Received: 28 January 2021 | Accepted: 5 May 2022

DOI: 10.1111/flan.12644

ORIGINAL ARTICLE

ACTFL Language Connects WILEY

Attention to verbal morphology in L2 Arabic reading: An eye-movement study

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The Challenge

Are L2 learners able to notice and learn novel verbal morphology when reading in a new writing system? What other aspects of language do they notice? The current study investigated if intermediate learners of Arabic can attend to and learn geminate verbs, and how they perceive written input in Arabic.

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Funding information
Hellman Fellows Program

Abstract

Attention is believed to help facilitate learning. Godfroid and Uggen found that attention to irregular verb morphology motivated the learning of novel second language (L2) German forms. The current study explored the generalizability of these findings to geminate and sound verbs in Arabic, a typologically different language with a novel writing system. Eleven fourth-semester learners of Arabic participated in the experiment. Participants completed a language learning background survey, took a fill-in-the blank pretest, read 20 sentence pairs while an Eyelink 1000 recorded their eye movements, and answered true/false comprehension questions that appeared on-screen following each sentence. A posttest, identical to the pretest, and a prior vocabulary knowledge scale task were then conducted. Learners' reflections were recorded in a subsequent recall task and a follow-up semistructured interview. Descriptive analyses of the eye-tracking metrics reveal generally equivalent reading times between verb types, although participants made more direct visual comparisons between geminate- than

between sound-verb conjugations. Participants did not report awareness of geminate verbs, but noticed other aspects of input, and, on average, improved their written productive knowledge by 2% after only one exposure. Pedagogical implications are discussed in terms of input enhancement in a communicative L2 classroom.

KEYWORDS
acquisition of L2 verbal morphology, attention in L2 learning, L2 Arabic learning, L2 reading

1 | INTRODUCTION

Three questions continue to engage second language (L2) researchers and practitioners: Can L2 learners acquire novel forms incidentally from exposure to input alone? What linguistic features do learners pay attention to or notice when reading in the L2? How does learner attention influence the learning of these features? For over three decades, researchers have proposed that attention in the form of noticing is a prerequisite for learning (Schmidt, 1990) or, at least, facilitates L2 development (Gass, 1997; Long, 1991; Robinson, 1995; Tomlin & Villa, 1994; VanPatten, 1990). Methodological advances such as eye tracking allow researchers to capture granular measures of attention in real time (Conklin & Pellicer-Sánchez, 2016; Godfroid, 2020). Godfroid and Uggen (2013) utilized eye-tracking metrics to explore the role of attention in the incidental acquisition of low-salient, irregular morphology. In their study, beginning L2 German learners read sentences containing stem-changing (irregular) verbs. They found that longer reading times led to modest gains in stem change production on subsequent posttests. The current study explored the generalizability of these findings in Arabic. It addresses the questions raised above by exploring whether L2 learners of Arabic attend to and acquire knowledge of geminate verbs—a stem-changing morphological form of low saliency—implicitly through a reading task on an eye tracker. The original methodology is furthermore extended by including qualitative data from recall protocols and participant interviews (M. Lee & Révész, 2018) to explore whether learners are consciously aware of specific L2 Arabic features during reading.

2 | LITERATURE REVIEW

2.1 | Cognitive perspectives on attention in learning

The primacy of attention in learning has been established in cognitive psychology, neuroscience, and applied linguistics (Baars, 2002; Cowan, 1995; Paradis, 2009; Posner & Rothbart, 2014; Weible, 2013). In a cognitive framework, attention is broadly defined as the allocation of processing resources to a task or stimulus (Anderson, 2015). Attention acts as a filter, enabling the mind to select, from among competing stimuli, those to be processed more

deeply (Wieser & Keil, 2020). Attention furthermore facilitates the binding of ideas, that is, concept formation (Cowan, 2014). The more that attention is focused on a set of stimuli, the more it will strengthen associations between these stimuli in the mind (Cowan et al., 2013). As such, attention is essential for both memory formation and retrieval (Baars, 2014; Jiménez, 2003).

Given its fundamental importance in learning, attention has played a paramount role in framing second language acquisition (SLA) theory (Robinson et al., 2012). Schmidt's (1990, 1993). Noticing hypothesis argues that all learning requires attention. Schmidt proposed noticing as the subjective correlate of attention. Learners must be consciously aware, at least at a minimal level, of the features they notice during L2 exposure, and can subsequently verbally report what they notice. Robinson (1995) further developed the concept of noticing as comprising both selective focal attention to a stimulus and its subsequent rehearsal in working memory. By attending to a specific linguistic feature in L2 input (i.e., noticing), this feature is selected to be processed more deeply in the learner's working memory.

Researchers have adopted many different techniques to capture and measure noticing (Bergsleithner et al., 2013). One technique gaining in popularity is eye tracking, in which a participant's pupil location on a visual plane is measured in real time (Godfroid, 2020). Eye tracking is based on the "eye-mind link" (Rayner, 1998), which theorizes that eye gaze (a measurable index of attention) can shed light on what is being noticed or cognitively processed (a covert index of attention).

The framework of attention has also influenced L2 pedagogy. In recognition that learners may need assistance in noticing specific forms, consciousness-raising interventions with varying degrees of explicitness or implicitness have been investigated in the field of SLA (Leow, 2018). Studies have explored the role of form-focused instruction (FFI) techniques such as input flood (i.e., providing numerous exemplars of target forms), textual enhancement (i.e., highlighting, underlining, and/or bolding), corrective feedback, and explicit grammar explanations in increasing the salience of linguistic forms and, thus, increasing the likelihood of learners noticing them (see Doughty & Williams, 1998; Kang et al., 2018; Norris & Ortega, 2000). Although these interventions differ in their approaches, all work toward the general goal of helping learners to more effectively notice and acquire forms which might otherwise prove difficult to pick up.

Following Godfroid and Uggen (2013) and the discussion above connecting attention, memory, and learning, it is proposed that the amount of attention that learners give to a language form may indicate the extent to which that form is processed in working memory and hence incorporated into long-term memory storage (i.e., acquired). Within the theoretical framework of attention, however, additional factors such as salience and the specifics of Arabic verbal morphology may influence noticing and acquisition of these forms.

2.2 | The role of salience in the acquisition of L2 verbal morphology

One of the major findings in attentional research in SLA is that not all linguistic forms are processed or learned in the same way (Goldschneider & DeKeyser, 2001; Spada & Tomita, 2010). One factor which influences the noticing, processing, and acquisition of novel forms (e.g., verb tense, case endings, and vocabulary items) in L2 input is salience (e.g., Azaz & Frank, 2017; Nassif, 2019; Simoens et al., 2018). Salience refers to the extent to which a specific property of the stimulus (e.g., a linguistic form) stands out compared to others in input (Ellis, 2018).

