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Can the First Letter Advantage Be Shaped by Script-Specific Characteristics?

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We examined whether the first letter advantage that has been reported in the Roman script disappears, or even reverses, depending on the characteristics of the orthography. We chose Thai because it has several "nonaligned" vowels that are written prior to the consonant but phonologically follow it in speech (e.g., แฟน <ɛ:fn> is spoken as /fɛ:n/) whereas other "aligned" vowels are written and spoken in a corresponding order, as occurs in English (e.g., ฟาก <fa:k> is spoken as /fa:k/). We employed the forced choice decision paradigm of Adelman, Marquis, and Sabatos-DeVito (2010) to examine letter identification across letter positions in 3- and 4-letter Thai legal nonword pairs. Results showed an advantage of the initial letter position for the aligned legal nonwords, as occurs in Roman script (e.g., Scaltritti & Balota, 2013). However, for the nonaligned legal nonwords, an advantage of second letter position was found which is in line with the characteristics of these types of stimuli: the critical initial consonant occurs in the second letter position. These results highlight the importance of the initial phonological letter in Thai, which is crucial for mapping orthography to phonology and for lexical access. In conclusion, these results illustrate that initial letter advantage can be shaped by the characteristics of the orthography.

Keywords: initial letter advantage, letter position processing, nonaligned vowels, visual-word recognition, Thai

In a series of experiments, Scaltritti and Balota (2013; see also Aschenbrenner, Balota, Weigand, Scaltrittri, & Besner, 2017) employed a paradigm similar to that used by Adelman et al. (2010) to investigate accuracy in letter identification and how it varies depending on the position within the word. This paradigm involves a forced choice decision between two alternative words; one corresponding to the briefly presented target word and the other representing a distracter word. In this paradigm, the target and the distracter pairs systematically vary by a single letter in each of the positions in the word or nonword (e.g., for first position the words *lung* vs. *sung*, for second position *salt* vs. *silt*, etc.). Scaltritti and Balota (2013) using three- to six-letter words, legal nonwords, consonant letter strings, and symbol strings found evidence for an initial letter advantage selectively for all word and letter-related stimuli (i.e., legal nonwords and consonant letter strings), but not for symbols.

An initial letter advantage has also been found in Roman script when participants identify briefly presented strings of five consonant letters (e.g., T G H K N) using a two-alternative forced choice (2AFC) procedure (Tydgat & Grainger, 2009; Winskel, Perea, & Peart, 2014; Ziegler, Pech-Georgel, Dufau, & Grainger, 2010). In the 2AFC procedure, a string of five characters is briefly presented followed by a choice of two characters, one occurring above and one below one of the characters in the array. The task is to select which of the two characters had occurred in that particular position in the string of five characters. A W-shaped serial position function and initial letter advantage (and, to a lesser extent, a final letter advantage) has been found in Roman script (Tydgat & Grainger, 2009; Winskel et al., 2014; Ziegler et al., 2010). In contrast, a Λ-shaped serial position function is typically found when identifying symbols or shapes (e.g., & @ $ % <) (Tydgat & Grainger, 2009; Winskel et al., 2014; Ziegler et al., 2010). With symbols, identification accuracy is optimal at the central letter position of fixation and declines as distance from the central position increases. Thus, a marked difference in how Roman script letters and symbols are processed was found (see Grainger, Dufau, & Ziegler, 2016, for a more detailed discussion).

The Modified Receptive Field (MRF) theory (Tydgat & Grainger, 2009) was formulated to account for this letter/symbol dissociation and for the initial letter advantage. Tydgat and Grainger (2009) posited that an adaptive process occurs while children are learning to read and identify letters in the extremely crowded conditions associ-

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ated with the orthography being learned. According to this theory, smaller receptive field sizes develop as reading skills become more attuned during the acquisition process. This particularly applies to the initial position letter in Roman script, as it provides crucial information about word identity in comparison to other letter positions. When the orthographic code is converted into phonological code, the initial letter plays a key role in lexical access (see Perry, Ziegler, & Zorzi, 2007; Tydgat & Grainger, 2009).

An open question is whether the first letter advantage that has been reported in the Roman script disappears, or even reverses, depending on the characteristics of the orthography. In the present experiment, we employed Thai. Thai has a distinctive alphabetic orthography, which makes interesting comparisons with other languages that use Roman script. Thai shares some common characteristics with other Brahmi-derived scripts. It has syllabic characteristics as it has inherent vowels for some consonants. Furthermore, it has a nonlinear configuration in that consonants are written in a linear order, but vowels can be written above, below, or to either side of the consonant as full letters or diacritics, and which commonly combine across the syllable to produce a single vowel or diphthong. Similar to Roman script, Thai is read from left to right. These Brahmi-derived scripts have been termed "alphasyllabaries" as they have hybrid characteristics of both alphabetic and syllabic scripts (Bright, 2000; Daniels & Bright, 1996). Notably, Thai is also a tonal language and does not normally have interword spaces, hence when reading, words have to be segmented using other cues besides spaces (for more detailed discussion of the characteristics of Thai refer to Winskel, 2014; Winskel & Iemwanthong, 2010).

