the root ك ت ب, which is related to writing. If mapped onto CaCaC the outcome is كتب [he wrote], and if mapped onto CuCuC the outcome is كتب [books]. Roots, on the other hand, are sequence-sensitive. For example, the root ب ح ر is related to sea and oceans, whereas the root ح ب ر is related to ink. Thus, although roots are not necessarily presented linearly within morphemic patterns, the letters of roots remain invariant. Root-based morphology is one of the salient features that characterize Arabic orthography.

Inflectional morphology is concerned with inflecting words. Words are linearly affixed, with most inflectional morphology done by suffixation (Abu-Rabia & Awwad,

2004). In Arabic, nouns are suffixed to inflect for gender, case (i.e., nominative, accusative, genitive), person, and number. Verbs are suffixed to inflect for gender, number, person, and mood (i.e., imperative). Additionally, verbs are both prefixed and suffixed to inflect for tense (e.g., past, present). Finally, prepositions and articles are suffixed to inflect for gender, person, and number. Arabic distinguishes between masculinity and femininity and recognizes three different numbers: singular, dual, and plural (i.e., more than two).

**Vocabulary**

The total number of Arabic words is debatable. Words are generated through derivational morphology, compounding roots, direct loan words (e.g., *okay* and *bye*), and loan words that are Arabicized due to the availability of equivalent Arabic roots (e.g., computer in Arabic is حاسوب, which literally means "the machine that computes"). Because words are mostly generated through derivational morphology, uncertainty remains regarding whether to calculate solely the roots or their derivatives as well.

The total number of roots in Arabic is also debatable. The Quran includes 1,767 roots of which 1,722 roots are tri-literal. The total number of words in the Quran is 77,476, yet this number is reduced to 17,622 if repetitions get excluded (Khedher & Zaki, 2011). On the other hand, classical Arabic dictionaries which are typically alphabetically organized according to roots record numbers ranging from 6,000 to 12,000 roots. All authors of classical dictionaries have explicitly noted that many roots were no longer active in their time. The current number of active roots in the Arabic language is estimated to be around 5,336 (Boudelaa & Marslen-Wilson, 2010).

Furthermore, around 185 morphemic patterns exist in classical Arabic, many of which occur infrequently (Ibrahim, 2008). However, there are estimated to only be around 35 frequently active morphemic patterns, both nominal and verbal, in Modern Standard Arabic (Abu-Rabia & Awwad, 2004). To calculate the total number of Arabic words, roots are multiplied by morphemic patterns. Computer estimations suggest that the total number of Arabic words may be approximately 200,000—of which verbs constitute 12% (n=23655), articles and prepositions 1% (n=115), and nouns 87% (Al Bawwab, Mirayati, Alam, & Al Tayyan, 1996). Al Kouly (2010) reported that an Arabic-speaking individual, on average, uses 31% articles and prepositions, 11% verbs, and 58% nouns in a written text.

Tibi, Tock, and Kirby (2019) found that Arabic morphology and vocabulary independently accounted for 44% and 5%, respectively, of third-grade reading variance in a comprehensive vowelized reading assessment battery. However, no studies have yet investigated whether Arabic morphology and vocabulary are distinct constructs.

### *The Reading Process*

Reading in alphabetic orthographies requires mapping graphemes into phonemes. However, according to the orthographic depth hypothesis, alphabetic orthographies differ in the degree of regularity and consistency by which printed graphemes are mapped onto oral phonemes (Frost, Katz, & Bentin, 1987; Katz & Frost, 1992). It follows, therefore, that reading strategies differ across alphabetic orthographies, depending on the degree of consistency regarding the GPM. A phonological recoding reading strategy that is best predicted by phonemic awareness may be sufficient for readers of transparent

orthographies in which GPM is highly regular (Seymour, Aro, & Erskine, 2003). In contrast, readers of deep orthographies must employ several reading strategies to compensate for irregular GPM (Aro & Wimmer, 2003). According to psycholinguistic grain size theory (Ziegler & Goswami, 2005), examples of such reading strategies include rhyming, reading by analogy, morphological decomposition, and whole-word reading, all of which depend on components larger than individual phonemes.

Vowelized Arabic script is highly regular, as all phonological information is represented, and all but four graphemes have regular GPM. Cross-sectional studies have consistently reported phonemic awareness (i.e., the conscious ability to manipulate sounds) as the most powerful significant predictor of vowelized script reading in the first six years of schooling, explaining up to 35% of the variance in vowelized word reading (Asadi, Khateb, Ibrahim, & Taha, 2017; Asadi & Khateb, 2017; Saiegh-Haddad & Geva, 2008; Saiegh-Haddad & Taha, 2017; Tibi & Kirby, 2018, 2019). A longitudinal study from kindergarten to the beginning of the second grade found that phonemic awareness significantly accounted for 33% of the variance in vowelized reading when controlled for morphology, vocabulary, and working memory (Abu Ahmad, Ibrahim, & Share, 2014). Furthermore, phonemic awareness significantly explained vowelized word reading variation between poor and skilled readers in grades 1–5 (Abu-Rabia, 1995; Abu-Rabia, Share, & Mansour, 2003; Saiegh-Haddad & Taha, 2017). The results of a phonological and alphabetic intervention indicate that phonemic awareness significantly reduced the gap between second graders at-risk of reading failure and their more typically developing peers in vowelized word and pseudoword reading (Makhoul, 2017a). Moreover, letter

knowledge and letter-to-phoneme naming have been consistently reported to exert a significant influence on vowelized script reading (Asadi, Khateb, Ibrahim, & Taha, 2017; Layes, Lalonde, & Rebaï, 2017; Tibi & Kirby, 2018, 2019). These findings suggest that a bottom-up reading strategy (i.e., phonological recoding) governs vowelized Arabic reading in grades 1–6.

Morphological awareness (i.e., the conscious ability to manipulate the morphological structure of words) is consistently reported to be the second-most powerful predictor of vowelized script reading. Results of a longitudinal study reported that morphological awareness significantly accounts for 9% of the variance in vowelized word reading in the second grade when controlling for phonemic awareness, vocabulary, and working memory (Abu Ahmad, Ibrahim, & Share, 2014). Similarly, Tibi and Kirby (2019) reported that morphological awareness can predict and uniquely explain 3% of the variance in vowelized word reading for third-grade students when controlling for phonemic awareness, orthographic processing, and vocabulary. In another study, morphological awareness successfully explained up to 14% of the variance in vowelized word reading for elementary students in grades 1–5 (Asadi, Khateb, Ibrahim, & Taha, 2017). The significant and unique contribution of morphological awareness to vowelized word reading for third-grade students has also been reported in factor analysis studies (Tibi & Kirby, 2017; Tibi, Tock, & Kirby, 2019). Finally, morphological awareness was found to significantly explain vowelized word-reading variation between poor and skilled readers in grades 3–5 (Abu-Rabia, Share, & Mansour, 2003; Layes, Lalonde, & Rebaï, 2017; Saiegh-Haddad & Taha, 2017).

Other significant predictors of vowelized script reading include vocabulary and orthographic knowledge (i.e., forming, storing, and retrieving conventions and patterns of the writing system). Orthographic knowledge has been reported to reliably predict vowelized word reading throughout grades 1–5, controlling for phonemic and morphological awareness (Asadi, Khateb, Ibrahim, & Taha, 2017; Tibi & Kirby, 2019). Vocabulary was also reported to make a small but significant contribution toward vowelized word reading in grades 1–3 when controlling for phonemic and morphological awareness (Abu Ahmad, Ibrahim, & Share, 2014; Asadi & Khateb, 2017; Tibi & Kirby, 2018, 2019).

Scholars hypothesize that three stages characterize progression in reading acquisition in alphabetic orthographies: the *logographic* stage, in which readers rely on salient orthographic features to decode words; the *alphabetic* stage, in which GPM is the main reading strategy for decoding unfamiliar words; and the *visual* stage, in which no mediation role for phonology is expected as readers recognize words as wholes (Frith, 1986; Harris & Coltheart, 1986). An analysis of studies that have investigated the contributors of vowelized word reading suggests the dominance of a phonological recoding strategy in vowelized script reading. However, findings also indicate that a bottom-up approach in word recognition is not the sole reading strategy. Morphological awareness, orthographic processing, and vocabulary also contribute to vowelized word recognition. Regardless of how much these skills contribute, findings indicate the existence of top-down reading strategies along with a phonological recoding strategy. The small contribution of vocabulary in grades as early as 1–3, as well as the consistent

contribution of orthographic processing, may indicate attempts to access words based on salient orthographic features and sight word knowledge. In addition, the consistent contribution of orthographic processing from the fourth grade onwards fuels speculation as to whether Arabic readers ever completely move beyond the logographic stage.

Furthermore, findings on the contribution of morphological awareness through elementary schooling suggest attempts to access words through either morphological decomposition or direct visual semantic access. However, the relevance of using morphological decomposition as a reading strategy depends on the extent of an orthography's morphological transparency—i.e., the degree to which phonological information, and therefore meaning, can be extracted from the morphological structure (Elbro & Arnbak, 1996). In an orthography such as English, wherein morphology is linear or concatenative (McCarthy, 1981), stems stand as independent words, and the process of attaching or detaching prefixes and/or suffixes preserves, for the most part, the words' phonological and orthographic identities. This then facilitates decoding. Arabic, however, has a root-based morphology and the order of the letters that constitute roots is often broken by infixes. Thus, Arabic readers either recognize familiar words as wholes (Abu-Rabia & Awwad, 2004) or mentally process all consonants within an unfamiliar word, regardless of consonants' morphemic role, as pure consonants, priming and selecting among them until a lexical match with a mentally stored root is found (Boudelaa, 2015). More evidence that the Arabic mental lexicon is consonant-based is that Arabic readers recognize both English words spelled correctly and those with missing vowels as identical in lexical decision tasks (e.g., department-dpartment, management-managment,

photograph-photogrph), confirming that Arabs focus on the consonant structure of words (Ryan & Meara, 1992). Arabs develop root awareness as early as the second grade (Taha & Saiegh-Haddad, 2017); elementary students in grades 3–6 score significantly lower on morphological decomposition tasks than in root-relatedness tasks. This suggests that Arabic readers have generally poor morphemic boundaries (Saiegh-Haddad & Geva, 2008), meaning that they could eliminate morphological decomposition as a decoding stagey, leaving only visual access of roots as a top-down decoding strategy. By doing this, Arabic readers attempt to understand a word's meaning directly, without phonological mediation.

The fact that Arab students begin formal education with a limited standard vocabulary (see diglossia section) may explain the modest contribution of morphological awareness to vowelized word reading through elementary schooling. The contribution of morphology in early grades is likely to be restricted to high-frequency words such as articles, prepositions, function words, demonstratives, pronouns, and connectives. An analysis of primary textbooks in two Arab countries shows that these types of words occurred frequently within texts (Belkhouche, Harmain, Al Najjar, Taha, & Tibi, 2010).

In summary, it appears that Arabic readers experience the three stages of reading development concurrently. Although the alphabetic stage seems to dominate vowelized script reading, early schooling witnesses an overlap between all three stages of reading development, suggesting a dynamic reading mechanism. A phonological recoding reading strategy appears to dominate most vowelized script reading, yet readers may switch to lexical reading channels upon the availability of semantics.

Few studies have investigated the reading process for unvowelized Arabic script, especially beyond the sixth grade when Arabic schools typically switch to unvowelized reading materials. Asadi and Khateb (2017) examined predictors of unvowelized scripts for first and second graders. Their results showed that phonemic awareness and vocabulary were both accurate predictors of word recognition in the first grade, with phonemic awareness exerting more influence, but that vocabulary contributed more to word recognition than phonemic awareness in the second grade. The findings clearly suggest that, in the absence of diacritical marks, students were inferring them for guiding their word recognition and that their underdeveloped phonological skills forced them to rely more heavily on a logographic decoding strategy in the second grade. The consistent contribution of phonemic awareness in both grades supports the notion that visual word recognition, as opposed to phonological decoding, is not feasible for beginner readers. Furthermore, Taouk and Coltheart (2004) compared college adults and fourth graders in unvowelized word reading. All stimuli were pronounceable, yet all letters were wrongfully represented by design using the medial shape regardless of their real positions (e.g., ثلجـ instead of ثلج, meaning "ice"). Their results showed no significant differences in terms of accuracy between the two groups. However, a significant delay in fluency was observed among the adults but not among the fourth graders. The superior fluency of the fourth graders suggests they had adopted letter-by-letter reading (i.e., a phonological recoding strategy). In contrast, the adults tried to access the words visually, meaning that the orthographic misrepresentation significantly affected their fluency. Although both studies were conducted in artificial settings, as no Arabic school

implements unvowelized script during primary education, both studies indicate that reading up until the fourth grade is substantially guided by GPM, even in unvowelized scripts.

Only two cross-sectional studies have investigated unvowelized word reading in natural settings beyond the sixth grade. Abu-Rabia (2007) and Abu-Rabia and Abu-Rahmoun (2012) reported that morphological awareness, specifically root identification, makes the most significant contribution to unvowelized word reading among eighth-grade, ninth-grade, and twelfth-grade students (n = 180), explaining up to 56% of the variance in unvowelized word reading. Phonology, as measured by vowelized word reading and the placing of diacritical marks on words and sentences, was identified as the second-most powerful predictor, making a significantly smaller contribution to unvowelized word reading among students across all three grades. Orthographic knowledge also made a small yet significant contribution to unvowelized word reading among students across all three grades. In another study, Saiegh-Haddad and Taha (2017) controlled for grade and phonemic awareness and reported that morphological awareness significantly predicted vowelized and unvowelized word reading for highly skilled readers (i.e., $\geq$ the $90^{th}$ percentile in word recognition). However, morphological awareness made the largest contribution in unvowelized script compared to vowelized script.

The findings regarding unvowelized script reading suggest a rotation of reading strategies. It appears that after several years of schooling, Arabic readers manage to develop a semantic repertoire that allows them to access words visually. A top-down reading strategy appears to dominate the process of unvowelized script reading, during

which direct visual access to words occurs. However, the small yet significant contribution of phonology indicates that Arabic readers may find themselves in a situation wherein a phonological recoding strategy may again be required. Most likely, such a situation will occur in the absence of semantic knowledge. Traditionally, literary, poetic, and complex Quranic classical texts are introduced in Arab education in upper grades. It is highly likely that a phonological recoding strategy is used when interacting with such texts, with which students are likely to be unfamiliar.

Taha (2019) trained a group of skilled Arabic readers (i.e., ≥ the 75$^{th}$ percentile in word recognition) on a list of pseudowords. The participants were divided into two groups. One group had training on word pronunciation and meaning while the second group received only pronunciation instruction. Both groups received no orthographic exposure to the target words. The first group demonstrated significantly better accuracy and speed at posttest. The results of this study support the claim that advanced and skilled Arabic readers who have successfully managed to build a phonological and semantic repertoire access words visually using a top-down reading strategy.

Overall, it appears that the same overlap experienced in vowelized script reading between the alphabetic and visual stages of reading development persists in unvowelized script reading. However, a rotation between bottom-up and top-down reading strategies seems to occur, with a top-down reading strategy dominating unvowelized script reading upon availability of semantics. However, readers may switch to sublexical reading channels in the absence of semantic knowledge.

The reading channels described in the dual-route model characterize the Arabic reading process (Coltheart, Curtis, Atkins, & Hailer, 1993; Seidenherg & McClelland, 1989). However, an Arabic reading mechanism is a dynamic process. Arabic readers rotate between sublexical and lexical channels; the dominance of one reading strategy over another is a function of script, grade, and lexical knowledge (Abu-Rabia, 1998; Abu-Rabia & Taha, 2004; Saiegh-Haddad, 2018). In early grades, when vowelized script is introduced, a bottom-up reading strategy governs word recognition and promotes access to meaning (Adams, 1994). In upper grades, when unvowelized script is introduced, a top-down reading strategy dominates word recognition of semantically familiar words. Nonetheless, encountering semantically unfamiliar words forces readers to use a bottom-up reading strategy in upper grades once again.

The three stages that characterize reading progression inform the understanding of how reading skills develop among Arabic readers. However, it is necessary to acknowledge these stages in Arabic as continuums rather than sequential stages (Abu-Rabia, 2012). Finally, perhaps Arabic is better labeled as having a semi-transparent orthography despite its highly regular GPM. A phonological recoding strategy is not the sole reading mechanism in the phonologically transparent vowelized script, despite substantial dependence on sublexical processing (Abu Ahmad, Ibrahim, & Share, 2014). Furthermore, the reading mechanism in the phonologically deep unvowelized script is related to lexical knowledge.

## Reading Disabilities

Beginner readers of alphabetic orthographies rely on phonemic awareness and knowledge of GPM to decode printed words (Seymour, Aro, & Erskine, 2003). It follows that poor reading of an alphabetic orthography is characterized by poor phonological decoding (Stanovich, 1988). Research shows that a phonological deficit is a major aspect that characterizes poor reading of vowelized Arabic script (Abu-Rabia, 1995; Abu-Rabia, Share, & Mansour, 2003; Al Ghanem & Kearns, 2014; Saiegh-Haddad & Taha, 2017; Tibi & Kirby, 2019).

Studies also show that a deficiency in morphological awareness is the second strongest predictor that explains the variations in vowelized reading between poor and skilled readers (Abu-Rabia, Share, & Mansour, 2003; Layes, Lalonde, & Rebaï, 2017; Saiegh-Haddad & Taha, 2017). However, poor readers demonstrate more knowledge of morphology than of phonology (Abu-Rabia & Abu-Rahmoun, 2012; Saiegh-Haddad & Taha, 2017). Furthermore, they also demonstrate a performance on orthographic knowledge comparable to skilled readers, although skilled readers have slight advantages (Abu-Rabia, 1995; Abu-Rabia, Share, & Mansour, 2003; Al Ghanem & Kearns, 2014). In other words, orthographic knowledge does not explain vowelized word-reading variation between poor and skilled readers. Instead, it appears that poor readers rely on their orthographic and morphological knowledge when encountering vowelized script to compensate for their phonological deficiencies, as well as relying on logographic and top-down reading strategies to compensate for their lack of knowledge regarding phonological recoding strategies (Tibi & Kirby, 2019). Accordingly, poor readers significantly lag

behind more skilled readers in vowelized script reading (Asadi & Shany, 2018; Saiegh-Haddad & Taha, 2017).

Another feature that characterizes poor reading in alphabetic orthographies, particularly transparent ones, is a naming speed deficiency (Wolf & Bowers, 1999). Transparent orthographies pose little phonological challenge for readers in developing accurate reading, yet reading fluency remains crucial for developing automaticity (Wimmer, 1993). Studies have shown that naming speed is the powerful predictor of vowelized Arabic fluency (Asadi, Khateb, Ibrahim, & Taha, 2017; Saiegh-Haddad, 2005; Tibi & Kirby, 2018, 2019). Asadi and Shany (2018) reported that students who had a naming speed deficiency (n = 31) significantly lagged behind skilled readers in vowelized word reading fluency. Readers with naming deficiencies attempted to compensate for their lack of speed by relying on their orthographic knowledge and sight word vocabulary for rapid reading (Asadi, Khateb, Ibrahim, & Taha, 2017; Tibi & Kirby, 2019). Consequently, their fluency is less than that of skilled readers who possess automatic word recognition abilities and a larger sight vocabulary and who rely less on orthographic processing (Layes, Lalonde, & Rebaï, 2017).

Only one study has investigated reading disability in unvowelized scripts. Dyslexic readers in the eighth grade scored significantly lower on measurements of unvowelized word reading, phonology, morphological awareness, and orthographic knowledge compared to non-dyslexic readers (Abu-Rabia & Abu-Rahmoun, 2012). It is reasonable to assume that, because poor readers of vowelized script lack adequate phonological and morphological knowledge, it is likely that such deficits will persist if they go unnoticed.

Skilled Arabic readers rely mostly on visual access to words, a skill that is underlined by morphological awareness—specifically root awareness when encountering unvowelized script. Additionally, even skilled readers rely on a phonological recoding strategy when they lack semantic knowledge. Moreover, skilled readers develop automaticity that facilitates rapid visual word recognition. Accordingly, poor readers who struggle to rapidly decode vowelized scripts are likely to struggle when encountering unvowelized script, owing to their lack of fundamental skills. Finally, orthographic knowledge explains unvowelized reading variations, unlike vowelized word reading (Abu-Rabia & Abu-Rahmoun, 2012). Interacting with unvowelized script in the upper grades requires less phonological processing and more visual processing (Elbeheri, Everatt, Mahfoudhi, Abu Al-Diyar, & Taibah, 2011).

### *Spelling*

Research suggests that acquiring proficiency in Arabic spelling is supported by a triangle of three skills: phonemic awareness, morphological awareness, and orthographic knowledge. These skills significantly and consistently predicted spelling in the first six years of schooling for 1,278 Arabic students (Asadi, Ibrahim, & Khateb, 2017). Furthermore, phonemic and morphological awareness consistently and significantly predicted word and pseudoword spelling for 160 students, both poor and skilled, in grades 1–4 when controlling for age, naming speed, and verbal memory (Saiegh-Haddad & Taha, 2017). Moreover, morphological awareness was reported to significantly facilitate the spelling of morphologically complex words (Saiegh-Haddad & Taha, 2017). Finally, in an experimental study (Taha & Saiegh-Haddad, 2016), second-grade, fourth-grade, and

sixth-grade participants (n=289) in experimental groups, who received a phonological and morphological six-month intervention, significantly outperformed their peers in control groups on both word and pseudoword spelling. In terms of the experimental groups in all three grades, both interventions were comparable and successful in developing spelling. No significant differences were reported between participants who received phonological training and those who received morphological training. Overall, knowledge of PGM, derivational and inflectional morphology, and orthographic patterns and conventions seem to be necessary skills for mastering Arabic spelling.