Goldscheider and Dekeyser (2021) describe salience in more colloquial terms as "how easy it is to hear or perceive a given structure" (p. 47).

One of the reportedly most difficult L2 forms to notice and acquire is verbal morphology (e.g., Behney et al., 2018; M. Cintrón-Valentín & Ellis, 2016). For years, Ellis and colleagues have consistently argued that verbal morphology features often have low salience compared to other more salient semantic cues, such as nouns and adverbs (N. C. Ellis, 2005, 2006; N. C. Ellis & Collins, 2009). The physical characteristics of these features (e.g., visual length or number of letters [Simoens et al., 2018]; stress; number of phones, syllabicity, and sonority [Goldschneider & DeKeyser, 2021]) make them less likely to stand out in both written and aural environments. For example, Nassif (2019) explored the role of salience on the noticing and production of future temporal indicators in L2 Arabic. She found that the low-salient future tense marker (the single-letter bound morpheme prefix حـ, ħa) was less likely to be picked up by learners than the highly salient syntactic feature of time telling (composed of two free morphemes, i.e, الساعة ستة essaːʕa sitte "six o'clock") in Levantine Arabic. Nassif concluded that temporal indicators which are short and low in stress were difficult for learners to perceive. Her results support the general findings that morphemes which are audiovisually shorter or less prominent are less salient and therefore more difficult for learners to notice and acquire without pedagogical interventions.

2.3 | Verbal morphology in Arabic

Words in Arabic, like in many Semitic languages, are made up of multiple discontinuous morphemes: the three[1] root letters (providing primary lexical meaning), the templatic pattern affixes (adding further grammatical meaning e.g., reflexivity or transitivity), and grammatical circumfixes (indicating tense, person, and case) (Watson, 2002).[2] Unlike in English, where morphemes fit together like boxcars (e.g., rent-*ed*, *anti*-establish-*ment*), the nonconcatenative morphology of Arabic means that morphemes "interleave together, like teeth in a zipper" (Freynik, 2016). Hence, a basic verb stem composed of the three root letters R_1-R_2-R_3 (e.g., d-r-s), when fit into pattern *a*-*a*, will exhibit the surface form $R_1aR_2aR_3$ (e.g., d*a*r*a*s).

Arabic verbs are conjugated by adding affixes to the verb stem. When affixation does not result in stem changing, these verbs (and their roots) are designated as "sound." Certain combinations of root letters, however, do trigger stem changes upon conjugation. One example is with geminate roots (also known as "doubled" roots), where the second and third root letters are the same (R_1-R_2-R_2; i.e., d-q-q). If a past tense, geminate verb is followed by a consonant-initial subject suffix (third-person conjugations), the stem would be $R_1aR_2aR_2$ (i.e., d*a*q*a*q-). However, if it is followed by a vowel-initial subject suffix (first- and second-person conjugations), the two geminate root letters merge into one (i.e., d*a*q-). This triggers a stem change, causing the final vowel-root bigram to disappear from the stem's written surface form[3] (changing from d*a*q*a*q- to d*a*q-) (see Table 1). In writing, this merging is sometimes indicated with a diacritic mark, although its use is generally limited to cases where including the diacritic would resolve semantic ambiguity. Further complicating matters, in most spoken colloquial varieties the geminate stem allomorphs have converged into a single hybrid form, as illustrated with the example of Cairene Colloquial Arabic in Table 1 (Holes, 2004). The fact that geminate verb allomorphy is not reinforced in spoken colloquial varieties may make its acquisition all the more difficult for L2 learners of Arabic.

The current study focuses on L2 acquisition of stem-changing geminate verbs in standard Arabic during reading.

TABLE 1 Sound (stem-stable) and geminate (stem-changing) verb conjugations in the past tense, first- and third-person singular forms for Modern Standard and Cairene Colloquial Arabic

Verb type	First person	Third person
Sound	katab-tu	katab-at
	wrote-I	*wrote-she*
	كَتَبْتُ	كَتَبَت
	"I wrote"	"she wrote"
Geminate (standard Arabic)	radad-tu	rad-at
	responded-I	*responded-she*
	رَدَدْتُ	رَدَّت
Geminate (cairene colloquial Arabic)	rad-eːt	*rad*-it
	responded-I	*responded-she*
	رَدّيت	رَدّت
	"I responded"	"she responded"

2.4 | Acquisition of stem-changing verbs in typologically different languages

Stem changes in Arabic geminate verbs present a unique case for the noticing and acquisition of L2 verbal morphology. From a salience perspective, geminate verb stems are similar to verbal morphology in many other languages: they are low-salient, bound forms with limited visual length. Furthermore, geminate stem changes do not affect the meaning of the word; readers could rely on lexis and affixation (conjugation) alone for comprehension. These characteristics make the noticing and acquisition of geminate verbs more difficult.

On the other hand, *unlike* stem changes in many other languages, stem changes in Arabic geminate verbs are regular: the rules governing them are fully productive (i.e., completely predictable). This regularity stands in sharp contrast to how stem-changing verbs are typically treated in theoretical models of grammatical processing. For example, the declarative/procedural model (Ullman, 2001a, 2001b, 2015) conceives of stem-changing verbs as irregular; stem changes are considered difficult to process, in part because there is no clear set of rules determining their morphological decomposition (see also the concept of diachronic "lexical arbitrariness" in Bybee's connectionist models [Bybee, 1995; Bybee & Newman, 1995]). Godfroid and Uggen (2013) situated L2 acquisition of German strong and weak verbs within this framework: because weak verbs in Germans are irregular and change their stems, they are likely difficult to acquire. Geminate verbs in Arabic also change stems, but do so based on a predictable application of rules (see discussion in previous section). Thus, from a theoretical perspective, it may be the case that stem-changing verbs in Arabic are perceived and processed in a different manner than the stem-changing verbs in German in the original study. With the points presented thus far in mind, the current study raised the following questions:

RQ1: Do intermediate learners of Arabic who are unfamiliar with geminate (stem-changing) verb conjugations pay more attention to those verbs as compared to sound (stem-stable) verbs during reading?

RQ2: Are learners more likely to learn the geminate verbs if they pay more attention to them?

RQ3: How do learners' self-reported subjective experiences align with the online and offline measures of awareness and learning?

