Journal of Experimental Child Psychology 169 (2018) 110–117

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Brief Report

Does visual letter similarity modulate masked form priming in young readers of Arabic?

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ARTICLE INFO

Article history:
Received 11 July 2017
Revised 26 October 2017
Available online 19 January 2018

Keywords:
Lexical access
Masked priming
Developing readers
Visual similarity
Lexical decision

ABSTRACT

We carried out a masked priming lexical decision experiment to study whether visual letter similarity plays a role during the initial phases of word processing in young readers of Arabic (fifth graders). Arabic is ideally suited to test these effects because most Arabic letters share their basic shape with at least one other letter and differ only in the number/position of diacritical points (e.g., ض - ص; ظ - ط; غ - ع; ث - ت - ن ب; ذ - د; خ - ح - ج; ق - ف; ش - س; ز - ر). We created two one-letter-different priming conditions for each target word, in which a letter from the consonantal root was substituted by another letter that did or did not keep the same shape (e.g., حدمة - خدمة vs. فدمة - خدمة). Another goal of the current experiment was to test the presence of masked orthographic priming effects, which are thought to be unreliable in Semitic languages. To that end, we included an unrelated priming condition. We found a sizable masked orthographic priming effect relative to the unrelated condition regardless of visual letter similarity, thereby revealing that young readers are able to quickly process the diacritical points of Arabic letters. Furthermore, the presence of masked orthographic priming effects in Arabic suggests that the word identification stream in Indo-European and Semitic languages is more similar than previously thought.

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https://doi.org/10.1016/j.jecp.2017.12.004
0022-0965/

Introduction

Most theorists would agree that, in a mature reading system, the abstract letter units that drive the process of lexical access are activated during the initial phases of processing (see Grainger, Dufau, & Ziegler, 2016). Indeed, in the masked priming paradigm, a visually dissimilar lowercase–uppercase identical pair such as arte–ARTE produces as much masked repetition priming—relative to an unrelated control—as a visually similar lowercase–uppercase identical pair such as kiss–KISS (Bowers, Vigliocco, & Haan, 1998; see also Jacobs, Grainger, & Ferrand, 1995). Importantly, the mapping from visual letter forms to abstract letter representations also appears to occur early in processing with developing readers (see Perea, Jiménez, & Gómez, 2015, for a replication of the Bowers et al. (1998) and Jacobs et al. (1995) experiments with Grade 5 children). However, most developmental research on visual word recognition and letter processing has been conducted in English or other Indo-European languages that employ the Roman alphabet (e.g., Grainger, Lété, Bertrand, Dufau, & Ziegler, 2012; Nation, 2009). In the current study, we examined the role of visual letter similarity during the initial stages of word processing—using the masked priming technique—in young readers of an underrepresented language (namely, Arabic) that has two distinctive characteristics in terms of morphology and visual features.

First, as in other Semitic languages (e.g., Hebrew), words in Arabic are typically created by putting together a three-letter consonantal root that denotes the general meaning and a word pattern that indicates the specific inflectional/derived form. For instance, the consonantal root سبح, which means to swim (the Buckwalter transliteration is sbH), can be used to form a number of different words such as سباحة (swimming [sbAHp]; word pattern: CCACp, where the Cs denote the consonants from the root), سباح (swimmer [sbAH]; word pattern: CCAC), and مسبح (swimming pool [msbH]; word pattern: mCCC). The consonantal root appears to play a prevalent role during lexical access in Semitic languages. In fact, it has been claimed that lexical space in Semitic languages is organized morphologically, whereas it is organized orthographically in Indo-European languages (Frost, 2009). A key finding supporting this dissociation is that whereas masked morphological priming in lexical decision is sizable in Hebrew or Arabic adult readers (e.g., جميل - جمال [gmyl–gmAl] lovely–beauty; the root is جمل [gml] in both cases), masked orthographic priming effects with word/nonword primes tend to be null or minimal (as in the word pair خيمة - غيمة [xymp–gymp] tent–cloud; the roots are خيم [xym] and غيم [gym]) (see Frost, Kugler, Deutsch, & Forster, 2005, for evidence in Hebrew and Arabic; see also Velan & Frost, 2009). In contrast, masked orthographic priming is a highly replicable finding in Indo-European languages (Forster, Davis, Schoknecht, & Carter, 1987; see also Castles, Davis, Cavalot, & Forster, 2007, and Comesaña, Soares, Marcet, & Perea, 2016, for evidence with young readers). Nonetheless, recent studies with adult Arabic readers reported significant masked orthographic effects in Arabic under some circumstances (e.g., using the go/no-go variant of the lexical decision task; see Perea, Abu Mallouh, et al., 2013).

