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Revisiting letter transpositions within and across morphemic boundaries

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Abstract Early morphological decomposition of complex words has been supported by evidence showing that the magnitude of masked transposed-letter (TL) priming effects is greater for within-morpheme transpositions than for between-morpheme transpositions. However, these findings have lately been called into question, and a recent article by Sánchez-Gutiérrez and Rastle (*Psychonomic Bulletin & Review*, *20*, 988–996, 2013) suggested that the above-mentioned interaction could have been the consequence of a false positive (i.e., a Type I error). Considering recent evidence showing that morpho-orthographic interactions are highly sensitive to individual differences in reading skills, we explored whether participants' averaged reading speeds were responsible for modulating the size of within- versus between-morpheme TL priming effects. A large-scale lexical decision experiment with a set of 420 suffixed Spanish words (N = 80 participants) was run using the masked-priming technique. The results revealed that individual differences modulated the magnitude of the masked TL priming effect between morphemes: Faster readers (but not slower readers) yielded greater TL priming for within- than for between-morpheme transpositions. The present data help reconcile previous divergent data by showing that *faster* readers revealed a morpho-orthographic interaction, whereas *slower* readers may rely more on a morphological-processing strategy that is not sensitive to morpho-orthographic interactions.

Keywords Morphological decomposition · Transposed letters · Lexical access

How readers encode and process morphologically complex words has become a central issue in cognitive psychology, especially in research on visual-word recognition. Recognizing an isolated polymorphemic word involves a number of underlying processes: encoding of letter position/identity, morphological segmentation, lexical retrieval of each morpheme, and whole-word semantic information retrieval. The precise manner and order in which these processes occur (or co-occur) is a matter of contention that is subject to empirical research (see Amenta & Crepaldi, 2012, for a comprehensive review).

Most researchers in visual-word recognition agree that the recognition of derived words (e.g., *violinist*) is guided by early morpheme detection processes occurring before whole-word processing has finished (*violin* + *ist*; e.g., Pastizzo & Feldman, 2002, 2004; Rastle, Davis, & New, 2004; Taft & Forster, 1975, 1976; see also Diependaele, Duñabeitia, Morris, & Keuleers, 2011, for evidence from nonnative speakers). Empirical evidence in favor of this view has generally been obtained from masked-priming experiments, in which the processing of a briefly presented prime is posited to reveal early nonstrategic processes (see Diependaele, Morris, Serota, Bertrand, & Grainger, 2013, for review). Consequently, most studies on derivational morphology have concluded that morphological decomposition occurs at a very early stage of visual-word recognition (see Lavric, Elchlepp, & Rastle, 2012).

Thus, one relevant question is whether (some of) the processes of morphological decomposition co-occur with letter position coding at very early stages of visual-word recognition.

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Following this line of reasoning, Christianson, Johnson, and Rayner (2005), conducted a masked-priming experiment (Exp. 3) examining whether letter transpositions across affix boundaries (e.g., *boas**et**r–BOASTER*) differed from transpositions that crossed a pseudo-affix boundary in a naming task (e.g., *blus**et**r–BLUSTER*; note that *blust* is not an English stem, as *-er* is not a real suffix in *bluster*). Transposed-letter (TL) effects are prototypical orthographic effects associated with letter-position coding mechanisms (e.g., Perea & Lupker, 2003; see Gomez, Ratcliff, & Perea, 2008; Grainger & Whitney, 2004, for theoretical implications). Christianson et al. found that "TL primes did not significantly differ from the orthographic controls" (p. 1334; in their case, one-letter substitution primes—e.g., *boas**l**er–BOASTER*) in the set of truly suffixed words. That is, naming latencies for suffixed words preceded by a TL nonword prime that crossed the affix boundary were similar to latencies for suffixed words preceded by an orthographic control (both ts < 1; see also Luke & Christianson, 2013, for related findings). Nonetheless, the statistical significance of the results was not fully unambiguous, and these data should be taken as suggestive rather than conclusive.

Stemming from these results, Duñabeitia, Perea, and Carreiras (2007) extended the finding that masked TL priming was affected by early morphological effects. In a series of lexical decision experiments with Basque and Spanish speakers, Duñabeitia et al. (2007) found significant masked TL priming effect for polymorphemic words when the letter transposition occurred within a morpheme (*vio**il**nist–VIOLINIST*), whereas they failed to find a parallel effect for affixed words when the transposed letters crossed the affix boundaries (*violi**in**st–VIOLINIST* vs. *violi**er**st–VIOLINIST*). To explain these findings, the authors suggested the existence of a morpheme detection mechanism operating "early in the process of visual word recognition, co-occurring with mechanisms responsible for assigning letter position" (p. 701; see also Duñabeitia, Perea, & Carreiras, 2008), akin to the prelexical affix-identification mechanism proposed by Taft and Forster (1975, 1976).

However, a recent experiment by Sánchez-Gutiérrez and Rastle (2013) directly disputed the Duñabeitia et al. (2007) findings. The authors reviewed other studies testing English participants in which the magnitudes of TL priming effects were similar in size, regardless of whether or not the transpositions crossed the morphemic boundary (e.g., Beyersmann, Coltheart, & Castles, 2012; Beyersmann, McCormick, & Rastle, 2013; Masserang & Pollatsek, 2012; Rueckl & Rimzhim, 2011). They then questioned whether the discrepancy between the data reported by Duñabeitia et al. (2007) and these studies could result from an inherent difference between the languages at test. To test their hypothesis, Sánchez-Gutiérrez and Rastle selected a set of 88 derived words that were cognates between English and Spanish (viz., words with highly similar orthographic, phonological, and semantic representations, such as *invisible*), and tested English and Spanish participants in a masked-priming TL experiment with a lexical decision task in which the manipulations took place either at the morphemic boundary (i.e., between morphemes) or within morphemes. Sánchez-Gutiérrez and Rastle found masked TL priming effects of similar magnitude for between- and within-morpheme transpositions, as deduced from the lack of a significant interaction. They concluded that "the findings of Duñabeitia et al. reflected idiosyncratic properties of the stimuli or the participants, or a Type I error" (p. 992). Certainly, one of the risks in psycholinguistic studies testing a relatively small set of items is the appearance of a false positive (Type I error). Of course, an identical argument applies to the possibility of reporting a false negative (Type II error), in particular when failing to detect an interaction when the expected effect size is very small.

What is the reason for these incongruent results? Leaving aside issues related to statistical power or to the potential particularities of the stimuli used in the previous experiments, the diverging results for TL manipulations across morphemic boundaries could potentially stem from individual differences in reading skills on morphological decomposition and morpho-orthographic interactions. In a compelling study on morphological priming on words with transparent and opaque relationships (i.e., walker–WALK vs. corner–CORN), Andrews and Lo (2013) demonstrated that the participants' reading styles (orthographic-based vs. semantic-based) modulated the magnitude of these effects, especially in the case of opaque relationships—note that these results have been considered as a marker of morpho-orthographic processing. Although good spellers with average vocabulary (i.e., readers with an orthographic profile) showed significant priming effects for opaque pairs, high-vocabulary participants with average spelling skills (i.e., readers with a semantic profile) showed minimal priming for opaque relationships. Andrews and Lo concluded that the "individual differences approach provides critical, novel evidence that explains the contradictions observed in published average data and provides new evidence that contributes to distinguishing the relative validity of theories of morphological priming" (p. 289).

To examine in detail whether morphological decomposition in suffixed words interacts with letter-position encoding, we conducted a large-scale masked-priming lexical decision experiment including transposed-letter manipulations between morphemes (across morphemic units) and within morphemes. Large-scale experiments partially solve the important issue of statistical power (Keuleers, Diependaele, & Brysbaert, 2010; see also Button et al., 2013). To this end, we selected a set of 420 suffixed Spanish words and tested 80 participants. Given the relatively large size of the sample, and considering that individual differences in reading skills modulate the extent to which a morpho-orthographic style of processing is followed (see Andrews & Lo, 2013), we divided the group of participants according to their reading speeds (using a median split), and examined whether individual differences could be responsible for the seemingly discrepant results reported in recent years. Previous psycholinguistic research has shown a close interrelation between variations in orthographic processing skills and individual differences in reading (e.g., Perfetti & Hart, 2001; Stanovich & West, 1989; see Perfetti, 2007, for review). As was recently reported by Hargreaves, Pexman, Zdrazilova, and Sargious (2012), orthographic skills are inversely correlated with reading speed in the lexical decision task (viz., shorter reaction times [RTs] for participants with high orthographic skills; see also Chateau & Jared, 2000, and Unsworth & Pexman, 2003, for a similar argument regarding the influence of increased sublexical skills on reading latencies), and they are also inversely correlated with semantic effects (e.g., participants with enhanced orthographic abilities show reduced effects of concreteness). Hence, following the hypothesis developed by Andrews and Lo regarding the close link between orthographic skills and morpho-orthographic interactions, on the one hand, and considering the evidence suggesting that readers with higher orthographic skills show faster RTs in the lexical decision task than do readers with lower orthographic skills, on the other hand, we expected to find that morpho-orthographic interactions were modulated by reading speed.