Studying incidental learning will shed light on the nature and type of pedagogical interventions needed for acquiring these unique aspects of grammar. Implications of the study will inform teachers and researchers about the role of incidental exposure to grammatical forms and whether a balanced approach, combining techniques of explicit and implicit exposure, can be adopted in the Arabic classroom. If learners pay more attention to geminate verbs relative to sound verbs, it may indicate that they are able to notice differences between the two forms and to attend to the novel form. Comparing gain scores against the online and offline measures of attention can elucidate the relationship between attention, awareness, and learning. Finally, retrospective reports can confirm whether or not participants' noticing occurred at the level of awareness.

3 | METHODOLOGY

3.1 | Participants

Eleven fourth-semester students of L2 Arabic from a large American public university participated in the study. All participants reported that they spoke English at home with their family. Three participants identified additional spoken home languages besides English (two listed Spanish, and one listed Telugu). Furthermore, all participants reported that they had studied one or more foreign languages besides Arabic. These L2's included Spanish ($n = 7$), French ($n = 2$), Latin ($n = 2$), Russian, Uzbek, Urdu, Japanese, Swahili, and Esperanto (all $n = 1$). In terms of time spent abroad in the Arabic-speaking world, two participants reported short travel experiences: one for a high school class trip and the other for a 1-month visit to see family. A third participant mentioned having spent time in US-based language immersion program for middle and high school learners of Arabic. On balance, it does not seem likely that participants had substantial exposure to spoken colloquial dialects of Arabic before the experiment.[4]

Participants were recruited from two sections of the same fourth-semester class. They were estimated by their instructor to be at the intermediate level on the ACTFL proficiency scale (ACTFL, 2012). They participated in the study 1 week before the formal introduction of geminate verbs in their Arabic textbook, *Al-Kitaab fii ta'allum al-'Arabiyya* (Brustad et al., 2013). The experiment lasted approximately 75 min.

3.2 | Materials

3.2.1 | Eye-tracking stimuli

Eight geminate (stem-changing) verbs were chosen as stimuli. Four familiar and four unfamiliar geminate forms were selected as targets to investigate the effect of prior familiarity on the learnability of irregular morphology. Prior familiarity was determined according to textbook coverage, confirmed by their instructor, and verified through a posttreatment prior

vocabulary knowledge scale task (Wesche & Paribakht, 1996). Additionally, eight sound (stem-stable) verbs, all familiar to the participants, were selected as fillers. Geminate and sound verbs were matched for templatic pattern affixation to control word length (see Table 2). Diacritic marks indicating doubling of the final consonant were not included on geminate verbs to avoid inducing unintentional salience. All verbs were embedded into sentence pairs ranging from eight to nine words in length ($M = 8.1$ words) for the reading portion of the experiment (Supporting Information: see Tables S1–S4). Sentence pairs were identical except for the change in subject verb conjugations (first or third person) to allow direct comparison of the two conjugated forms. Although Arabic is typically considered to be a null-subject language (c.f. Alnajadat, 2017), the inclusion of initial pronouns was intended for two reasons. First, it is recommended that the area of interest in the eye tracking screen does not fall in the beginning or the end of the stimuli because it will distort the accuracy of eye movement reports. Second, it was also important to draw learners' attention to the connection between the pronoun and the form of conjugation they see afterwards.

TABLE 2 Target and filler verbs

Verb type	Stem		Translation	Length	Pattern
Geminate (familiar)	ظنّ	zˤanː	To think	2	I
	أحبّ	ʔaħabː	To love	2	IV
	أعدّ	ʔaʕadː	To prepare (transitive)	3	IV
	استعدّ	ʔistaʕadː	To prepare (intransitive)	5	X
			Group mean (SD)	3 (1.41)	
Geminate (novel)	ردّ	radː	To reply	2	I
	حلّ	ħalː	To solve	2	I
	أطلّ	ʔatˤalː	To look out over	3	IV
	استمرّ	ʔistamarː	To continue	5	X
			Group mean (SD)	3 (1.41)	
Sound	عمل	ʕamil	To work	3	I
	خرج	xaradʒ	To exit	3	I
	رفض	rafadˤ	To refuse	3	I
	أصلح	ʔasˤlaħ	To fix	4	IV
	أكمل	ʔakmal	To complete	4	IV
	أرسل	ʔarsal	To send	4	IV
	استأجر	ʔistaʔdʒar	To rent	6	X
	استقبل	ʔistaqbal	To welcome	6	X
			Group mean (SD)	4.13 (1.25)	

Note: The transcriptions above reflect the fact that case endings were not marked in the experimental stimuli, as they do not affect comprehension. Recall that the geminate verbs stems, because of the doubled root letter, will always be one letter shorter than their sound verb counterparts.

Abbreviation: SD, standard deviation.

The ordering of sentences within each pair was counterbalanced: of the eight sentence pairs, five started with first-person conjugation, and three started with third-person conjugation. Counterbalancing was adopted to reduce potential noise in the data related to the structuring of the experimental design. All instruments used in the present study (available for free download on the IRIS Database; iris-database.org) were piloted off-line in two separate rounds by the first researcher. Participants for the piloting rounds were fourth-semester students of Arabic studying at different universities than the ones utilized in the main study, but using the same textbook.

In addition to the target verb sentences, four filler sentences of similar structure were created as distractors. To conceal the intention of the experiment, a true-or-false comprehension task followed each sentence pair. The true-or-false statements were based on key nouns (i.e., the direct object) or adjectives (i.e., the predicate) in the sentence pairs. Results of this task were also used to ensure that participants remained focused on the meaning of the reading. The presentation of sentence pairs during the reading portion was randomized to avoid ordering effects.

3.2.2 | Pre-/posttests

The experiment followed a pre-/posttest format (see Figure 1). The pre-/posttest was an identical fill-in-the-blank task, designed to disguise the structure under inquiry by eliciting a mixture of verbs (10 geminate [6 familiar, 4 novel] and 9 sound) and filler items (6 nouns) (see pre-/posttest in the Supporting Information). Participants were provided with the target translations below each blank to facilitate completion of the task and to ensure that the correct form was being prompted. The purpose of the task was to establish the participants' pretreatment knowledge baseline.

3.3 | Procedure

Participants completed a background questionnaire and consent form online before arriving at the lab one at a time. They first took the pencil and paper pretest (Phase 2 in Figure 1).