Spelling is thought to progress in alphabetic orthographies in three stages: the *pre-alphabetic* stage, in which salient graphic features of words (e.g., consonants) are recognized; the *alphabetic* stage, in which PGM is the primary strategy for spelling and the understanding of vowels becomes solid; and the *orthographic* stage, in which the conventional spelling of the orthography is recognized and the spelling of both regular and irregular words is grasped (Frith, 1986). In other words, there seem to be two routes for accessing correct spelling: sublexical and orthographic (Perry, Ziegler, & Coltheart, 2002). Some scholars argue that the transition from the sublexical to the orthographic route only characterizes deep orthographies (Goswami, 2013). PGM inconsistency forces spellers of deep orthographies to rely on orthographic knowledge. In transparent orthographies, however, such a transition may remain unnecessary because PGM is reliable; hence, the sublexical route becomes dominant and spelling seems to reach a ceiling by the end of the first and/or second grade (Shatil & Share, 2003).

Qualitative analysis of spelling errors has been used to examine the knowledge and cognitive strategies used in Arabic spelling. Azzam (1993) analyzed spelling errors made by 150 students in grades 2–6. Invented spelling and insufficient knowledge of long vowel sounds among second graders reflect features of the pre-alphabetic stage. An analysis of errors in grades 3–6 found both phonological and orthographic errors among students in all grades. Examples of phonological errors were wrongful representations of consonants (e.g., homophonic sounds) and lengthening short vowel sounds. Examples of orthographic errors were misrepresenting irregular graphemes (e.g., Hamza, Alif) and null sounds (i.e., representing them as /n/ sounds instead of diacritical marks) and representing silent sounds in irregularly spelled words. Such findings indicate a concurrent progression into the alphabetic and orthographic stages. Other errors made by students in grades 5–6 that were related to the wrongful use of morpho-syntactic morphemes suggest the existence of a fourth stage in Arabic orthography: the morpho-syntactic stage.

Qualitative analysis of spelling errors made by second- and fifth-grade students (n = 60) revealed the same types of errors and the same overlap between stages (Abu-Rabia & Taha, 2004). Finally, a qualitative analysis of spelling errors among typically developed students (n = 288) in grades 1–9 showed that 60% of errors across all grades were phonologically based and 40% were orthographically based (Abu-Rabia & Taha, 2006). Both types of errors existed in each grade level with no significant differences between grades in the percentage of phonological errors, unlike orthographic errors, which tended to be proportionally more frequent in upper grades than in lower grades, simply because the complex conventional rules of Arabic spelling are typically introduced only in the

upper grades. These findings provide more evidence of the concurrent progression of the stages of spelling acquisition among Arabic students. The finding that the majority of errors are phonologically based does not indicate that most Arabic students have a phonological deficiency; rather, it is seen as the fault of Arabic schools, which place very little emphasis on phonological training (Al Ghanem & Kearns, 2014), along with other socio-cultural factors (see diglossia section).

In summary, spelling development in Arabic further confirms that Arabic has a semi-transparent orthography. Despite highly regular PGM, Arabic readers use multiple encoding strategies aside from PGM. They also seem to rotate between sublexical and orthographic encoding strategies. In other words, the same overlap witnessed between alphabetic and visual stages of reading development among Arabic students is manifested in spelling as well. These stages in Arabic must be acknowledged as continuums rather than sequential stages. Consistently, up to the higher grades, phonological, orthographic, and morpho-syntactic errors persist among even skilled Arabic students (Abu-Rabia & Taha, 2004). Across grades, even those Arabic readers with considerable skills do not show significant improvements on measures of spelling except between the first grade and later grades (Saiegh-Haddad & Taha, 2017). The spelling performance of skilled second, fourth, and sixth graders is statistically and qualitatively comparable (Taha & Saiegh-Haddad, 2016). Limited writing opportunities in diglossic Arabic communities are partially responsible for such a stable performance (see the diglossia section) yet poor teaching is more to blame. Skilled spellers perform significantly better than poor spellers at all grade levels (Abu-Rabia, 1995, 2007; Abu-Rabia & Abu-Rahmoun, 2012; Abu-

Rabia, Share, & Mansour, 2003; Saiegh-Haddad & Taha, 2017). However, spelling errors and development in Arabic orthography seem to be a matter of quantity, not quality; many Arabic students seem far from being accomplished in conventional spelling (Abu-Rabia & Taha, 2006; Azzam, 1993).

**Spelling Disabilities**

Beginner readers and spellers of alphabetic orthographies lack orthographic knowledge due to a lack of systematic exposure and instruction. Orthographic knowledge only develops in the later stages of literacy acquisition (Asadi, Khateb, Ibrahim, & Taha, 2017). Systematic exposure to printed works allows students to develop and store mental visual orthographic images that foster automatic word recognition and accurate spelling (Ehri & Snowling, 2004). Thus, it follows that reading and spelling via GPM and PGM strategies remain the optimal choices for beginner students when decoding and encoding in alphabetic orthographies. Accordingly, it seems reasonable to assume that reading and spelling may be parallel processes, at least in the early grades in a given orthography, until other reading and spelling strategies have developed (Ehri, 2000). Subsequently, the reading and spelling processes begin to diverge, becoming largely independent processes that remain somewhat interdependent (Fitzgerald & Shanahan, 2000). If the two processes are parallel, it follows that the same skills that underpin reading also underpin spelling.

Research has shown that vowelized Arabic reading and spelling are parallel processes in early schooling. Mohamed, Elbert, and Landerl (2011) reported no significant differences between the reading and spelling scores of Egyptian first and second graders (n = 111). However, significant differences were reported between second and third

graders. Moreover, Taha (2016b) reported that reading and spelling were parallel until the end of the fourth grade among Palestinian students (n = 143). In the first four years of schooling, students' orthographic knowledge as measured by orthographic decision tasks significantly lagged behind their knowledge of GPM as measured by vowelized word reading. In the fifth and sixth grades, significant differences were reported between reading and spelling scores. Furthermore, no significant differences were reported between spelling scores and orthographic decision task scores. In contrast, scores on orthographic decision tasks were significantly better than reading scores. The findings indicate that the development of orthographic knowledge causes Arabic spelling skills to diverge from vowelized script reading.

Phonemic and morphological awareness are the strongest contributors to vowelized reading, explaining the variations in vowelized reading between poor and skilled readers (Abu-Rabia, Share, & Mansour, 2003; Layes, Lalonde, & Rebaï, 2017; Saiegh-Haddad & Taha, 2017). Since vowelized reading and spelling are parallel, at least for the first four years of primary education, it follows that phonemic and morphological awareness contribute to spelling and explain the variations in spelling accuracy between poor and skilled spellers. Additionally, orthographic knowledge contributes to spelling (Taha, 2016b), meaning that it could also explain variations in spelling. A quantitative analysis of dyslexic students in the fifth grade, in comparison to the age-matched and reading level-matched group (second grade), found that dyslexic students made more phonologically based spelling errors than non-dyslexic students (Abu-Rabia & Taha, 2004). This indicates that dyslexic students' phonological deficiencies in reading are also

manifested in spelling. Furthermore, it was reported that the percentage of spelling errors that were based on morphology and orthographic knowledge were significantly more common among dyslexic students than among their non-dyslexic peers. This indicates that dyslexic students' morphological deficiencies in reading also manifest in spelling. While orthographic knowledge does not explain vowelized reading variations (Abu-Rabia, 1995; Abu-Rabia, Share, & Mansour, 2003; Al Ghanem & Kearns, 2014), it does differentiate between poor and skilled spellers. This suggests that the level of orthographic knowledge among dyslexic students is at the service level (i.e., identification) and not at the production level required for accurate spelling (Abu-Rabia & Taha, 2004). To conclude, poor Arabic spellers make the same spelling errors that skilled Arabic spellers make, but at a significantly larger magnitude due to deficiencies in phonemic, morphological, and expressive orthographic knowledge.

### *Reading Comprehension*

Reading comprehension—the extraction and construction of meaning from printed texts—is the ultimate goal of reading (Hoover & Tunmer, 2018). The Simple View of Reading (SVR) proposes that reading comprehension is the product of decoding and listening comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990; Hoover & Tunmer, 2018). SVR does not suggest simplicity in reading, but rather partitions or expresses its complexity as these two components. Neither component is sufficient alone, as a deficit in one component causes comprehension difficulties. SVR is commonly used as a model to classify reading disabilities (Catts, Adlof, & Weismer, 2006). The validity of SVR has been documented across several orthographies (Joshi, Ji, Breznitz, Amiel, &

Yulia, 2015; Joshi, Tao, Aaron, & Quiroz, 2012). Studies have shown that the contribution of decoding and listening comprehension varies across different orthographies as a function of the orthography's depth and the grade level (Florit & Cain, 2011; Landi, 2010). In transparent orthographies, the contribution of decoding is expected to be larger than listening comprehension in early grades. However, reliable GPM fosters the rapid development of decoding skills. Hence, the contribution of decoding gradually decreases, giving listening comprehension the largest influence in upper grades (Florit & Cain, 2011). In contrast, the ambiguity of GPM in deep orthographies slows the development of decoding skills; therefore, the large contribution of decoding is expected to last throughout the upper grades until decoding automaticity is attained (Joshi, Tao, Aaron, & Quiroz, 2012).

Asadi and Ibrahim (2018) report that SVR explained 52% and 42% of the variance in vowelized reading comprehension, a transparent script, in terms of GPM, for first and second graders (n = 460), respectively. The contribution of decoding was significant in the first grade and decreased in the second grade. Listening comprehension, on the other hand, had a stable, significant contribution larger than that of decoding in both grades. In a similar study with a nationally representative sample (n = 1385), Asadi, Khateb, and Shany (2017) reported that SVR explained 56%, 53%, 50%, 41%, 38%, and 40% of the variance in vowelized reading comprehension among students in grades 1–6, respectively. The contribution of decoding was highest in the first grade and then gradually diminished and stabilized in the fourth grade. The contribution of listening comprehension was

significantly stable across grades and was larger than the contribution of decoding in all grades.

In a follow-up study, Asadi (2018) classified the large sample (n = 1,385) that was recruited in the study by Asadi, Khateb, and Shany (2017) into the four conventional reading groups: normal readers, dyslexics, hyperlexics, and garden variety. The researcher was able to successfully fit 95% of the sample into their respective groups. However, two non-specific groups comprising 77 students emerged. The first group (n = 7) was characterized by poor reading comprehension but had adequate decoding and listening comprehension skills. The second group (n = 70) was characterized as having adequate reading comprehension but poor decoding and listening comprehension. The emergence of non-specific groups has been reported in other studies and attributed to either the depth of the orthography or the existence of components other than decoding and listening comprehension that make additional contributions (Aaron, Joshi, & Williams, 1999; Catts, Hogan, & Fey, 2003) (Sparks, 2015). However, in Asadi's study (2018), the emergence of non-specific groups may simply be attributable to the cutoff points used for classification purposes (i.e., below the 25$^{th}$ percentile for a poor skill and above the 30$^{th}$ percentile for adequately developed skill) despite speculations that the nature of SVR is additive rather than multiplicative. Nonetheless, Asadi's findings support SVR's capacity to distinguish between poor and skilled readers of vowelized Arabic script.

Asadi and Ibrahim (2018) assessed SVR in unvowelized reading comprehension for 460 first and second graders. They reported that SVR explained 38% and 43% of the variation in unvowelized reading comprehension in the first and second grades,

respectively. The contribution of decoding was significant in the first grade and significantly increased in the second grade. Listening comprehension had a stable, significant contribution in both grades, larger than that of decoding in both grades.

Arabic appears to align with the general understanding on how decoding contributes to reading comprehension. In vowelized Arabic, the contribution of decoding reaches its zenith in the first and second grades, then gradually diminishes and stabilizes by the fourth grade. Such findings are in line with those from other transparent orthographies (Florit & Cain, 2011). In unvowelized Arabic, the contribution of decoding increases as students advance in grades. Such findings align with deep orthographies (Joshi, Tao, Aaron, & Quiroz, 2012). Arabic, however, deviates from other orthographies, both transparent and deep, in terms of listening comprehension. Across all grades, the contribution of listening comprehension has been reported to surpass decoding; it remains significantly stable across grades. Overall, the contribution of listening comprehension explains most of the variance in Arabic reading comprehension across grades. Such findings may be explained by the diglossic nature of Arabic literacy acquisition. Oral exposure to standard Arabic remains a crucial factor that affects reading comprehension among Arabic-speaking students (see diglossia section).

Listening comprehension entails processes and skills that resemble those needed for reading comprehension. Both types of comprehension require that readers have knowledge of the language, attentively process information, hold information in their working memory, monitor understanding, and make connections and inferences (Diakidoy, Mouskounti, & Ioannides, 2011). It follows that the same skills may underpin

both types of comprehension. Thus, enriching understanding in one type of comprehension will benefit the other, given the transfer of skills across modalities (Gottardo, Mirza, Koh, Ferreira, & Javier, 2018; Kieffer, Petscher, Proctor, & Silverman, 2016).

Asadi (2020) reported that working memory, morphological awareness, vocabulary, and orthographic knowledge could significantly predict listening comprehension among Arabic speakers (n = 262). Likewise, working memory was reported to predict vowelized and unvowelized reading comprehension when controlling for vocabulary and morphological awareness, explaining up to 5% of the variance (Abu Ahmad, Ibrahim, & Share, 2014; Elsayyad, Everatt, Mortimore, & Haynes, 2017). Morphological awareness was reported to predict reading comprehension, explaining up to 22% of the variance in vowelized script (Abu Ahmad, Ibrahim, & Share, 2014; Abu-Rabia, 2007; Asadi, Khateb, & Shany, 2017; Layes, Lalonde, & Rebaï, 2017; Tibi & Kirby, 2019) and up to 25% of the variance in unvowelized script (Layes, Lalonde, & Rebaï, 2017; Mahfoudhi, Elbeheri, Al-Rashidi, & Everatt, 2010) in grades 1–6 when controlling for vocabulary and working memory. Orthographic knowledge has been reported to predict reading comprehension for poor and skilled readers, explaining up to 12% of the variance for vowelized script (Tibi & Kirby, 2019) and up to 10% of the variance for unvowelized script (Elbeheri, Everatt, Mahfoudhi, Abu Al-Diyar, & Taibah, 2011) in grades 1–5 when controlling for vocabulary and working memory. Vocabulary predicts reading comprehension, explaining up to 40% of the variance in vowelized script (Abu Ahmad, Ibrahim, & Share, 2014; Elsayyad, Everatt, Mortimore, & Haynes, 2017;

Tibi & Kirby, 2018, 2019; Tibi, Tock, & Kirby, 2019) and up to 45% of the variance in unvowelized script (Elsayyad, Everatt, Mortimore, & Haynes, 2017) in grades 1–6 when controlling for morphological awareness, orthographic knowledge, and working memory. Finally, in a 20-week vocabulary intervention, seventh-grade participants (n = 166) in experimental groups significantly outperformed the control group in unvowelized reading comprehension; vocabulary explained 28% of the variability between groups (Makhoul & Sabah, 2019). It seems that the influences of morphological awareness, orthographic knowledge, vocabulary, and working memory work both ways for Arabic listening and reading comprehension. All skills are independent of each other and make unique contributions to listening and reading comprehension. Reading comprehension instruction would certainly benefit from teaching these skills.

To conclude, SVR may explain 40–60% of the variation in reading comprehension of Arabic orthography, both vowelized and unvowelized, and distinguish between poor and skilled readers in grades 1–6. However, although SVR explains a considerable amount of the variance, it does not explain all of it. Studies on Arabic reading comprehension have focused primarily on cognitive and linguistic skills. Cognitive and linguistic models of reading comprehension inform the understanding of Arabic reading comprehension. Nevertheless, given the diglossic nature of Arabic literacy acquisition (see diglossia section), other factors must be considered when investigating Arabic reading comprehension. The componential model of reading seems promising and is likely to interest future researchers since it considers the involvement of psychological and

ecological factors in explaining variations in reading comprehension (Aaron, Joshi, Gooden, & Bentum, 2008; Joshi & Aaron, 2000).

**Oral Reading Fluency and Silent Reading Comprehension**

The automatic operation of word recognition maintains the proficiency of the reading comprehension process (Ehri, 2005). When word recognition becomes rapid and effortless, readers can allocate their cognitive resources (i.e., working memory) to invoke and process the higher-order thinking skills required for reading comprehension (LaBerge & Samuels, 1974). Thus, it follows that a deficiency in word recognition hinders reading comprehension (Perfetti, 1977).

Automaticity in word recognition is commonly defined as the fluent, accurate pronunciation of words (Perfetti, 1992). It is also thought that the association between oral reading fluency and reading comprehension varies as a function of grade (Jenkins & Jewell, 1993). Individual differences in decoding in early grades indicate the strong relationship between fluency and reading comprehension. This association is likely to weaken during the upper grades due to variations in listening comprehension and background knowledge as decoding reaches a ceiling. Since decoding in deep orthographies develops at a slower rate than it does in transparent orthographies (Joshi, Tao, Aaron, & Quiroz, 2012), it may be safe to assume that fluency serves as a more general indicator of reading comprehension in deep orthographies than in transparent orthographies (Saiegh-Haddad, 2003a).

Studies on the relationship between fluency (as defined by words read correctly in one minute) and Arabic reading comprehension have yielded mixed findings. Word and

text reading fluency were reported to significantly correlate with, predict, and explain variations in vowelized reading comprehension (Asadi & Ibrahim, 2018; Asadi, Khateb, & Shany, 2017; Elsayyad, Everatt, Mortimore, & Haynes, 2017; Layes, Lalonde, & Rebaï, 2017; Tibi & Kirby, 2018; 2019). In contrast, both word and text fluency reportedly have no significant positive association with vowelized reading comprehension (Abu-Leil, Share, & Ibrahim, 2014). For unvowelized script, word and text fluency were not consistently found to significantly correlate with, predict, or explain variations in unvowelized reading comprehension (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Leil, Share, & Ibrahim, 2014; Abu-Rabia, 2001; Eviatar, Ibrahim, Karelitz, & Simon, 2019; Saiegh-Haddad, 2003a).

In terms of vowelized script, more confidence can be placed in the results reported in the majority of studies shown above. Little confidence can be placed in the one study that reported divergent findings (Abu-Leil, Share, & Ibrahim, 2014), for two reasons. First, phonological recoding is the dominant reading strategy for vowelized Arabic script (see the reading process section). Readers use full phonological representations in vowelized script to gain semantic access. Accurate and rapid word recognition in early grades fosters the development of autonomous lexical items (i.e., vocabulary) that are required for reading comprehension—a meaning-based task (Perfetti, 1992). The variation in reading comprehension for second graders in one longitudinal study was shown to be significantly explained by sublexical skills (45%) rather than supra-lexical skills (27%) (Abu Ahmad, Ibrahim, & Share, 2014). Second, the study by Abu-Leil et al. (2014) utilized a setting developed for experimental purposes, unlike the other studies, which were conducted in

natural settings. Tibi and Kirby (2017, 2018) recruited third-grade Emirati students. In the United Arab Emirates, textbooks are vowelized until the end of the fifth grade. Asadi et al. (2017, 2018) and Layes et al. (2017) recruited Palestinian elementary students in grades 1–4 living in Israel, where textbooks are vowelized until the end of the fourth grade. In contrast, Abu-Leil et al. (2014) recruited eighth-grade Palestinian students who had not been using vowelized scripts for four years. Accordingly, Abu-Leil et al.'s (2014) findings may not accurately reflect the association between oral reading fluency and vowelized reading comprehension. Overall, most evidence suggests an association between oral reading fluency and vowelized reading comprehension in primary education as both processes are underlain by the same skill (i.e., phonological recoding).

On the other hand, studies on the association between oral reading fluency and unvowelized reading comprehension have recruited fifth-grade, eighth-grade, and college-level participants (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Leil, Share, & Ibrahim, 2014; Abu-Rabia, 2001; Eviatar, Ibrahim, Karelitz, & Simon, 2019; Saiegh-Haddad, 2003a). Unvowelized script reading is dominated by a visual word recognition strategy (see the reading process section). Advanced Arabic readers can directly access meaning via their root recognition and visuo-perceptual processing skills. Together, morphology, orthographic knowledge, and vocabulary explain nearly 60% of the variance in unvowelized reading comprehension in upper grades (Elbeheri, Everatt, Mahfoudhi, Abu Al-Diyar, & Taibah, 2011; Layes, Lalonde, & Rebaï, 2017; Mahfoudhi, Elbeheri, Al-Rashidi, & Everatt, 2010; Makhoul & Sabah, 2019). Thus, the two processes of oral reading—in which readers are forced to rely on phonological recoding and silent reading

comprehension, where root identification facilitates access to meaning—are underlain by different skills. Fluency mediates recognizing words and accessing meaning in oral reading tasks whereas fluency is a consequence of rapid sematic accessing in silent reading comprehension (Saiegh-Haddad, 2003a). Additionally, asking participants who become accustomed to reading unvowelized script to absorb unnecessary phonological information would only consume working memory and disrupt lexical processing (Roman & Pavard, 1987; Taha & Azaizah-Seh, 2017). Accordingly, no association between oral reading fluency and unvowelized reading comprehension is reported in the upper grades.