Method

Participants

A group of 80 undergraduate and graduate students (49 females, 31 males) took part in this experiment. All of them were native Spanish speakers, had normal or corrected-to-normal vision, reported no history of neurological disorder, and signed informed consent forms before the experiment. Their mean age was 25.47 years (range: 18–40, *SD* = 5.94).

Materials

A set of 420 Spanish suffixed words was selected from B-Pal (Davis & Perea, 2005). The characteristics of these words are reported in Table 1, and the full list of materials is presented in Appendix A. The set of words included 25 different suffixes, thus comprising a representative subset of Spanish affixed words. These words acted as targets (e.g., *VIOLINISTA*, *violin* + *ista*; translated as *violinist*) and could be preceded by a prime that was (1) a nonword created by transposing two adjacent letters that crossed the morphemic boundary (TL-between condition; e.g., *violi**in**sta*); (2) a nonword created by replacing those two transposed letters with others (replaced-letter [RL]-between condition; e.g., *violi**er**sta*); (3) a nonword created by transposing two adjacent letters that did not cross the morphemic boundary (TL-within condition; e.g., *vio**il**nista*); or (4) a nonword created by replacing those two transposed letters with others (RL-within condition; e.g., *vio**at**nista*). As in previous research (e.g., Sánchez-Gutiérrez & Rastle, 2013), we restricted the criteria for replacements, minimizing the variability in height (i.e., trying to preserve the amount of vertical space occupied by each transposed letter), and replacing letters as a function of their consonant–vowel status. None of the letter transpositions or replacements involved two vowels (see Perea & Acha, 2009, for a demonstration of weaker TL effects for vowel combinations than for manipulations involving consonants) or the initial or final letters of the strings, and all of the bigrams manipulated resulted in existing letter combinations in Spanish (see Frankish & Turner, 2007). Special attention was paid to the frequencies of the manipulated bigrams, which were matched across TL and RL conditions in a pairwise manner: TL-between = 2,210.63, RL-between = 2,250.59, paired samples $t(419) = -1.11$, $p = .27$; TL-within = 1,639.22, RL-within = 1,625.74, paired samples $t(419) = 0.32$, $p = .75$ (see Frankish & Barnes, 2008, and Perea & Carreiras, 2008, for evidence regarding the importance of matching the different conditions in their bigram frequencies). Additionally, a set of 420 Spanish nonword targets was created (e.g., *DULEFO*; see Appendix A). We used Wuggy (Keuleers & Brysbaert, 2010) to create these nonwords from the real words; this program provides a valid matching of the items in subsyllabic structure and transition frequencies. These nonwords were matched to the words in length in a pairwise manner, they respected Spanish orthotactics, and they had bigram frequencies and orthographic neighborhoods similar to those of the word set (for the words: mean length = 8.97, mean type bigram frequency = 369.24, mean token bigram frequency = 77.11, mean $N = 0.37$; for the nonwords: mean length = 8.98, mean type bigram frequency = 341.69, mean token bigram frequency = 70.09, mean $N = 0.04$). Considering the specific characteristics of the matching algorithm used by Wuggy, some nonwords ended in a sequence of letters that matched a real Spanish suffix, and others did not. Half of the nonword targets were preceded by a nonword prime that included an internal adjacent transposition, and half were preceded by a nonword prime that included a double-letter replacement. The manipulations carried out in the nonwords were distributed among different string (internal) locations, in order to emulate the manipulations in the word set. All of the word targets appeared in each of the four lists that were created, but each time in a different priming condition. Twenty participants completed each of the four lists, following a counterbalanced design.

Table 1 Characteristics (means, standard deviations [*SD*s], minimum values, and maximum values) of the different indices of the words used in the experiment

	Mean	*SD*	Min	Max
Word frequency (per million)	4.13	6.84	0.18	65.54
Word length (in number of letters)	8.97	1.41	6	12
Word *N*	0.37	0.67	0	4
Base frequency (per million)	32.40	64.30	0.18	689.82
Base length (in number of letters)	6.56	1.46	3	10
Base *N*	1.80	2.71	0	24
Suffix length (in number of letters)	3.25	0.68	2	5
Levenshtein distance between base and root (in number of edits)	1.01	0.55	0	5
Base morphological family	5.21	2.95	2	22
Suffix morphological family	338.18	166.52	10	525
Base cumulative frequency (per million)	70.51	101.51	0.36	832.87
Suffix cumulative frequency (per million)	1,102.71	967.67	5.55	4,357.84
Boundaries' bigram frequency	2,587.98	1,302.87	47	4,511

Procedure

The experiment was conducted in acoustically shielded individual test cabins, using PCs (Dell Optiplex 760) with CRT monitors working at 1,024 × 768 and 90 Hz. Stimulus presentation and data collection were controlled by DMDX software (Forster & Forster, 2003). Each trial consisted of the centered presentation of a mask (# symbols) for 500 ms, followed by brief presentation of the prime in lowercase Courier New font for 55 ms (five cycles of 11.11 ms each). After this, the target appeared in uppercase letters and stayed on the screen for 2,500 ms or until the participant responded. The length of the mask varied from trial to trial, depending on the number of characters in the primes/targets. Participants had to press one of two labeled buttons on an Empirisoft DirectIN High Speed Button-Box, to indicate whether the displayed string was or was not an existing word in Spanish. They were instructed to do so as quickly and accurately as possible, and they were trained with a short practice consisting of ten words and ten nonwords. All of the experimental items were randomly presented. The whole experimental session lasted approximately 20 min.

Results

Trials associated with erroneous responses (3.94 %) and response latencies faster than 250 ms or slower than 1,500 ms (3.37 %) were excluded from the RT analysis. Then, a median-split procedure was followed in order to identify *faster* and *slower* participants (see Häikiö, Bertram, Hyönä, & Niemi, 2009, for a similar procedure). The mean RT for each participant across word and nonword trials was calculated, and individual participants were then split into two groups, depending on whether their mean RT fell above (i.e., slower group) or below (i.e., faster group) the median RT value of the averaged latencies for the whole set of items (median = 741 ms, mean = 761 ms, $SD = 144$ ms). The slower group ($N = 40$) had a mean overall RT of 881 ms ($SD = 94$ ms), whereas the faster group ($N = 40$) had a mean RT of 641 ms ($SD = 62$ ms). Next, participant- and item-based analyses of variance (ANOVAs) were run on the word data following a 2 × 2 × 2 × 4 design, including the factors Place of Manipulation (within | between), Type of Manipulation (TL | RL), Group (slower | faster), and List (1 | 2 | 3 | 4); List was included as a dummy variable in the design (Pollatsek & Well, 1995). The mean RTs and percentages of errors for each group and condition are presented in Table 2.

The ANOVAs on the RTs for the word trials showed a main effect of place of manipulation [$F_1(1, 72) = 43.82$, $p < .001$; $F_2(1, 416) = 58.52$, $p < .001$] and a main effect of type of manipulation [$F_1(1, 72) = 32.98$, $p < .001$; $F_2(1, 416) = 36.05$, $p < .001$]. The effect of group was also significant [$F_1(1, 72) = 170.22$, $p < .001$; $F_2(1, 416) = 5{,}856.25$, $p < .001$]. Critically, the three-way interaction was significant [$F_1(1, 72) = 9.46$, $p = .003$; $F_2(1, 416) = 6.80$, $p = .009$]. Separate analyses were conducted for the faster and slower groups, to understand the origin of this interaction. For the faster participants, we observed a significant two-way interaction between place of manipulation and type of manipulation [$F_1(1, 36) = 15.31$, $p < .001$; $F_2(1, 416) = 9.77$, $p = .002$], reflecting a sizeable 18-ms TL effect for within-morpheme manipulations (TL = 597 ms, RL = 615 ms) [$F_1(1, 36) = 49.84$, $p < .001$; $F_2(1, 416) = 34.18$, $p < .001$], but not for between-morpheme manipulations (TL = 589 ms, RL = 593 ms) [$F_1(1, 36) = 2.36$, $p = .13$; $F_2(1, 416) = 2.61$, $p = .11$]. In contrast, the critical interaction did not approach significance for the slower participants [$F_1(1, 36) = 1.37$, $p = .25$; $F_2(1, 416) = 1.09$, $p = .30$]; note that both the place of manipulation [$F_1(1, 36) = 15.12$, $p < .001$; $F_2(1, 416) = 20.40$, $p < .001$] and type of