The third phase of the experiment, the sentence reading, took place on a computer connected to an EyeLink 1000 eye-tracking apparatus (SR Research, 2020). Participants positioned themselves at the headrest, located approximately 50 cm away from the camera. They were instructed that they would read sentences in Arabic and then answer comprehension questions about each pair of sentences, progressing through the experiment by clicking. At the beginning of each of the two experimental blocks, participants were run

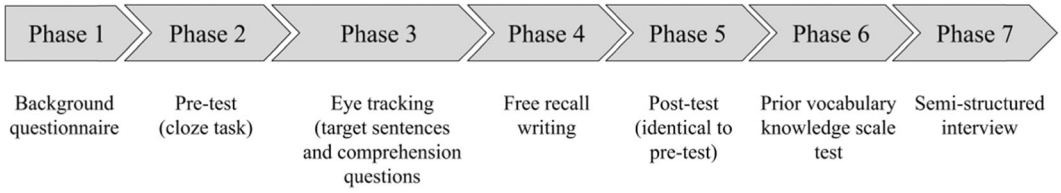

FIGURE 1 Overview of the experimental phases

through a nine-point calibration procedure to improve the accuracy of the eye tracker. Each experimental block consisted of 10 trials, each containing a pair of sentences. At the beginning of each trial, drift was manually corrected by having participants look at a fixation cross on the screen. They then read two sentences on the screen, which were identical except for subject conjugation. Participants read at their own pace. After each sentence pair, participants completed a short true-or-false comprehension task in English about what they had just read (see Figure 2). Participants were given a break after the first experimental block (10 sentence pairs) and were encouraged to take breaks as necessary throughout the study. At the end of both experimental blocks, participants completed the posttests, the prior vocabulary knowledge scale task, and the semistructured interview (Phases 4–7 in Figure 1).

3.4 | Data analysis

3.4.1 | Analysis of pre-/posttest scores

Responses to pre- and posttest items were scored on a 0–0.5–1 scale. One point was awarded if the participant displayed knowledge of the conjugation (i.e., using the correct stem), 0.5 points for partial knowledge (i.e., overgeneralization of the doubled stem to second or third person conjugations), and 0 points for no knowledge (i.e., providing a completely different word). Errors that were unrelated to the stem and conjugation, such as spelling mistakes, were ignored. Pre- and posttests were first scored by each researcher individually, then compared. Any discrepancies were resolved through discussion until the research team reached consensus. Given the sample size, only descriptive statistics are reported.

3.4.2 | Analysis of qualitative data (free recall, interviews)

The first phase of data analysis involved an open coding process (Friedman, 2012) to identify major themes emerging in the data (e.g., noticing geminate verb grammar, noticing verbal

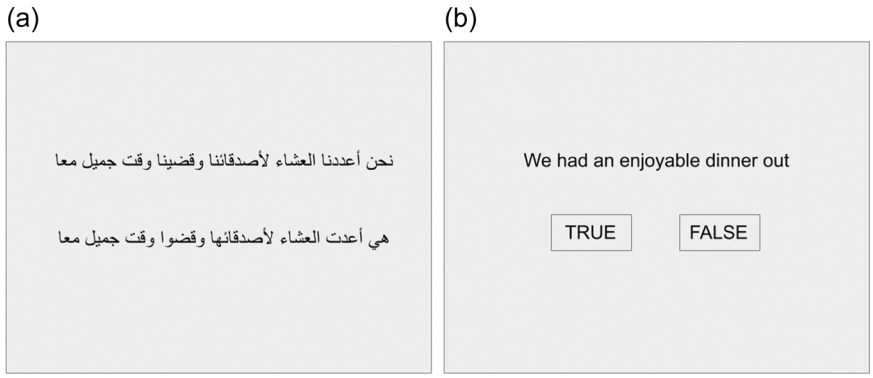

FIGURE 2 Eye tracking procedure. Participants read the sentence pairs ("We prepared a dinner for our friends and (we) enjoyed a nice time together // She prepared dinner for her friends and (they) enjoyed a nice time together") on the first screen (a), clicked to continue, then answered a comprehension question by clicking their answer (b).

morphology, type of noticing: lexical, grammatical, etc.,). The second phase of data analysis involved axial coding to verify the applicability of these themes (Saldaña, 2016). Every aspect of the data that dealt with these themes was tallied and, if appropriate, grouped into larger categories (Table 6). We compared categories across the participants to establish patterns, and chose representative quotations from participants for inclusion in this paper. At each stage of analysis, data were first analyzed separately by the authors. After the analysis, the authors met to present their findings. All discrepancies were resolved through discussion until the authors came to an agreement about the categories.

3.4.3 | Analysis of eye-tracking metrics

The eye-tracking metrics chosen for the current study matched those used by Godfroid and Uggen (2013): durational fixation measures (first fixation duration, gaze duration, and total dwell time) and comparison measures. These two types of measures were chosen because they offer a broad array of indices for measuring the extent to which participants attended to the target forms. First fixation duration is the length of the initial fixation on a word. It is considered a measure of early lexical processing; that is to say, the participant may be starting to recognize the form or meaning of a word at a subconscious level (e.g., Godfroid et al., 2013; Mohamed, 2017). Participants could make more than one fixation on a word before moving on to another word of interest; the sum of the duration of these fixations within the first visit is known as gaze duration. Gaze duration does not count fixations from any subsequent visits. Gaze duration, like first fixation duration, is a measure of early processing which suggests lexical and perhaps grammatical awareness but at a (likely) subconscious level. Finally, total dwell time is the sum of all fixations in the area of interest across all visits. Unlike first fixation duration and gaze duration, total dwell time is thought to reflect later processing measures in which readers have, whether consciously or not, decided to revisit the area of interest.[5] As for the second type of eye-tracking metric, comparison measures quantify the extent to which participants made direct visual comparisons between the differently conjugated verbs in the two sentences which appeared on the screen. Comparisons were calculated as both a count measure (number of saccades between the target areas of interest) and a binary variable (whether or not participants made comparisons between verbs). As with the test score data, only descriptive statistics are reported given the sample size. To assist with interpreting the data, multiple statistics (means, interquartile range, standard deviations [SD], and outlying datapoints) are presented both in tables and in graphs.

Before analysis, the eye-tracking data were cleaned and inspected (Conklin et al., 2018; Godfroid, 2020). First, playback animation, spatial overlays, and temporal graph data for all trials were checked for congruence of metrics (Godfroid & Hui, 2020). Then, the automated four-stage fixation cleaning process in Data Viewer software (SR Research, 2020) was conducted, followed by manual correction of any remaining vertically misaligned fixation points. Trials with unusual or implausible reading patterns (i.e., only reading one sentence, fixations horizontally shifted) were removed. Likewise, all trials for one of the geminate verbs (ظنّ/zˤanː/"to think") were removed as the geminate form was unintentionally obscured by the subject–verb pairing chosen for the stimulus. Average track loss of the remaining data was calculated at 3.37% (SD = 3.5%). This is within the range of normal track loss (2%–5%) for an average European population as established by Holmqvist et al. (2011).