A critical analysis of all studies that have investigated the association between oral fluency and unvowelized reading comprehension shows that all studies used narrative and informational texts as experimental stimuli. Abu-Hamour et al. (2013) used narrative texts, whereas informational texts borrowed from the school curriculum and Israeli college admission tests were used in other studies (Abu-Leil, Share, & Ibrahim, 2014; Eviatar, Ibrahim, Karelitz, & Simon, 2019; Saiegh-Haddad, 2003a). Arabic readers have been shown to use a visual word recognition strategy when encountering familiar unvowelized texts. However, they also switch to a phonological recoding strategy when they lack semantic knowledge. It is highly likely that oral reading fluency would show a significant association with unvowelized Quranic and poetic classical texts with which students are not semantically familiar. Overall, although studies report a dissociation between oral reading fluency and unvowelized reading comprehension, it is reasonable to speculate that the association between oral reading fluency and unvowelized reading comprehension may be both conditional and text-sensitive.

Oral reading fluency may serve as a general index of reading comprehension in both vowelized script and unfamiliar unvowelized script. Variations in fluency at word and text level are reflected in vowelized reading comprehension and in unfamiliar unvowelized script. However, variability in familiar unvowelized reading comprehension may be better explained by meaning-related skills, such as morphology and vocabulary (i.e., how much is known about the continuums of roots and vocabulary as measured by receptive identification, and production tasks), instead of the conventional method (i.e., words read correctly in one minute). Additionally, fluency in lexical decision tasks might also serve as an appropriate index of reading proficiency for familiar unvowelized script. Latency in lexical responses may be interpreted as dysfluent visual word recognition (Taha & Azaizah-Seh, 2017).

To conclude, unvowelized Arabic, which has a deep orthography in terms of phonology, deviates once again from deep orthographies in which fluency may serve as a general index of reading comprehension. To label alphabetic orthographies as transparent or deep based solely on GPM is a narrow definition that cannot be extrapolated across all orthographies (see the section below). While unvowelized Arabic deviates from Latin-based deep orthographies in terms of the association between oral reading fluency and reading comprehension, unvowelized Arabic is similar to Hebrew, another Semitic orthography, in which a dissociation exists between oral reading fluency and unpointed reading comprehension (Abu-Rabia, 2001; Eviatar, Ibrahim, Karelitz, & Simon, 2019; Saiegh-Haddad, 2003a).

## *Factors Affecting Arabic Literacy Acquisition*

### Visual Complexity

The Anglocentric tendencies of current reading development models and theories are understandable because these models and theoretical frameworks were developed to conceptualize literacy acquisition in Latin-based orthographies (Share, 2008). For example, the transparency of alphabetic orthographies is often determined by how regularly printed graphemes are mapped onto oral phonemes (Frost, Katz, & Bentin, 1987; Katz & Frost, 1992). However, some scholars argue that judging orthographies' transparency based solely on associations between letters and sounds reflects a narrow view (Daniels & Share, 2018; Share & Daniels, 2016). Some orthographies are characterized by unique features that are highly likely to affect literacy acquisition. It is often argued that diglossia, morphological complexity, the omission of phonological elements (i.e., diacritical marks), and visual complexity are all factors that affect Arabic literacy acquisition (Daniels & Share, 2018; Share & Daniels, 2016). Hence, a comprehensive acknowledgment of all dimensions of complexity in a given orthography better informs the applicability of reading models and theories and informs understanding of the literacy acquisition process for a particular orthography.

The visual complexity of the Arabic orthography typically refers to the fact that 20 Arabic letters have similar shapes that are distinguishable only by location and the number of dots. Furthermore, 23 letters connect from both sides, and five letters are spelling-specific (i.e., they either do not connect or they connect from the right side only), giving Arabic writing a cursive nature. Studies have validated that the complexity of Arabic

letters affects literacy acquisition for Arabic-speaking students, whereas the connectivity of letters does not.

Children in the first, third, and fifth grades (n = 96) grasped Arabic letters of unique visual shape significantly faster than letters with visual neighbors (Asaad & Eviatar, 2013). This pattern was observed across all three grades, with significant differences between grades. Older students took significantly less retrieval time than younger students. In another study (Abdelhadi, Ibrahim, & Eviatar, 2011), third and sixth graders (n = 82) were asked to read both real and pseudowords. Stimuli were divided into three groups: simple (i.e., words in which letters do not connect and do not have dots, e.g., درر [meaning "pearls"]), connected (i.e., words in which letters connect but do not have dots, e.g., معد [meaning "contagious"]), and complex (i.e., words in which letters connect and have dots, e.g., نتج [meaning "was produced"]). The results indicate that in both grades, connected items were read with more significant levels of accuracy and fluency than complex or simple items. The researchers also found that, while the connectivity of letters does not affect the accuracy and fluency of word recognition, the dots do. Because dots significantly affect word recognition, their appearance yielded better results than unconnected and undotted words.

The visual complexity of Arabic orthography makes it more difficult for beginners to read automatically, despite the highly regular GPM in vowelized script. After a seven-month alphabetic awareness intervention (25 minutes per day), kindergarten participants (n = 30) managed to name only 63% of Arabic letters, 17 letters in total (Levin, Saiegh-Haddad, Hende, & Ziv, 2008). In a longitudinal study, after two years of instruction in

kindergarten and first grade, students (n = 194) managed to name only 70% of letters, 19 letters in total, even though all the letter names have their sounds embedded within them (Abu Ahmad, Ibrahim, & Share, 2014). Furthermore, results from Latin-based transparent orthographies have reported that readers had nearly reached a ceiling (87%) in word recognition by the end of first grade (Seymour, Aro, & Erskine, 2003). In Arabic, however, the reading accuracy for vowelized words was reported to be 67% by the end of the first grade (Abu Ahmad, Ibrahim, & Share, 2014). In a study that recruited a nationally representative sample in grades 1–6, it was reported that decoding measures reached a ceiling in the fourth grade (Asadi, Khateb, Ibrahim, & Taha, 2017). Furthermore, the fluency rate for first-grade students reading highly transparent orthographies (e.g., Finnish, Greek, Italian, Spanish, German) was reported to be 1.5 seconds/word on average (Seymour, Aro, & Erskine, 2003). In Arabic, however, this rate is 4 seconds/vowelized word on average (Asadi, 2017). Finally, a Stroop effect is reported among Arabic students beginning the third grade. This suggests some degree of automaticity in word recognition has been achieved by the third grade, but no earlier (Asaad & Eviatar, 2013). Although latency in reaching automatic word recognition is not solely attributed to the complexity of Arabic letters, as other factors such as diacritical marks and diglossia (see later sections) are also influential, the visuo-perceptual processing of Arabic letters remains a significant factor in understanding such latencies.

Comparisons between Arabic and Hebrew, both Semitic orthographies that share remarkable commonalties (Abu-Rabia, 2001), further confirms the visual complexity of Arabic. Highly proficient undergraduate Arabs and Israelis were asked to name letters and

to read aloud comparable college admission texts in their native languages. The results showed that Arabs lagged significantly behind Israelis in naming speed. Moreover, despite comparable accuracy and reading comprehension, Israelis read unpointed Hebrew significantly faster than Arabs read unvowelized Arabic (Eviatar, Ibrahim, Karelitz, & Simon, 2019). Similar findings were reported by Saiegh-Haddad (2003a), who showed that undergraduate Arabs and Israelis read English as their second language at an equivalent rate, yet unpointed Hebrew was read significantly faster than unvowelized Arabic despite comparable reading comprehension between Arab and Israeli students.

In summary, the transparency of the Arabic orthography is a multi-dimensional construct. Despite highly regular GPM and PGM, Arabic may not be considered fully transparent owing to its visual complexity and other factors. Visual complexity affects alphabetic awareness, word recognition accuracy and fluency, and text fluency. A consensus among scholars interested in Arabic orthography is that Arabic may be considered a semi-transparent orthography (Abu Ahmad, Ibrahim, & Share, 2014; Abu-Rabia & Taha, 2006; Aram, Korat, Saiegh-Haddad, Arafat, Khoury, & Elhija, 2013; Asadi, Khateb, Ibrahim, & Taha, 2017; Mohamed, Elbert, & Landerl, 2011; Schiff & Saiegh-Haddad, 2017).

**Diglossia**

Two forms of the Arabic language exist across all Arabic-speaking countries: vernacular Arabic and standard Arabic (Saiegh-Haddad & Spolsky, 2014). Although the two forms share several linguistic similarities, they also differ remarkably (Saiegh-Haddad, 2003b). Moreover, Arabic vernaculars differ from one country to another and

vernaculars within the same country can vary according to geographic location (e.g., urban, Bedouin, rural, coastal). The two forms of Arabic are functionally distinct across all Arabic-speaking countries. The situation in which there are two forms of a language that differ linguistically and functionally is referred to as diglossia (Ferguson, 1959). Since oral language is used for communication, it remains open to change, development, and evolution, whereas the written language remains rigid and restricted to limited writing opportunities.

Oral, vernacular Arabic is used for daily oral social communications including teaching, commercial, judicial, and political communications, and audio-visual media (e.g., TV shows, movies, songs). Arabic vernaculars do not have standardized writing systems. However, when used in social media, spelling typically follows one of two patterns (Mallek, Belainine, & Sadat, 2017). The first pattern is *Arabiglizi* (i.e., Arabglish)—writing Arabic words using Latin letters and numbers. For example, the number 7 is equivalent to the sound /ħ/ (e.g., A7mad as in the name *Ahmad*). The second pattern is spelled-as-sounded: writing using Arabic letters yet with the words not necessarily following standard writing rules (e.g., هاذا [meaning "this"] instead of هذا, a word that has four sounds but three letters). In contrast, written standard Arabic is the language adopted for school textbooks, official documentation (e.g., road signs, passports, and identification cards), formal written communications across official departments and ministries, and print productions (e.g., newspapers, books, novels, children's literature). Oral, standard Arabic, which is no one's mother tongue, is used consistently for news

broadcasting, presidential speeches addressing nations, and religious ceremonies (e.g., praying and reciting the Quran).

The two forms of Arabic differ linguistically in many ways (Brosh & Attili, 2009; Khamis-Dakwar, Froud, & Gordon, 2012; Saiegh-Haddad, 2003b); it is beyond the scope of this dissertation to discuss them all. Because Arabic vernaculars differ tremendously, it is not reasonable to generalize on differences between them. However, the principle stands that remarkable differences exist between standard Arabic and any Arabic vernacular at all linguistic levels. Phonologically, Palestinian Arabic, for example, contains the majority of standard phonemes yet lacks four standard Arabic phonemes in its phonological structure. Syllabically, Palestinian Arabic entails standard structures such as CV, CVV, and CVC; yet it lacks certain structures such as CVCC and CVVCC (its counterparts in the vernacular are CCVC and CVCVC). Morphologically, duality in numbers is not recognized when discussing the process of word derivation in Palestinian Arabic. Grammatically, negation is not attained via negation articles, which is the case in standard Arabic. Negation in Palestinian Arabic is accomplished via rising intonations of sentences (e.g., got milk?). Lexically, an analysis of 4,500 words spoken by a five-year-old Palestinian boy living in Israel in a single day of kindergarten revealed that 93% of these words were vernacular Arabic, 5% were standard Arabic, and 2% were Hebrew (Saiegh-Haddad & Spolsky, 2014). Of the 93% of Palestinian Arabic words, 40% of the words were labeled cognates (standard Arabic words with slight phonological deviations but the same lexical meaning), 21% were labeled identical (the same lexico-phonological structure as standard Arabic words), and 31% were labeled unique Palestinian Arabic

words with which the standard Arabic equivalent words are completely different both phonologically and lexically. Of the 40% cognate words, 42% of the words differed in one phonological aspect, 24% differed in two aspects, and 11% differed in three aspects.

The fact that vernacular and standard Arabic share similarities does have some benefits. Vernacular phonological and morphological awareness and word recognition skills significantly correlate with and predict up to 10% of standard word recognition (Schiff & Saiegh-Haddad, 2017; 2018). In another study, vernacular morphological awareness significantly predicted standard vowelized word reading (Tibi & Kirby, 2017). Furthermore, vernacular Arabic is commonly used to facilitate an understanding of standard vocabulary and texts (Brosh & Attili, 2009). However, the negative implications of diglossia outweigh the few advantages.

Diglossia in the Arab world does not foster a natural development of literacy acquisition for Arabic-speaking students. Arabs speak vernacular Arabic for six years before formal education, when systematic exposure to standard Arabic begins. This is not to say that awareness, familiarity with, and the ability to speak and comprehend standard Arabic is entirely dysfunctional (Leikin, Ibrahim, & Eghbaria, 2014). Yet the exposure to standard Arabic via audio-visual media remains insufficient to support standard literacy skills for beginner readers and spellers. Oral language skills transfer to support reading comprehension (Gottardo, Mirza, Koh, Ferreira, & Javier, 2018; Kieffer, Petscher, Proctor, & Silverman, 2016).

Moreover, word recognition in alphabetic orthographies is best predicted by phonological mediation and phonemic awareness (Al Ghanem & Kearns, 2014; Seymour,

Aro, & Erskine, 2003). Studies have consistently reported significant superiority in performing phonological tasks using vernacular Arabic over using standard Arabic among elementary Arabic students. Manipulation of Palestinian vernacular phonemes is consistently and significantly better than that of standard phonemes missing from Palestinian Arabic among students from kindergarten to the fifth grade, as shown by isolation tasks (Saiegh-Haddad, 2003b, 2004, 2007), recognition tasks (Saiegh-Haddad, Levin, Hende, & Ziv, 2011), segmentation tasks (Asadi & Ibrahim, 2014; Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020; Schiff & Saiegh-Haddad, 2018), deletion tasks (Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020; Schiff & Saiegh-Haddad, 2018) and blending tasks (Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020). Furthermore, manipulation of syllabic structures affiliated with Palestinian Arabic that are impermissible in standard Arabic (e.g., CCVC, CVCVC) is significantly better than manipulation of standard syllabic structures (e.g., CVCC) among students from kindergarten to fifth grade (Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020). Impaired standard phonological ability is one reason that sight vocabulary and orthographic knowledge, even among skilled readers, support vowelized word reading as a compensatory reading strategy (see the reading process section). Although Arabic readers show significant standard phonological development across academic grades, research shows that it takes three to five years of systematic exposure for students to master the phonological structure of standard Arabic (Asadi & Ibrahim, 2014; Saiegh-Haddad, 2007; Saiegh-Haddad & Haj, 2018; Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020; Schiff & Saiegh-Haddad; 2017).

The phonological distance between vernacular and standard Arabic is thought to affect the quality of the standard phonological and lexical representations stored in an Arabic speaker's mental lexicon. The absence of some standard phonemes and syllabic structures in vernacular Arabic and the absence of systemic exposure to standard Arabic slow the process of encoding high-quality, standard phonological structures in an Arabic speaker's mental lexicon (Goswami, 2000). Phonological processing abilities in word recognition are affected by the quality of the stored underlying phonological representations (Swan & Goswami, 1997a; 1997b). Studies have repeatedly reported significant superiority in decoding vernacular Arabic words over standard Arabic words. Standard Arabic words are decoded significantly less accurately and rapidly than vernacular Arabic words (Saiegh-Haddad, 2003b; Saiegh-Haddad & Schiff, 2016; Schiff & Saiegh-Haddad, 2017, 2018). Unlike phonological abilities, the gap in word recognition between vernacular and standard Arabic does not decline with development and persists even in the tenth grade (Saiegh-Haddad, 2003b; Saiegh-Haddad & Schiff, 2016; Schiff & Saiegh-Haddad, 2017, 2018). It is reasonable, therefore, to argue that impaired phonological abilities (i.e., low-quality phonological representations) may be responsible for explaining variations in word recognition between vernacular and standard Arabic up until the fifth grade. However, there appears to be another factor that explains the variability in word recognition beyond fifth grade: diglossia. This is because the distinct sociolinguistic functions of both forms of Arabic minimize exposure to standard Arabic even after the start of formal education.

Research has shown that, across all linguistic skills, Arabs demonstrate significantly better performance in vernacular Arabic than in standard Arabic; yet a statistically comparable performance has been observed when stimuli are linguistically affiliated with both forms of Arabic. Kindergarten children's narrative ability in vernacular Arabic is better than in standard Arabic (Leikin, Ibrahim, & Eghbaria, 2014). Moreover, retrieving standard letters that correspond to standard phonemes available within students' vernacular Arabic was significantly faster than retrieving standard letters that correspond to standard phonemes missing from students' vernacular Arabic for students in grades 1–5 (Asaad & Eviatar, 2013). Morphological awareness for vernacular Arabic items is significantly better than standard items up until the eighth grade, when performance for both becomes comparable (Schiff & Saiegh-Haddad, 2018). Syntactic awareness for students in grades 1–5 for vernacular Arabic items in a mismatched condition (i.e., vernacular Arabic's unique grammatical rules) is significantly better than for standard items across all grades (Khamis-Dakwar, Froud, & Gordon, 2012). However, no significant difference has been reported between vernacular and standard Arabic across all grades for items in a matched condition (i.e., grammatical rules that are shared in both vernacular and standard Arabic). In another study, students in kindergarten, first, second, and sixth grade were asked to judge the accuracy of presented vernacular and standard words. Words were divided into three groups: identical, cognate, and standard unique. Across all grades, words with the same lexico-phonological structure (i.e., identical) and slight phonological deviation (i.e., cognate) were accurately judged significantly faster than standard unique words (Saiegh-Haddad & Haj, 2018). Additionally, cognate words

with one phonological deviation were judged faster than cognate words with two phonological deviations. The closer the standard words are to vernacular Arabic, the faster the judgment. Finally, an analysis of standard Arabic descriptive writing essays for twelfth-grade students shows a substantive inclusion of morpho-syntactic structures and vocabulary that are affiliated with vernacular Arabic even though the essays were required for graduation. In follow-up interviews, the participants (n = 30) attributed their behavior to their lack of knowledge of standard Arabic (Brosh & Attili, 2009).

One conclusion that can be deduced from the above-mentioned studies is that the superiority of vernacular Arabic over standard Arabic may be attributed to the large amount of exposure to vernacular Arabic. The Matthew effect seemingly explains why standard Arabic literacy-related skills lag significantly behind vernacular Arabic (Stanovich, 1986). Additionally, the comparable performance between vernacular and standard Arabic reported in some studies may be attributed to the availability of items within both forms of Arabic—equal exposure. Thus, literacy acquisition in the Arabic context is grounded not only in linguistic factors, but also in sociolinguistic factors.

The degree of exposure appears to be a crucial factor in the development of literacy-related skills. Not only does this substantially lower exposure to standard Arabic explain variability with vernacular literacy-related skills, it also explains the slow development of standard Arabic literacy-related skills. In two studies (n = 1,800), seventh and ninth graders displayed comparable receptive vocabulary knowledge (Makhoul, 2017b; Makhoul, Olshtain, Sabah, & Copti-Mshael, 2018). Furthermore, knowledge of productive vocabulary lagged significantly behind receptive knowledge in both grades

despite a slight but significant advantage for ninth graders. There seems to be inadequate standard vocabulary development among Arabic students across these two school years. This may indicate that exposure to standard Arabic in these two years may have been comparable and gave very little, if any, novel vocabulary to students. The significant lag in productive vocabulary is explained by the limited standard writing opportunities in diglossic communities. Similarly, standard syntactic awareness among Arabic students did not experience significant development across five consecutive years in elementary schooling despite a slight increase across grades (Khamis-Dakwar, Froud, & Gordon, 2012).

Reading instruction consists of explaining and understating the structure of oral language and how it is encoded in print. Because of the differences between oral and written Arabic—the former is mainly expressed via vernacular Arabic while the latter is limited to formal education and specific social opportunities—a gap exists that does not support a natural development of literacy acquisition for Arabs. Arabs start school with underdeveloped standard oral language skills. Thus, an exposure to oral standard Arabic before formal education starts, which does not occur in Arabic-speaking countries (Feitelson, Goldstein, Iraqi, & Share, 1993; Saiegh-Haddad & Spolsky, 2014), seems necessary to bridge this gap. Since both forms of Arabic share many similarities, standard Arabic should not be alien, although adults often believe that early exposure to standard Arabic is a burden (Feitelson, Goldstein, Iraqi, & Share, 199). In fact, Arabic children in grades 1–5 state that listening to and comprehending standard Arabic is easier than reading and comprehending standard Arabic (Makhoul, Copti-Mshael, & Khamis-Dakwar, 2015).

Additionally, Arabs find listening to vowelized standard Arabic to be attractive, easy to understand, and musical (Abu-Rabia, 2019b). However, these forms of Arabic differ markedly as well. Hence, a controlled (i.e., structured) exposure would be particularly useful. Introducing children to standard linguistic elements missing from their vernacular Arabic seems essential, with the exposure being explicit and systematic to yield benefits.