Winskel et al. (2014) conducted a similar experiment to Tydgat and Grainger (2009) but with Thai and English native speakers with Roman script consonant letters, Thai consonant letters, and symbols. In the English participants with no knowledge of Thai, Winskel et al. (2014) found an initial letter advantage for Roman letters, whereas this effect did not occur for symbols or Thai letters—there was a Λ shaped function. In the Thai participants, Winskel et al. (2014) found that the pattern for Thai letters, Roman letters and symbols displayed a remarkably similar linear trend. Thus, while Winskel et al. (2014) observed qualified support for the MRF theory for Thai participants, in that they found an advantage for initial position in Thai, this effect also applied to symbols. These results suggest that a specialized orthography-specific adaptive mechanism for reading in Thai has developed.

Of particular relevance to the current study is that the orthographic order of vowels in Thai does not necessarily correspond to the phonological order. There are five commonly used vowels (i.e., เ/e:/, แ/ɛ:/, โ/o:/, ไ /aj/, ใ /aj/) that precede the consonant in writing but phonologically follow it in speech (e.g., แฟน <ɛ:fn > →/fɛ:n/) whereas other vowels are spoken in the order that they are written, as occurs in English (e.g., ฟาก <fa:k > →/fa:k/). In this paper, they are termed "nonaligned" and "aligned" vowel words/nonwords respectively. It can be seen that in these nonaligned vowel words, the initial consonant occurs in second letter position. This nonalignment of vowels is a characteristic shared by other Brahmi-derived scripts (e.g., Devanagari, Kannada, Sinhala and Burmese). This implies that letter position coding in Thai needs to be flexible enough so that readers can appropriately encode the letter positions of words with or without these types of vowels. Previous research on Thai indicates that the role played by the initial letter in Thai is not as critical as in other languages. Winskel, Perea, and Ratitamkul (2012) examined if initial letters have a privileged position in comparison to internal letters during normal silent reading while eye movements were monitored. Participants read sentences with target words with internal (for example, *porblem*) and external (e.g., *rpoblem*) transposed letters. Results revealed that there was no apparent difference in degree of disruption caused when reading internal and initial transposed-letter pseudowords. This was in marked contrast with results found in Roman script where greater disruption was caused by initial than internal transpositions (e.g., White, Johnson, Liversedge, & Rayner, 2008; see also Perea, Winskel, & Gomez, 2017, for an examination of the modeling differences between English and Thai in letter position coding).

The primary aim of the present study is to investigate how accuracy in letter identification varies as a function of the location in Thai legal nonwords using the experimental paradigm of Adelman et al. (2010). Legal nonwords were used as it was not possible to construct minimal pair words with a similar number of aligned and nonaligned vowel words for all letter positions. Notably, Scaltritti and Balota (2013) found similar results with legal nonwords (Experiment 3) as they did with words (Experiments 1 and 2). In contrast to the Tydgat and Grainger paradigm, word level rather than single letter processing is emphasized in the Adelman et al. paradigm. Thus, through using this paradigm, we can gain greater insight into how letters in Thai are differentially recognized when attention is directed to whole-word or legal nonword representations.

In the current study, the stimuli were three-letter and four-letter legal nonwords. We were particularly interested in how the aligned and nonaligned vowel characteristics of Thai affect letter identification in the initial and second letter positions in three-letter and four-letter stimuli. Based on the MRF theory, one could expect an initial letter advantage for both aligned and nonaligned vowel words, as has been found in Roman script (e.g., Scaltritti & Balota, 2013). A second possibility, based on a slight modification of the MRF theory, is that an adaptive mechanism could occur that encompasses both first and second letter positions leading to a similar advantage of both letter positions. Finally, a third option, based on the proposal put forward by Aschenbrenner et al. (2017)—they reported a first position advantage in the Roman script even when vertically and horizontally presented items are intermixed—is that there is a rapid and flexible spatial attentional mechanism that directs attention toward the useful initial letter of the string of letters regardless of orientation or, in the current scenario, position. As the critical initial consonant occurs in the second letter position in the nonaligned vowel nonwords in Thai, one could predict an initial letter advantage for aligned vowel nonwords, but a second letter position advantage for nonaligned vowel nonwords. In order to test these hypotheses, we will primarily focus on the first and second letter positions.