Second, Arabic is written in a right-to-left semicursive script in which some letters may be connected to the previous letter, thereby forming subwords (e.g., the word راحة [comfort; rAHp] is composed of three subwords: [r-A-Hp]). Importantly, most Arabic letters share their basic shape with at least one other letter and differ only in the number/position of diacritical points diacritical points (e.g., ض - ص; ظ - ط; غ - ع; ث - ت - ن - ب; ذ - د; خ - ح - ج; ق - ف; ش - س;ز - ر). As a result, many Arabic words look physically the same except for the presence/location of diacritical points (e.g., بحار [sailor; bHAr], بخار [steam; bxAr]). The evidence concerning the role of the visual similarity effect during the early stages of word processing with young readers in Arabic is very scarce. Perea, Abu Mallouh, et al. (2013) examined whether the ligation pattern of Arabic words plays a role during the early moments of word recognition with Grade 3 and Grade 6 children. They employed a masked priming lexical decision task in which the target words could be preceded by a morphologically related substituted-letter prime that kept the same ligation pattern (e.g.,كتزب - كتاب [ktzb–ktAb]) or not (كتخب – كتاب [ktxb–ktAb]). As a further control, an unrelated condition was also included (e.g., طيلر - كتاب [Tylr–ktAb]). Results showed slower word identification times in the unrelated condition than in the morphologically related conditions, but there were no differences due to the ligation pattern. The authors concluded that young developing readers have fast access to the word's abstract representations over and above the ligation pattern. A potential limitation of Perea, Abu Mallouh et al.'s (2013) experiment is that the morphological priming effect could have produced a ceiling effect, thereby obscuring the potential role of visual similarity; nonetheless, a parallel experiment with adult readers that included the identity condition (their Experiment 3) showed an advantage of the identity condition over the morphologically related condition.

A more direct approach to examine visual similarity effects during word processing in Arabic is not in terms of the ligation pattern of the words but rather in terms of visual letter similarity (e.g., *nevtral* and *docurnent* may be initially processed as *neutral* and *document,* respectively; see Marcet & Perea, 2017; Marcet & Perea, in press, for evidence with the Roman alphabet). As indicated above, many Arabic letters differ from other letters solely in the number/position of diacritical marks. In a masked priming lexical decision experiment with adult readers, Perea, Abu Mallouh, Mohammed, Khalifa, and Carreiras (2016) employed substituted-letter primes that kept the same shape as the replaced letter and differed only in the number/position of the diacritical points (e.g., صخفية – صحفية [SHfyp–Sxfyp]) and substituted-letter primes that had a different shape from the replaced letter (e.g., سكفية – صحفية [SHfyp–Skfyp]). (In all cases, the replaced letter was a letter from the consonantal root.) As a control, an identity priming condition was employed (e.g.,صحفية - صحفية [SHfyp–SHfyp]). Results showed remarkably similar word identification times in the two replaced-letter conditions, which in turn produced slower word identification times than the identity condition. Perea et al. (2016) concluded that adult Arabic readers are able to process the letter's diacritical points very quickly (see Wiley, Wilson, & Rapp, 2016, for a pivotal role of diacritical points with Arabic readers in a same–different task with pairs of letters). A potential limitation of this study was the lack of an unrelated condition. That is, it could be argued that there could have been a floor effect due to the fact that the replaced-letter pairs did not share the consonantal root with the target word. Furthermore, one important remaining question is whether the effects of visual letter similarity on masked orthographic priming can be obtained with normally developing young readers of Arabic.