Studies suggest that systematic home literacy activities for kindergarten children that build rich, standard phonological representations (e.g., reading to children in standard Arabic and providing standard Arabic via audio-visual media) significantly predict 3% of alphabetic knowledge, 9% of print concepts, and 6% of phonological awareness, when controlling for socioeconomic status (Aram, Korat, Saiegh-Haddad, Arafat, Khoury, & Elhija, 2013). Furthermore, 15 minutes per day of explicit and systematic exposure to standard stories where no demand for language use was needed was reported to be beneficial over a period of five months. Kindergarten children in the experimental group (n = 258) significantly outperformed the control group in standard listening comprehension and standard narrative ability (Feitelson, Goldstein, Iraqi, & Share, 1993). In an experimental study, 25 minutes a day of systematic exposure to standard letters and phonological awareness activities helped kindergarten children in the experimental group (n = 30) significantly outperform the control group in standard alphabetic and phonological tasks over seven months (Levin, Saiegh-Haddad, Hende, & Ziv, 2008). Finally, one longitudinal study reported that one hour per day of systematic exposure to oral standard Arabic during the entire kindergarten year via songs, stories, and basic teacher-student dialog improved vowelized reading comprehension in formal education

(Abu-Rabia, 2000). A year later, in the first grade, participants in the experimental group (n = 144) significantly outperformed the control group in literal reading comprehension, whereas inferential reading comprehension was at the base level for both groups. In the second grade, the experimental group significantly outperformed the control group in both literal and inferential reading comprehension. In conclusion, systematic exposure to oral standard Arabic for as little as 15 minutes per day and as much as 60 minutes per day yielded good results in bridging the literacy-orality gap, despite being an artificial exposure that has no social function (Saiegh-Haddad & Spolsky, 2014).

A key point to understand in the Arabic literacy context is that literacy in the Arab world is not characterized by proficiency in standard Arabic alone. There are two forms of Arabic that are linguistically and functionally distanced. While vernacular Arabic dominates oral communication, standard Arabic dominates written communication. Proficiency in both forms of Arabic is necessary for the social functions encountered in real life. In fact, the highly educated and prestigious cultural elite in the Arab world are those who demonstrate the ability to proficiently code-switch between Arabic varieties and to demonstrate the correct usage for each form (Brosh & Attili, 2009). This process is mentally demanding and may not be attainable for all Arabs. Arabic children display explicit functional knowledge, interconnection knowledge, meta-diglossic knowledge, and awareness of code-switching between the varieties of Arabic in the third grade (Makhoul, Copti-Mshael, & Khamis-Dakwar, 2015). Despite having this knowledge, Arabic students fail to act on it due to ineffective teaching and a lack of adequate and systematic exposure to standard Arabic (Brosh & Attili, 2009). Being skilled in vernacular

Arabic may come naturally. However, skilled reading and writing in standard Arabic, along with the ability to efficiently code switch, is a long journey. Evidence from an electroencephalogram study clearly shows that switching between the varieties of Arabic produces neurological patterns seen in code-switching between two distinct orthographies, suggesting that the varieties of Arabic may be represented in the brain as two separate and distinct languages (Khamis-Dakwar & Froud, 2007).

In summary, diglossia has negative implications for literacy acquisition among Arabic-speaking students. While they appear to close the gap between vernacular and standard Arabic phonologically after three to five years of schooling, they remain challenged by word recognition, morpho-syntactic knowledge, vocabulary, writing, and reading comprehension even after many years of formal education. It is little surprise that the results of the 2018 Programme for International Student Assessment (PISA) showed that 55% of 15-year-old Arabic teenagers (from six Arab countries, but not Arabs living in Israel) are struggling readers, reading below the basic level, with 43.6% having average proficiency and only 1.4% being highly proficient readers (OECD, 2018). Palestinian Arabs living in Israel scored below the OECD average reading score (487), obtaining an average score of 362. The linguistic and sociofunctional distance between the two forms of Arabic, along with poor teaching, appears to account for the low scores. The amount of systematic exposure to standard Arabic remains significantly low, which affects the development of standard literacy-related skills. Arabic students compensate for their lack of standard Arabic knowledge by using vernacular Arabic, in which they are well-versed, when engaged in standard literacy tasks. Proficiency in

Arabic is reflected through skillfulness in code-switching, with appropriate use of each variety in a given social function.

## Relevant Literature Review

Arabic orthography has both vowelized and unvowelized scripts. Across the Arab world, the vowelized script is traditionally used when formal education begins. Its use continues to a certain grade in the educational ladder, when diacritical marks are dropped and exposure to unvowelized script begins. There is no specific grade in which this happens across the Arabic-speaking countries. Palestinian Arabic schools in Israel drop diacritical marks after the fourth grade, while the Gulf States, Egypt, and Lebanon drop diacritical marks after the fifth grade. In Jordan and Syria, however, all textbooks are vowelized, even in the twelfth grade. The policy of transitioning to unvowelized script has not been supported by scientific evidence (Al Ghanem & Kearns, 2014). Anecdotal evidence, however, suggests educators believe that diacritical marks are only necessary for beginning readers because they provide phonological and morpho-syntactic information that supports reading. Educators also claim that advanced readers have already developed the necessary skills to read and comprehend Arabic, so unvowelized texts can be introduced.

Scholars interested in Arabic orthography have investigated the importance of diacritical marks in word recognition from first grade to adulthood. These continuous studies have generated two extreme points of view. Proponents of diacritical marks have advocated the importance of keeping all texts vowelized, even during adolescence and adulthood (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 2019a). Proponents

have also reported findings showing that diacritical marks promote accuracy and fluency among Arabic students, as they reduce phonological ambiguity in texts and disambiguate homographs. Opponents, however, consider diacritical marks an additional visual burden to the visual complexity of Arabic letters, further complicating Arabic literacy acquisition (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Opponents have also reported that diacritical marks do not promote accuracy and fluency among Arabic students. In the middle of the spectrum, some scholars report mixed findings and argue that findings on accuracy and fluency vary as a function of grade level (Asadi, 2017; Saiegh-Haddad & Taha, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). They argue that beginner readers rely on a sublexical reading strategy. Hence, diacritical marks that provide readers with phonological information are necessary, whereas advanced readers in upper grades access words visually, minimizing the need for phonological information.

Typically, the importance of diacritical marks in word recognition is evaluated with repeated measures by comparing word recognition (i.e., accuracy, fluency, or both) between vowelized and unvowelized words/texts. Proponents of diacritical marks have conducted studies in the fifth, ninth, tenth, eleventh, and twelfth grades, as well as at the college level, and reported significant advantages in accuracy and fluency for words/texts in the vowelized condition (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1996, 1997a, 1997b, 1997c, 1998, 2001; Abu-Rabia & Siegel, 1995). Opponents of diacritical marks have conducted studies in the eighth grade and reported significant advantages in accuracy and fluency for words/texts in the unvowelized condition (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Scholars reporting mixed findings have conducted studies

in elementary school from grades 1–6, finding significant advantages for accuracy and fluency for words/texts in the vowelized condition only in the early grades. In contrast, the advantage shifts to the unvowelized condition in the upper grades (Asadi, 2017; Saiegh-Haddad & Taha, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a).

Three perspectives have been offered to explain the findings of studies that have investigated the importance of diacritical marks in word recognition. Each perspective explains findings reported within each study but fails to explain and connect previous findings. For example, proponents believe that diacritical marks reduce the phonological ambiguity of words, but they fail to explain findings that report the significant advantages of unvowelized word reading conditions over vowelized conditions (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Likewise, opponents claim that diacritical marks are an additional visual burden for Arab readers, yet they fail to explain findings that report significant advantages of the vowelized condition over the unvowelized condition (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1996, 1997a, 1997b, 1997c, 1998, 2001; Abu-Rabia & Siegel, 1995). Finally, the argument that findings vary as a function of grade level is restricted only to elementary schooling and fails to explain Abu-Rabia's findings (1997a, 1998, 2001), which reported a significant advantage for vowelized reading conditions in the upper grades of high school and college.

Two recent commentary articles speculate that the overall discrepancy observed in studies investigating the importance of diacritical marks in word recognition could be attributed to methodological differences (Abu-Rabia, 2019a; Saiegh-Haddad, 2018). Major issues raised were the types of stimuli used (i.e., homographic vs. non-

homographic), the conditions in which the stimuli were introduced (i.e., isolated words vs. connected texts), and the distinction between phono-morphemic and phono-syntactic marks. The commentary articles, however, simply provide general guidelines to consider for future research design and fail to validate their guidelines in their entirety.

The previously suggested three guidelines cannot resolve all the variations reported in the findings. For example, the type of stimuli can explain the variations between Abu-Rabia's studies (Abu-Rabia, 1996, 1997c; Abu-Rabia & Siegel, 1995), which were based entirely on homographic stimuli, and Ibrahim's study (2013), in which non-homographic stimuli were used. However, the type of stimuli does not explain the variability between studies that reported mixed findings although all stimuli were non-homographic (Asadi, 2017; Saiegh-Haddad & Taha, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Furthermore, comparability between findings is arguably invalid since the conditions in which stimuli were introduced are incomparable in the first place—some studies used isolated words while other studies used running texts (Abu-Rabia, 2019a). However, even if the findings that used running text stimuli were excluded (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1997a, 1998, 2001), the studies that used isolated stimuli still yielded contradictory findings (Asadi, 2017; Saiegh-Haddad & Taha, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a).

Regarding the distinction between phono-morphemic and phono-syntactic marks, it is argued that phono-syntactic marks are intended to mark the ending of words in running texts and not in isolation (Saiegh-Haddad, 2018). Phono-syntactic marks indicate the grammatical function of words in a complicated grammatical word order. Thus, adding

them to isolated words for research participants would bias the findings, as they are likely to complicate accuracy. In addition, they will increase accuracy errors and delay fluency because they increase the phonological structure of words compared to unvowelized stimuli, even if the stimuli used in both the vowelized and unvowelized conditions are the same (Saiegh-Haddad, 2018). However, studies that did not distinguish between the type of diacritical marks have yielded similar results (Asadi, 2017; Taha, 2016a), whereas studies that did distinguish between the type of diacritical marks have yielded contradictory findings (Saiegh-Haddad & Taha, 2017; Schiff & Saiegh-Haddad, 2017). It is clear that, although following these three general guidelines would add more robustness to methodologies, they certainly do not explain all of the variability in the reported findings.

A typical approach to understanding the importance of diacritical marks in Arabic word recognition is conducting investigations in certain grade levels, making generalizations, and highlighting methodological differences to explain discrepancies with previous findings. Instead of adopting such an approach, this meta-synthesis seeks to find patterns within the findings reported over the past 25 years. I argue that the overall findings are not as explicitly contradictory as they appear. Reported findings follow a reliable pattern, and all three justifications provided by scholars—that diacritical marks reduce phonological ambiguity in words, that they are an additional visual burden that further complicates Arabic reading, and that their importance varies as a function of grade level—are valid assumptions. Generalizations about the absolute inclusion or exclusion of diacritical marks and the absolute functionality of grade level are the only invalid

assumptions. However, there seems to be a missing component that bridges these three justifications. The frequency of morphological and lexical items is often ignored as a variable when designing studies in this field and analyzing and reporting findings (Seraye, 2004, 2017).

I propose a comprehensive theory on the role of diacritical marks in Arabic word recognition and specify the conditions in which they are necessary and the conditions in which they become a visual burden for typically developed Arabic students. The primary components of my theory are diglossia, Arabic visual complexity, the nature of the Arabic reading mechanism, and the association between word recognition and reading comprehension.

I discuss two theoretical arguments in the next section. The first argument relates to the sociolinguistic context of standard Arabic literacy acquisition. The second concerns the association between word recognition and reading comprehension. With these arguments, I establish cases in which vowelized script is necessary and cases in which vowelized script becomes a visual burden.

### *Theoretical Argument*

Eye-tracking studies have clearly shown that diacritical marks negatively impact reading in Arabic. They significantly reduce reading speed and significantly increase the number of fixations and the fixation and gaze duration, even though they guide accurate pronunciation for novel words (Roman & Pavard, 1987). Diacritical marks, if present, cannot be visually ignored. Even skilled readers find themselves forced to process them, thereby increasing their perceptual and visual load. Studies that have conducted lexical

decision tasks consistently report that the presence of diacritical marks in vowelized stimuli significantly increases lexical decision latency compared to unvowelized stimuli (Roman & Pavard, 1987; Taha & Azaizah-Seh, 2017). In other words, their presence forces the eye to process them, which delays access to meaning even if the words are highly familiar.

More evidence that diacritical marks cannot be visually ignored comes from behavioral and statistical observations. Studies in which texts were wrongfully vowelized by design, in an attempt to signal to readers that they should disregard the diacritical marks, reported that even skilled readers nevertheless processed them as legitimate marks, leading to substantive reading errors (Abu-Rabia, 1998; Seraye, 2017; Taouk & Coltheart, 2004). Furthermore, Asadi, Khateb, Ibrahim, and Taha (2017) recruited a nationally representative sample in grades 1–6. Even though decoding measures reached a ceiling in the fourth grade for Palestinian Arab students, and readers in the upper grades were likely to switch to a visual reading strategy, the contribution of phonemic awareness in the fifth and sixth grades did not decline sharply in artificial experimental conditions that introduced vowelized texts to upper-grade participants accustomed to unvowelized texts.

Notwithstanding this scientific evidence, diacritical marks remain a necessary evil in the lives of all educated Arabs for specific occasions, even at the expense of reading fluency and the meaning-accessing response. The importance of diacritical marks in Arabic word recognition cannot be established unless the sociolinguistic context of standard Arabic literacy acquisition is understood. Arabic diglossia does not foster a natural development in Arabic reading. Children start the first grade with little knowledge

of standard vocabulary and very little, if any, knowledge of standard orthography, let alone Arabic visual complexity (see earlier sections). Systematic exposure to standard Arabic begins during formal education. Additionally, while Arabic students develop root awareness as early as the second grade, they develop morphemic pattern awareness by the sixth grade (Taha & Saiegh-Haddad, 2017). Knowledge of morphemic patterns fosters the process of inferring diacritical marks because patterns are reliable prosodic templates. These findings indicate that students in primary education largely lack the capacity to visually access Arabic reading or to interact with unvowelized words. Studies conducted in artificial experimental settings using unvowelized script in primary education have further confirmed that visual reading, as opposed to a phonological recoding strategy, is not feasible (Asadi & Khateb, 2017; Taouk & Coltheart, 2004).

All schools across the Arab world implement vowelized script for beginning readers. Research has shown that phonemic awareness is the powerful predictor of vowelized script (see the reading process section). Phonological recoding is the dominant reading strategy in primary education. Beginning readers rely on GPM to access words and to develop autonomous lexical items (i.e., vocabulary) supporting both word recognition and reading comprehension (Adams, 1994). All available evidence points to the fact that Arabic reading in primary education is substantially mediated by phonology. Consequently, it is reasonable to speculate that diacritical marks that contribute phonological information are likely to facilitate word reading in primary education because they reduce the phonological ambiguity of words (Abu-Rabia, 2019a).

Despite the highly consistent GPM of vowelized Arabic script, Arabic students do not reach a ceiling in decoding until the fourth grade (Asadi, Khateb, Ibrahim, & Taha, 2017). Arabic students are phonologically impaired when they begin primary education. The diglossic context of Arabic literacy acquisition slows the process of encoding high-quality, standard phonological structures in an Arabic reader's mental lexicon (Goswami, 2000). Phonological processing abilities in word recognition are affected by the quality of stored underlying phonological representations (Swan & Goswami, 1997a; 1997b). It takes three to five years for Arabs to develop full, high-quality phonological representations that support word recognition skills (see diglossia section). Thus, automaticity in word recognition is delayed. Qualitative analyses of reading error studies have reported the inaccurate pronunciation of diacritical marks to be by far the most dominant reading error in primary education (Abu-Rabia, 1995; Abu-Rabia & Taha, 2004; Azzam, 1993). These findings further confirm the slow development of phonological skills among Arabic students. They also clearly demonstrate that vowelized texts should be maintained over several years during primary education to help students fully grasp them and develop high-quality phonological representations. Control over diacritical marks not only promotes accuracy and fluency in word recognition but is also related to lexical knowledge. A slight change in the pronunciation of words leads to different morphemic patterns and therefore different lexical meanings.

At a certain grade (typically in middle school), Arabic students transition to unvowelized texts. By this time, standard phonological representations, vocabulary, morphology, and orthographic knowledge have increased to an extent allowing reading

strategies to rotate (Asadi, Khateb, Ibrahim, & Taha, 2017; Tibi & Kirby, 2019). Direct visual access by root identification becomes the predominant reading strategy, whereas GPM is only used in the absence of semantic knowledge (see the reading process section). This situation is likely to occur when encountering classical Arabic texts typically introduced from middle school onwards. Arab educational systems are highly homogeneous; texts introduced in primary education are strictly narrative and informational, as they encompass high-frequency words, roots, and morphemic patterns used in Modern Standard Arabic (Saiegh-Haddad & Spolsky, 2014). It seems highly possible that the morphological, orthographic, and lexical familiarity developed by Arabic students may not support visual access to religious (e.g., Quranic) and literary (e.g., poetic) classical texts that include unfamiliar high-frequency words, as well as low-frequency words, roots, and morphemic patterns with which students are unfamiliar.

In summary, vowelizing texts with which students are familiar may hinder the visual reading strategies adopted in upper grades, placing a further visual burden on readers and forcing them to process irrelevant phonological information (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Familiar lexical items are typically accessed via a lexical reading channel (Coltheart, Curtis, Atkins, & Hailer, 1993; Seidenherg & McClelland, 1989). However, vowelizing unfamiliar classical texts may be necessary to promote phonological, and therefore lexical, access. This further confirms that the alphabetic stage in Arabic reading development is better perceived as a continuum (Abu-Rabia, 2012).

A second argument through which the importance of diacritical marks can be established relates to the association between word recognition and reading

comprehension. The nature of the Arabic reading mechanism is dynamic across all grade levels and rotates between sublexical and lexical channels. However, although a phonological recoding strategy dominates word recognition in the early grades, a visual access reading strategy dominates upper-grade reading; the phonological recoding strategy resurfaces in upper grades in certain texts. The dominant reading strategy in word recognition relates to lexical knowledge (Abu-Rabia, 1998; Abu-Rabia & Taha, 2004; Saiegh-Haddad, 2018). In turn, this is related to reading comprehension, a meaning-based task, which is the ultimate goal of reading. There is a direct association between word recognition and reading comprehension in the early grades and a conditional association in the upper grades (see oral reading fluency and silent reading comprehension). Given such associations, it follows that the processes that underpin word recognition in early grades also underpin reading comprehension in the same grades, and the processes that underpin word recognition in upper grades also underpin reading comprehension in the same grades. Put differently, it seems reasonable to validate the importance of diacritical marks in word recognition if their importance in reading comprehension is validated.

Although very few studies have investigated the importance of diacritical marks in reading comprehension in the past 30 years, the findings nevertheless reveal a reliable pattern. The reading comprehension of elementary students on narrative and informational texts was significantly better in vowelized conditions than in unvowelized conditions (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1999; Seraye, 2017). In contrast, studies with middle and high school participants have reported that students reading unvowelized narrative and informational texts had significantly better reading

comprehension scores than they did when reading vowelized texts (Elsayyad, Everatt, Mortimore, & Haynes, 2017; Seraye, 2004). Nevertheless, the reading comprehension of seventh and ninth graders and college adults in the vowelized condition was significantly better than in the unvowelized condition for Quranic and poetic classical texts (Abu-Rabia, 2001; Abu-Rabia & Hijjazi, 2020).

The pattern here is that beginner readers who read basic narrative and informational texts benefit from diacritical marks and a sublexical reading strategy to access semantics. The variation in reading comprehension for second graders in one longitudinal study was shown to be substantially explained by sublexical skills (45%) compared to supra-lexical skills (27%) (Abu Ahmad, Ibrahim, & Share, 2014). A few years later, when students' knowledge of word roots and vocabulary has presumably increased, unvowelized reading of narrative and informational texts would better support reading comprehension as words become familiar; vowelizing words would only distract readers' working memory with irrelevant information (e.g., accuracy) and disrupt fluent access to meaning (Taha & Azaizah-Seh, 2017). When combined, morphology, orthographic knowledge, and vocabulary explain nearly 60% of the variance in unvowelized reading comprehension in the upper grades (Elbeheri, Everatt, Mahfoudhi, Abu Al-Diyar, & Taibah, 2011; Layes, Lalonde, & Rebaï, 2017; Mahfoudhi, Elbeheri, Al-Rashidi, & Everatt, 2010; Makhoul & Sabah, 2019). However, despite being advanced readers, adolescents and adults have benefited from diacritical marks in unfamiliar Quranic and poetic classical texts because direct visual access was not feasible in the

absence of semantics. Hence, a sublexical reading strategy again becomes necessary to fill in the lexical gap.

The importance of diacritical marks in reading comprehension varies as a function of grade, stimuli familiarity and text affiliation. Vowelization is necessary for reading comprehension in early grades when narrative and informational texts are introduced. However, the importance of vowelization in upper grades is conditional. Vowelization only supports semantically unfamiliar texts and disrupts the comprehension of familiar narrative and informational texts. Given the direct and conditional associations between word recognition and reading comprehension in lower and upper grades, respectively, it is reasonable to assume that the importance of diacritical marks in word recognition varies as a function of grade and stimuli familiarity and text affiliation.

One final issue concerns homographic Arabic words. Isolated homographic words have multiple correct pronunciations if presented unvowelized, whereas there is only one choice of pronunciation when they are presented vowelized. Thus, comparing the accuracy and/or fluency between isolated vowelized homographic stimuli and isolated unvowelized homographic stimuli will naturally yield a significant advantage for the vowelized condition (Abu-Rabia, 1996, 1997c; Abu-Rabia & Siegel, 1995). Furthermore, comparing vowelized and unvowelized homographic stimuli in context is not scientifically rigorous. A brief discussion on the importance of context in Arabic orthography seems necessary for understanding this statement.