Method

Participants

Forty students from Chulalongkorn University in Bangkok participated in the experiment. All were native Thai speakers and reported normal or corrected-to-normal vision.

Materials

Stimuli consisted of three- and four-letter legal nonwords. Half the stimuli in each position had aligned vowel nonwords and half had nonaligned vowel nonwords. The legal nonwords were created by substituting one or two letters of real words. Their status was also checked by Thai linguists. Within each pair of nonwords, the two nonwords differed by only one letter at each position (see Table 1, for examples of the pairs selected). One hundred fifty-four pairs of nonwords were selected as stimuli (see Table A1 and Table A2 in Appendix). The two pairs of nonwords were separated into two different lists, such that one of the nonwords served as the target and the other nonword as the distracter. The lists were counterbalanced across participants. The location of targets and distracters in the two-alternative forced choice was counterbalanced, so that each nonword appeared equally often as a response alternative in the right and left visual field.

Procedure

Each trial started with a forward mask consisting of a string of six hash marks (######) displayed at the center of the screen. The procedure was similar to that used by Scaltritti and Balota (2013). After 500 ms, the forward mask was replaced by the target word, which stayed on the screen for 33 ms, which was followed by a blank screen of 17 ms. The backward mask was then presented in conjunction with the two response alternatives, which were presented below the backward mask, one in the left and one in the right visual field. The experimental procedure is schematically represented in Figure 1. The two response alternatives remained on the screen until the participant pressed the response key. If no response was detected, the display was terminated after 3,000 ms. The experimental session lasted about 15 min.

Participants were told that a stimulus would be briefly displayed and that their task was to choose between the two subsequently presented nonwords, which target was previously presented by pressing the right key when the correct alternative is placed at the left of fixation and the left key when it is placed at the right of fixation. Participants were also instructed to guess if they were not sure of the correct response. Accuracy was emphasized, but they were also encouraged to make their response as quickly as possible. Ethics approval was received from the institutional review board.

Results

Mean response times and accuracy data per condition were analyzed across participants (*F*1) and items (*F*2). In order to examine first and second letter positions in the aligned and nonaligned nonword types, a nonword type (aligned, nonaligned) by letter position (first letter, second letter) by length (three-letter nonwords, four-letter nonwords) ANOVA was conducted to assess variations in accuracy and response times (RTs). (For the interested reader, the ANOVAs separately for three- and four-letter nonwords including all positions are presented in Appendix.) For analyses of response latencies, errors (18.83%) were not considered. RTs below 200 ms (0.03%) and above 1800 ms (3.03%) were excluded from the latency analyses. The factor List (list 1, list 2) was included in the statistical analyses to separate out the variance due to the lists (Pollatsek & Well, 1995).

For accuracy, there was a significant effect of nonword type, $F1\ (1, 39) = 9.43$, $p = .004$, $\eta_p^2 = .199$; $F2\ (1, 87) = 18.47$, $p < .001$, $\eta_p^2 = .101$, as participants were more accurate with aligned nonwords (.79) than nonaligned nonwords (.72), and for letter position, $F1\ (1, 39) = 11.25$, $p = .002$, $\eta_p^2 = .228$; $F2\ (1, 87) = 11.12$, $p = .001$, $\eta_p^2 = .063$, as participants were more accurate for second letter position (.79) than first letter position (.73). The effect of length was not significant (both $ps > .3$). We also found an interaction between length and nonword type, $F1\ (1, 39) = 8.79$, $p = .005$, $\eta_p^2 = .188$; $F2\ (1, 87) = 5.86$, $p = .016$, $\eta_p^2 = .021$. This was due to significantly greater accuracy for nonaligned three-letter nonwords (.75) than four-letter nonwords (.69) by-subjects, $F1\ (1, 39) = 7.20$, $p = .011$, $\eta_p^2 = .159$ but not by-items, $F2\ (1, 87) = 1.89$, $p = .172$, $\eta_p^2 = .024$ and to greater accuracy of aligned four-letter nonwords (.81) than nonaligned four-letter nonwords, $F1\ (1, 39) = 18.49$, $p < .001$, $\eta_p^2 = .327$; $F2\ (1, 87) = 14.53$, $p < .001$, $\eta_p^2 = .081$. Importantly, there was a significant interaction effect between nonword type and letter position, $F1\ (1, 39) = 60.90$, $p < .001$, $\eta_p^2 = .616$; $F2\ (1, 87) = 68.59$, $p < .001$, $\eta_p^2 = .295$. This interaction showed that, for the aligned nonwords, more accurate responses were made to first letter (.84) than second letter position (.75), $F1\ (1, 39) = 13.90$, $p = .001$, $\eta_p^2 = .268$; $F2\ (1, 43) = 18.83$, $p < .001$, $\eta_p^2 = .180$, but for the nonaligned nonwords, the reverse was the case as more accurate responses were made to second letter position (.82) than first letter position (.62), $F1\ (1, 39) = 54.66$, $p < .001$, $\eta_p^2 = .590$; $F2\ (1, 43) = 47.73$, $p <$