The two main goals of the current lexical decision experiment, therefore, were to examine whether sharing the letters of the consonantal root is a requisite for masked priming effects to occur with normally developing young readers (fifth graders) of a Semitic language (Arabic) and whether these masked priming effects are modulated by visual letter similarity. To that end, we created two orthographically related priming conditions for each target word: one in which a letter from the consonantal root was replaced by another letter that kept the same shape (same-shape substituted-letter condition; e.g., خـ → حـ in the pair خدمة -حدمة [service خدمة; the transliteration of the pair is Hdmp–xdmp]) and another in which a letter from the consonantal root was replaced by a letter with a different shape but kept the same subword structure (different-shape substituted-letter condition; e.g., خـ → فـ in the pair فدمة – خدمة [fdmp–xdmp). Clearly, with developing readers, if there is some degree of uncertainty in processing the letters' diacritical marks during the early moments of word processing (i.e., حدمة could be processed as خدمة), one would expect an advantage of the same-shape substituted-letter condition over the different-shape substituted-letter condition. Alternatively, if developing readers are able to quickly process the diacritical marks, the visually similar prime حدمة would not be more effective than the visually dissimilar prime فدمة at activating the word خدمة. Furthermore, we used two control conditions. One was the identity condition. This allowed us to examine the degree of activation of the orthographically related conditions relative to the identity condition (e.g., خدمة - خدمة). The other[1] was the unrelated condition (e.g.,سكاب – خدمة [skAb–xdmp]). This allowed us to examine the degree of activation of the orthographically related conditions relative to the unrelated condition (i.e., the effect of masked orthographic priming). If, as argued by Frost (2009), lexical space in Semitic languages is organized morphologically via the consonantal root (e.g., the letters *xdm* in the word *xdmp* [service]), orthographic (but not morphological) letter primes (e.g., *Hdmp*) should not be more effective at activating the target word than an unrelated prime (e.g., skAb). Alternatively, if the difference in word processing between Semitic and Indo-European languages is more quantitative

[1] For word trials, identity primes were words, whereas the orthographically related primes were pseudowords; the number of word pairs such as بحار and بخار is very small. Of note, prior research in the Roman alphabet has reported slightly faster word response times for word targets when preceded by an identity prime than when preceded by a visually similar pseudoword prime (e.g., document-DOCUMENT vs. docurnent-DOCUMENT; Marcet & Perea, 2017; Marcet & Perea, in press).

(e.g., more dense lexical space in Semitic languages) than qualitative, a processing advantage of the orthographically related conditions over the unrelated condition could be expected.

We employed the go/no-go variant of the lexical decision task because it produces shorter word identification times and higher accuracy rates than the two-choice variant in developing readers (see Perea, Soares, & Comesaña, 2013). Furthermore, Perea, Soares, et al. (2013) found sizable masked orthographic priming effects with adult readers in Arabic using this procedure. Finally, because Arabic does not have a lowercase/uppercase distinction, and to minimize visual continuity between primes and targets, the primes were presented in a smaller size than the targets (see Frost, Kugler, Deutsch, & Forster, 2005; Perea, Abu Mallouh, et al., 2013; Perea et al., 2016, for the same procedure).

Method

Participants

A total of 32 Grade 5 children of (11 or 12 years old, all boys) from a public school in Qatar participated in the experiment, which took place at the end of the academic year. All participants were native speakers of Arabic and had normal or corrected-to-normal vision. None of them had any learning or reading difficulties. Children's parents signed an informed consent form before the experiment.