Studies on Latin-based orthographies have reported that context influences reading and that poor readers rely on context more than skilled readers (Stanovich, 1980, 1986;

Stanovich & Feeman, 1981). In Arabic orthography, context influences reading and skilled readers rely on context significantly more than poor readers (Abu-Rabia & Siegel, 1995; Abu-Rabia, 1996, 1997a, 1997b, 1997c, 2001). No significant difference between poor and skilled readers has been reported in terms of reading isolated unvowelized homographic stimuli (Abu-Rabia & Siegel, 1995; Abu-Rabia, 1996, 1997c). However, when placed in context, the accuracy of reading such stimuli significantly increases for both poor and skilled readers, with a significant advantage for skilled readers. Furthermore, a significant difference in accuracy has been reported between isolated unvowelized stimuli and reading the same target words in context; accuracy is higher with contextual reading (Abu-Rabia, 2001). This finding indicates the substantial influence of context in unvowelized Arabic reading for readers of all levels, but particularly for skilled ones. In contrast, the context has either minimal or no effect on vowelized script. No significant difference in accuracy was reported between reading isolated vowelized stimuli and reading the same target words in context (Abu-Rabia, 2001).

Therefore, comparing vowelized with unvowelized homographic stimuli in context is not scientifically rigorous because the effect of context is not comparable for both scripts. The comparison is not between vowelized and unvowelized word reading, but rather between the effects of vowelization and context. Hence, comparing vowelized and unvowelized homographic stimuli in context is not appropriate for studying the importance of diacritical marks in word recognition, because the effect of vowelization, compared to context, gives a significant advantage to the vowelized condition (Abu-Rabia

& Siegel, 1995; Abu-Rabia, 1996, 1997c). Processing the diacritical marks, if present, precedes semantic access and context processing.

Accordingly, this meta-synthesis only considers non-homographic stimuli. I also hypothesize that the mixed findings presented earlier on the importance of diacritical marks in word recognition may be resolved and organized into one comprehensive theory if two factors are considered: grade level and stimuli familiarity and text affiliation. Establishing a cutoff point is the first step.

Arabic schools design their curricula homogeneously (Saiegh-Haddad & Spolsky, 2014). Narrative and informational texts are only introduced in primary education, both in literacy blocks and content areas. In the upper grades, narrative texts are phased out and informational texts become dominant in literacy blocks and content areas. In addition, religious (e.g., Quranic) and literary (e.g., poetic) classical texts constitute an integral part of literacy blocks in the upper grades. For over 1,400 years, the common belief among Arabs has been that these texts, especially the Quran, are sacred and have managed to save the Arabic language from extinction. These texts contain a significant portion of Islamic civilization's history, culture, science, ideologies, literature, and arts (e.g., Arabic calligraphy). Thus, they are passed from one generation to another as part of their cultural heritage (Saiegh-Haddad & Spolsky, 2014).

The most essential question concerns the specific grade at which diacritical marks become less effective in supporting word recognition for narrative and informational texts and shift to becoming a visual burden. Despite the highly regular GPM of vowelized script, Arabic readers do not reach a ceiling in word recognition in either the first or second grade

(Abu Ahmad, Ibrahim, & Share, 2014). The negative implications of diglossia, in addition to Arabic's visual complexity, do not support a rapid consolidation of the phonological recoding mechanism. Arabic students start formal education with limited phonological processing skills, which hampers word recognition abilities. It takes three to five years to develop full, high-quality phonological representations (Asadi & Ibrahim, 2014; Saiegh-Haddad, 2007; Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020; Saiegh-Haddad & Haj, 2018; Schiff & Saiegh-Haddad; 2017). Reading error analysis studies have clearly shown the significant number of decoding errors in primary education (Abu-Rabia, 1995; Abu-Rabia & Taha, 2004; Azzam, 1993). However, Arab students begin to show a degree of automaticity in the third grade (Asaad & Eviatar, 2013).

Given the available evidence, it is reasonable to eliminate grades 1–3 as potential cutoff points. Arabic schools follow one of two patterns for categorizing years within the educational ladder: 6-3-3 or 5-4-3. In other words, the period of elementary schooling ends at fifth grade in some Arab countries and sixth grade in others, leaving grades 4–6 as potential cutoff points. I have chosen to eliminate the fifth and sixth grades and use the fourth grade as a cutoff point for examining the importance of diacritical marks in word recognition, for two reasons. First, all studies investigating the importance of diacritical marks have been conducted in Palestinian Arabic schools in Israel where students transition to unvowelized script in the fourth grade. Second, two studies that recruited a nationally representative sample of Palestinian Arabs in grades 1–6 reported that decoding measures reached a ceiling and a stable contribution to reading comprehension in the fourth grade (Asadi, Khateb, Ibrahim, & Taha, 2017; Asadi, Khateb, & Shany, 2017).

This meta-synthesis examines studies that have investigated the importance of diacritical marks in Arabic word recognition before and after fourth grade as a cutoff point. I conduct a deep investigation regarding stimuli familiarity and text affiliation for items used in the studies. This will help resolve and organize the discrepancies reported in earlier findings, in order to develop a comprehensive theory on the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers.

Finally, a brief justification for excluding poor readers from this meta-synthesis seems appropriate. Phonemic awareness is the primary determinant of individual variations in word recognition of alphabetic orthographies (Seymour, Aro, & Erskine, 2003). Poor Arabic readers display a significant advantage in phonological processing skills compared to morphological and orthographic skills (see reading disability section). The processing of Arabic diacritical marks is dependent on phonemic awareness. Two studies have reported that poor readers, as defined by a score of ≤ the 25$^{th}$ percentile in word recognition, show no significant differences between vowelized and unvowelized conditions in word-reading accuracy in grades 1–4. In grades 5–6, the unvowelized condition presents an advantage in accuracy (Schiff & Saiegh-Haddad, 2017; Taha, 2016a). The findings seemingly align with the characteristics of poor Arabic readers. The non-significant advantage in the early grades is explainable given poor phonemic awareness and underdeveloped orthographic and morphological knowledge. Findings in the upper grades indicate that poor Arabic readers access words through their developed visuo-perceptual processing given their phonological deficit. A full discussion concerning didactical marks and poor readers is beyond the scope of this meta-synthesis.

### *Operational Definitions*

The importance of diacritical marks in word recognition is operationally defined in this meta-synthesis as a significant advantage in accuracy in vowelized reading conditions compared to unvowelized reading conditions. Accurate word recognition is the desired outcome in Arabic, as it contributes to lexical knowledge; a minor error in diacritical marks can create a different lexical meaning. Thus, the major question to be asked across all grade levels is whether phonology (diacritical marks) should be represented explicitly (the vowelized condition) or left to be inferred (the unvowelized condition). There are three possible answers to this question: a) the vowelized condition gives a significant advantage in accuracy across all grade levels; b) the unvowelized condition gives a significant advantage in accuracy across all grades; and c) the results change as a function of grade level. In any case, the importance of diacritical marks can be determined; therefore, accuracy is a reliable variable for comparing vowelized and unvowelized reading.

On the other hand, word recognition fluency is not a reliable variable for comparing vowelized and unvowelized reading. Comparing fluency as defined by the number of words read correctly in a designated time between vowelized and unvowelized conditions in early grades is meaningless when it is known that diacritical marks significantly reduce reading speed yet are necessary for accessing words (Roman & Pavard, 1987). Furthermore, comparing fluency between vowelized and unvowelized conditions in the upper grades is also meaningless, since the dominant reading mechanism

is direct visual access. Forcing advanced readers to use a phonological recoding strategy is likely to decrease fluency due to visual fatigue.

Fluency in Arabic word recognition is a product of the dominant reading mechanism, which differs across vowelized and unvowelized scripts. Fluent reading is advantageous for readers. Studies have shown that Arabic readers experience significant development in vowelized word-reading fluency across elementary grades (Asadi, 2017; Asadi, Khateb, Ibrahim, & Taha, 2017; Mohamed, Elbert, & Landerl, 2011). Nevertheless, this type of fluency is unique in the presence of diacritical marks. Indeed, although diacritical marks reduce reading speed, the speed with which they are processed improves by grade. Researchers interested in Arabic orthography must acknowledge that Arabic fluency is script-sensitive. The definition of Arabic reading fluency varies as a function of script. Fluency in vowelized Arabic is better defined as the number of words read correctly in a designated time, whereas fluency in unvowelized Arabic is better defined as a rapid lexical response time. While measures of fluency can be used as a general index of reading competence within each script, comparing these measures across scripts is meaningless. Thus, in this meta-synthesis, I do not consider findings on word recognition fluency from studies that compare vowelized and unvowelized reading.

Stimuli familiarity and text affiliation in this meta-synthesis refer to the frequency of roots, root derivatives (i.e., vocabulary), and morphemic patterns. Both classical Arabic and Modern Standard Arabic encompass low-, average-, and high-frequency roots, derivatives, and morphemic patterns (Bateson, 2003; Fischer, 2002). However, classical Arabic texts (e.g., Quranic and poetic texts) are characterized by the substantial inclusion

of low-frequency roots, derivatives, and morphemic patterns (Abu-Rabia, 1998; Brosh & Attili, 2009). In other words, classical texts do include high-frequency roots, derivatives, and morphemic patterns, but at a significantly lower rate in comparison to low-frequency roots, derivatives, and morphemic patterns. Furthermore, classical texts include a considerable number of average-frequency roots. However, derivatives produced through these roots are characterized as low-frequency (Abu-Rabia, 1998; Brosh & Attili, 2009).

Classical Arabic is known for using complex morphology, vocabulary, and grammar to preserve prosody (Saiegh-Haddad, 2018), with 86% of Quranic verses retaining a prosodic rhythm (Al Najjar, 2002). Classical Arabic prose and poems were highly influenced by the Quranic style, which was considered the norm for composing and writing. Classical texts published during the Islamic civilization, an era that started in the 8$^{th}$ century and ended with the collapse of the Ottoman Empire in the 19$^{th}$ century, are astonishingly homogeneous (Bateson, 2003; Fischer, 2002). Furthermore, sentences in classical Arabic texts are extremely concise due to Arabic's agglutinative nature. Taken together, understanding the morphological and grammatical density of classical Arabic is a cognitively demanding task that requires several processes to unpack the lexical load embedded within texts. Reading accuracy and comprehension of Quranic and poetic texts lag significantly behind reading accuracy and comprehension of narrative and informational texts (Abu-Rabia, 1998, Abu-Rabia & Hijjazi, 2020). Moreover, answering literal reading comprehension questions on Quranic and poetic texts is significantly and substantially easier than answering inferential, analytical, synthetic, and evaluative questions (Abu-Rabia & Hijjazi, 2020).

On the other hand, narrative and informational texts written in Modern Standard Arabic are characterized by the substantial inclusion of average- and high-frequency roots, derivatives, and morphemic patterns (Bateson, 2003; Fischer, 2002). Modern Standard Arabic texts include low-frequency roots, derivatives, and morphemic patterns but at a significantly lower rate in comparison to average- and high-frequency roots, derivatives, and morphemic patterns. Modern Standard Arabic is known for its simple choice of semantics, morphology, and syntax, as modern writers have rarely been influenced by the Quranic style (Saiegh-Haddad, 2018).

Arabic schools typically start education in both literacy blocks and content areas using narrative and informational texts written in Modern Standard Arabic. Textbooks used in literacy blocks in lower grades across the Arab world are typically named "Arabic is my beautiful language," whereas in upper grades the name shifts to "Arabic literature." Diglossia does not allow for earlier exposure to classical Arabic literature, so teaching Arabic across the Arab world is strikingly homogeneous (Saiegh-Haddad & Spolsky, 2014). I provide a deep analysis of the stimuli included in studies that have investigated the importance of diacritical marks in Arabic word recognition. I analyze the stimuli using the ARALEX database (Boudelaa & Marslen-Wilson, 2010).

Finally, typically developed Arabic readers (i.e., average readers) in this meta-synthesis refers to readers who obtain a score of ≥ the 50$^{th}$ percentile in word recognition measures and have no history of reading disabilities as indicated in school records. Studies that use reading achievement models vary in determining cutoff points that characterize poor, average, and highly skilled readers (Abu-Rabia, 1996, 1997a, 1997b, 1997c, 2001;

Abu-Rabia & Siegel, 1995; Asadi, 2018; Asadi & Shany, 2018; Jiměnez, Siegel, & Lòpez, 2003; Lyon, Fletcher, & Barnes, 2002; Saiegh-Haddad & Taha, 2017). For example, a reader with a score of ≤ the 25$^{th}$ percentile in word recognition may be categorized as a poor reader in some studies, while other studies may extend the range to ≤ the 40$^{th}$ percentile. Similarly, highly skilled readers may refer to readers with a score of ≥ the 70$^{th}$ percentile in some studies or ≥ the 90$^{th}$ percentile in other studies. Labeling average readers is even more problematic, given the tentative boundaries between cutoff points.

Since this study does not investigate the importance of diacritical marks in word recognition among poor readers, I have defined average readers as having a score of ≥ the 50$^{th}$ percentile in word recognition measures, which mitigates issues concerning the tentative boundary between poor and average readers. Readers with a score of ≥ the 50$^{th}$ percentile in word recognition fall in the middle of a normal distribution bell curve. This score provides a level of confidence that is both satisfactory and uncontroversial.

### *Hypothesis*

The importance of diacritical marks for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation. In early grades, Arabic readers rely predominantly on a phonological recoding reading strategy to access phonologically and semantically unfamiliar words. Hence, word/text reading is advantageous for the vowelized condition. Four years of systematic exposure to standard Arabic gives readers sufficient morphological, orthographic, and lexical knowledge, which in turn promotes a shift to a visual-access dominant reading strategy. Thereafter, diacritical marks become a visual burden in processing phonologically and semantically

familiar words that are typically affiliated with narrative and informational texts. This then causes errors in accuracy resulting from processing irrelevant phonological information, delaying lexical access. Hence, word/text reading is advantageous for the unvowelized condition. However, even advanced Arabic readers are forced to rely on a phonological recoding reading strategy when encountering unfamiliar words typically affiliated with religious and literary classical texts traditionally introduced in upper grades. Hence, the importance of diacritical marks is restored once again, and word/text reading again becomes advantageous for the vowelized condition.

The main hypotheses of this meta-synthesis can be stated as follows:

1) Studies that investigate the influence of diacritical marks on reading accuracy up until the end of fourth grade, and which use non-homographic stimuli that are frequently affiliated with narrative and informational Modern Standard Arabic texts, would report significant advantages for vowelized word/text reading compared to unvowelized word/text reading.
2) Studies that investigate the influence of diacritical marks on reading accuracy beyond the fourth grade, and which use non-homographic stimuli that are frequently affiliated with narrative and informational Modern Standard Arabic texts, would report significant advantages for unvowelized word/text reading compared to vowelized word/text reading.
3) Studies that investigate the influence of diacritical marks on reading accuracy beyond the fourth grade, and which use non-homographic stimuli that are frequently affiliated with religious, Quranic, literary, and poetic classical texts,

would report significant advantages for vowelized word/text reading compared to unvowelized word/text reading.

### *Study Significance*

Many educational practices and policies across the Arab world lack scientific evidence (Al Ghanem & Kearns, 2014). For example, Arabic schools place very little emphasis on phonology despite compelling evidence that phonological recoding is the dominant reading strategy with vowelized script (see the reading process section), and despite the negative implications of diglossia on Arabic students' standard phonological abilities (Feitelson, Goldstein, Iraqi, & Share, 1993; Levin, Saiegh-Haddad, Hende, & Ziv, 2008; Saiegh-Haddad, 2018). Moreover, at a certain grade on the educational ladder, most Arabic schools choose to transition from vowelized to unvowelized script, while some Arab countries choose to use vowelized textbooks up until the twelfth grade. None of these countries provide scientific evidence for their decisions (Al Ghanem & Kearns, 2014). Also, Arab publishers choose to publish vowelized children's literature and vowelized books related to classical Arabic that are designated for advanced readers interested in Arabic language and culture. These decisions are based solely on anecdotal beliefs.

My study is perhaps one of the first attempts to validate educational practices and policies that have existed for at least the past 70 years in the modern Arab era, since the independence of Arab nations from British, French, and Italian colonialism (Saiegh-Haddad & Spolsky, 2014). Establishing that vowelization is a linguistic necessity in primary education supports the current policy of starting formal education with vowelized textbooks. Likewise, establishing that diacritical marks have a certain age expectancy in

early schooling and that they also serve a specific purpose in the upper grades demonstrates the necessity of transitioning to unvowelized textbooks while maintaining Quranic, literary, and poetic classical texts vowelized in the upper grades and in commercial publications.

I also challenge the practices and policies in the Arab countries (e.g., Syria and Jordan) that maintain vowelization for the entire K-12 education period. Keeping all textbooks vowelized is disadvantageous for many reasons. Despite their advantages in primary education, diacritical marks consume readers' cognitive resources, cause visual fatigue, and delay access to meaning (Roman & Pavard, 1987; Taha & Azaizah-Seh, 2017). Furthermore, they cannot be visually ignored.

Unless a transition to unvowelized script occurs in Arabic schools, students are forced to read via a phonological recoding mechanism, as opposed to a visual reading strategy, for the remainder of their school years (Abu-Rabia, 2002). The ramifications of this decision are accuracy errors, latency in lexical decisions, and poor practice of the higher thinking skills necessary for reading comprehension, which result from using working memory capacity to process irrelevant information.

The findings of this meta-synthesis are not generalizable to all Arabs—only to Palestinian Arabs living in Israel. However, almost all Arab countries share educational experiences with Palestinians: diglossia, transition policy, and homogeneous educational systems (Saiegh-Haddad, 2018). The hypothesis I have developed organizes findings published in the past 25 years regarding the importance of diacritical marks in Arabic word recognition. This hypothesis, if confirmed, will serve as a theory guiding future research,

educational practices and policies, and commercial publication policies across the entire Arab world.

# CHAPTER III

# METHODOLOGY

## Databases and Search Procedures

To locate relevant studies, I searched the following databases: Education Source, ERIC, JSTOR, Linguistics and Language Behavior Abstracts, Linguistics Abstracts Online, ProQuest Dissertations, Theses Global, PsycINFO, Psychology & Behavioral Sciences Collection, Taylor & Francis Online, Web of Science, and Wiley Online Library.

Major search descriptors consisted of: Arabic, Arabic orthography, Arabic reading, Arabic texts, decoding, deep orthographies, diacritical marks, diglossia, diglossic reading, dynamic reading, early literacy, elementary reading, fluency, lexicality effect, literacy acquisition, nonword reading, opaque orthographies, phonological recoding, pseudoword reading, reading, reading accuracy, reading acquisition, reading ability, reading analysis, reading development, reading difficulties, reading errors, reading process, reading speed, Semitic orthographies, Semitic reading, shallow orthographies, short vowels, transparent orthographies, visual word recognition, vowelization, vowels, vowel signs, vowelized texts, word reading, word recognition, and word familiarity. After the searches were completed, I located 11 studies.

To locate additional studies, I manually searched eight journals in which studies related to Arabic orthography are often published: *Applied Psycholinguistics*, *Dyslexia*, *Journal of Learning Disabilities*, *Reading Research Quarterly*, *Reading and Writing*, *Reading Psychology*, *Scientific Studies of Reading*, and *Writing Systems Research*.

Furthermore, I examined the reference sections of articles obtained during the initial search. Three more studies were identified with this expanded search.

## Selection Criteria

Interest in Arabic orthography emerged during the 1990s. Since 1995, Salim Abu-Rabia has conducted a series of studies on several topics related to the reading process of Arabic orthography that have inspired successive scholars (Abu-Rabia, 1995, 1996, 1997a, 1997b, 1997c, 1998, 1999; Abu-Rabia & Siegel, 1995). Before 1995, there were few studies on Arabic orthography (Azzam, 1993; Feitelson, Goldstein, Iraqi, & Share, 1993; Roman & Pavard, 1987). Accordingly, I have only considered studies investigating the importance of diacritical marks in Arabic word recognition from 1995–2020. Book chapters, doctoral dissertations, and journal articles published in Arabic or English were also considered, but the journal articles had to have been peer-reviewed. Participants targeted in this meta-synthesis had to be native Arabic speakers from grade 1 through college. Studies had to include explicit statements describing the participants' reading proficiency level. Typically developed Arabic readers who obtained a score of ≥ the 50$^{th}$ percentile in word recognition measures and who had no history of reading disabilities are the target for this meta-synthesis. I included findings on average readers from studies that recruited both poor and average readers; I excluded findings on poor readers.

Both qualitative and quantitative studies are considered in this meta-synthesis. To be included, quantitative studies had to use repeated measures and within-group comparisons as a methodology. In other words, participants had to undergo both of the experimental conditions (i.e., vowelized and unvowelized script) and the superiority of

one condition over the other had to be reported through the statistical calculation of mean differences. If the same list of stimuli was used for both experimental conditions, an adequate time interval between experimental conditions to prevent carryover had to be explicitly reported. Quantitative studies that used between-group comparisons were excluded.