Table 1
Examples of Minimal Pair Legal Nonwords Used

Letter position	Three-letter aligned nonwords	Three-letter nonaligned nonwords	Four-letter aligned nonwords	Four-letter nonaligned nonwords
1	ยาต – ลาต <**ja:**t – **la:**t> /**ja:**t – **la:**t/	แยด – เยด <ɛ:jd – **e:**jd> /j**ɛ:**t – j**e:**t/	ขลาก – ปลาก <kʰl**a:**k – pl**a:**k> /kʰl**a:**k – pl**a:**k/	ไนมล – โนมล <**aj**nml – **o:**nml> /n**aj**mon – n**o:**mon/
2	ธาย – ธวย <tʰ**a:**j – tʰ**uaj**> /tʰ**a:**j – tʰ**uaj**/	เสจ – เทจ <**e:**stɕ – **e:**tʰtɕ> /s**e:**t – tʰ**e:**t/	มบาย – มหาย <mb**a:**j – mh**a:**j> /mab**a:**j – mah**a:**j/	เลวน – เดวน <**e**lwn – **e**dwn> /l**e**won – d**e**won/
3	ฝอง – ฝอด <fɔ:ŋ – f**ɔ:**d> /fɔ:ŋ – f**ɔ:**t/	แทม – แทก <**ɛ:**tʰm – **ɛ:**tʰk> /tʰ**ɛ:**m – tʰ**ɛ:**k/	คมอด – คมาด <kʰmɔ:d – kʰm**a:**d> /kʰamɔ:t – kʰam**a:**t/	เกทด – เกยด <**e:**ktʰt – **e:**kjt> /k**e:**tʰot – k**e:**jot/
4			หยอบ – หยอม <hj**ɔ:**b – hj**ɔ:**m> /j**ɔ:**p – j**ɔ:**m/	โขยม – โขยณ <**o:**kʰjm – **o:**kʰjn> /kʰ**o:**jom – kʰ**o:**jon/

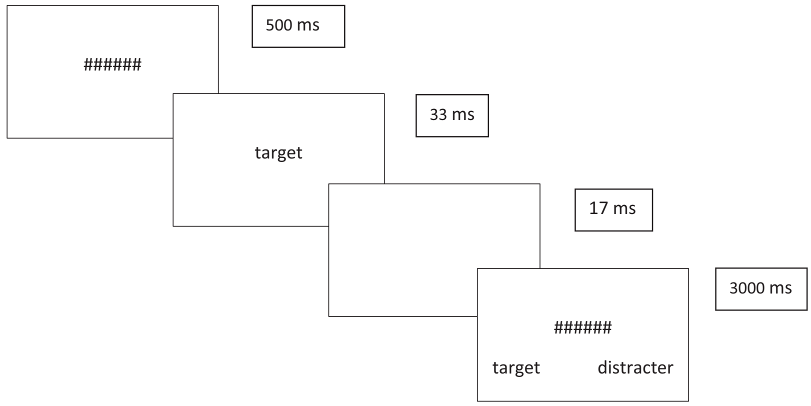

Figure 1. Representation of the experimental procedure. Stimuli and masks were displayed in Courier Proportional Thai 24 point font.

.001, $\eta_p^2 = .380$. Finally, the interaction between length, nonword type and letter position was significant in the analysis by participants, $F1$ (1, 39) = 8.29, $p = .007$, $\eta_p^2 = .179$; $F2$ (1, 87) = 2.72, $p = .067$, $\eta_p^2 = .020$ —as can be seen in Table 2, the interaction between nonword type and letter position was more pronounced for four-letter nonwords, $F1$ (1, 39) = 69.63, $p < .001$, $\eta_p^2 = .647$; $F2$ (1, 87) = 58,95, $p < .001$, $\eta_p^2 = .424$, than for three-letter nonwords $F1$ (1, 39) = 21.67, $p < .001$, $\eta_p^2 = .363$; $F2$ (1, 87) = 19.05, $p < .001$, $\eta_p^2 = .185$.