Table 2 Means and standard deviations of the lexical decision times (in milliseconds) and percentages of errors (within parentheses) for the word targets across the different conditions and groups

	Within-Morpheme			Between Morphemes		
Group	TL	RL	Priming	TL	RL	Priming
All	701 (4.87 %)	714 (5.24 %)	13 (0.37 %)	688 (4.23 %)	698 (4.13 %)	10 (–0.10 %)
Slower	804 (5.02 %)	813 (4.90 %)	9 (–0.12 %)	788 (4.45 %)	804 (4.57 %)	16 (0.12 %)
Faster	597 (4.71 %)	615 (5.57 %)	18 (0.86 %)	589 (4.00 %)	593 (3.69 %)	4 (–0.31 %)

Priming effects were calculated by subtracting the transposed-letter (TL) conditions from the replaced-letter (RL) conditions. The mean RTs and percentages of errors associated with nonword trials were 821 ms (3.29 %) in the TL condition and 830 ms (3.26 %) in the RL condition for the whole group of participants; 964 ms (4.18 %) in the TL condition and 972 ms (3.77 %) in the RL condition for the slower group; and 678 ms (2.40 %) in the TL condition and 688 ms (2.74 %) in the RL condition for the faster group

manipulation [$F_1(1, 36) = 12.81$, $p < .001$; $F_2(1, 416) = 16.19$, $p < .001$] main effects were significant—the overall TL priming effect was 12 ms.[1]

The analysis on the error data showed a main effect of place of manipulation [$F_1(1, 72) = 22.01$, $p < .001$; $F_2(1, 416) = 18.00$, $p < .001$] that interacted with group in the analysis by participants [$F_1(1, 72) = 4.36$, $p = .04$; $F_2(1, 416) = 2.94$, $p = .09$]. This revealed that within-morpheme manipulations led to higher error rates than did manipulations between morphemes, and that this difference was larger for the faster than for the slower group (a 1.30 % and a 0.45 % difference, respectively). No other effects/interactions were significant.

In sum, the present data reveal that for faster readers, TL priming effects were greater for within-morpheme than for between-morpheme transpositions, whereas no such difference occurred for the slower readers.[2] To obtain further evidence of the relationship between the overall RTs of the whole group of participants and the magnitudes of the TL effects within and between morphemes, two additional analyses were conducted. First, the magnitude of the TL effect for the within-morpheme manipulation was calculated for each participant ($N = 80$). The individual within-morpheme TL effects did not significantly correlate with the participants' mean RTs [$r = –.14$, $t(78) = 1.22$, $p = .22$], showing that this effect was relatively independent from the processing speed. Importantly, the magnitude of the TL effect in the between-morpheme condition was positively correlated with the participants' overall RTs [$r = .26$, $t(78) = 2.40$, $p = .02$], showing that the magnitude of the critical between-morpheme TL effect increased as a function of the general processing speed in the task (see Fig. 1).

Second, to further examine the manner in which the magnitude of TL priming effects is modulated by the participant's rapidity in the task, we reexamined the data using a centile-based analysis of the RT distribution (see Andrews & Lo, 2013; Balota, Yap, Cortese, & Watson, 2008; and Yap, Tse, & Balota, 2009, for similar approaches; see also Ratcliff, 1979, for a description of the advantages of examining RT distributions over mean RTs, and Johnson, Staub, & Fleri, 2012, for further evidence regarding the relationship between reading speed and TL effects). We computed the RT distributions in each critical condition and obtained nine representative centiles (from the 10th to the 90th centiles, in steps of 10; see Fig. 2). Then we calculated the difference of the magnitudes of the TL effects for the between-morpheme and within-morpheme conditions for each participant. As can be seen in Fig. 2, the TL effects for within-morpheme manipulations were relatively unaffected by the speed of response, coinciding with the results from the correlational analyses. In contrast, the TL effects for between-morpheme manipulations increased as a function of the speed of response. ANOVAs performed on the whole set of data showed significant interactions between place of manipulation and type of manipulation in the 10th, 20th, 30th and 40th centiles (all Fs > 4, all ps < .05), whereas the interaction was negligible in the upper centiles (all Fs < 1, all ps > .30). Besides, as can also be observed in Fig. 2, the within- and between-morpheme TL

[1] As can be seen in Table 2, the two RL conditions led to significantly different RTs (shorter RTs for between-morpheme RL than for within-morpheme RL). This difference is similar to that observed by Sánchez-Gutiérrez and Rastle (2013) in their suffixed sets of Spanish and English words (8 and 7 ms, respectively), and a similar difference was found by these authors in the error rates. Similarly, Duñabeitia et al. (2007) also found a difference of 9 ms between these conditions. Nonetheless, it should be considered that these differences in the RL conditions are not of special theoretical or experimental interest, given that transposed-letter effects are the result of substracting the TL and RL conditions in a manner that is sensitive to the location where the manipulations are carried out within the strings (between and within morphemes, separately).

[2] A parallel analysis was carried out for word trials using the participants' z-transformed averaged data in each condition, in order to compensate for individual participants' processing speed differences (see Faust, Balota, Spieler, & Ferraro, 1999). The results fully replicated the analysis carried out on the nontransformed data, showing a significant three-way interaction [$F(1, 36) = 11.32$, $p = .001$]. The critical two-way interaction between place of manipulation and type of manipulation was significant for the faster group [$F(1, 36) = 13.45$, $p = .001$], whereas it was not for the slower group, who showed a generalized TL effect [type of manipulation, $F(1, 36) = 11.57$, $p = .002$; interaction, $F(1, 36) = 1.09$, $p = .304$]. The faster group showed a significant type of manipulation effect within morphemes [$F(1, 36) = 50.84$, $p < .001$], but not between morphemes [$F(1, 36) = 2.08$, $p = .158$].

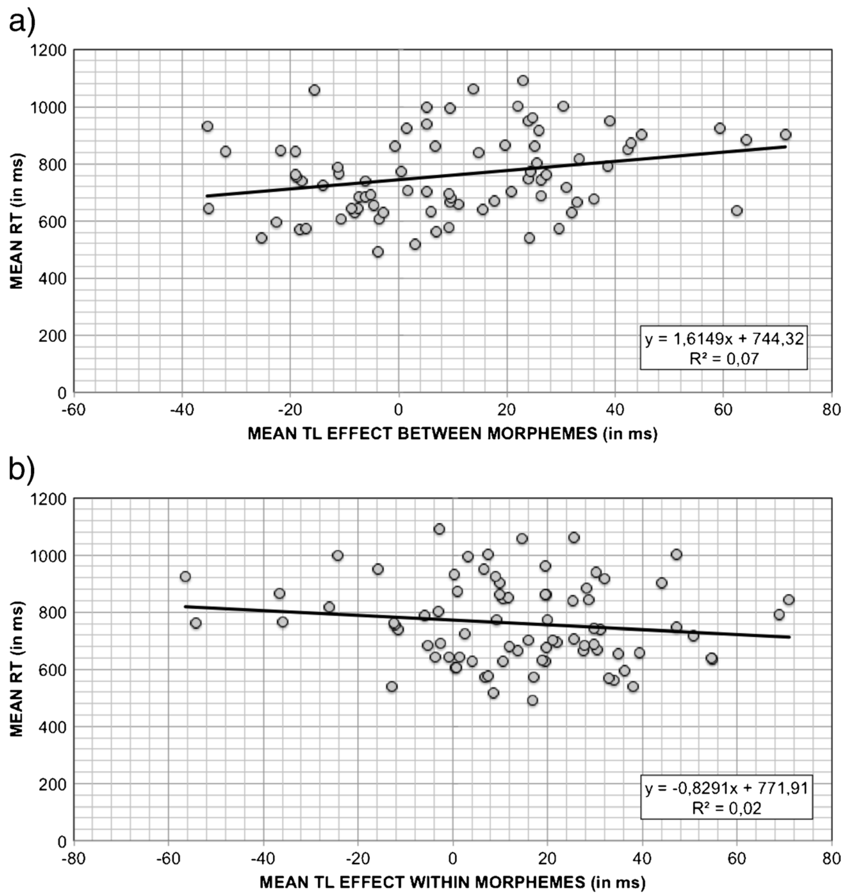

Fig. 1 Scatterplots of the mean transposed-letter (TL) effects (between morphemes [panel a] and within morphemes [panel b], respectively) for the whole set of participants as a function of the participants' mean reaction times (RTs) in the lexical decision task

priming effects were clearly different from each other in the group of faster readers, and this difference held constant across the entire RT distribution.