4 | RESULTS

4.1 | Pre-/posttest scores

Pretests were used to verify the lack of prior knowledge of geminate verb conjugations. Answers were scored on a 0–0.5–1 scale. On average, participants demonstrated greater prior knowledge of sound verbs ($M = 0.27$, SD = 0.2) than geminate verbs ($M = 0.19$, SD = 0.14), and likewise greater prior knowledge of the familiar geminate verbs ($M = 0.30$, SD = 0.19) than the novel geminate verbs ($M = 0.03$, SD = 0.06). While the descriptive summaries of the scores supported our assumption that the learners lacked prior knowledge of the geminate verb conjugations, it is surprising that the learners scored commensurately low on the sound verb conjugations. This finding may stem from unforeseen differences in proficiency between the participants who piloted the materials and those in the main study. Another possibility is that the nature of the main study (i.e., sitting in an enclosed lab, compared to the offline nature of the piloting phase) negatively affected the participants' L2 skills.

To look for evidence of learning, gain scores between pre- and posttests were calculated (see Table 3). Participants showed minimal improvement from pretests to posttests on sound and known geminate verbs, and slight regressions in overall geminate and unknown geminate verb knowledge.

4.2 | Eye-tracking metrics

4.2.1 | Durational measures

The first operationalization of attention was through durational measures; that is, the length of time spent reading (first fixation duration) and rereading the verbs of interest (gaze duration, and total dwell time). The descriptive results for all three measures suggest that participants did not differentiate their attention between verb types (see Table 4). Participants, on average, looked comparatively long at both sound and geminate verbs, as well as at both familiar geminate and novel geminate verb types. The overlapping boxplots across conditions in Figures 3–5 support the conclusion that these participants likely did not differentially attend to the two verb types.

Taken in totality, the apparent lack of difference across both early and late durational measures supports the conclusion that this group of participants spent similar amounts of time attending to both sound and geminate verbs.

TABLE 3 Accuracy means and standard deviations (presented in decimal format) for pretest, posttest, and gain scores

Verb type	Pretest	Posttest	Gain score
Sound	0.27 (0.2)	0.32 (0.24)	0.05 (0.08)
Geminate	0.19 (0.14)	0.18 (0.13)	−0.005 (0.04)
Known	0.03 (0.06)	0.06 (0.09)	0.02 (0.08)
Unknown	0.3 (0.19)	0.27 (0.02)	−0.02 (0.07)

TABLE 4 Descriptive statistics of fixation measures (in milliseconds) for each verb type

Measurement	Verb type	*N*	*M*	Med	SD	Min	Max
First fixation duration	Sound	158	295	251	134	141	747
	Geminate	130	305	263	145	141	778
	Known	56	285	235	144	141	778
	Unknown	74	320	285	145	142	699
Gaze duration	Sound	158	1147	996	814	141	3725
	Geminate	130	1110	953	873	143	4292
	Known	56	1196	999	1009	154	4292
	Unknown	74	1045	917	754	143	4099
Total time	Sound	158	2065	1747	1545	222	15,620
	Geminate	130	2046	1603	1421	174	7919
	Known	56	1969	1600	1357	174	5649
	Unknown	74	2105	1611	1474	338	7919

Abbreviation: SD, standard deviation.

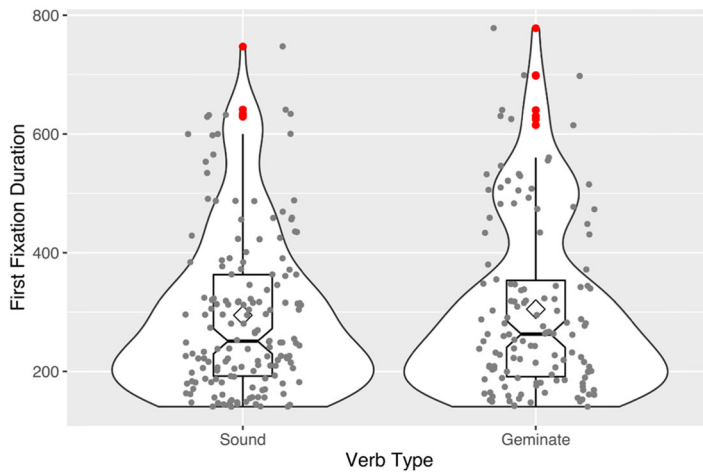

FIGURE 3 Jittered violin box plots illustrating first fixation duration by verb type [Color figure can be viewed at wileyonlinelibrary.com]

4.2.2 | Count measures

Attention was measured not only through durational fixation measures but also through the degree to which direct visual comparisons were made between the critical verbs in the sentence pairs which appeared on the screen. Direct visual comparisons may indicate that the participants in this study noticed a change between the two verbs on the screen and were trying to reconcile the different forms. These comparisons were analyzed as both a count measure (average number of direct visual comparisons) and a binary measure (whether or not direct

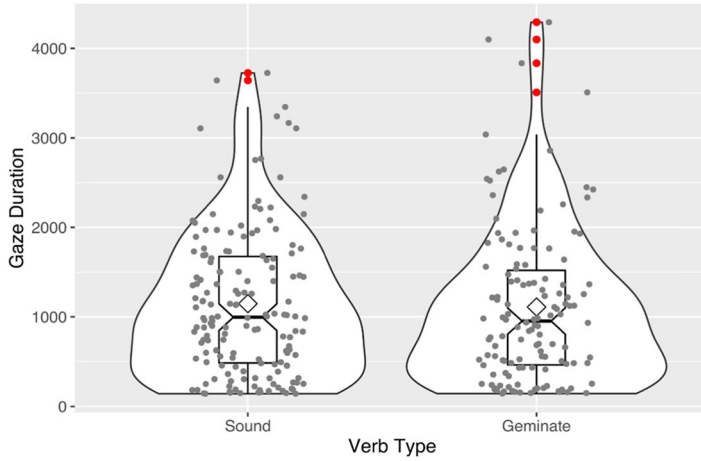

FIGURE 4 Jittered violin box plots illustrating gaze duration by verb type [Color figure can be viewed at wileyonlinelibrary.com]

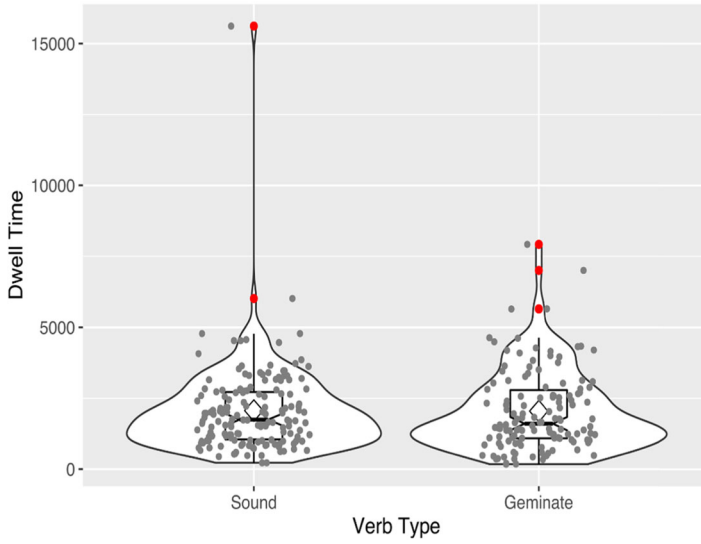

FIGURE 5 Jittered violin box plots illustrating total dwell time by verb type [Color figure can be viewed at wileyonlinelibrary.com]

visual comparisons were made). Unlike the fixation measures, the descriptive results of the comparison measures here reveal some differences in how the 11 participants paid attention to different verb types (see Table 5).