For response times, nonword type was not significant (ps > .2) and letter position was not significant (ps > .7). There was a significant effect of length, $F1$ (1, 39) = 9.97, $p < .003$, $\eta_p^2 = .208$; $F2$ (1, 87) = 7.90, $p = .006$, $\eta_p^2 = .048$, which was due to shorter response times to the three-letter nonwords (998 ms) than four-letter nonwords (1,012 ms). The interaction between length and nonword type approached significance in the by-subjects analysis, $F1$ (1, 39) = 3.66, $p = .063$, $\eta_p^2 = .088$ but not in the by-items analysis, $F2$ (1, 87) = .42, $p = .518$. But the central finding was that, as occurred with the accuracy data, there was a significant interaction between nonword type and letter position, $F1$ (1, 39) = 44.72, $p < .001$, $\eta_p^2 = .541$; $F2$ (1, 87) = 57.26, $p < .001$, $\eta_p^2 = .259$. This interaction showed that, for the aligned words, faster responses were made to first letter (952 ms) than second letter position (1,041 ms), $F1$ (1, 39) = 32.30, $p < .001$, $\eta_p^2 = .459$; $F2$ (1, 43) = 30.29, $p < .001$, $\eta_p^2 = .260$, but for the nonaligned words, the reverse was the case as faster responses were made to second letter position (962 ms) than first letter position (1,045 ms), $F1$ (1, 39) = 26.53, $p < .001$, $\eta_p^2 = .411$; $F2$ (1, 43) = 27.14, $p <$ .001, $\eta_p^2 = .258$. Finally, we failed to find a significant interaction between length, nonword type, and letter position, $F1$ (1, 39) = 2.73, $p = .107$; $F2$ (1, 87) = 1.13, $p = .289$.

Table 2
Mean Proportion of Correct Responses for First Letter and Second Letter Position in the Aligned and Nonaligned Three-Letter and Four-Letter Legal Nonwords

Nonword type	Aligned nonwords: First letter position	Aligned nonwords: Second letter position	Nonaligned nonwords: First letter position	Nonaligned nonwords: Second letter position
3-letter nonwords	.82	.74	.68	.82
4-letter nonwords	.86	.76	.55	.83

Discussion

In the current study, the forced choice decision experimental paradigm of Adelman et al. (2010) was used to investigate letter identification accuracy in the various letter positions of three- and four-letter Thai legal nonword pairs. This paradigm emphasizes lexical rather than single letter processing and gives us greater insight into how letters are differentially recognized when attention is directed to whole-word or legal nonword representations. The results for the three- and four-letter aligned legal nonwords converged with previous findings for Roman script (Aschenbrenner et al., 2017; Scaltritti & Balota, 2013). In other words, there was an advantage of first letter position in comparison to the second letter position—or the other positions within the letter string. But the key finding was that, for the three- and four-letter nonaligned legal nonwords, a different pattern of results emerged. Instead of an advantage of the initial letter, an advantage of second letter position was found which is in line with the characteristics of these types of stimuli; the critical initial consonant occurs in second letter position. The interaction between nonword type and letter position was more pronounced for the longer four-letter than three-letter nonwords but, importantly, both the three- and the four-letter nonwords showed the same characteristic pattern.

These dissociative outcomes for aligned and nonaligned word types highlight the importance of the initial phonological letter of the word which in Thai can occur in either first or second letter positions (or with consonant clusters in third letter position). We must bear in mind that the initial phonological letter—which may occur in either position—is particularly important as it provides critical information for converting the orthographic codes into phonological codes. It appears that attentional focus may vary dependent on the position of the critical phonological letter in the word. According to the MRF theory (Tydgat & Grainger, 2009), smaller receptive field sizes develop as reading skills become more honed during the acquisition process. Based on a slight modification of the MRF theory, we predicted that an adaptive mechanism could occur such that accuracy on the first letter could be extended to the second letter position; however, we specifically found an initial letter advantage for the aligned nonwords and a second letter position advantage for the nonaligned nonwords. Thus, these results support the view that there is a selective attentional effect for the critical initial phonological letter in the aligned and nonaligned nonwords rather than a more general inclusive effect of first and second letter positions. The MRF theory can be modified so that it accounts for differences in position of the critical initial consonant letter in these types of scripts. Nonetheless, a more parsimonious account for the current data is that the MRF theory could be combined with the flexible spatial attentional mechanism proposed by Aschenbrenner et al. (2017), so that attention is directed toward the useful initial letter of the string of letters regardless of where it is located, that is, whether it occurs in initial, second or even third position. Another consideration is that the MRF hypothesis predicts that a left elongation of the receptive field for the leftmost character occurs in Roman script with its interword spaces. However, this might not be the case for scripts such as Thai without interword spaces. If we consider that the MRF hypothesis predicts that orthography-specific adaptive mechanisms/features of letter detectors develop over time with experience of learning to read a particular orthography (e.g., see Grainger, Bertrand, Lété, Beyersmann, & Ziegler, 2016; Tydgat & Grainger, 2009), then the MRF hypothesis would not necessarily predict a first-position advantage at all for Thai (thanks to an anonymous reviewer for this perspective).