Discussion

The present large-scale masked-priming experiment helps reconcile earlier research on the interaction between early orthographic coding and morphological decomposition processes, by providing a tentative explanation for the divergent results reported in recent years. First, as Sánchez-Gutiérrez and Rastle (2013) observed, it is possible to obtain (fairly small) masked-priming effects when the transposed-letter manipulation crosses the affix boundary (around 10 ms, when averaging faster and slower readers), thus suggesting that the null effect reported in our earlier study (Duñabeitia et al., 2007) may have been the consequence of a Type II error (viz., a false negative). Second, and more importantly, when the individual differences of the participants in their reading speeds were taken into account, clear-cut differences emerged in the magnitudes of the TL priming effects for between- and within-morpheme manipulations. Specifically, even though the slower participants showed significant TL priming effects, irrespectively of the place of manipulation (hence replicating the results of Sánchez-Gutiérrez & Rastle, 2013, among others), the group of faster participants only showed TL priming effects in within-morpheme conditions, but not between morphemes (replicating Duñabeitia et al., 2007, among others). Hence, the present data demonstrate that the interaction reported by Duñabeitia et al. (2007) was not the result of a Type I error (a false positive), and that the null interaction effect reported by Sánchez-Gutiérrez and Rastle for the Spanish set is not a fully generalizable finding, given that it is dependent on the participants' reading performance. These observations were further reinforced by correlational analyses and RT distributional analyses.

The present results add to a growing body of literature demonstrating the impact of individual differences in reading skills on the different stages of word processing (see Chace, Rayner, & Well, 2005; Häikiö et al., 2009; Janack, Pastizzo, & Feldman, 2004; Rayner, Slattery, & Bélanger, 2010; Yap, Tse, & Balota, 2009; Ziegler, Jacobs, & Klüppel, 2001, to cite just a few examples). Of particular interest is the recent study by Andrews and Lo (2013), in which the participants' reading "profiles" (orthographic vs. semantic) modulated the

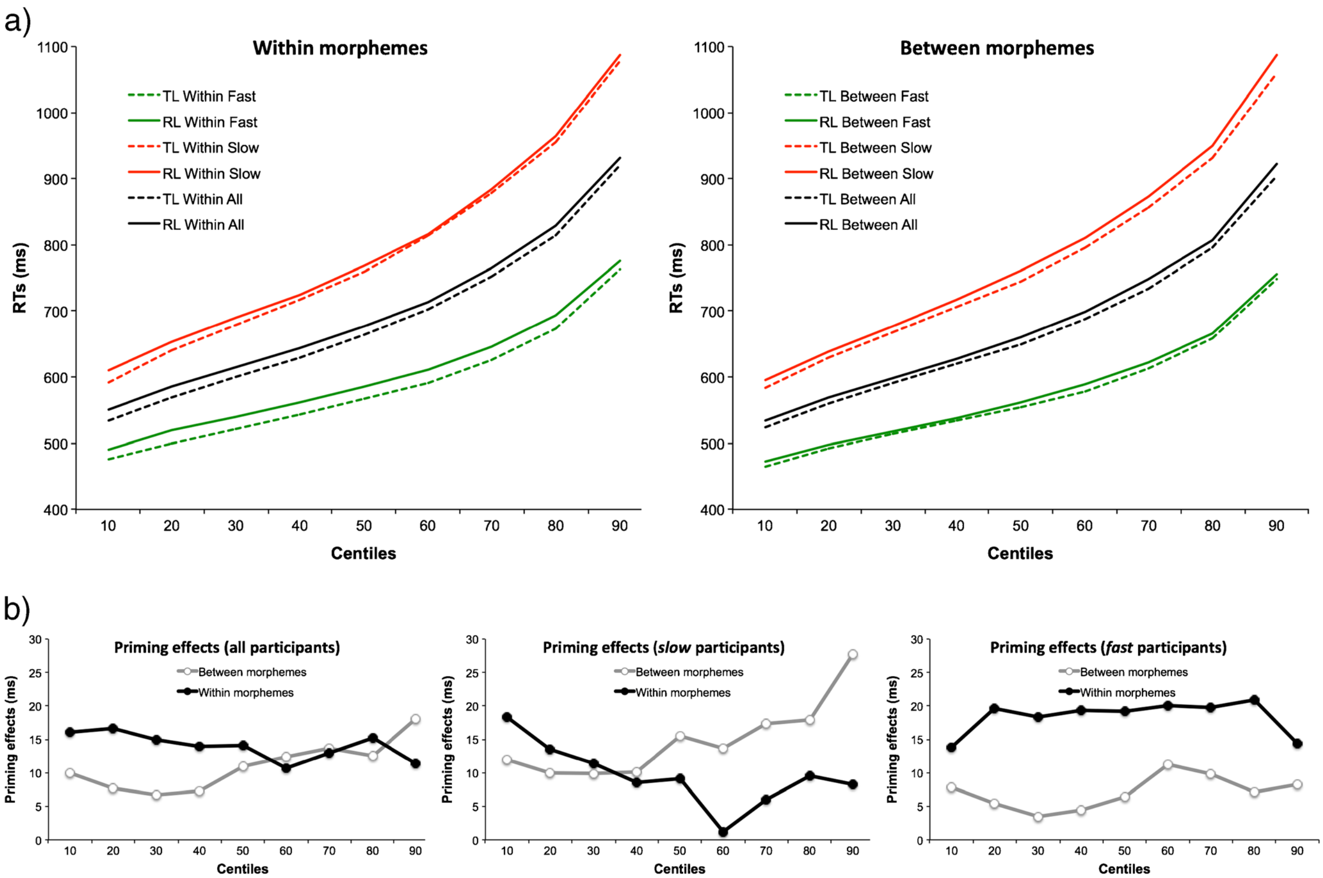

Fig. 2 (a) Averaged reaction time (RT) distributions for the whole sample of participants ($N = 80$, central lines), and for the slow and fast groups ($n = 40$ each; top and bottom lines, respectively) in the transposed-letter (TL) and replaced-letter (RL) conditions (dotted and solid lines, respectively) for the between- and within-morpheme manipulations. (b) Scattering of the difference between the TL effects for the within- and between-morpheme manipulations according to the 10th- to 90th-centile distribution for the whole sample and for the slow and fast groups

magnitude of masked morphological priming effects—in particular, for morphologically opaque relationships (e.g., corner–CORN). The present data set and the different analyses reported validate Andrews and Lo's argument in favor of studies testing individual differences in morphological priming, and they offer a tentative explanation for the seemingly inconsistent results reported in the literature on morpho-orthographic interactions. We found that the faster readers (who are, potentially, the best readers) are highly sensitive to morpho-orthographic interactions: When the transposed letters involved the final letter of the stem and the initial letter of the suffix in a polymorphemic word (e.g., "*ni*" in *violi**ni**sta*; i.e., a manipulation between morphemes), the magnitude of the TL effect was half the size of that of similar manipulations that exclusively involved two letters of the stem (e.g., "*li*" in *vio**li**nista*; i.e., within-morpheme manipulations). On the contrary, the slower readers failed to display a significant morpho-orthographic interaction.

The present data replicate and extend preceding studies that have suggested that minimal orthographic positional changes lead to manifestly different effects, depending on whether or not the morphological properties of the words are kept intact (Christianson et al., 2005, Exp. 3; Duñabeitia et al., 2007; see also Luke & Christianson, 2013, for additional evidence), and support a claim for the existence, at least for the most skilled readers, of an early stage of morphological decomposition that is sensitive to morpho-orthographic interactions (see also Taft & Nillsen, 2013). More importantly, the present study offers an (admittedly speculative, but suggestive) explanation for the different results that have been provided in recent studies on the same issue (see Beyersmann et al., 2013; Rueckl & Rimzhim, 2011; Sánchez-Gutiérrez & Rastle, 2013).

We suggest that TL effects across morphemes do not respond to a dichotomous all-or-nothing reality. Instead, TL effects across morphemic boundaries can be captured better by a continuum that may be linked to individual differences in reading performance and/or to participants' reading styles/profiles. Considering the tight link between reading efficiency and orthographic knowledge (see, e.g., Perfetti, 2007), and taking into account recent evidence demonstrating that increased orthographic skills lead to shorter RTs in the lexical decision task (e.g., Hargreaves et al., 2012), we initially hypothesized that the faster participants would be the ones with an increased sensitivity to morpho-orthographic factors, and consequently the ones who would show minimal TL effects between morphemes. The results of the present experiment fully satisfied this hypothesis, suggesting that faster readers follow a reading style based on fast-acting automatic morphological decomposition processes (akin to the morpho-orthographic account proposed by, among others, Diependaele, Sandra, & Grainger, 2005). In contrast, the slower readers are hypothesized to focus less on orthographic information, probably basing their reading profile on semantic-based pieces of information (note, for instance, that the concreteness effect is inversely correlated with the orthographic skills of the readers, as was shown by Hargreaves et al., 2012). In this line, we found that slower readers showed no morpho-orthographic interactions and robust between-morpheme TL effects. In spite of the strength of the analyses reported here, we acknowledge that further studies should be aimed at reexamining the relationship between reading speed, orthographic skill, and morpho-orthographic interactions, probably using fully independent indices for each construct.