Participants, on average, made twice as many visual comparisons between geminate verbs ($M = 0.28$, SD = 0.58) as between sound verbs ($M = 0.14$, SD = 0.36). They directly compared verb conjugations in 13% of sound-verb trials, as compared to 22% of geminate-verb trials. Overall, the direct visual comparison descriptive data suggest that the participants in this study did indeed make more comparisons between verbs conjugated in the geminate paradigm than

TABLE 5 Descriptive statistics of direct comparisons between verb conjugations for each verb type

Measurement	Verb type	*N*	Total	*M*	SD	Min	Max
Count	Sound	160	22	0.14	0.36	0	2
	Geminate	130	36	0.28	0.58	0	3
	Known	56	6	0.11	0.31	0	1
	Unknown	74	30	0.41	0.7	0	3
Binary	Sound	160	21	0.13	0.34	-	-
	Geminate	130	28	0.22	0.41	-	-
	Known	56	6	0.11	0.31	-	-
	Unknown	74	22	0.3	0.36	-	-

Abbreviation: SD, standard deviation.

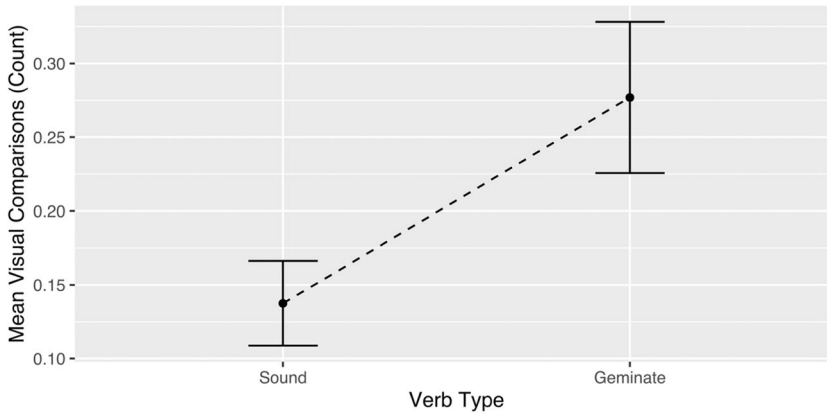

FIGURE 6 Line chart illustrating average number of direct visual comparisons by verb type

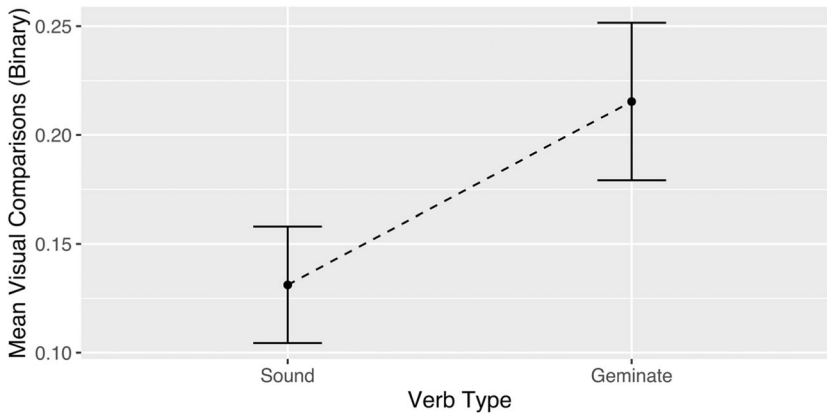

FIGURE 7 Line chart illustrating presence or absence of visual comparisons by verb type

they did for sound verbs. This conclusion is supported by Figures 6 and 7, in which the error bars for the two verb types do not appear to overlap for either metric.

4.3 | Qualitative data

The third research question explored whether learners' self-reported subjective experiences aligned with the online and offline measures of awareness and learning during the reading task. In line with findings from the quantitative data showing minimal to negative gain scores on the pre/posttests, qualitative data from the recall task and structured interviews showed that participants did not report awareness or learning of geminate verbs. Participants generally approached the reading task as a reminder of some familiar words or concepts. Only four participants reported noticing specific geminate verbs, but they were unable to explain or infer the pattern of stem change in geminate verbs. Beyond geminate verbal morphology, however, participants' overall comments did display patterns of noticing other aspects of input which merit discussion (see Table 6).

4.3.1 | Lexical noticing

All learners reported noticing vocabulary items, and many instances revealed that readers relied on vocabulary to support reading comprehension. Interestingly, the most noticed lexical items were verbs. Five participants reported a specific focus on verbs to foster comprehension. Participant (P)1 remarked:

TABLE 6 Patterns of noticing in qualitative data (recall and interviews)

	Focus of awareness in verbal reports					
	Lexical		Morphological			
Participant	Verbs	Other[a]	Verbs	Other[b]	Root	(Some) Learning
P01	✓	✓	✓	✓	✓	✓
P02	✓	✓	-	-	✓	✓
P03	✓	✓	✓	-	✓	✓
P04	✓	-	✓	-	✓	✓
P05	✓	✓	✓	-	✓	✓
P06	✓	✓	-	-	-	-
P07	-	✓	-	-	-	-
P08	✓	✓	-	-	-	✓
P09	✓	✓	-	-	-	✓
P10	-	✓	✓	-	-	-
P11	✓	-	✓	-	-	-

[a]Nouns, conjunctions.

[b]Possessive endings.

> I try and focus more on the verb...Um, just because with a verb you can tell a lot about what the sentence is going to be about. Um, like, who the subject is based on the verb conjugation. And um, like, depending on the meaning of the verb what the sentence is most likely going to be about.

Additionally, all participants noticed that the verbs were provided in different conjugations within the sentence pairs. Participants generally stated that this juxtaposition helped them to better understand these verbs (as opposed to helping them notice the stem changes). P1 noted:

> But I think just looking at the verbs in different—like in different conjugations, like learning the verbs that way like "oh! It's not just this is like a weird form." It's like you have to look at both kind of, to help you get a better understanding.