In sum, the key finding of the current experiment is that the first letter advantage, which has been reported consistently in the Roman script, is not a universal phenomenon but rather it can be shaped by the characteristics of the orthography: while aligned legal nonwords in Thai (e.g., ฟาก <fa:k > →/fa:k/) show a first letter advantage, nonaligned legal nonwords in Thai (e.g., แฟน <ɛ:fn > →/fɛ:n/) show a second letter advantage instead. This demonstrates how the characteristic features of a script need to be incorporated into theories of how letters are initially processed.

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(*Appendix follows*)

Appendix

Separate Analyses for Three-Letter and Four-Letter Legal Nonwords

A nonword type (aligned, nonaligned) by letter position ANOVA was conducted separately for three-letter and four-letter legal nonwords, in order to assess variations in accuracy and response times (RTs) as a function of the letter position.

Three-Letter Nonwords

For accuracy, nonword type was not significant (*ps* > .1), and letter position was only marginally significant for subjects, $F1$ (1, 39) = 2.52, p = .087, η_p^2 = .062; $F2$ (1, 65) = 1.95, *nsd.* More important, there was an interaction effect between nonword type and letter position, $F1$ (2, 39) = 10.25, $p < .001$, η_p^2 = .212; $F2$ (2, 65) = 9.57, $p < .001$, η_p^2 = .138. For RTs, nonword type was not significant (*ps*>.2) and position was not significant (*ps* > .7). However, the nonword type by position interaction was significant, $F1$ (2, 39) = 11.08, $p < .001$, η_p^2 = .226; $F2$ (2, 65) = 14.24, $p < .001$, η_p^2 = .192.

It can be seen from the planned comparisons in Table 2 that for aligned nonwords, more correct responses were made in identifying letters in position 1 than positions 2 or 3. The response times were aligned with these results as shorter durations were found for identifying letter position 1 correctly than letter positions 2 or 3. In contrast, in the nonaligned nonwords, more correct responses were made to letter position 2 in comparison to positions 1 and 3. For latencies, there were significantly faster responses in identifying letter position 2 than position 1 nonwords correctly (see Figure A1).

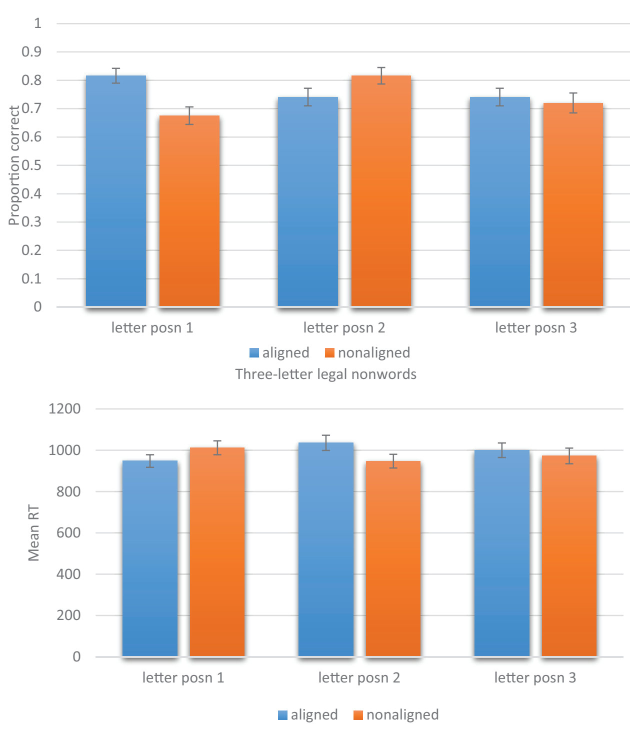

Figure A1. Mean proportion of correct responses and RTs (reaction time (RT)) in milliseconds for the different letter positions in three-letter aligned and nonaligned legal nonwords. Error bars represent standard error of the mean. See the online article for the color version of this figure.