At a methodological level, we believe that one of the most efficient avenues to shed more light on the existence of morpho-orthographic interactions will be the implementation of masked-priming experiments testing: (1) a sufficiently large and heterogeneous sample of items that are representative of each language, and (2) a large sample of participants with varying degrees of reading skills. This joint approach may provide enough power to detect small differences that are inherent in subtle manipulations, as we have demonstrated in the present experiment. Following this strategy, the present data reinforce the view that although large effects in masked priming are reliable and consistent across labs, "anything finer-grained is extremely difficult to detect" (Gomez et al., 2008, p. 598), at least in typical experiments testing subtle effects with a relatively small set of words per condition. Furthermore, a large-scale approach would allow researchers to explore whether the individual characteristics of the words modulate the pattern of priming effects. In this light, we tested whether (and how) the specific properties of the words used in the experiment had an influence on the magnitude of the critical TL effect between morphemes in a set of regression analyses (see Appendix B). The results of these analyses did not highlight any relevant property of the words as being a modulating factor for slower readers. Similarly, the regression models for faster readers showed relatively poor fits, thus leading to the conclusion that the reason for the differences in the magnitudes of the TL effect is not "idiosyncratic properties of the stimuli," as was suggested by Sánchez-Gutiérrez and Rastle (2013).

To sum up, the present data suggest that the process of letter position coding is not completely blind to the context in which the manipulations take place (e.g., between morphological units) or to the individual differences of the participants in their reading skills. Taking into account the data provided by Andrews and Lo (2013) and the present results, further research should try to clarify the influence of orthographic skill in the morphological decomposition of polymorphemic words.

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Appendix A

Table 3 Word and nonword items

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
dulzura	dagmura	duluzra	dluzura	duloxra	dbezura
vencedor	fandedor	vencdeor	vnecedor	venctoor	vmicedor
ricachón	siradron	ricacóhn	riacchón	ricacébn	riischón
quemadura	neucasura	quemdaura	qumeadura	quemteura	qusaadura
vecindario	leroncario	vecinadrio	veicndario	vecinolrio	veenndario
determinismo	depengilisto	determiinsmo	detreminismo	determiersmo	detcaminismo
florista	clolusta	floirsta	folrista	floemsta	fadrista
resultón	renopton	resulótn	reslutón	resulédn	resbetón
detonador	demisadar	detondaor	deotnador	detonteor	deednador
mujeriego	muhireifo	mujeirego	muejriego	mujeemego	muipriego
poseedor	bomaodor	posedeor	poesedor	posetoor	pouredor

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
enfermero	enmislero	enferemro	enfremero	enferirro	enfcamero
paracaidista	sagemiadista	paracaiidsta	parcaaidista	paracaialsta	parreaidista
voladura	bomasuro	voldaura	vloadura	volteura	vdiadura
regulador	bafuladar	reguldaor	reuglador	regulteor	reijlador
hechicero	betletero	hechiecro	hecihcero	hechiasro	hecufcero
delgadez	detmidez	delgaedz	delagdez	delgaotz	delopdez
medallón	sedallal	medalóln	meadllón	medaládn	meolllón
dictadura	mostatura	dictdaura	dcitadura	dictteura	dnatadura
nitidez	nitadid	nitiedz	niitdez	nitiotz	niafdez
donante	tovonte	donnate	dnoante	doncite	dseante
piratería	sodemeria	piraetría	piartería	piraulría	piontería
jardinería	nonlaneria	jardienría	jaridnería	jardiicría	jaralnería
embarcadero	ertulnadero	embarcdaero	embracadero	embarcteero	embcocadero
calidez	caradiz	caliedz	caildez	caliotz	caatdez
chispeante	glosciante	chispenate	chsipeante	chispecite	chmopeante
costero	cascera	cosetro	csotero	cosulro	ccutero
cantante	canreste	cantnate	cnatante	cantcite	ccitante
estimulador	esmacuradar	estimuldaor	estiumlador	estimulteor	estiavlador
luchador	vutridor	luchdaor	lcuhador	luchteor	lsohador
imaginario	isefiraria	imagianrio	imaignario	imagiorrio	imaepnario
voluminoso	bonunilozo	volumionso	voluimnoso	volumiarso	voluunnoso
excitante	erfenante	excitnate	exctiante	excitcite	excleante
narrador	tadridor	narrdaor	nrarador	narrteor	ncorador
sexagenario	songepenario	sexageanrio	sexaegnario	sexageorrio	sexaapnario
conocedor	dimocodor	conocdeor	concoedor	conoctoor	conraedor
cocotero	dimomero	cocoetro	cooctero	cocoulro	coivtero
matadero	pamasera	matdaero	mtaadero	matteero	mliadero
flacucho	clatublo	flauccho	falcucho	flaizcho	fidcucho
flotador	blocidor	flotdaor	foltador	flotteor	fadtador
soldador	sulsidor	solddaor	slodador	soldteor	sdidador
motorista	momorenca	motoirsta	mootrista	motoemsta	moedrista
positivismo	sosamibisto	positiivsmo	posiitvismo	positiocsmo	posiafvismo
dibujante	mimugunte	dibujnate	dibjuante	dibujcite	dibyeante
escalador	anfagador	escaldaor	esclaador	escalteor	escdoador
pescador	senrador	pescdaor	psecador	pescteor	pnocador
telefonazo	henagonaso	telefoanzo	teleofnazo	telefoorzo	teleebnazo
comunicante	toluceconte	comunicnate	comnuicante	comuniccite	comzoicante
golfista	fuljista	golifsta	glofista	goludsta	gdifista
rotulador	bomugadar	rotuldaor	rotluador	rotulteor	rotbeador
obligatorio	ocrejatecio	obligtaorio	oblgiatorio	obligdoorio	oblpoatorio
pajarería	sazirolia	pajaerría	paajrería	pajainría	paiqrería
simplista	domblista	simpilsta	smiplista	simpatsta	sneplista
dormitorio	dalmelorio	dormtiorio	dromitorio	dormleorio	dmamitorio
adaptador	afecnador	adaptdaor	adpatador	adaptteor	adgotador
pajarraco	mafadrano	pajararco	paajrraco	pajaronco	paiqrraco
frescura	clenlura	fresucra	frsecura	fresizra	frnocura
estirón	encirin	estiórn	esitrón	estiánn	esafrón
triunfante	pransfante	triunfnate	trinufante	triunfcite	trizofante