Of the nine participants who reported noticing specific verbs, six were able to provide examples of geminate verbs but none reported noticing a novel geminate verb. In fact, the participants did not report noticing or learning new lexical items from the reading sessions. Rather, they consciously referred to vocabulary items with which they had difficulty recalling in the pretest, but were able to remember when encountered in the reading context. Some participants also expressed awareness that while they noticed verbs, they did not incorporate them on the posttest. P3 stated: "I knew 'sent,' like I didn't know the actual word, but I remember reading it. And I remember recognizing it when I read it, but I couldn't recall it to write it down."

Despite noticing and reporting different verb conjugations in the sentence pairs, none of the participants reported paying special attention to geminate verbs compared to sound verbs. This lack of overt distinguishing between verb types is congruous with the durational eye-tracking measures discussed above, where both verb types were fixated on for equally long periods of time (but recall that participants did make more direct visual comparisons between geminate verbs than between sound verbs, indicating that some degree of differentiating between verb types was present). In addition to verbs, an overall focus on vocabulary was reported by nine participants, with four giving more attention to nouns to support their reading and meaning comprehension.

4.3.2 | Noticing of verbal morphology and lexical roots

Participants reported using their metalinguistic knowledge during reading. Six participants commented on specific aspects of verbal morphology, mainly past tense conjugations (suffixes) and realization of grammatical case on verb endings. They referred to these conjugations and verb endings as facilitators for comprehension. They stated that the sentences became easier to comprehend when they noticed the conjugation and realized the temporal references of the verb.

Furthermore, five participants reported relying on knowledge of roots in comprehension and production. For example, P4 focused on roots for meaning, commenting: "If I'm reading a single sentence, I pretty much look at the roots of every word and I try to fluently speak through from the first word to the final word of the sentence." Other participants noted recognizing roots from the reading task, and incorporating this knowledge into responses on the posttest. For example, one participant who correctly translated the sound verb *ʔarsal*

("sent") in English on the pretest noticed a word with the same root in the reading, *risa:la* ("letter"). S/he commented on them being "kind of close," and transferred this recognition into an appropriate verb use on the posttest. Two other participants (2 and 4) applied their prior knowledge of the adverb *bi-ʔistimra:r* ("continuously") to the geminate verb *ʔistamar:* ("continued") on the posttest. However, they did not recognize the stem change rule of geminate verbs.

Only one participant came close to recognizing the stem change pattern in geminate verbs, in which root knowledge was key. Having come across the verb *ʔaħab:* ("loved") with one overt letter "*ba*" rather than two (as s/he knew from words from the same root, *ħabi:bi:* and *ħabi:bti*: ["my male/female beloved"), s/he wondered whether the second "*ba*" would appear "when you break it [the verb] down." S/he accurately applied this conjecture to the geminate verb ("loved") on the posttest. However, s/he did not apply this knowledge with other geminate verbs.

4.3.3 | Reporting of (some) learning

Although participants did not report on conscious noticing of novel geminate verb morphology, they did describe strategies utilized for reading. All readers reported that reading refreshed the vocabulary items that were difficult to recall from memory. P1 wrote down the word *ʔistaʔdʒar* ("rented") in the free recall sheet, indicating that s/he was aware that s/he knew the word but was not sure of the form. P2 reported the verb *ʔasˤlaħ* ("repaired") and the nouns "employee" and "translator" as examples of lexical items s/he struggled to recall but immediately recognized upon reading.

During the interviews, the researchers asked participants what they had learned. P4 reported learning "not much," but pointed out that s/he may have learned more from the pre-/posttests than from the reading session. Similarly, P9 stated "I don't think I learned anything," referring to the same idea of only remembering words and noticing verbs in different conjugations. P7 stated "I don't know if I learned," but s/he referred to her/his reliance on Arabic word order in reading comprehension.

Furthermore, unconscious learning was minimally implied. Students were asked to reflect on some of their responses in the posttest. For example, P1 included the geminate diacritic mark on the verb *zˤan*: ("he thought"), but s/he could not explain why s/he added that in the posttest and not the pretest. P07 could not explain why s/he wrote *ʔaḥbabtu* ("I liked/loved") with double (*baa*) in the posttest. Finally, P11 was not sure why s/he (correctly) produced the correct stem in *radadtu* ("I replied"), stating that "I am not good at spelling, I just guessed."

5 | DISCUSSION

The current study extends the line of research on incidental acquisition of novel verbal morphology to Arabic, a language which is orthographically and typologically distinct from English and German (the language pairing in the original study being replicated). In response to the first research question (do learners pay more attention to stem-changing verbs than to stem-stable verbs?), the results were ambiguous. The descriptive findings of the online eye-movement data indicate that there were no differences in the duration of attention paid to stem-changing (geminate) compared to stem-stable (sound) verbs, although participants did

make more direct visual comparisons between geminate verb conjugations than between sound ones. As for the follow-up second research question (if learners pay more attention to stem-changing verbs, are they more likely to learn them?), participants made minimal gains between pre- and posttests. Their written productive knowledge of geminate verb forms increased by 2% after only one exposure. It may be that the productive nature of the test (item recall) was too difficult to adequately capture evidence of learning. Finally, the current study asked if learners' self-reported subjective experiences align with the online and offline measures of awareness and learning (RQ3). Results from the recall and interview data show that participants were overall unaware of geminate verbs during the reading portion of the experiment. However, the qualitative data reveal that participants did notice other aspects of input, such as lexical meaning and root identification. The results, taken together, indicate that some noticing occurred, although insufficient to be internalized in the learners' awareness. This finding is in line with Schmidt's (1993, 1995) differentiation between awareness at the level of noticing (which may be unconscious) and at the level of understanding.

Unlike the L2 German learners in Godfroid and Uggen's (2013) original study, participants in the current study did not show evidence of differentially paying attention to and subsequently learning novel stem-changing verbs. These conflicting results are unexpected on two levels: first, as discussed above, stem-changing verbs in Arabic are regular whereas in German they are irregular. Furthermore, the L2 Arabic participants in the current study received more instruction (four semesters) than the L2 German participants did (one semester). It seems that the application of Godfroid and Uggen's (2013) original experimental design (providing one exposure per target verb) was not enough to facilitate acquisition in the current study for L2 Arabic learners.