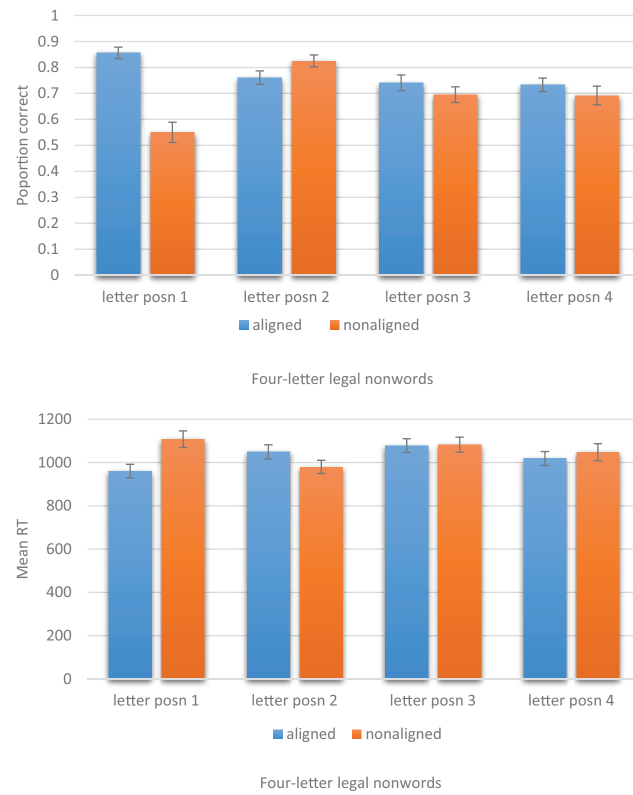

Figure A2. Mean proportion of correct responses and RTs (RT) in milliseconds for the different letter positions in aligned and nonaligned four-letter legal nonwords. Error bars represent standard error of the mean. See the online article for the color version of this figure.

Four-Letter Nonwords

For accuracy, nonword type was significant, $F1$ (1, 39) = 8.88, $p < .01$, η_p^2 = .189; $F2$ (1, 87) = 21.87, $p < .001$, η_p^2 = .125 and letter position was significant, $F1$ (3, 39) = 6.31, p = .001, η_p^2 = .142; $F2$ (3, 87) = 5.17, $p < .01$, η_p^2 = .092. There was an interaction effect between nonword type and letter position, $F1$ (3, 39) = 26.83, $p < .001$, η_p^2 = .414; $F2$ (3, 87) = 18.70, $p < .001$, η_p^2 = .268.

(*Appendices continue*)

Table A1
List of the Three-Letter Aligned and Nonaligned Nonword Pairs

1st Letter		2nd Letter		3rd Letter	
กรป	พรป	ทอพ	ทาพ	กอธ	กอล
สาพ	ถาพ	ธาย	ธวย	ฝอง	ฝอด
ยาต	ลาต	หาธ	หอธ	ธาย	ธาว
กาซ	พาซ	นาล	นอล	หอส	หอร
หอป	สอป	ลาข	ลอข	ชาพ	ชาศ
หาล	วาล	ฝวล	ฝาล	บาม	บาฉ
กวป	อวป	สวล	สาล	รอล	รอธ
มวต	รวต	นอส	นาส	ฉาล	ฉาท
สาธ	จาธ	ปอท	ปาท	คลบ	คลน
กอฟ	ลอฟ	กาค	กอค	อาล	อาท
ปลพ	สลพ	หยบ	หรบ	บาม	บาย
เรป	แรป	เรบ	เอบ	แหป	แหต
เมพ	แมพ	เสจ	เทจ	แสพ	แสล
ไนย	โนย	โกพ	โคพ	แฉน	แฉบ
แขล	เขล	แขป	แจป	ไขม	ไขร
เปจ	แปจ	เปว	เพว	เดย	เดม
แสม	เสม	เสอ	เหอ	แทม	แทก
แปม	เปม	แปข	แสข	แฟณ	แฟท
แยด	เยด	แยด	แมด	แฟว	แฟม
แถฉ	เถฉ	แวค	แถค	เลฟ	เลม
แสถ	เสถ	แสต	แกต	เสฟ	เสซ
เกฟ	แกฟ	เจย	เถย	แขธ	แขล