To be included, reading error analysis studies had to ask participants to read both vowelized and unvowelized stimuli and report error rates for each experimental condition. I have excluded qualitative studies that use one experimental condition. This meta-synthesis focuses primarily on how reading accuracy varies with the stimuli; reading fluency is not of concern. Therefore, studies that only report a mean difference in reading fluency are excluded. For studies that report the mean difference in both reading accuracy and fluency, only the findings regarding accuracy are included; findings regarding fluency are excluded.

For a study to be included, explicit examples of reading stimuli had to be provided, whether in the materials section or the appendices. In the absence of explicit examples, an explicit statement specifying the stimuli's text affiliation had to be written (e.g., a paragraph was taken from the Quran). I excluded studies that failed to provide explicit examples of stimuli or a stimuli's text affiliation, along with studies that used homographic stimuli. However, if a study used both homographic and non-homographic stimuli, only the findings on non-homographic stimuli are included. Finally, studies that investigate the importance of diacritical marks at both a micro-level (i.e., isolated word) and a macro-level (i.e., connected text) are also considered in this meta-synthesis.

## Overview of the Included Studies

Overall, I located 14 studies during the initial and expanded searches. Five studies were then excluded—three because they used isolated homographic stimuli (Abu-Rabia, 1996, 1997c; Abu-Rabia & Siegel, 1995) and two because they failed to report both explicit examples of stimuli and the stimuli's text affiliation (Abu-Rabia, 1997b; Saiegh-Haddad & Taha, 2017).

In total, nine studies met the inclusion criteria (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Leil, Share, & Ibrahim, 2014; Abu-Rabia, 1997a, 1998, 2001; Asadi, 2017; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Two of the included studies were published in the 1990s and seven were published in the 2000s. All of the included studies are journal articles published in English-language, peer-reviewed journals. All studies explicitly describe participants as having a score of ≥ the 50$^{th}$ percentile in word recognition measures and no history of reading disabilities. Of the nine studies, two studies recruited both poor and average readers (Schiff & Saiegh-Haddad, 2017; Taha, 2016a). I have excluded findings on poor readers, defined as a score of ≤ the 25$^{th}$ percentile in word recognition; I have included findings on average readers.

All of the studies included were quantitative studies that used repeated measures. Participants were tested on vowelized and unvowelized words/texts; within-group statistical analyses of mean difference were used to report findings. All studies reported mean differences in reading accuracy. Six of the studies reported mean differences for both reading accuracy and fluency (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Leil,

Share, & Ibrahim, 2014; Asadi, 2017; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Findings pertaining to reading fluency were excluded from data analysis.

Six of the studies provided explicit examples of stimuli used in experimental conditions, and the other three studies made explicit statements regarding the stimuli's text affiliation, stating both the authors of the text and the reference. All included studies used only non-homographic stimuli. Finally, five of the included studies used micro-level stimuli; two studies used macro-level stimuli; two studies used both micro- and macro-level stimuli. Table 1 provides a descriptive summary of the studies included in this meta-synthesis.

## Analysis of Stimuli

ARALEX is a database encompassing a corpus of 40 million Arabic words collected from Arabic newspapers published online (Boudelaa & Marslen-Wilson, 2010). Words in the database are displayed by their vowelized status, derivatives, derivative frequency, roots, root frequency, morphemic patterns, and morphemic pattern frequency. Frequency in the database refers to the frequency with which a derivative, root, or morphemic pattern appears in the corpus. A manual search allows for several options, including search by root—in which all derivatives related to the root are displayed—and search by individual word (i.e., derivative). To establish credibility, the overall corpus was cross-checked with two Modern Standard Arabic dictionaries to assess the accuracy of roots and morphemic patterns used in ARALEX. A random sample of 500,000 words from each dictionary was selected and cross-checked with the corpus. The match rate was 90% for vowelized words and 80% for unvowelized words.

Six of the included studies provide explicit examples of the stimuli used for experimental conditions. Five of these studies explicitly state that stimuli (i.e., derivatives only) had an average frequency as validated by Arabic teachers, inclusion in primary textbooks, or availability in vernacular and standard Arabic (Abu-Leil, Share, & Ibrahim, 2014; Asadi, 2017; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). To further confirm these statements and conduct a comprehensive analysis that includes not only derivative frequency but also root and morphemic pattern frequency, I collected and manually searched all available stimuli (n = 48) reported in these five studies in ARALEX. Table 2 displays the results of the frequency analysis of all derivatives, roots, and morphemic patterns used in these studies. The results show that low-frequency derivatives, roots, and morphemic patterns constitute 12%, 13%, and 15% of all stimuli, respectively. Average-frequency derivatives, roots, and morphemic patterns constitute 46%, 35%, and 32% of all stimuli, respectively. High-frequency derivatives, roots, and morphemic patterns constitute 42%, 52%, and 53% of all stimuli, respectively.

I also conducted an individual analysis of the pattern of frequency within each study. A total of six available stimuli were collected from two studies that used the same stimuli (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Low-frequency derivatives, roots, and morphemic patterns constituted 0% of all stimuli; average-frequency derivatives, roots, and morphemic patterns constituted 66%, 84%, and 34% of all stimuli, respectively; high-frequency derivatives, roots, and morphemic patterns constituted 34%, 16%, and 66% of all stimuli, respectively.

A total of 25 available stimuli were collected from Asadi (2017), of which low-frequency derivatives, roots, and morphemic patterns constituted 20%, 12%, and 8% of all stimuli, respectively; average-frequency derivatives, roots, and morphemic patterns constituted 32%, 20%, and 28% of all stimuli, respectively; high-frequency derivatives, roots, and morphemic patterns constituted 48%, 68%, and 64% of all stimuli, respectively. Seven available stimuli were collected from Schiff and Saiegh-Haddad (2017), of which low-frequency derivatives, roots, and morphemic patterns constituted 0%, 14%, and 0% of all stimuli, respectively. Average-frequency derivatives, roots, and morphemic patterns constituted 43%, 57%, and 14% of all stimuli, respectively; high-frequency derivatives, roots, and morphemic patterns constituted 57%, 29%, and 86% of all stimuli, respectively. Finally, 10 available stimuli were collected from Taha (2016a), of which low-frequency derivatives, roots, and morphemic patterns constituted 10%, 20%, and 20% of all stimuli, respectively; average-frequency derivatives, roots, and morphemic patterns constituted 70%, 30%, and 50% of all stimuli, respectively; high-frequency derivatives, roots, and morphemic patterns constituted 20%, 50%, and 30% of all stimuli, respectively.

The collective pattern observed in these five studies shows that the rate of average- and high-frequency derivatives, roots, and morphemic patterns substantially surpasses low-frequency derivatives, roots, and morphemic patterns. Individual patterns observed in each of the five studies align completely with the collective pattern, which accords with the nature of narrative and informational texts written in Modern Standard Arabic (Bateson, 2003; Fischer, 2002). Average- and high-frequency derivatives, roots, and

morphemic patterns constitute the vast majority of narrative and informational morphological and lexical items.

A semantic analysis of the 48 available words in these five studies shows semantic affiliations with the following semantic domains: social communication, science and medicine, jobs and professions, personalities and adjectives, house-related words, instruments, food and beverages, school, places, proper nouns, animals, and sports.

One of the included studies provides explicit examples of stimuli used in experimental conditions, as well as a statement of the stimuli's text affiliation (Abu-Hamour, Al-Hmouz, & Kenana, 2013). The text used in this study had a religious nature, describing the life of the prophet Job. To further confirm this statement and conduct a comprehensive frequency analysis of derivatives, roots, and morphemic patterns, I collected and manually searched all available stimuli reported in this study (n = 13) in ARALEX.

Table 2 displays the results of the frequency analysis of all the derivatives, roots, and morphemic patterns used in this study. A total of 13 available stimuli were collected from Abu-Hamour, Al-Hmouz, and Kenana (2013), of which low-frequency derivatives, roots, and morphemic patterns constituted 54%, 23%, and 54% of all stimuli, respectively; average-frequency derivatives, roots, and morphemic patterns constituted 23%, 69%, and 8% of all stimuli, respectively; and high-frequency derivatives, roots, and morphemic patterns constituted 23%, 8%, and 38% of all stimuli, respectively. In religious texts, low-frequency derivatives constitute the vast majority of lexical items (Abu-Rabia, 1998; Brosh & Attili, 2009). Moreover, the rate of low-frequency roots and morphemic patterns

substantially increases compared to narrative and informational texts (Bateson, 2003; Fischer, 2002). Additionally, despite the high rate of average-frequency roots in religious texts, derivatives of these roots are typically found at a low frequency and are not often associated with narrative and informational texts (Abu-Rabia & Hijjazi, 2020).

The pattern observed in this study aligns with the nature of religious and literary classical texts that are characterized by the substantial inclusion of low-frequency derivatives, roots, and morphemic patterns (Abu-Rabia, 1998; Brosh & Attili, 2009). A semantic analysis of the 13 available words shows that religion is the dominant semantic category to which stimuli are affiliated. Finally, although three of the included studies do not provide explicit examples of the stimuli used in experimental conditions, explicit statements were made regarding the stimuli texts' affiliation, indicating affiliation with Quranic, literary, and poetic classical texts (Abu-Rabia, 1997a, 1998, 2001). Therefore, it is reasonable to assume that if the stimuli used in these three studies were to be analyzed, the findings would follow the pattern observed in Abu-Hamour et al. (2013).

## Data Analysis

Three major variables can be used to organize and report the findings of the included studies: grade level, the level of stimuli, and stimuli frequency with text affiliation. In terms of grade level, the included studies can be categorized into two groups: ≤ the fourth grade and > the fourth grade. Regarding the level of stimuli, the included studies can be categorized into micro-level and macro-level studies. Finally, regarding stimuli frequency and text affiliation, the included studies can be categorized into two groups: narrative and informational stimuli, and religious and literary stimuli.

The logical method for reporting findings would be:

a) Micro-level narrative and informational stimuli in grades 1–4
b) Micro-level religious and literary stimuli in grades 1–4
c) Macro-level narrative and informational stimuli in grades 1–4
d) Macro-level religious and literary stimuli in grades 1–4
e) Micro-level narrative and informational stimuli in grades 5–12 and college
f) Micro-level religious and literary stimuli in grades 5–12 and college
g) Macro-level narrative and informational stimuli in grades 5–12 and college
h) Macro-level religious and literary stimuli in grades 5–12 and college.

Table 1 distributes the included studies across the eight levels mentioned above. No match was found for four levels, two of which make sense because religious and literary classical texts are not traditionally introduced in primary education. The remaining two levels are related to macro-level narratives and informational stimuli in both the lower and upper grades. Apparently, investigating the importance of diacritical marks using micro-level narrative and informational stimuli is preferred among scholars of Arabic orthography. Accordingly, the findings of the included studies, which are reported in Chapter IV, are organized as follows:

a) Micro-level narrative and informational stimuli in grades 1–4 (n=3)
b) Micro-level narrative and informational stimuli in grades 5–12 and college (n=5)
c) Micro-level religious and literary stimuli in grades 5–12 and college (n=2)
d) Macro-level religious and literary stimuli in grades 5–12 and college (n=3).

# CHAPTER IV

# RESULTS AND DISCUSSION

## Results

### *Micro-Level Narrative and Informational Stimuli in Grades 1–4*

#### Summary of Experimental Conditions

Three studies investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 1–4. Taha (2016a) and Schiff and Saiegh-Haddad (2017) tested second and fourth graders. Asadi (2017) tested students in grades 1–4. Data collection was administered at the beginning of the school year in one study (Schiff & Saiegh-Haddad, 2017), and near the end of the school year in two studies (Asadi, 2017; Taha, 2016a). Taha (2016a) developed two word lists: one list for second-grade students and another for fourth-grade students. Within each grade, the same list was presented to students in two conditions: vowelized and unvowelized. Asadi (2017) developed one list for all grades he investigated. This list was developed using stimuli from a third-grade Arabic textbook. Within each grade, the same list was presented to students in both vowelized and unvowelized conditions. Schiff and Saiegh-Haddad (2017) developed two word lists, one vowelized and one unvowelized. The same lists were used for both second- and fourth-grade students. Across all three studies, the order of administration was counterbalanced. In the two studies that used the same word list in both experimental conditions, the time interval between testing sessions was reported to be three weeks (Asadi, 2017; Taha, 2016a).

**Summary of the Findings**

Taha (2016a) reported that the results from the second and fourth graders showed a significant advantage for word recognition accuracy in the unvowelized condition. Asadi (2017) reported that the results from the first and second graders showed no significant differences in word recognition accuracy between the vowelized and unvowelized conditions. The results from the third and fourth graders, however, showed a significant advantage for word recognition accuracy in the unvowelized condition. Schiff and Saiegh-Haddad (2017) reported that the results from the second and fourth graders showed a significant advantage for word recognition accuracy in the vowelized condition. Overall, the findings of these three studies, which investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 1–4, appear to be contradictory.

*Micro-Level Narrative and Informational Stimuli in Grades 5–12 and College*

**Summary of the Experimental Conditions**

Five studies investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 5–12 and college. Asadi (2017) tested fifth and sixth graders. Taha (2016a) and Schiff and Saiegh-Haddad (2017) tested sixth-grade students. Ibrahim (2013) and Abu-Leil, Share, and Ibrahim (2014) tested eighth graders. Asadi (2017) developed a single word list for the two grade levels that were investigated. This list was developed using stimuli from the third-grade Arabic textbook. Within each grade, the list was presented to students in two conditions: vowelized and unvowelized. Schiff and Saiegh-Haddad (2017) developed two different word lists, one vowelized and

one unvowelized. Taha (2016a) developed a single word list for his participants. The list was presented to students in two conditions: vowelized and unvowelized. Ibrahim (2013) and Abu-Leil, Share, and Ibrahim (2014) also developed vowelized and unvowelized word lists. Both studies used similar word lists. In three studies, the order of administration was counterbalanced (Asadi, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). In the two studies that used the same word list in both experimental conditions, the time interval between testing sessions was reported to be three weeks (Asadi, 2017; Taha, 2016a). In two studies, the order of administration was not counterbalanced (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). The vowelized word list was introduced first in both studies.

**Summary of the Findings**

Asadi (2017) reported that the results of the fifth and sixth graders indicated a significant advantage for word recognition accuracy in the unvowelized condition. Taha (2016a) and Schiff and Saiegh-Haddad (2017) reported that the results from the sixth-grade students showed a significant advantage for word recognition accuracy in the unvowelized condition. Ibrahim (2013) and Abu-Leil, Share, and Ibrahim (2014) reported that the results from the eighth-grade students showed a significant advantage for word recognition accuracy in the unvowelized condition. Overall, all five studies that investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 5–12 and college consistently reported that the unvowelized condition presents an advantage in word recognition accuracy.

*Micro-Level Religious and Literary Stimuli in Grades 5–12 and College*

**Summary of the Experimental Conditions**

Two studies investigated the importance of diacritical marks using micro-level religious and literary stimuli in grades 5–12 and college. Abu-Rabia tested tenth graders (1997a) and college adults (2001). For both studies, a vowelized and an unvowelized word list of literary stimuli were developed. The order of administration was counterbalanced in both studies.

**Summary of the Findings**

The results in both studies, which investigated the importance of diacritical marks using micro-level religious and literary stimuli in grades 5–12 and college, were consistent. A significant advantage for word recognition accuracy in the vowelized condition was observed for tenth graders and college adults reading literary stimuli (Abu-Rabia, 1997a, 2001).

*Macro-Level Religious and Literary Stimuli in Grades 5–12 and College*

**Summary of the Experimental Conditions**

Four studies investigated the importance of diacritical marks using macro-level religious and literary stimuli in grades 5–12 and college. Abu-Hamour, Al-Hmouz, and Kenana (2013) tested fifth graders. Abu-Rabia tested tenth graders (1997a), eleventh graders (1998), and college adults (2001). Abu-Hamour, Al-Hmouz, and Kenana (2013) developed two different religious texts. One text was vowelized, and the other text was presented unvowelized. Abu-Rabia (1997a, 1998, 2001) also developed vowelized and

unvowelized literary texts and Quranic texts (1998). Across all four studies, the order of administration was counterbalanced.

### Summary of the Findings

Abu-Hamour, Al-Hmouz, and Kenana (2013) reported that the results from the fifth-grade students showed a significant advantage for religious text accuracy in the vowelized condition. Abu-Rabia (1997a, 1998, 2001) reported that the results from the tenth- and eleventh-grade students and college adults showed a significant advantage for literary text accuracy in the vowelized condition. Abu-Rabia (1998) reported that the results from the eleventh-grade students showed a significant advantage for Quranic text accuracy in the vowelized condition. Overall, all four studies that investigated the importance of diacritical marks using macro-level religious and literary stimuli in grades 5–12 and college reported consistent findings indicating greater text accuracy in the vowelized condition.

## Discussion

The importance of diacritical marks in Arabic word recognition has attracted scholarly attention since 1995, with three perspectives offered. Proponents of diacritical marks believe that they reduce phonological ambiguity, whereas opponents consider them to be a perceptual and visual burden that further complicates Arabic literacy acquisition. However, between these two positions, some scholars have argued that diacritical marks support word recognition in early grades only, whereas more advanced readers in upper grades benefit more from an unvowelized script. Results reported by studies published over the past 25 years have often been contradictory. A typical approach among scholars

who have investigated the importance of diacritical marks in Arabic word recognition is to attribute contradictory findings to methodological differences and to generalize findings conducted at specific grade levels with particular stimuli.

In this meta-synthesis, I argue that all three perspectives regarding diacritical marks are valid assumptions. However, generalizing these assumptions is the only invalid assumption. The findings published over the past 25 years are not as explicitly contradictory as they first appear. Instead, the findings follow a reliable pattern that connects all three assumptions if a variable that is often neglected is considered. Stimuli frequency and text affiliation help resolve discrepancies in the reported findings; their consideration can promote the development of a comprehensive theory to guide related research inquiries.

I have developed a comprehensive hypothesis positing that the importance of diacritical marks for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation. In early grades (i.e., ≤ the fourth grade), Arabic readers rely predominantly on a phonological recoding reading strategy to access phonologically and semantically unfamiliar words. Thus, the vowelized condition is advantageous to word/text reading. After four years of systematic exposure to standard Arabic, readers generally develop sufficient morphological, orthographic, and lexical knowledge to shift to a reading strategy based on visual access. Thereafter, diacritical marks become a visual burden when processing phonologically and semantically familiar words that are typically affiliated with narrative and informational texts. This can cause latency in lexical access, as well as accuracy errors resulting from processing irrelevant

phonological information. Hence, word/text reading in upper grades (i.e., > the fourth grade) is better facilitated by the unvowelized condition. However, even advanced Arabic readers are forced to rely on a phonological recoding reading strategy when encountering unfamiliar words typically affiliated with the religious and literary classical texts traditionally introduced in upper grades. Hence, the importance of diacritical marks is restored, and word/text reading is facilitated by the vowelized condition.

The results reported in this meta-synthesis have illustrated the apparently contradictory findings of studies that have investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 1–4. Furthermore, studies on the importance of diacritical marks using micro-level narrative and informational stimuli in grades 5–12 and college have consistently reported that the unvowelized condition yields greater word recognition accuracy. Finally, other studies—which have investigated the importance of diacritical marks using micro- and macro-level religious and literary stimuli in grades 5–12 and college—have consistently reported that the vowelized condition is better for word and text accuracy. Overall, these results substantiate my hypothesis. Nevertheless, contradictory findings from studies that have investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 1–4 require further explanation to refine my research hypothesis.

Three studies investigated the effects of diacritical marks on word recognition accuracy using micro-level narrative and informational stimuli in grades 1–4 (Asadi, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Schiff and Saiegh-Haddad (2017) reported that their results from second and fourth graders showed a significant advantage in word

recognition accuracy with the vowelized condition. These results align with my hypothesis. Concerning second graders, beginner Arabic readers in primary education lack the capacity to visually access Arabic reading or interact with unvowelized words (Asadi & Khateb, 2017; Taouk & Coltheart, 2004). Children begin the first grade with little knowledge of standard vocabulary and very little (if any) knowledge of standard orthography—let alone Arabic visual complexity—due to an absence of systematic exposure to standard Arabic (see diglossia section). Moreover, root awareness (which underlies a visual access reading strategy), as well as the knowledge of morphemic patterns (which fosters the process of inferring diacritical marks, because patterns are reliable prosodic templates) are skills that develop at later stages of literacy acquisition, as a result of systematic exposure and instruction (Taha & Saiegh-Haddad, 2017). Hence, a bottom-up reading strategy via phonological recoding remains the optimal choice for beginner students for decoding Arabic words (Abu Ahmad, Ibrahim, & Share, 2014; Abu-Rabia, 1995; Abu-Rabia, Share, & Mansour, 2003; Asadi, Khateb, Ibrahim, & Taha, 2017; Asadi & Khateb, 2017; Makhoul, 2016; Saiegh-Haddad & Geva, 2008; Saiegh-Haddad & Taha, 2017; Tibi & Kirby, 2018, 2019). Diacritical marks give readers phonological information that supports word recognition, thereby promoting reading accuracy and lexical access. Thus, reading benefits from the vowelized condition.