Materials

We extracted 180 Arabic five-letter words from textbooks aimed at primary school in Qatar. To verify that Grade 5 children knew the words, we asked four children from Grade 4 in Qatar (i.e., a lower grade than the participants in the experiment) to read and give the meanings of the words. None of them had any problems indicating the meanings of these words. We also presented the list of words to two primary school teachers to verify that Grade 5 children would know the words. The average frequency per million of these words in the Modern Standard Arabic database (Aralex; Boudelaa & Marslen-Wilson, 2010) was 26.9 (range = 0.03–360.4). Each selected word had critical pairs of letters with the same basic shape (e.g., خ - ح; ق - ف; ش - س; ن - ب). The prime–target conditions were as follows. First, the prime was the same as the target (e.g., خدمة - خدمة [xdmp–xdmp] service; identity condition; the root is خدم [xdm]). Second, the prime was a pseudoword created by substituting a letter from the consonantal root that kept the same shape (e.g., حدمة – خدمة [Hdmp–xdmp]; same-shape replaced-letter condition). Third, the prime was a pseudoword created by substituting a letter from the consonantal root that had a different shape but kept the ligation pattern (e.g., فدمة – خدمة [fdmp–xdmp]; different-shape substituted-letter condition). Finally, the prime was an unrelated pseudoword (e.g., سكاب – خدمة [skAb–xdmp]; unrelated condition). (Given the difficulty of creating the pseudoword primes, three of the primes were actually infrequent Arabic words that probably were unknown to the children; excluding these trials did not affect the pattern of findings.) We rotated the four prime–target conditions across each list in a Latin square manner. Eight participants were assigned to each of the four lists; they received 45 items per condition (4320 data points overall). For the purposes of the lexical decision task, we also created 180 five-letter pseudowords (e.g., حمهر, مائس) that contained the same critical pairs of letters as the word stimuli. For these pseudoword trials, we created prime stimuli with the same characteristics as those for word trials. The entire set of stimuli is presented in the online supplementary material.

Procedure

The experiment took place in a silent room equipped with a computer running DMDX (Forster & Forster, 2003). Each trial had the following sequence: (1) a 500-ms pattern mask (i.e., a series of # symbols), (2) a 50-ms prime stimulus in DejaVu 14-point Sans Mono, and (3) a target stimulus in DejaVu 28-point Sans Mono that was displayed until the participant's response or 2 s had elapsed. All stimuli were presented in the center of the computer monitor. Participants were told to press the "yes" button if the letter string was an Arabic word and to withhold the response otherwise. Both speed and accuracy were stressed in the instructions. The 360 experimental trials were preceded by a short practice phase consisting of 16 trials. To minimize tiredness, we included short breaks every 90 trials. Each participant received a random ordering of the stimuli. The session lasted for approximately 20 min.

Results

Very fast lexical decision responses (<250 ms; 11 data points) and incorrect responses were removed from the response time (RT) analyses. Table 1 displays the mean correct lexical decision times (in milliseconds) and accuracy (in proportion) for word targets in each experimental condition (identity condition, same-shape substituted-letter priming condition, different-shape substituted-letter priming condition, or unrelated condition); for nonword targets (i.e., no-go trials), we indicated the accuracy in each condition.

To answer the research questions posed in the Introduction, we conducted three orthogonal contrasts using linear mixed-effects models with prime–target relationship as a fixed factor in the design. First, is there an advantage of the identity condition over the form-related conditions? (identity condition vs. substituted-letter conditions). Second, is there a visual letter-similarity effect for the orthographically related primes? (same-shape substituted-letter prime condition vs. different-shape substituted-letter condition). Third, is there an orthographic priming effect? (substituted-letter conditions vs. unrelated condition). The number of data points in the RT analyses was 5388. To maintain the normality assumption of linear mixed-effects models, RTs were inverse-transformed (-1000/RT). The model included prime–target as a fixed factor with the above-cited orthogonal contrasts with a maximal random effect structure of participants and items. These analyses were conducted in R using the packages *lme4* (Bates, Maechler, Bolker, & Walker, 2015) and *lmerTest* (Kuznetsova, Brockhoff, & Christensen, 2016).