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
apagón	adimon	apaógn	aapgón	apaápn	aeggón
blusón	drunon	bluósn	bulsón	bluámn	betsón
determinista	decanjilista	determiinsta	detreminista	determiersta	detcaminista
barrigón	larravon	barriógn	barirgón	barriápn	baremgón
encefalitis	endabalimes	encefailtis	enceaflitis	encefaattis	enceitlitis
adiestrador	apiarflador	adiestrdaor	adisetrador	adiestrteor	adinotrador
circulatorio	doctulatoria	circultaorio	circluatorio	circuldoorio	circbeatorio
simulador	bomudadar	simuldaor	siumlador	simulteor	siavlador
esponjoso	escucnoso	esponojso	espnojoso	esponupso	espsejoso
humanismo	busaristo	humainsmo	huamnismo	humaersmo	huosnismo
programador	proflifadar	programdaor	progarmador	programteor	progonmador
torturador	hispurador	torturdaor	tortruador	torturteor	tortveador
analizador	aleripadar	analizdaor	anlaizador	analizteor	andoizador
comunista	comularna	comuinsta	coumnista	comuersta	coavnista
fulminante	hoslinante	fulminnate	fulmniante	fulmincite	fulmceante
acelerador	alareladar	acelerdaor	acelreador	acelerteor	acelcaador
frutería	frulicio	fruetría	furtería	fruulría	festería
visitante	bimenante	visitnate	vistiante	visitcite	visleante
comunismo	comucarso	comuinsmo	coumnismo	comuersmo	coavnismo
navideño	gadedepo	naviedño	naivdeño	naviotño	naocdeño
espumoso	enmusovo	espuomso	esupmoso	espuusso	esojmoso
recibidor	pemefidor	recibdior	reicbidor	recibloor	reenbidor
funcionario	humpianario	funcioanrio	funiconario	funcioorrio	funenonario
pegamento	mepadenta	pegmaento	pgeamento	pegroento	pjaamento
segador	mepidor	segdaor	sgeador	segteor	sjaador
legionario	bevierario	legioanrio	leigonario	legioorrio	leeponario
habitante	bafenante	habitnate	habtiante	habitcite	hableante
terrorismo	beflocisco	terroirsmo	terorrismo	terroemsmo	teranrismo
corredor	cefleror	corrdeor	croredor	corrtoor	cmaredor
tabernero	vabanlero	taberenro	taebrnero	tabericro	taofrnero
solidario	mocilaria	soliadrio	soildario	soliolrio	soatdario
hogareño	bodanefo	hogaerño	hoagreño	hogainño	hoopreño
churrero	grufleto	churerro	chrurero	churinro	chverero
dulzón	dusbon	dulózn	dluzón	duláxn	dbezón
entendedor	ensargedor	entenddeor	entnededor	entendtoor	entmidedor
lavadero	bafasera	lavdaero	lvaadero	lavteero	lñoadero
pasador	mapidor	pasdaor	psaador	pasteor	pmeador
brasero	clacera	braesro	barsero	braurro	bonsero
robustez	sogostez	robusetz	roubstez	robusulz	roodstez
simpatizante	sonsetijante	simpatiznate	simptaizante	simpatizcite	simpliizante
seguidor	meviodor	segudior	sgeuidor	seguloor	sjauidor
pastelería	sorteroria	pasteelría	pasetlería	pasteabría	pasullería
ligadura	bicaluro	ligdaura	lgiadura	ligteura	lpoadura
zapatero	bamacera	zapaetro	zaaptero	zapaulro	zaegtero
rapidez	savidiz	rapiedz	raipdez	rapiotz	raejdez
dormilón	dalcilon	dormióln	dorimlón	dormiádn	dorunlón
sancionador	moncuicador	sanciondaor	sancinoador	sancionteor	sanciseador
organizador	osbemizadar	organizdaor	organziador	organizteor	organxuador

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
frenazo	brenimo	freanzo	fernazo	freorzo	finnazo
hablador	naflidor	habldaor	hbalador	hablteor	hfelador
paredón	sacedos	pareódn	paerdón	pareíbn	paindón
resultante	remecnante	resultnate	reslutante	resultcite	resbetante
modernista	movanlista	moderinsta	modrenista	moderersta	modcanista
cursilería	dorbirelia	cursielría	curislería	cursiabría	curaclería
explorador	asgrirador	explordaor	expolrador	explorteor	expadrador
ocupante	omubince	ocupnate	ocpuante	ocupcite	ocjeante
gallinero	nafretero	gallienro	galilnero	galliicro	galatnero
chiquillería	psiviaflelia	chiquilelría	cihquillería	chiquilabría	cufquillería
ignorante	iudoconte	ignornate	ignroante	ignorcite	ignmaante
sartenazo	mortirazo	sarteanzo	saretnazo	sarteorzo	sarulnazo
servidor	saslidor	servdior	srevidor	servloor	scavidor
ayudante	airbinte	ayudnate	auydante	ayudcite	aeqdante
diseñador	mimivador	diseñdaor	disñeador	diseñteor	disxoador
madrugador	bachubadar	madrugdaor	madurgador	madrugteor	madesgador
ventilador	bontecador	ventildaor	ventliador	ventilteor	venttaador
investigador	inlurtisadar	investigdaor	investgiador	investigteor	investpoador
ligamento	bipalenta	ligmaento	lgiamento	ligroento	lpoamento
paseante	maciunte	pasenate	paesante	pasecite	paurante
aplastante	adhextonte	aplastnate	apalstante	aplastcite	apidstante
feminismo	veserismo	femiinsmo	feimnismo	femiersmo	feunnismo
congresista	conchedarta	congreissta	congersista	congreacsta	conginsista
observatorio	occensatoria	observtaorio	obsrevatorio	observdoorio	obscavatorio
temerario	beselaria	temearrio	teemrario	temeonrio	teirrario
bajura	tafuro	baujra	bjaura	baoqra	bgeura
modernismo	mopanlismo	moderinsmo	modrenismo	moderersmo	modcanismo
diccionario	diudierario	diccioanrio	diciconario	diccioorrio	dicenonario
hombretón	fempleton	hombreótn	hombertón	hombreédn	hombintón
determinante	depenjirinte	determinnate	determniante	determincite	determceante
tacañería	taleholia	tacaeñría	taacñería	tacaovría	taisñería
emigrante	ecefrinte	emigrnate	emgirante	emigrcite	emporante
acelerón	amilerad	aceleórn	aceelrón	aceleánn	aceabrón
cornudo	calfudo	corundo	cronudo	corzodo	cmanudo
traficante	frabelante	traficnate	trafciante	traficcite	trafnaante
futbolista	hobmolista	futboilsta	futoblista	futboatsta	fututlista
pegajoso	mefahoto	pegaojso	peagjoso	pegaupso	peopjoso
curandero	cumistero	curanedro	curnadero	curanotro	curcidero
gruñón	bruvon	gruóñn	gurñón	gruúxn	gesñón
mediador	sevoidor	medidaor	meidador	mediteor	mealador
criador	flaudor	cridaor	cirador	criteor	cemador
mechón	pebron	mecóhn	mcehón	mecébn	mnihón
sesentón	meranton	sesenótn	sesnetón	sesenédn	sesmitón
comunicador	colutitadad	comunicdaor	comnuicador	comunicteor	comzoicador
carterista	cosmirista	carteirsta	caretrista	carteemsta	carulrista
fundamento	birdadento	fundmaento	fnudamento	fundroento	fzodamento
anonimato	alicilago	anoniamto	anoinmato	anoniosto	anoermato
huesudo	faumudo	hueusdo	huseudo	hueomdo	hunoudo

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
secretario	meflinario	secreatrio	secertario	secreilrio	secintario
cargante	canrente	cargnate	cragante	cargcite	ccogante
millonario	pibrolaria	milloanrio	milolnario	milloorrio	miladnario
feminista	beserista	femiinsta	feimnista	femiersta	feunnista
picadero	mivacera	picdaero	pciadero	picteero	pnaadero
liderazgo	fidiralzo	lidearzgo	ldierazgo	lideonzgo	lloerazgo
dirigente	mimebente	dirignete	dirgiente	dirigmite	dirpoente
vigilante	bibecante	vigilnate	vigliante	vigilcite	vigtaante
celibato	cemigaza	celiabto	ceilbato	celielto	ceatbato
escudería	inlunenia	escuedría	esucdería	escuotría	esizdería
soñador	rofidor	soñdaor	sñoador	soñteor	svaador
temeroso	besiroto	temeorso	teemroso	temeanso	teirroso
goleador	bomiadar	goledaor	goelador	goleteor	goabador
generador	necinador	generdaor	genreador	generteor	gencaador
canoso	cadola	caonso	cnaoso	caarso	ccioso
comedero	corimera	comdeero	cmoedero	comtoero	csiedero
azucarero	agufamora	azucaerro	azcuarero	azucainro	azsoarero
moderador	pofinador	moderdaor	modreador	moderteor	modcaador
surtidor	dirtador	surtdior	srutidor	surtloor	svetidor
sujetador	puhinador	sujetdaor	suejtador	sujetteor	suiptador
colador	celeror	coldaor	cloador	colteor	cdiador
educador	amugadar	educdaor	edcuador	educteor	edsoador
detonante	remocinte	detonnate	detnoante	detoncite	detseante
colaborador	cotafenadar	colabordaor	colabroador	colaborteor	colabmaador
gobernante	bofisnante	gobernnate	gobrenante	goberncite	gobcanante
aspirador	ambenador	aspirdaor	aspriador	aspirteor	aspsoador
latigazo	batepago	latiagzo	laitgazo	latiopzo	laafgazo
mostrador	suntrador	mostrdaor	msotrador	mostrteor	mcutrador
paracaidismo	sageciadisto	paracaiidsmo	parcaaidismo	paracaialsmo	parreaidismo
esbeltez	esvaptez	esbeletz	esbletez	esbelulz	esbtitez
exquisitez	erliasitaz	exquisietz	exquiistez	exquisiulz	exquiactez
granero	claceno	graenro	garnero	graicro	gonnero
operador	omidadar	operdaor	opreador	operteor	opcaador
secuestrador	metiantrador	secuestrdaor	secusetrador	secuestrteor	secunotrador
pistoletazo	sontoretalo	pistoleatzo	pistloetazo	pistoleilzo	pistdietazo
ajedrecista	agirrocisma	ajedreicsta	ajedercista	ajedreensta	ajedincista
cincuentón	cenduinton	cincuenótn	cincunetón	cincuenédn	cincumitón
solicitante	pinaritante	solicitnate	solictiante	solicitcite	solicleante
jugador	zudidor	jugdaor	jguador	jugteor	jpiador
repelente	pefirente	repelnete	repleente	repelmite	reptiente
secador	tevidor	secdaor	sceador	secteor	sniador
torero	nodeto	toerro	troero	toinro	tmaero
cuarentón	celventon	cuarenótn	cuaerntón	cuarenédn	cuainntón
criadero	freupero	cridaero	ciradero	criteero	cemadero
blancura	clindura	blanucra	balncura	blanizra	bidncura
gritón	lleton	griótn	girtón	griédn	gemtón
purgante	mulbante	purgnate	prugante	purgcite	pvegante
oratorio	omasonia	ortaorio	oartorio	ordoorio	oontorio