In a study by Schiff and Saiegh-Haddad (2017), the results from fourth graders show that the vowelized condition significantly improves word recognition accuracy at the beginning of the school year. The results align with other studies indicating that Arabic students reaching a ceiling in word reading measures near the end of the fourth grade,

despite a highly reliable GPM of vowelized Arabic script (Asadi, Khateb, Ibrahim, & Taha, 2017). Diglossia does not foster a natural development of Arabic reading acquisition. Arabic students begin primary education phonologically impaired. The diglossic context of Arabic literacy acquisition slows the process of encoding high-quality standard phonological structures in students' mental lexicons (Goswami, 2000). Phonological processing abilities in word recognition are affected by the quality of stored underlying phonological representations (Swan & Goswami, 1997a, 1997b). It takes three to five years for Arabic students to develop full and high-quality phonological representations that support word recognition skills (see diglossia section). Thus, automaticity in word recognition is delayed. The findings reported by Schiff and Saiegh-Haddad (2017) concerning fourth graders further confirm the slow development of phonological skills among Arabic students. The findings demonstrate that maintaining a vowelized script for several years during primary education helps students fully grasp standard Arabic phonological structure and develop high-quality phonological representations. Control over diacritical marks not only promotes accuracy and fluency in word recognition but also relates to lexical knowledge. A slight change in a word's pronunciation generates different morphemic patterns and a different lexical meaning.

Schiff and Saiegh-Haddad (2017) suggested that diacritical marks support word recognition in primary education when students interact with narrative and informational stimuli. There is a direct association between word recognition and reading comprehension in early grades (see oral reading fluency and silent reading comprehension section). The reading comprehension of elementary students with narrative and

informational texts was significantly better in the vowelized condition than in the unvowelized condition (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1999; Seraye, 2017). Taken together, diacritical marks support both word recognition and reading comprehension with narrative and informational words and texts in primary education.

Asadi (2017) investigated the effects of diacritical marks on word recognition accuracy using micro-level narrative and informational stimuli in grades 1–4. The results from the first and second graders show no significant differences in word recognition accuracy between the vowelized and unvowelized conditions. The results from the third and fourth graders, however, show significantly better word recognition accuracy in the unvowelized condition. The findings on first and second graders require further explanations, while the findings from third and fourth graders do not discredit my hypothesis, but rather contribute another variable to the hypothesis: timing.

Concerning first and second graders, Asadi (2017) used a single word-reading measure to gauge participants' word recognition accuracy and fluency. Although findings pertaining to word recognition fluency are excluded from this meta-synthesis, using a single word-reading measure might have confounded the results on word recognition accuracy. No significant difference between vowelized and unvowelized word recognition accuracy was reported. However, a slight and insignificant advantage in accuracy was observed with the unvowelized condition in both grade levels. Likewise, no significant difference between vowelized and unvowelized word recognition fluency was reported. However, a slight and insignificant advantage in fluency was observed with the vowelized

condition in both grade levels. It is highly likely that using a single word-recognition measure to calculate word reading accuracy and fluency might have led students engaging in the vowelized condition to pursue word reading fluency at the expense of accuracy and students engaging in the unvowelized condition to pursue word reading accuracy at the expense of fluency. It is highly unusual that first and second graders in Asadi's study experienced a slight advantage in word reading accuracy in the unvowelized condition, given the sociolinguistic context of Arabic reading acquisition, in which beginner readers interact poorly with an unvowelized script (Asadi & Khateb, 2017; Taouk & Coltheart, 2004). One study (which used only word-reading accuracy measures) excluded from this meta-synthesis reported significantly better word reading accuracy with the vowelized condition than with the unvowelized condition among first and second graders (Saiegh-Haddad & Taha, 2017). Although this particular study was excluded because it failed to report both explicit examples of stimuli and the stimuli's text affiliation, Saiegh-Haddad tends to use stimuli of average frequency in her area of research (Saiegh-Haddad, 2003b, 2004, 2007; Saiegh-Haddad, Levin, Hende, & Ziv, 2011; Saiegh-Haddad, Shahbari-Kassem, & Schiff, 2020; Schiff & Saiegh-Haddad, 2018). Furthermore, the results of Saiegh-Haddad's included study, in which separate measures of word reading accuracy and fluency were used, indicate a significant advantage in word reading accuracy with the vowelized condition among second graders (Schiff & Saiegh-Haddad, 2017). Thus, the explanation—that the results of word reading accuracy were confounded—seems reasonable.

Concerning third and fourth graders, Asadi (2017) used stimuli developed from a third-grade Arabic textbook. It is entirely reasonable to speculate that students were already familiar with the experimental stimuli since Asadi collected data near the end of the school year. Third and fourth graders may have been familiar with the experimental stimuli, given the timing of the experiment. This potential familiarity may be further confirmed by the results of the word reading fluency of third and fourth graders. Word reading fluency among third and fourth graders was significantly better with the unvowelized condition than with the vowelized condition. The difference between the means of vowelized and unvowelized word reading fluency for first and second graders was four and eight points, respectively. However, the difference between the means of vowelized and unvowelized word reading fluency for third and fourth graders was 21 and 30 points, respectively. The large and significant difference between the means of word reading fluency among third and fourth graders indicates rapid visual access due to lexical familiarity (Taha & Azaizah-Seh, 2017), whereas the minor and insignificant difference between the means of word reading fluency observed among first and second graders indicates undeveloped word recognition fluency in both the vowelized and unvowelized conditions. Thus, although the findings on the third and fourth graders appear to contradict my hypothesis, they actually show that if familiarity with narrative and informational stimuli is attained earlier than in the fourth grade, the shift to a visual decoding strategy may be earlier than expected, at least for some narrative and informational stimuli.

Taha (2016a) investigated the effects of diacritical marks on word recognition accuracy using micro-level narrative and informational stimuli in grades 1–4. The results

from the second and fourth graders show a significant advantage in word recognition accuracy with the unvowelized condition. Rather than discrediting my hypothesis, Taha's findings contribute another variable to the hypothesis: the type of reader. Taha recruited highly skilled Arabic readers ($\geq 90^{th}$ percentile in word recognition measures). Typically developed Arabic readers reach a ceiling in word recognition measures by the end of the fourth grade (Asadi, Khateb, Ibrahim, & Taha, 2017). However, Taha's findings indicate that highly skilled Arabic readers may reach a ceiling in word reading measures by the end of the second grade. The consolidated phonological skills in word reading promote a shift toward visual and orthographic decoding strategies (Ehri & Snowling, 2004; Frith, 1986; Harris & Coltheart, 1986). Thus, the highly skilled Arabic readers in Taha's study demonstrated significantly better accuracy with unvowelized stimuli and correctly inferred the required phonological information. It is critical to determine whether the significant accuracy in word recognition can be attributed to the mastery of phonology and an early shift to a visual reading strategy or to stimuli familiarity.

Various mechanisms have been suggested to explain the relationship between semantic knowledge and word reading. The triangle model proposes several routes or pathways through which a word can be read (Harm & Seidenberg, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996). One route, for example, maps from orthography to phonology indirectly via semantics. Other models, such as the dual route, suggest that the semantic activation of familiar or regular words may not be necessary (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Other scholars seem more certain that top-down reading strategies are accompanied by semantic knowledge and that the

laborious decoding witnessed with unfamiliar regular or irregular words results from a lack of semantic knowledge (Share, 1995). While it remains unreasonable to generalize any conclusion regarding Arabic readers, it is plausible that there is a relationship between semantic knowledge and visual reading strategies in Arabic orthography (Abu-Rabia, 1998; Abu-Rabia & Taha, 2004; Saiegh-Haddad, 2018). A simple non-homographic tri-literal Arabic word has more than 12 mathematically possible pronunciations, given that each short vowel can be mapped to each consonant within that word in four different ways. However, Taha's results show that highly skilled readers have better accuracy in the unvowelized condition. Had highly skilled readers been engaged in priming and selecting possible pronunciations (in other words, randomly guessing words' pronunciations), this advantage in word recognition accuracy would not be attained. Thus, it appears that highly skilled Arabic readers were familiar with the narrative and informational stimuli used in Taha's study. Accordingly, one conclusion here is that highly skilled readers who reach, or almost reach, a ceiling in word recognition measures experience an early shift toward visual and orthographic decoding strategies; this shift is accompanied by lexical knowledge that facilitates interaction with the unvowelized script.

To summarize, the first part of my hypothesis posits that typically developed Arabic readers in early grades (i.e., $\leq$ the fourth grade) rely predominantly on a phonological recoding reading strategy to access phonologically and semantically unfamiliar words; thus, word/text reading is advantageous to the vowelized condition. This assertion is supported by one study (Schiff & Saiegh-Haddad, 2017). Furthermore, the results of the two studies that reported contradictory findings do not discredit my

hypothesis—rather, they highlight a critical methodological concern that must be avoided in future studies and refine my hypothesis by drawing attention to two additional variables (Asadi, 2017; Taha, 2016a). The critical methodological concern regards using separate word-reading measures to gauge word recognition accuracy and fluency. The additional variables are timing and the type of reader. Accordingly, the first part of my hypothesis should be adjusted. A more accurate statement is that typically developed Arabic readers rely predominantly on a phonological recoding reading strategy to access phonologically and semantically unfamiliar narrative and informational words; thus, word/text reading is advantageous to the vowelized condition. However, average readers who are already familiar with certain narrative and informational stimuli may engage in unvowelized reading for these stimuli only. Furthermore, highly skilled Arabic readers (who reach a ceiling in word recognition measures earlier than average Arabic readers) can engage in unvowelized reading for narrative and unvowelized stimuli at least two years earlier than typically developed Arabic readers.

The second part of my hypothesis asserts that four years of systematic exposure to standard Arabic is sufficient for typically developed Arabic students to reach a ceiling in phonological word recognition measures. This, in turn, promotes a shift toward a top-down reading strategy based on the visual access of words. At this point, students have managed to develop sufficient morphological, orthographic, and lexical knowledge, all of which enable interaction with the unvowelized script and the processing of phonologically and semantically familiar words that are typically affiliated with narrative and informational texts. Thus, word/text reading in upper grades is facilitated by the

unvowelized condition, and diacritical marks become a visual burden. Of the five studies I have discussed that investigated the importance of diacritical marks using micro-level narrative and informational stimuli in grades 5–12 and college, all consistently reported that the unvowelized condition yielded superior word recognition accuracy (Abu-Leil, Share, & Ibrahim, 2014; Asadi, 2017; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). These findings align with my hypothesis.

Morphology is the powerful predictor of the visual reading strategy in Arabic orthography (Abu-Rabia, 2007; Abu-Rabia & Abu-Rahmoun, 2012; Saiegh-Haddad & Taha, 2017). Narrative and informational stimuli are characterized by their substantial inclusion of average- and high-frequency derivatives, roots, and morphemic patterns (Bateson, 2003; Fischer, 2002). Beyond the fourth grade, knowledge of morphology, vocabulary, and orthographic processing increases among Arabic-speaking students (Asadi, Khateb, Ibrahim, & Taha, 2017; Tibi & Kirby, 2019). Thus, narrative and informational stimuli become phonologically and semantically familiar. Familiar lexical items are often accessed via lexical reading channels (Coltheart, Curtis, Atkins, & Hailer, 1993; Seidenherg & McClelland, 1989). Hence, word recognition accuracy is significantly better in the unvowelized condition for upper-grade students. The presence of diacritical marks occupies readers' working memories with the processing of irrelevant phonological information, causing significant visual fatigue, accuracy errors, and delays in lexical access (Roman & Pavard, 1987; Taha & Azaizah-Seh, 2017). Furthermore, reading accuracy is related to lexical knowledge in Arabic orthography (Abu-Rabia, 1998; Abu-Rabia & Taha, 2004; Saiegh-Haddad, 2018). There is a conditional association between

word recognition and reading comprehension in upper grades (see oral reading fluency and silent reading comprehension section). Studies that recruited middle- and high-school participants reported unvowelized narrative and informational texts to yield significantly better reading comprehension scores than vowelized texts (Elsayyad et al., 2017; Seraye, 2004). The vowelization of narrative and informational stimuli in upper grades is a visual burden; vowelization disrupts the comprehension of familiar narrative and informational texts because it interferes with word recognition processing.

The third part of my hypothesis states that even advanced Arabic readers are forced to switch to a phonological recoding reading strategy when encountering unfamiliar words typically affiliated with religious and literary classical texts traditionally introduced in upper grades. Hence, the importance of diacritical marks is restored, and word/text reading is facilitated by the vowelized condition. The findings of all four studies that investigated the importance of diacritical marks using religious and literary stimuli in grades 5–12 and college at the micro level (Abu-Rabia, 1997a, 2001) and the macro level (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1997a, 1998, 2001) consistently demonstrate that the vowelized condition provides better word and text accuracy. These findings confirm my hypothesis.

Religious and literary classical texts are characterized by their substantial inclusion of low-frequency derivatives, roots, and morphemic patterns with which Arabic students are unfamiliar, as they are traditionally introduced in upper grades (Abu-Rabia, 1998; Brosh & Attili, 2009). It seems likely that the morphological, orthographic, and lexical familiarity that Arabic students have developed may not support visual access in religious

(e.g., Quranic) and literary (e.g., poetic) classical texts. Thus, Arabic readers rely, once again, on a sub-lexical reading strategy to gain phonological and semantic access to unfamiliar words. Diacritical marks provide readers with full phonological information that supports word recognition. Hence, the vowelized condition is conducive to word recognition with religious and literary stimuli (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Rabia, 1997a, 1998, 2001). These findings align with studies showing that the reading comprehension of seventh and ninth graders and college adults in the vowelized condition was significantly better than it was in the unvowelized condition for Quranic and poetic classical texts (Abu-Rabia, 2001; Abu-Rabia & Hijjazi, 2020). This further confirms the strong association between word recognition accuracy and lexical knowledge in Arabic orthography.

The pattern of findings I have observed—that vowelization hinders Arabic word recognition for narrative and informational stimuli for upper-grade Arabic readers, yet supports Arabic word recognition for religious and literary classical stimuli that are characterized by low-frequency morphological and lexical items—is also observed in Hebrew. Hebrew has two orthographic systems: pointed (vowelized) and unpointed (unvowelized). Similar to the traditions implemented in the Arab world, pointed Hebrew in Israel is used in children's literature, poetry, and religious texts (Abdelhadi, Ibrahim, & Eviatar, 2011; Abu-Rabia, 2001; Saiegh-Haddad, 2003a). Studies conducted in Hebrew have found that unpointed high-frequency stimuli associated with modern Hebrew are read with significantly better accuracy in word recognition tasks and are judged more quickly in lexical decision tasks than pointed high-frequency stimuli associated with

modern Hebrew (Bentin & Frost, 1987; Frost, Katz, & Bentin, 1987; Navon & Shimron, 1981, 1984). On the contrary, pointed low-frequency stimuli associated with biblical Hebrew were read with significantly better accuracy in word recognition tasks and were judged more quickly in lexical decision tasks than unpointed low-frequency stimuli associated with biblical Hebrew (Koriat, 1984, 1985). Arabic and Hebrew are Semitic languages that share several commonalities and intersections in terms of the sociolinguistic context of language acquisition (Abdelhadi, Ibrahim, & Eviatar, 2011; Abu-Rabia, 2001; Saiegh-Haddad, 2003a). Thus, studies conducted on one language may very well inform studies conducted on the other language. Cross-linguistic experimental studies on the importance of diacritical marks (the pointing system) in word recognition and reading comprehension would further confirm and broaden the understanding of the pattern of findings observed in both languages.

To conclude, the results reported in this meta-synthesis substantiate my hypothesis. I have discussed the contradictory findings reported in two studies on the importance of diacritical marks using micro-level narrative and informational stimuli in grades 1–4. I identified two additional variables, using them to refine the first part of my research hypothesis. Nevertheless, based on all of the available evidence published in the past 25 years, I conclude that the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers varies as a function of grade level, stimuli frequency, and text affiliation.

# CHAPTER V

# CONCLUSIONS

The results reported in this meta-synthesis substantiate my hypothesis. The findings of seven studies agree with my hypothesis. The results of two other studies, which report contradictory findings, do not discredit my hypothesis but rather refine it by identifying two additional variables. Diacritical marks support Arabic word recognition accuracy for beginner Arabic readers in grades 1–4, when only narrative and informational stimuli are introduced in schools throughout the Arab world. Due to the negative implications of diglossia and the lack of systematic exposure to standard Arabic, Arabic students cannot access words visually. Beginning Arabic readers rely on a phonological recoding strategy. Diacritical marks provide full phonological information to readers and help them access phonologically and semantically unfamiliar words typically affiliated with narrative and informational texts. However, typically developed Arabic readers may be familiar with specific narrative and informational stimuli as a result of early exposure. Hence, these words are best read in the unvowelized condition. Nevertheless, it takes four years on average of systematic exposure for typically developed Arabic readers to reach a ceiling in word recognition measures and become largely prepared for the unvowelized script. Highly skilled Arabic readers in primary education, however, may reach a ceiling in word recognition measures earlier than average Arabic readers. Therefore, highly skilled Arabic readers can engage in unvowelized script reading at least two years earlier than typically developed Arabic readers. Once typically developed Arabic readers reach a ceiling in word recognition measures, the reading mechanism shifts from a dominant

phonological recoding strategy to a dominant visual reading strategy; therefore, interaction with narrative and informational stimuli becomes feasible in the unvowelized script. Thereafter, the presence of diacritical marks in upper grades (i.e., > the fourth grade) complicates Arabic reading, causing substantial accuracy errors stemming from the processing of irrelevant phonological information. Nevertheless, the knowledge of morphology, vocabulary, and orthography that Arabic students develop over time does not facilitate word recognition with religious and literary classical texts, which are characterized by the substantive inclusion of low-frequency morphological and lexical items with which students are unfamiliar. Hence, the utility of diacritical marks is restored, and word recognition is significantly facilitated in the vowelized condition (see Appendix A for a graphical conclusion).

## Limitations

The limited number of studies included in this meta-synthesis may be of concern. Research on Arabic orthography began receiving significant attention in the 1990s. However, a brief analysis of all the studies related to Arabic orthography used throughout this review indicates that interest in Arabic orthography has still not substantially advanced over the past 30 years. To prepare for this meta-synthesis, I thoroughly searched 12 major English databases, two Arabic databases, and eight individual journals. A total of 100 research studies published between 1990 and 2020 were located, 14 of which related to the importance of diacritical marks in Arabic word recognition. Of the 100 studies, 70% of the studies were conducted and written by Arabic scholars living in Israel, 20% were conducted and written by Arabic scholars living in the Arab world, and 10%

were conducted and written by international scholars interested in Arabic orthography. Concerning the Arabic scholars in Israel, the publications of six authors alone constitute 90% of the overall percentage of publications. Within the Arab world, a term that encompasses 22 Arabic-speaking countries, studies originated from only seven countries: Bahrain (n = 1), Egypt (n = 2), Jordan (n = 2), Kuwait (n = 4), Lebanon (n = 1), Saudi Arabia (n = 2), and the United Arab Emirates (n = 8). Thus, the limited number of studies included in this meta-synthesis that address the importance of diacritical marks in Arabic word recognition reflects the relatively low interest in Arabic orthography compared to the interest in Latin-based orthographies such as English (Share, 2008).

A second limitation in this meta-synthesis relates to the frequency analysis of derivatives, roots, and morphemic patterns for available stimuli in the included studies. Of the nine included studies, only one provided a full list of the stimuli used (Asadi, 2017). The remaining studies either gave a sample of the stimuli used (n = 5) or specified the stimuli's text affiliation (n = 3). Accordingly, the frequency analysis for five studies was based on all available stimuli mentioned in the studies (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). This may raise concerns that any conclusions reached in the frequency analysis for the available stimuli (e.g., the majority of stimuli used in study X are of average frequency) may not necessarily apply to the unavailable stimuli. It is important to recall that the conclusions or assumptions that the stimuli were of average frequency were validated by the authors of the included studies. The researchers made explicit statements that the stimuli (i.e., derivatives only) had an average frequency, as

validated by Arabic teachers, inclusion in primary textbooks, or availability in vernacular and standard Arabic (Abu-Leil, Share, & Ibrahim, 2014; Asadi, 2017; Ibrahim, 2013; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Thus, the frequency analysis conducted in this meta-synthesis has aimed to further confirm the researchers' claims and broaden the analysis to include other morphological and lexical items, such as the frequency of roots and morphemic patterns. Hence, although the frequency analysis of derivatives, roots, and morphemic patterns was restricted to all available stimuli in the included studies, the patterns observed in my frequency analysis align with the authors' claims. Although I initiated contact with some of the authors, requesting the full word lists used in their studies, I received no replies.

Finally, findings pertaining to word recognition fluency were excluded from the data analysis in this meta-synthesis. However, one study used a single word recognition measure to calculate word recognition accuracy and fluency (Asadi, 2017). As a result, the findings on word recognition accuracy reported in this study may have been confounded. A more rigorous methodology would exclude studies that used a single word-recognition measure. However, I became aware of this issue after reporting the results while trying to explain the findings in the discussion. Thus, a decision was made to keep this study and point out this important issue for consideration in future research.

## Directions for Future Research

This meta-synthesis provides a comprehensive theoretical framework to guide future studies investigating the importance of diacritical marks in Arabic word recognition for typically developed Arabic readers. This theoretical framework proposes that the

importance of diacritical marks in Arabic word recognition varies as a function of grade level, stimuli frequency, and text affiliation. The current evidence substantiates this hypothesis. However, more experimental studies are needed to further confirm this theory.