Question 1: Identity versus orthographically related conditions

Word recognition times were, on average, 16.5 ms faster when preceded by the identity prime than when preceded by the form-related prime, $t = -3.67$, $b = -0.06$, $SE = 0.02$, $p < .001$.

Question 2: Visual similarity effects in orthographically related conditions

On average, lexical decision times were virtually the same for those words preceded by a replaced-letter visually similar prime and those words preceded by a replaced-letter visually dissimilar prime (667 vs. 668 ms, respectively), $t < 1.1$, $p > .29$.

Question 3: Orthographically related versus unrelated conditions

Word identification times were, on average, 21.5 ms faster when preceded by an orthographically related prime than when preceded by an unrelated prime, $t = 5.42$, $b = 0.067$, $SE = 0.01$, $p < .001$.

The statistical analyses of the accuracy data on word trials and nonword trials were similar to those described above except that we employed the *glmer* function in R. None of the contrasts approached significance, all *ps* > .21.

Discussion

The main findings of the current masked priming experiment with Grade 5 children in Arabic are as follows. First, we found a sizable 21.5-ms masked orthographic priming effect (e.g., فدمة – خدمة [fdmp–xdmp] is recognized faster than سكاب – خدمة [skAb–xdmp]), thereby showing that the consonantal root is not critical for the initial contact to lexical entries in developing readers of Arabic. Second, word identification times were similar for those target words that were preceded by a same-shape substituted-letter prime (حدمة – خدمة [Hdmp–xdmp]) and by a different-shape substituted-letter

Table 1
Mean response times and accuracy for words and nonwords in the four prime–target conditions of the experiment.

	Identity	Same shape, substituted letter	Different shape, substituted letter	Unrelated
Words				
RT (ms)	651 (25)	667 (29)	668 (26)	689 (24)
Accuracy	.931 (.009)	.940 (.010)	.942 (.006)	.937 (.007)
Nonwords				
RT (ms)	–	–	–	–
Accuracy	.913 (.012)	.910 (.014)	.919 (.011)	.915 (.009)

Note. Standard errors are in parentheses. RT, response time.

prime (خدمة – فدمة [fdmp–xdmp]), thereby showing that participants had access to abstract letter/word representations not mediated by visual letter similarity—at least not in terms of letter shape. Third, the two orthographically related conditions produced longer word RTs than the identity condition, thereby showing that the cognitive system was sensitive to the full match of all the letters from the prime stimuli.

As indicated in the Introduction, a common claim in the literature on visual word recognition and reading is that lexical space of Semitic languages is organized differently from that of Indo-European languages (see Frost, 2009). A benchmark finding supporting this view is that, unlike Indo-European languages, masked orthographic priming is absent—or minimal—in Hebrew and Arabic (Frost, 2009; Frost et al., 2005). However, we found a statistically robust 21.5-ms masked orthographic priming effect with developing readers in Arabic; this extends the findings reported by Perea, Mallouh, and Carreiras (2014) with adult readers in Arabic. Furthermore, the magnitude of the effect is similar to that obtained in prior orthographic priming experiments with developing readers in Indo-European languages (e.g., see Comesaña et al., 2016). Therefore, sharing the root letters is not necessary to access whole-word units in Arabic. Taken together, the data from adults and developing children suggest that any potential differences between masked priming effects in Semitic and Indo-European words are not qualitative. Indeed, there is evidence suggesting that the mechanisms underlying visual word recognition are also similar in other writing systems (e.g., the hiragana and katakana scripts of Japanese; see Okano, Grainger, & Holcomb, 2013).