Table A2
List of the Four-Letter Aligned and Nonaligned Nonword Pairs

1st Letter		2nd Letter		3rd Letter		4th Letter	
พลาว	คลาว	มบาย	มหาย	หปาย	หปวย	ฝราน	ฝราค
ขลาก	ปลาก	หลาด	หนาด	สหวย	สหอย	กลาจ	กลาม
ปวาบ	กวาบ	พนาย	พจาย	พราณ	พรอณ	อวาย	อวาน
สลาฟ	หลาฟ	กลาท	กหาท	ตรวด	ตรอด	หมอต	หมอป
ชนวง	ฉนวง	ขหวม	ขรวม	หณอน	หณาน	ปลาง	ปลาม
ขลอน	ปลอน	ปราส	ปวาส	คมอด	คมาด	หลอง	หลอบ
ปรวด	ครวด	ครอด	คจอด	สะบัม	สะพัม	วรรม	วรรพ
กรอน	ตรอน	ครอย	คบอย	สาทัพ	สารัพ	ควอก	ควอม
ผยอส	สยอส	สหาน	สงาน	หงาพ	หงอพ	พลาส	พลาจ
หนาพ	สนาฟ	อธอย	อมอย	หมอร	หมวร	หยอบ	หยอม
ขยาบ	สยาบ	ธก้รม	ธม้รม	หพ้าด	หพ้อด	กลอบ	กลอณ
เหจา	แหจา	เลี้ยป	เบี้ยป	เฉล้า	เฉย้า	โขยม	โขยณ
เหว่า	แหว่า	แสลม	แถลม	แหล่ล	แหว่ล	เสียก	เสียล
แวล่ง	เวล่ง	แหนก	แสนก	แหมม	แหวม	เหลบ	เหลง
แบยง	เบยง	เลวน	เดวน	แวกท	แวขท	เปรข	เปรพ
แยบก	เยบก	เกือน	เซือน	แสกง	แสธง	เตือป	เตือฟ
เหลด	แหลด	เอี้ยป	เคี้ยป	แนบก	แนลก	แคยป	แคยฟ
โธยง	ใธยง	เปยก	เฟยก	เหกล	เหธล	เหมง	เหมบ
เกบง	แกบง	เหรว	เกลว	แธยง	แธทง	แกลม	แกลพ
เจปด	แจปด	เตียฟ	เถียฟ	เกทด	เกยด	แถลฟ	แถลธ
เลบก	แลบก	โตงด	โฉงด	เจสด	เจปด	เสอส	เสอร
ไนมล	โนมล	โกพง	โคพง	แฉสน	แฉมน	แฉนม	แฉมบ

(*Appendices continue*)

Table A3
Planned Comparisons for Proportions of Correct Responses and Reaction Times (RT) Between Different Positions of Target-Distractor Match With Each Legal Nonword Aligned and Nonaligned Vowel Word Type

Nonword length and positions of mismatch	Accuracy		RT	
	*F*1	*F*2	*F*1	*F*2
Three-letter legal nonwords - aligned				
1 vs. 2	7.39*	7.53*	14.52***	11.98**
1 vs. 3	5.72*	5.16*	5.70*	6.52*
2 vs. 3	.00	.00	1.93	1.51
Three-letter legal nonwords - nonaligned				
1 vs. 2	15.12***	12.54**	8.80**	17.33***
1 vs. 3	2.17	1.25	2.59	4.04
2 vs. 3	7.17*	9.52**	1.80	2.58
Four-letter legal nonwords - aligned				
1 vs. 2	11.52**	11.25**	24.46***	18.47***
1 vs. 3	12.02**	12.31**	37.04***	20.72***
1 vs. 4	16.55***	20.72***	15.50***	5.36*
2 vs. 3	.40	.12	2.12	.21
2 vs. 4	.98	.82	3.54	3.30
3 vs. 4	.06	.25	10.96**	4.72*
Four-letter legal nonwords - nonaligned				
1 vs. 2	62.05***	48.90***	20.64***	12.31***
1 vs. 3	18.60***	13.86**	.67	.00
1 vs. 4	14.75***	13.10**	3.01	3.34
2 vs. 3	21.90***	8.76**	18.23***	20.20***
2 vs. 4	14.16**	8.85**	5.22*	2.60
3 vs. 4	.01	.01	1.60	5.31*

* $p < .05$. ** $p < .01$. *** $p < .001$.

For RTs, nonword type was significant for subjects, $F1$ (1, 39) = 4.59, $p < .05$, $\eta_p^2 = .108$; $F2$ (3, 87) = 1.58, *nsd* and letter position was significant, $F1$ (3, 39) = 7.12, $p < .001$, $\eta_p^2 = .158$; $F2$ (3, 87) = 4.88, $p < .01$, $\eta_p^2 = .087$. In addition, there was an interaction effect between nonword type and letter position, $F1$ (3, 39) = 11.08, $p < .001$, $\eta_p^2 = .226$; $F2$ (3, 87) = 10.13, $p < .001$, $\eta_p^2 = .166$.

As can be seen from the planned comparisons in Table A3 for four-letter nonwords with aligned vowel nonwords, more correct responses were made to initial letter positon than second, third or fourth positions. This was also reflected in the corresponding reaction times. However, for four-letter nonwords with nonaligned vowel nonwords, less accurate responses were made to letter position 1 than letter positions 2, 3 or 4. In addition, significantly more correct responses were made to letter position 2 in comparison to letter position 4. In relation to reaction times, faster response times were made to letter position 2 in comparison to letter positions 1 or 3 (see Figure A2).

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