Several methodological concerns must be addressed in future research. Eight of the included studies recruited small samples (Table 1). Asadi's study (2017) was the only study that recruited a nationally representative sample. Studies with large sample sizes are more likely to produce accurate and generalizable findings. Additionally, participants' levels of reading proficiency must be indicated in future studies. The type of reader, as a variable, may affect the findings of a study. More specifically, highly skilled Arabic readers in primary education may reach a ceiling in word recognition measures earlier than most average Arabic readers; hence, they can engage in unvowelized script reading at least two years earlier than typically developed Arabic readers (Taha, 2016a). Only four of the included studies implemented a reliable word recognition measure to gauge accuracy (Abu-Hamour, Al-Hmouz, & Kenana, 2013; Asadi, 2017; Schiff & Saiegh-Haddad, 2017; Taha, 2016a). Across all four studies, word recognition measures were researcher-developed. However, these measures were piloted, and Cronbach's alpha was used as an index for the reliability coefficient. In the remaining five studies, the researchers also implemented researcher-developed measures yet failed to establish reliability (Abu-Leil, Share, & Ibrahim, 2014; Abu-Rabia, 1997a, 1998, 2001; Ibrahim, 2013). Reliable measures yield more consistent findings. Furthermore, studies that seek to gauge both word recognition accuracy and fluency must use separate measures. Using speeded and timed measures to gauge both outcomes concurrently might force students, especially

beginning readers, to sacrifice accuracy in favor of reading fluency (Asadi, 2017). Moreover, two studies did not counterbalance the measures used, failing to control for the order effect (Abu-Leil, Share, & Ibrahim, 2014; Ibrahim, 2013). Finally, future researchers must provide a sample of stimuli and state the stimuli's text affiliation to further support the theory discussed in this meta-synthesis. ARALEX is one tool that future researchers may consult to guide the process of stimuli selection (Boudelaa & Marslen-Wilson, 2010).

Three topics seem particularly interesting for future research. None of the included studies investigated the effects of diacritical marks in grades 1–4 using narrative and informational stimuli at the macro level. Diacritical marks were shown to support word recognition accuracy in grades 1–4 using narrative and informational stimuli at the micro level (Schiff & Saiegh-Haddad, 2017). My theory is based in part on the existence of a direct association between word recognition and reading comprehension in early grades. Previous studies in Arabic orthography have shown that both isolated word reading and text reading are equally correlated ($r = 0.7$) to reading comprehension (Tibi & Kirby, 2018, 2019). Thus, it seems highly likely that diacritical marks would support text recognition accuracy in grades 1–4 using narrative and informational stimuli at the macro level.

A second topic that seems particularly interesting for future research concerns investigating the importance of diacritical marks using religious and literary stimuli among college students majoring in classical Arabic language and literature. Students majoring in classical Arabic interact with classical texts substantially more frequently than most Arabic readers to satisfy their program of study (Saiegh-Haddad, 2018). Thus, it would be unsurprising if the findings of such studies reveal that word/text reading

accuracy for college students majoring in classical Arabic is best supported in the unvowelized condition. Research inquiries of this nature could further broaden the theory discussed in this meta-synthesis.

Finally, a third interesting topic would compare the importance of diacritical marks in Arabic to that of the pointing system in Hebrew. The current evidence suggests a similar functionality of the optional phonological systems in both languages. However, most Hebrew studies examining the importance of the pointing system in word recognition were conducted in the 1980s (Bentin & Frost, 1987; Frost, Katz, & Bentin, 1987; Koriat, 1984, 1985; Navon & Shimron, 1981, 1984). Thus, more updated research is needed.

## Implications

The results of this meta-synthesis support the current educational and commercial policies in most Arab countries concerning the transition from a vowelized to an unvowelized script. However, the results add a further component to this educational policy—religious and literary classical texts traditionally introduced in upper grades that are embedded in the upper grades' unvowelized textbooks must be vowelized to support word recognition in these specific texts. Moreover, these results raise concerns for educators in Syria and Jordan, in that the policy of keeping all textbooks vowelized throughout the entire K-12 education period may not be in advanced readers' best interests. Despite their advantages in primary education, diacritical marks, which cannot be visually ignored, consume advanced readers' cognitive resources, cause visual fatigue and accuracy errors, and delay access to meaning, all of which could disturb reading comprehension by forcing the processing of irrelevant phonological information (Roman

& Pavard, 1987; Taha & Azaizah-Seh, 2017). Unless a transition to an unvowelized script occurs in Arabic schools, students are forced to read via a phonological recoding mechanism (as opposed to a visual reading strategy) for the remainder of their school years (Abu-Rabia, 2002).

The results of this meta-synthesis are not generalizable to all Arabs—only to Palestinian Arabs living in Israel. However, almost all Arab countries share educational experiences with Palestinians: diglossia, a transition policy, and homogeneous educational systems (Saiegh-Haddad, 2018). The hypothesis I have developed organizes findings published in the past 25 years regarding the importance of diacritical marks in Arabic word recognition. This hypothesis is substantiated by the currently available evidence. Accordingly, it could serve as a theoretical framework to guide future research, educational practices and policies, and commercial publication policies across the entire Arab world. More research is needed, especially from Arabic scholars living in the Arab world, given their poor contribution to the field of Arabic orthography.

The findings that diacritical marks support word recognition accuracy for beginning readers in primary education have further implications that extend the need for introducing vowelized primary education textbooks. These findings necessitate an emphasis on major phonological training in primary education (Al Ghanem & Kearns, 2014). Diacritical marks are phonological elements; the faster they are encoded in Arabic readers' mental lexicon and the higher the quality with which these elements are stored, the better the phonological processing abilities in vowelized word recognition are supported (Goswami, 2000; Swan & Goswami, 1997a, 1997b). Furthermore, a greater

emphasis on morphological training is needed, because Arabic readers transition to an unvowelized script more quickly as they become familiar with more roots and derivatives (Taha, 2016a). Additionally, more emphasis on the explicit teaching of morphemic patterns is required. Research suggests that Arabic readers develop an awareness of morphemic patterns in the sixth grade (Taha & Saiegh-Haddad, 2017). Knowledge of morphemic patterns supports the inference of words' phonological structures in unvowelized script when needed. High-quality phonological and morphological training in primary education fosters preparation and readiness for interaction with unvowelized scripts in the upper grades. Underdeveloped skills at the word level (e.g., phonological and morphological processing) prevent readers' working memory from efficiently activating and invoking higher thinking skills, such as integrating world knowledge with textual information, monitoring the meaning-making process, and making inferences (Perfetti, Landi, & Oakhill, 2005). Thus, reading comprehension—the ultimate goal of reading—may become severely compromised.

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APPENDIX A

FIGURES

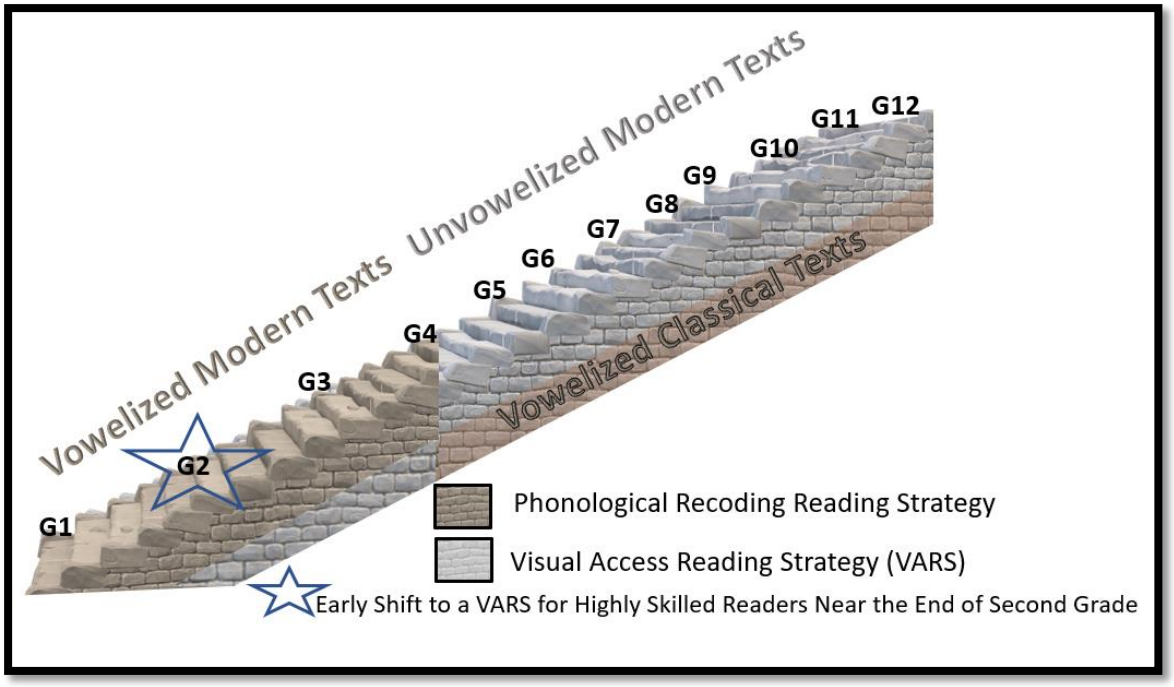


**Figure 1. Graphical conclusion**

# APPENDIX B

# TABLES

## Table 1: Descriptive Summary of the Included Studies

| Study | N | Type of Readers | Definition of Type of Reader | Grade | Level of Stimuli | Stimuli Explicit Examples | Stimuli's Text Affiliation Statement |
|---|---|---|---|---|---|---|---|
| Abu-Rabia (1997a) | 70 | Average | $\geq 50^{th}$ percentile in word recognition measures | 10 | Micro-Level & Macro-Level | No | Stimuli taken from the complete collection of Jobran Khalil Jobran (1964). |
| Abu-Rabia (1998) | 32 | Average | $\geq 50^{th}$ percentile in word recognition measures | 11 | Macro-Level | No | Stimuli taken from the Quran and classical poetry. |
| Abu-Rabia (2001) | 65 | Average | $\geq 50^{th}$ percentile in word recognition measures | College | Micro-Level & Macro-Level | No | Stimuli taken from the poetic collection "Love" by Ghada Al Samman (1973). |
| Abu-Hamour, Al-Hmouz, & Kenana (2013) | 89 | Average | $\geq 60^{th}$ percentile in word recognition measures | 5 | Macro-Level | Yes | Religious text about the prophet Job. |
| Ibrahim (2013) | 75 | Average | $\geq 50^{th}$ percentile in word recognition measures | 8 | Micro-Level | Yes | Stimuli described as having an average frequency as judged by Arabic teachers. |
| Abu-Leil, Share, & Ibrahim (2014) | 75 | Average | $\geq 50^{th}$ percentile in word recognition measures | 8 | Micro-Level | Yes | Stimuli described as having an average frequency as judged by Arabic teachers. |
| Taha (2016a) | 143 | Highly Skilled | $\geq 90^{th}$ percentile in word recognition measures | 2,4,6 | Micro-Level | Yes | Stimuli described as having an average frequency with progressive increases in syllabic length. |
| Asadi (2017) | 1,516 | Average | $\geq 50^{th}$ percentile in word recognition measures | 1, 2, 3, 4, 5, 6 | Micro-Level | Yes | Stimuli described as having an average frequency, taken from third-grade Arabic textbook. The same list was used for all grade levels. |
| Schiff & Saiegh-Haddad (2017) | 60 | Average | $\geq 50^{th}$ percentile in word recognition measures | 2,4,6 | Micro-Level | Yes | Stimuli described as having an average frequency as judged by Arabic teachers. Two-thirds of the stimuli were affiliated with both vernacular and standard Arabic. |

**Table 2: Frequency Analysis of Derivatives, Roots, and Morphemic Patterns Used in the Included Studies**

| Study | Derivative | English Translation | Derivative Frequency | Root | Root Frequency | Morphemic Pattern | Pattern Frequency |
|---|---|---|---|---|---|---|---|
| Abu-Hamour, Al-Hmouz, & Kenana (2013) | وسوسة | Devilish solicitation | Low | و س و س | Low | فَعلَلَة | Low |
| | نبي | Prophet | Low | ن ب و | Average | فَعيل | High |
| | نعم | Graces | Average | ن ع م | Average | فِعَل | Low |
| | محرومين | Deprived | Low | ح ر م | Average | مفعولين | High |
| | ابتلاء | Agonized | Low | ب ل ي | Average | افعلاء | Low |
| | مصيبة | Calamity | High | ص و ب | Average | فَعيلَة | High |
| | عاري | Naked | Low | ع ر ي | Average | فاعِل | High |
| | يكسو | To cover up the needy | Low | ك س و | Low | يُفَعِّل | High |
| | اشتدّ | Intensified | Low | ش د د | Average | افتَعَل | Low |
| | ضعفاء | Weak | High | ض ع ف | Average | فُعلاء | Low |
| | جيران | Neighbors | High | ج ي ر | Low | فِعْلان | Low |
| | يكافئ | Reward | Average | ك ف ء | Average | يُفاعِل | Average |
| | يطعم | To feed the needy | Average | ط ع م | High | يُفَعِّل | Low |
| Abu-Leil, Share, & Ibrahim (2014)<br><br>Ibrahim (2013) | جريء | Courageous | Average | ج ر ء | Average | فَعيل | High |
| | بريء | Innocent | Average | ب ر ء | Average | فَعيل | High |
| | وفاق | Agreement | Average | و ف ق | Average | فِعال | Average |
| | سباق | Race | High | س ب ق | High | فِعال | Average |
| | فريدة | Farida (girl's name) | Average | ف ر د | Average | فَعيلَة | High |
| | جريدة | Newspaper | High | ج ر د | Average | فَعيلَة | High |
| Asadi (2017) | ممرضة | Nurse | High | م ر ض | High | مُفعِلَة | Average |
| | تحسين | To enhance + boy's name | High | ح س ن | High | تَفعيل | High |
| | مجوف | Cavity | Low | ج و ف | Low | مُفعَّل | High |
| | منضدة | Table | Low | ن ض د | Low | مِفعَلَة | Low |
| | تطعيم | Vaccination | Average | ط ع م | High | تَفعيل | High |
| | انتشارا | Spread | High | ن ش ر | High | افتعال | Average |
| | عمال | Workers | High | ع م ل | High | فُعّال | Average |
| | مزروع | Planted | Average | ز ر ع | High | مَفعول | High |
| | إهداء | Gifting | Average | هـ د ي | High | إفعال | Average |
| | سيئ | Bad | Average | س و ء | Average | فَعْل | Low |
| | صبورا | Patient | High | ص ب ر | High | فَعول | High |
| | جزاء | Reward | Average | ج ز ي | Average | فَعال | Average |
| | جوهر | Essence | Average | ج و هـ ر | Average | فَعْلَل | Low |
| | تكيّف | Adaptation | Low | ك ي ف | Average | تَفَعُّل | High |
| | مسألة | Issue | High | س ي ل | High | مَفعَلَة | High |
| | مخبز | Bakery | High | خ ب ز | High | مَفعَل | High |
| | مدرسة | School | High | د ر س | High | مَفعِلَة | High |
| | بيضاء | White | High | ب ي ض | High | فَعلاء | Low |
| | شرين | They drank | Low | ش ر ب | High | فَعِلْنَ | Low |
| | رسام | Painter | Average | ر س م | Average | فَعّال | High |
| | لعبتي | My toy | High | ل ع ب | High | فَعلَتي | High |
| | جلسوا | They sat | High | ج ل س | High | فَعَلوا | High |
| | منطاد | Air balloon | Low | ط و د | Low | مفعال | Average |
| | اختيار | Choice | Average | خ ي ر | High | افتعال | Average |
| | مسؤول | In charge | High | س ي ل | High | مَفعول | High |
| Schiff & Saiegh-Haddad (2017) | باب | Door | High | ب و ب | Average | فَعْل | Average |
| | أكل | He ate | High | ء ك ل | High | فَعَلَ | High |
| | ألف | He composed | Average | ء ل ف | High | فَعَّل | High |
| | بيئة | Environment | High | ب ي ء | Low | - | - |
| | مقلمة | Pencil bag | Average | ق ل م | Average | مَفعَلَة | High |
| | مثلث | Triangle | Average | ث ل ث | Average | مُفَعَّل | High |
| | وضع | He put | High | و ض ع | Average | فَعَلَ | High |

## Table 2 Continued

| Study | Derivative | English Translation | Derivative Frequency | Root | Root Frequency | Morphemic Pattern | Pattern Frequency |
|---|---|---|---|---|---|---|---|
| Taha (2016a) | قارب | Boat | Average | ق ر ب | High | فاعِل | High |
| | ضباب | Fog | Average | ض ب ب | Low | فَعال | Average |
| | كبش | Sheep | Average | ك ب ش | Low | فَعْل | Average |
| | استجمع | He gathered | Average | ج م ع | High | استَفعل | Low |
| | انتقل | He moved | Average | ن ق ل | High | افتَعَل | High |
| | قليل | Little | High | ق ل ل | High | فَعيل | High |
| | نبع | Spring water | Average | ن ب ع | Average | فَعْل | Average |
| | مطرب | Singer | High | ط ر ب | Average | مُفَعِل | Average |
| | تتابع | Succession | Average | ت ب ع | Average | تَفاعُل | Average |
| | استقرض | He asked for a loan | Low | ق ر ض | High | استَفعَل | Low |

APPENDIX C

STANDARD ARABIC LETTERS AND GRAPHEME-TO-PHONEME MAPPING

| Letter | Pronunciation (IPA) | Corresponding to Phoneme | Corresponding phoneme (IPA) |
|---|---|---|---|
| ا | /ʔalif/ | Inconsistent | /ʔ/, /aː/, /an/ |
| ب | /baːʔ/ | Consistent | /b/ |
| ت | /taːʔ/ | Inconsistent | /t/, /ħ/ |
| ث | /θaːʔ/ | Consistent | /θ/ |
| ج | /dʒiːm/ | Consistent | /dʒ/ |
| ح | /ħaːʔ/ | Consistent | /ħ/ |
| خ | /xaːʔ/ | Consistent | /x/ |
| د | /daːl/ | Consistent | /d/ |
| ذ | /ðaːl/ | Consistent | /ð/ |
| ر | /raːʔ/ | Consistent | /r/ |
| ز | /zaːj/ | Consistent | /z/ |
| س | /siːn/ | Consistent | /s/ |
| ش | /ʃiːn/ | Consistent | /ʃ/ |
| ص | /sˤaːd/ | Consistent | /sˤ/ |
| ض | /dˤaːd/ | Consistent | /dˤ/ |
| ط | /tˤaːʔ/ | Consistent | /tˤ/ |
| ظ | /ðˤaːʔ/ | Consistent | /ðˤ/ |
| ع | /ʕajn/ | Consistent | /ʕ/ |
| غ | /ɣajn/ | Consistent | /ɣ / |
| ف | /faːʔ/ | Consistent | /f/ |
| ق | /qaːf/ | Consistent | /q/ |
| ك | /kaːf/ | Consistent | /k/ |
| ل | /laːm/ | Consistent | /l/ |
| م | /miːm/ | Consistent | /m/ |
| ن | /nuːn/ | Consistent | /n/ |
| هـ | /haːʔ/ | Consistent | /h/ |
| و | /waːw/ | Inconsistent | /w/, /uː/ |
| ي | /jaːʔ/ | Inconsistent | /j/, /in/ |

APPENDIX D

STANDARD ARABIC PHONEMES AND PHONEME-TO-GRAPHEME MAPPING

| Phoneme (IPA) | Type | Corresponding to Grapheme | Corresponding Grapheme |
|---|---|---|---|
| /ʔ/ | Consonant | Inconsistent | ء أ إ ا ؤ ئ |
| /b/ | Consonant | Consistent | ب |
| /t/ | Consonant | Consistent | ت |
| /θ/ | Consonant | Consistent | ث |
| /dʒ/ | Consonant | Consistent | ج |
| /ħ/ | Consonant | Consistent | ح |
| /x/ | Consonant | Consistent | خ |
| /d/ | Consonant | Consistent | د |
| /ð/ | Consonant | Consistent | ذ |
| /r/ | Consonant | Consistent | ر |
| /z/ | Consonant | Consistent | ز |
| /s/ | Consonant | Consistent | س |
| /ʃ/ | Consonant | Consistent | ش |
| /sˤ/ | Consonant | Consistent | ص |
| /dˤ/ | Consonant | Consistent | ض |
| /tˤ/ | Consonant | Consistent | ط |
| /ðˤ/ | Consonant | Consistent | ظ |
| /ʕ/ | Consonant | Consistent | ع |
| /ɣ / | Consonant | Consistent | غ |
| /f/ | Consonant | Consistent | ف |
| /q/ | Consonant | Consistent | ق |
| /k/ | Consonant | Consistent | ك |
| /l/ | Consonant | Consistent | ل |
| /m/ | Consonant | Consistent | م |
| /n/ | Consonant | Consistent | ن |
| /h/ | Consonant | Consistent | هـ |
| /w/ | Consonant | Consistent | و |
| /j/ | Consonant | Consistent | ي |
| /aː/ | Long Vowel | Inconsistent | آ ا ى |
| /uː/ | Long Vowel | Consistent | و |
| /iː/ | Long Vowel | Consistent | ي |
| /a/ | Short Vowel | Consistent | ◌َ |
| /u/ | Short Vowel | Consistent | ◌ُ |
| /i/ | Short Vowel | Consistent | ◌ِ |
| /an/ | Nunation Sound | Consistent | ◌ً |
| /un/ | Nunation Sound | Consistent | ◌ٌ |
| /in/ | Nunation Sound | Consistent | ◌ٍ |