Another key question of the current experiment was whether masked orthographic priming was modulated by visual letter similarity in developing readers. To shed some light on this issue, we employed two orthographically related conditions: one in which the replaced letter kept the same shape as the original letter (i.e., the only difference was the number/position of diacritical points) and another condition in which the replaced letter was visually different (e.g., خدمة – حدمة vs. خدمة – فدمة). Results showed virtually the same word identification times in these two conditions, thereby replicating the findings reported by Perea et al. (2016) with adult Arabic readers. These results suggest that diacritical points are particularly important when processing words in Arabic, and this is so even with young readers. Bear in mind that lack of processing of diacritical points would produce a large amount of uncertainty in the word recognition system. Further research should examine whether this pattern holds for beginning readers of Arabic or for adult readers of an Indo-European language acquiring Arabic as a second language. Importantly, Carreiras, Perea, and Abu Mallouh (2012) and Carreiras, Perea, Gil-López, Abu Mallouh, and Salillas (2013) investigated whether visual form influenced letter processing in the Arabic alphabet by using masked priming paradigms with isolated letters that had a different letter shape depending on the position within a word. Whereas Carreiras et al. (2012) showed masked repetition priming effects of the same magnitude for letter pairs with similar and dissimilar visual features, Carreiras et al. (2013) showed an early transient effect of visual similarity in early components (P/N150), followed by an effect of abstract letter priming in a later component (P300) in adult skilled readers. Therefore, it is possible that effects of visual letter similarity can occur in skilled Arabic readers at early stages of processing, but they can be weaker at later stages of processing or when processing becomes more complex (e.g., during the processing of whole words as compared with isolated letters). A masked priming experiment in which the participants' event-related potentials are recorded would be necessary to test this hypothesis.

To sum up, we found that masked orthographic priming can be readily obtained in Arabic with developing readers, hence suggesting that the word identification stream in Semitic and Indo-European languages is more similar than previously thought. Furthermore, typically developing Arabic readers are able to quickly and effectively process the diacritical marks of Arabic letters. Additional longitudinal research with children and/or adults learning to read Arabic is necessary to establish the mechanisms underlying the processing of diacritical points during letter and word recognition.

Acknowledgments

This article was made possible by a National Priorities Research Program (NPRP) award (Grant No. 6-378-5-035z) from the Qatar National Research Fund (a member of the Qatar Foundation). The statements made herein are solely the responsibility of the authors.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jecp.2017.12.004.