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
rigidez	sigidid	rigiedz	riigdez	rigiotz	riepdez
encendedor	enmarfedor	encenddeor	enecndedor	encendtoor	enasndedor
archivador	ancrebador	archivdaor	archviador	archivteor	archzaador
domador	soridor	domdaor	dmoador	domteor	dsiador
veraneante	tegeceinte	veranenate	veraenante	veranecite	veraicante
protestante	promartonte	protestnate	protsetante	protestcite	protnotante
asaltante	amirnante	asaltnate	aslatante	asaltcite	asdotante
panadero	macasera	panaedro	pnaadero	panaotro	pciadero
violinista	buelelista	violiinsta	vioilnista	violiersta	vioatnista
salvamento	mosvadento	salvmaento	slavamento	salvroento	sdovamento
zapatería	naminelia	zapaetría	zpaatería	zapaulría	zgoatería
cenicero	cemelera	ceniecro	ceincero	ceniasro	ceercero
debutante	remudinte	debutnate	deubtante	debutcite	deodtante
cocinero	corecera	cocienro	coicnero	cociicro	coennero
justificante	nortivicunte	justificnate	justifciante	justificcite	justifnaante
estudiante	enmusuente	estudinate	estduiante	estudicite	estfoiante
emisario	esedaria	emiasrio	eimsario	emiecrio	eunsario
amigdalitis	amabsalizos	amigdailtis	amigadlitis	amigdaattis	amigollitis
viajante	veifente	viajnate	vijaante	viajcite	vigeante
comedor	ceceror	comdeor	cmoedor	comtoor	csiedor
coordinador	coesliradar	coordindaor	coordniador	coordinteor	coordceador
participante	mextinivante	participnate	particpiante	participcite	particguante
palidez	malidid	paliedz	paildez	paliotz	paatdez
agitador	amacadar	agitdaor	agtiador	agitteor	agleador
pistolero	mimpocero	pistoelro	pisotlero	pistoabro	pisedlero
pluralismo	brunanisto	plurailsmo	pulralismo	pluraatsmo	petralismo
merecedor	pecitedor	merecdeor	merceedor	merectoor	merniedor
albañilería	armosilinia	albañielría	albaiñlería	albañiabría	albaehlería
humillante	bunegrante	humillnate	humlilante	humillcite	humtalante
pesimismo	pecedisto	pesiimsmo	peismismo	pesiunsmo	peacmismo
zapatazo	wasanalo	zapaatzo	zaaptazo	zapailzo	zaegtazo
humanista	bumalarta	humainsta	huamnista	humaersta	huosnista
monetario	mosinaria	moneatrio	moentario	moneilrio	moictario
colorista	cocorensa	coloirsta	coolrista	coloemsta	coadrista
alcoholismo	artoñoristo	alcohoilsmo	alcoohlismo	alcohoatsmo	alcoeblismo
tapicería	tacarolia	tapiecría	taipcería	tapiasría	taejcería
comerciante	cosanriante	comercinate	comreciante	comercicite	comcaciante
tendedero	foncidero	tenddeero	tnededero	tendtoero	tmidedero
ebanista	emanarna	ebainsta	eabnista	ebaersta	eelnista
borrador	tollidor	borrdaor	brorador	borrteor	bmarador
papelón	pavelal	papeóln	paeplón	papeádn	paiglón
ciclista	cifrinda	cicilsta	ccilista	cicatsta	cnalista
escudero	enmumera	escuedro	esucdero	escuotro	esizdero
entrenador	esgricador	entrendaor	entrneador	entrenteor	entrmiador
velatorio	benaroria	veltaorio	vleatorio	veldoorio	vtiatorio
contestador	consacdador	contestdaor	contsetador	contestteor	contnotador
florero	clodeto	floerro	folrero	floinro	fadrero
militante	mimerinte	militnate	miltiante	militcite	milleante

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
arenoso	aniroto	areonso	aernoso	arearso	ainnoso
fumadero	burasera	fumdaero	fmuadero	fumteero	fñaadero
pensador	panvidor	pensdaor	pnesador	pensteor	pmisador
solidez	rolidid	soliedz	soildez	soliotz	soatdez
fregadero	premamera	fregdaero	frgeadero	fregteero	frjaadero
clasista	blacusta	claissta	calsista	claacsta	cidsista
velocista	becodisto	veloicsta	veolcista	veloensta	veadcista
cobrador	ceflaror	cobrdaor	cborador	cobrteor	cfarador
cabezón	cadezal	cabeózn	caebzón	cabeáxn	caofzón
escasez	esciced	escaesz	esacsez	escaurz	esissez
congelador	comnitador	congeldaor	cnogelador	congelteor	csegelador
insultante	inmoznante	insultnate	inslutante	insultcite	insbetante
hermosura	vaslosura	hermousra	heromsura	hermoomra	herussura
hospitalario	tunditalaria	hospitaalrio	hosiptalario	hospitaidrio	hosejtalario
cristalería	psimbarelia	cristaelría	crsitalería	cristaabría	crmotalería
mandatario	monvanaria	mandaatrio	manadtario	mandailrio	manoltario
sanatorio	maraloria	santaorio	snaatorio	sandoorio	sciatorio
amortiguador	amistiferdor	amortigudaor	amoritguador	amortiguteor	amorafguador
boxeador	bungiador	boxedaor	boexador	boxeteor	boazador
gobernador	godanrador	goberndaor	goebrnador	gobernteor	goofrnador
estimulante	esmacuninte	estimulnate	estimluante	estimulcite	estimbeante
competidor	cadmitidor	competdior	comeptidor	competloor	comigtidor
letrero	necrera	leterro	lterero	letinro	ldarero
gelatinoso	tetacirozo	gelationso	gelaitnoso	gelatiarso	gelaafnoso
madrugón	paclumon	madruógn	madurgón	madruápn	madesgón
veraniego	benaneifo	verainego	vearniego	veraerego	veonniego
originario	ogafiraria	origianrio	oriignario	origiorrio	oriepnario
nadador	favidor	naddaor	ndaador	nadteor	nteador
montañoso	pintazoto	montaoñso	mnotañoso	montauxso	msetañoso
deportista	remirtisto	deporitsta	deoprtista	deporafsta	deagrtista
enfermería	enlorcolia	enferemría	enefrmería	enferirría	enahrmería
calmante	carcente	calmnate	camlante	calmcite	cankante
paliducho	safitudro	paliudcho	pailducho	paliifcho	paatducho
herrero	nelleto	hererro	hrerero	herinro	hcarero
vaporoso	bavonoto	vapoorso	vaoproso	vapoanso	vaagroso
elitista	amatilta	eliitsta	eiltista	eliafsta	eattista
guerrero	neuflero	guererro	gurerero	guerinro	gucarero
cargamento	cosmacento	cargmaento	cragamento	cargroento	ccogamento
frutero	grucera	fruetro	furtero	fruulro	festero
refranero	petlalera	refraenro	refarnero	refraicro	refonnero
cafetería	dagecolia	cafeetría	caeftería	cafeulría	caahtería
bancario	bartaria	banacrio	bnacario	banisrio	bcicario
negociador	gevotiodor	negocidaor	neogciador	negociteor	neapciador
patrullero	marruprera	patrulelro	paturllero	patrulabro	pateslero
tendero	bincero	tenedro	tnedero	tenotro	tmidero
misionero	riciarero	misioenro	miisonero	misioicro	miaconero
integrante	incifrunte	integrnate	inetgrante	integrcite	inulgrante
vocabulario	tolefurario	vocabualrio	voacbulario	vocabuidrio	voisbulario