One potential, heretofore unexamined explanation for the discrepancy in outcomes between Godfroid and Uggen (2013) and the current study is that English is orthographically and typologically much closer to German than it is to Arabic. From an orthographic perspective, the L2 Arabic participants may still be relying on lower-level processing skills (such as letter and word recognition) during reading (Hansen, 2010). As such, they likely do not have the necessary cognitive resources available for higher-level processing of morphological information (Koda, 1992, 2012). From a typological perspective, the L2 Arabic participants may not have accumulated enough exposures to develop a mental representation of nonconcatenative verbal morphology such that they could furthermore distinguish between sound and geminate forms in the context of a new alphabet. Further research is thus needed on how the effects of exposure frequency may be mitigated by novel morphology and orthography.

In the current study, it can be further argued that morphological aspects are less salient than vocabulary and thus might not have triggered noticing. This finding is unsurprising given findings from previous studies showing that learners at many different levels of proficiency tend to notice lexical items over morphological ones (R. Ellis et al., 2001; Gurzynski-Weiss & Baralt, 2014; Hanaoka, 2007; Mackey et al., 2000; Swain & Lapkin, 1995). In addition to being more perceptually salient, content lexical items are nonredundant and have higher communicative value which might better orient participants' attention to them (see VanPatten, 2002, 2004). In the current study, nine out of 11 participants reported a focus on lexical items.

Although five participants did report attention to verbal morphology and noticed that verbs carried different conjugations, they looked at them as a source of information to help them understand the sentence better. Learners' attention was, therefore, meaning-based and oriented toward the comprehension task demands rather than grammar. This orientation toward lexical

interpretation (see VanPatten's, 2004 Primacy of Meaning Principle) might explain the fact that participants did not overtly notice the additional letter in the verb stem: the verb ending was more salient and critical in determining the meaning.

Prior experience might have played a role in the findings as well. Previous L1 and L2 experiences might have directed learned attention to the past tense suffix rather than to the stem change. As L1 speakers of English and L2 learners of Arabic, participants may have associated suffixes with regularity (see Bybee & Newman, 1995) and viewed them as a source of meaning. Once that meaning was established, participants may not have further noticed stem changes.

5.1 | Pedagogical implications

The findings of the current study have pedagogical implications. First, the salience of verbal morphology could be enhanced. "Structured-input" (J. F. Lee & VanPatten, 2003) or Focus on Form (Doughty & Williams, 1998) activities would be especially helpful in such training. For example, instructors could provide numerous exemplars of target structures in meaning-bearing input (i.e., input flood) and design activities that draw learners' attention to these forms in comprehension questions. Then, by explicitly asking learners to notice these forms in their linguistic contexts and analyze the way they are structured to convey specific meanings, instructors can help learners establish form-meaning connections.

According to Spada and Lightbown (2008), isolated FFI "might be useful for creating the necessary salience to help learners notice language forms that occur frequently but are semantically redundant or phonologically reduced or imperceptible in the oral input" (p. 195). Azaz (2017) also remarked that learners' attention could be drawn to the "internal structure of bigger syntactic constructions," and, additionally, that learners could "linguistically analyze complex constructions in which two or more features are bundled" (p. 230). For example, the verb yuħib.baːniha (They [both] like it) involves a complex construction with the third person masculine present tense prefix yu, the merging of the two ba letters in the geminate verb stem uħibː (to love), the dual inflection suffix aːn, and the object pronoun (feminine ha, it). Learners could analyze such verbs by identifying and understanding the purpose of each morpheme, as well as how the morphemes are collectively used to convey specific meanings in context. Analysis may also involve comparing these verbs to familiar base forms and constructions. Given learners' predisposition to read and process L2 input for meaning, it is important to design tasks that reinforce form-function mappings and that create the need to fulfill a communicative purpose in such a way that it will draw learners' attention to the forms that are required to perform these communicative functions.

5.2 | Limitations and directions for future studies

The present study initially investigated the processing of geminate verbs during reading; however, the results shed further light on specific aspects of learners' reading behavior of Arabic text. Insights from the qualitative data added to our understanding of how learners of Arabic perceive written input while providing motivation for future research to explore the relationship between attention and acquisition. Conducting studies on a larger pool of learners

of Arabic can further elucidate this intricate association while controlling for individual differences.

Enhancing input and increasing the frequency of target features is crucial to allowing readers sufficient exposure and to providing room for investigating learning outcomes. The learning gains in the present study were minimal, as measured by a productive posttest. The amount of exposure to the target feature was not sufficient to be internalized in learners' linguistic system. Future studies should include receptive measures that can capture some traces of knowledge acquired from the given input. Time limit was also a limitation, restricting measurement of the production gains of the germinate verb to an immediate written test only. Future studies should explore longer durations, allowing for measurements in both writing and speech.

The present study identified a significant gap in Arabic language acquisition research, particularly grammar learning and teaching. This can have important implications for instructed SLA of Arabic and can invite more attention to the building of sound pedagogical models informed by research. Future studies are encouraged to provide further insights into the growing field of Arabic language instruction.

ACKNOWLEDGMENTS

This research was made possible by a generous award from the Hellman Fellows Program in collaboration with Williams College, and by the support of the Second Language Studies Program at Michigan State University (MSU). We are especially grateful to Dr. Aline Godfroid for her guidance and for making data collection possible at the eye-tracking lab at MSU. We would also like to thank the research participants, three anonymous reviewers for their valuable feedback on this manuscript, and Drs. Julie Sykes and Luke Plonsky for their guidance throughout the review process.

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ENDNOTES

[1] The majority of Arabic roots are triliteral; however, there are also bi- and quadriliteral roots. These two- and four-letter roots do not exhibit gemination and were thus not covered in the current study.

[2] A fourth morpheme which contributes meaning to lexical items are the intercalated vowels. They denote variation, such as voice and agency. The intercalated vowels are beyond the scope of the current study; see Watson (2002) for further discussion.

[3] In spoken form, the final root letter in the stem of first- and second-person conjugations is doubled in length, that is, R_1aR_2: (i.e.,/marr/). This doubling is sometimes indicated in written form by a diacritic (i.e., mar̄), but this was not done in the current study to avoid inducing additional salience to target items.

[4] We do not believe any of the participants would be categorized as "heritage speakers" in terms of having had extensive exposure to Arabic before their formal studies. Although one participant reported travel to the Arab world to visit family, in the open-ended language questions the participant reported only using English at home and offered no details indicating any Arabic language usage.

[5] Godfroid and Uggen (2013) calculated the difference between stem-changing and nonstem-changing forms (subtracted durational fixation measures). Because the current study opted to instead counterbalance the ordering of changing and nonchanging forms, subtraction measures are not calculated here.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Nassif, L., Huntley, E., & Mohamed, A. (2022). Attention to verbal morphology in L2 Arabic reading: An eye-movement study. *Foreign Language Annals*, 55, 769–792. https://doi.org/10.1111/flan.12644