References

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*, 1–48.
Boudelaa, S., & Marslen-Wilson, W. D. (2010). Aralex: A lexical database for Modern Standard Arabic. *Behavior Research Methods, 42*, 481–487.
Bowers, J. S., Vigliocco, G., & Haan, R. (1998). Orthographic, phonological, and articulatory contributions to masked letter and word priming. *Journal of Experimental Psychology: Human Perception and Performance, 24*, 1705–1719.
Carreiras, M., Perea, M., & Abu Mallouh, R. (2012). Priming of abstract letter representations may be universal: The case of Arabic. *Psychonomic Bulletin and Review, 19*, 685–690.
Carreiras, M., Perea, M., Gil-López, C., Abu Mallouh, R., & Salillas, E. (2013). Neural correlates of visual vs. abstract letter processing in Roman and Arabic scripts. *Journal of Cognitive Neuroscience, 25*, 1975–1985.
Castles, A., Davis, C., Cavalot, P., & Forster, K. (2007). Tracking the acquisition of orthographic skills in developing readers: Masked priming effects. *Journal of experimental child psychology, 97*, 165–182.
Comesaña, M., Soares, A. P., Marcet, A., & Perea, M. (2016). On the nature of consonant/vowel differences in letter position coding: Evidence from developing and adult readers. *British Journal of Psychology, 107*, 651–674.
Forster, K. I., Davis, C., Schoknecht, C., & Carter, R. (1987). Masked priming with graphemically related forms: Repetition or partial activation? *Quarterly Journal of Experimental Psychology, 39*, 211–251.
Forster, K. I., & Forster, J. C. (2003). DMDX: A windows display program with millisecond accuracy. *Behavior Research Methods, 35*, 116–124.
Frost, R. (2009). Reading in Hebrew vs. Reading in English: Is there a qualitative difference? In K. Pugh & P. McCradle (Eds.), *How children learn to read: Current issues and new directions in the integration of cognition, neurobiology and genetics of reading and dyslexia research and practice* (pp. 235–254). New York: Psychology Press.
Frost, R., Kugler, T., Deutsch, A., & Forster, K. I. (2005). Orthographic structure versus morphological structure: Principles of lexical organization in a given language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1293–1326.
Grainger, J., Dufau, S., & Ziegler, J. C. (2016). A vision of reading. *Trends in Cognitive Sciences, 20*, 171–179. https://doi.org/10.1016/j.tics.2015.12.008.
Grainger, J., Lété, B., Bertrand, D., Dufau, S., & Ziegler, J. C. (2012). Evidence for multiple routes in learning to read. *Cognition, 123*, 280–292.
Jacobs, A. M., Grainger, J., & Ferrand, L. (1995). The incremental priming technique: A method for determining within-condition priming effects. *Perception & Psychophysics, 57*, 1101–1110.
Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2016). lmerTest: Tests for random and fixed effects for linear mixed effect models [lmer objects of lme4 package]. Version 2.0-36. <https://CRAN.R-project.org/package=lmerTest>.
Marcet, A., & Perea, M. (in press). Can I order a burger at rncdonalds.com? Visual similarity effects of multi-letter combinations at the early stages of word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Advance online publication. http://doi.org/10.1037/xlm0000477.
Marcet, A., & Perea, M. (2017). Is nevtral NEUTRAL? Visual similarity effects in the early phases of written-word recognition. *Psychonomic Bulletin & Review, 24*, 1180–1185.
Nation, K. (2009). Form-meaning links in the development of visual word recognition. *Philosophical Transactions of the Royal Society B: Biological Sciences, 364*, 3665–3674.
Okano, K., Grainger, J., & Holcomb, P. J. (2013). An ERP investigation of visual word recognition in syllabary scripts. *Cognitive, Affective, & Behavioral Neuroscience, 13*, 390–404.
Perea, M., Abu Mallouh, R., & Carreiras, M. (2013). Early access to abstract representations in developing readers: Evidence from masked priming. *Developmental Science, 16*, 564–573.
Perea, M., Abu Mallouh, R., Mohammed, A., Khalifa, B., & Carreiras, M. (2016). Do diacritical marks play a role at the early stages of word recognition in Arabic? *Frontiers in Psychology, 7*. https://doi.org/10.3389/fpsyg.2016.01255.

Perea, M., Jiménez, M., & Gómez, P. (2015). Do young readers have fast access to abstract lexical representations? Evidence from masked priming. *Journal of Experimental Child Psychology, 129*, 140–147.
Perea, M., Mallouh, Abu., & Carreiras, M. (2014). Are root letters compulsory for lexical access in Semitic languages? The case of masked form-priming in Arabic. *Cognition, 132*, 491–500.
Perea, M., Soares, A. P., & Comesaña, M. (2013). Contextual diversity is a main determinant of word-identification times in young readers. *Journal of Experimental Child Psychology, 116*, 37–44.
Velan, H., & Frost, R. (2009). Letter-transposition effects are not universal: The impact of transposing letters in Hebrew. *Journal of Memory and Language, 61*, 285–302.
Wiley, R. W., Wilson, C., & Rapp, B. (2016). The effects of alphabet and expertise on letter perception. *Journal of Experimental Psychology: Human Perception and Performance, 42*, 1186–1203.