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
probador	trodidor	probdaor	prboador	probteor	prfaador
gravedad	clabedaz	gravdead	grvaedad	gravtoad	grñoedad
caluroso	camutova	caluorso	caulroso	caluanso	caetroso
purgatorio	pizpalorio	purgtaorio	prugatorio	purgdoorio	pvegatorio
martillazo	mortefravo	martilalzo	mratillazo	martilidzo	mcotillazo
concursante	condaldante	concursnate	concrusante	concurscite	concvesante
petrolero	meflodera	petroelro	petorlero	petroabro	petanlero
repetidor	bafitidor	repetdior	reeptidor	repetloor	reigtidor
preparador	pramadadar	prepardaor	preaprador	preparteor	preegrador
pacifista	mamebista	paciifsta	paicfista	paciudsta	paenfista
limonero	birorera	limoenro	liomnero	limoicro	liusnero
guitarrista	boicadrista	guitarirsta	guitrarista	guitaremsta	guitcorista
triunfador	trensfidor	triunfdaor	trinufador	triunfteor	trizofador
pacifismo	masiñisto	paciifsmo	paicfismo	paciudsmo	paenfismo
orador	icaror	ordaor	oardor	orteor	oondor
cubertería	duborlolia	cuberetría	cuebrtería	cuberulría	cuofrtería
cervecería	dombeneria	cerveecría	cerevcería	cerveasría	ceruñcería
secundario	merincario	secunadrio	secnudario	secunolrio	seczodario
cargador	calpidor	cargdaor	cragador	cargteor	ccogador
moralista	momalensa	morailsta	moarlista	moraatsta	moonlista
sencillez	sensalled	sencilelz	seniсllez	sencilabz	senenllez
apeadero	aleamoca	apedaero	aepadero	apeteero	aigadero
camionero	cacuerera	camioenro	cmaionero	camioicro	croionero
lugareño	buvanefo	lugaerño	lguareño	lugainño	lpiareño
espejismo	espefanco	espeijsmo	esepjismo	espeugsmo	esigjismo
papelería	satarelia	papeelría	paeplería	papeabría	paiglería
barrigudo	vatrepudo	barriugdo	barirgudo	barriijdo	baremgudo
pesimista	seredista	pesiimsta	peismista	pesiunsta	peacmista
prisionero	primailera	prisioenro	pirsionero	prisioicro	pemsionero
comprador	cosclidor	comprdaor	cmoprador	comprteor	csiprador
animador	amabadar	animdaor	ainmador	animteor	aermador
absolutismo	anlirutisto	absoluitsmo	absoultismo	absoluafsmo	absoettismo
colgante	cobsente	colgnate	clogante	colgcite	cdigante
progresista	proflisarta	progreissta	progersista	progreacsta	proginsista
remolcador	resadmador	remolcdaor	remlocador	remolcteor	remdicador
admirador	azpenador	admirdaor	adimrador	admirteor	adunrador
gigantón	fipenton	giganótn	giagntón	giganédn	giopntón
calculador	cosfurador	calculdaor	calcluador	calculteor	calcbeador
delineante	detacointe	delinenate	delnieante	delinecite	delceeante
acomodador	alocedadad	acomoddaor	acomdoador	acomodteor	acomlaador
borrón	lollon	borórn	brorón	boránn	bmarón
decorador	demetadar	decordaor	decroador	decorteor	decmaador
negociante	gevolionte	negocinate	negoicante	negocicite	negoenante
tesorería	lerocolia	tesoerría	teosrería	tesoinría	teamrería
jardinero	janvetero	jardienro	jaridnero	jardiicro	jaralnero
llevadero	frehalera	llevdaero	llveadero	llevteero	llruadero
chillón	trirron	chilóln	chlilón	chiládn	chtalón
cacería	caticio	caecría	ccaería	caasría	creería

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
contestón	cancecton	contesótn	cnotestón	contesédn	csetestón
exportador	ernectador	exportdaor	exprotador	exportteor	expmatador
telefonista	tecaselista	telefoinsta	teleofnista	telefoersta	teleebnista
realizador	teecipadar	realizdaor	reailzador	realizteor	reaatzador
consumidor	calmusidor	consumdior	consmuidor	consumloor	consñaidor
espinoso	escecoto	espionso	esipnoso	espiarso	esejnoso
faringitis	banispitis	farinigtis	farnigitis	farineptis	farcegitis
interrogante	incallegunte	interrognate	intrerogante	interrogcite	intcarogante
optimista	osmidisca	optiimsta	opitmista	optiunsta	opafmista
sillón	rirron	silóln	slilón	siládn	stalón
recordatorio	retescatoria	recordtaorio	recrodatorio	recorddoorio	recmadatorio
proveedor	profiodar	provedeor	proevedor	provetoor	prouñedor
votante	tocente	votnate	vtoante	votcite	vdeante
maletero	macilera	maleetro	maeltero	maleulro	maabtero
relojería	telibolia	reloejría	reoljería	reloipría	readjería
guardería	nansleria	guaredría	guradería	guarotría	gucodería
oxidante	olzemante	oxidnate	oxdiante	oxidcite	oxloante
volador	loridor	voldaor	vloador	volteor	vdiador
aceitoso	amoicoto	aceiotso	aecitoso	aceiedso	aasitoso
consejero	conmihera	conseejro	cnosejero	conseipro	csesejero
absolutista	anlarutisma	absoluitsta	absoultista	absoluafsta	absoettista
llorón	flolon	lloórn	lolrón	lloánn	ladrón
imitador	omasadar	imitdaor	imtiador	imitteor	imleador
apendicitis	atorbicimis	apendiictis	apenidcitis	apendientis	apenalcitis
picotazo	rimonalo	picoatzo	pioctazo	picoilzo	piivtazo
especulador	estanumadar	especuldaor	espeuclador	especulteor	espeizlador
practicante	priltelante	practicnate	pracitcante	practiccite	pracafcante
picajoso	mimahoto	picaojso	piacjoso	picaupso	piisjoso
portería	mostinia	poretría	protería	porulría	pmatería
simplón	silclon	simpóln	smiplón	simpádn	sneplón
conquistador	conmoiorador	conquistdaor	cnoquistador	conquistteor	csequistador
sensatez	sancitez	sensaetz	senastez	sensaulz	senectez
timbrazo	timpligo	timbarzo	tmibrazo	timbonzo	tnebrazo
cabezudo	camifuda	cabeuzdo	caebzudo	cabeoxdo	caofzudo
observador	osmanvador	observdaor	obesrvador	observteor	oburrvador
optimismo	obtedisto	optiimsmo	opitmismo	optiunsmo	opafmismo
pastelero	mantirero	pasteelro	pasetlero	pasteabro	pasullero
amargura	acespura	amarugra	amragura	amarijra	amcogura
tontorrón	bintoblon	tontorórn	tnotorrón	tontoránn	tsetorrón
coladero	dimadoro	coldaero	cloadero	colteero	cdiadero
lanzador	vinjador	lanzdaor	lnazador	lanzteor	lcizador
basurero	vamucera	basuerro	bausrero	basuinro	baomrero
vendedor	finsedor	venddeor	vnededor	vendtoor	vmidedor
tolerante	bomirinte	tolernate	toelrante	tolercite	toabrante
cuidador	ciapidor	cuiddaor	cudiador	cuidteor	culoador
futbolero	hapsolero	futboelro	futoblero	futboabro	fututlero
fundador	fuspidor	funddaor	fnudador	fundteor	fzodador
terrorista	beflonisca	terroirsta	trerorista	terroemsta	tcarorista

Table 3 (continued)

TARGET WORD	TARGET NONWORD	TL BETWEEN MORPHEMES	TL WITHIN MORPHEME	RL BETWEEN MORPHEMES	RL WITHIN MORPHEME
caminante	cacecinte	caminnate	caimnante	camincite	caunnante
humorista	bumonarta	humoirsta	huomrista	humoemsta	huusrista
monedero	pomimero	moneedro	moendero	moneotro	moicdero
principiante	prindevuente	principinate	prinicpiante	principicite	prinenpiante
cabelludo	camifruda	cabeluldo	caeblludo	cabeletdo	caoflludo
patrocinador	safroniradar	patrocindaor	patroicnador	patrocinteor	patroennador
pensionista	monfianista	pensioinsta	penisonista	pensioersta	penaconista
laboratorio	tagoracocie	labortaorio	labroatorio	labordoorio	labmaatorio
relojero	pemobera	reloejro	reoljero	reloipro	readjero
destilería	desmarolia	destielría	desitlería	destiabría	desaflería
navegante	bapipante	navegnate	naevgante	navegcite	nauñgante
acogedor	amibodor	acogdeor	aocgedor	acogtoor	aivgedor
librería	biflinia	liberría	lbirería	libinría	lharería
trabajador	pramasadar	trabajdaor	trabjaador	trabajteor	trabgeador
salvador	sarfidor	salvdaor	slavador	salvteor	sdovador
emprendedor	erplercedor	emprenddeor	emprnededor	emprendtoor	emprmidedor
bromista	clodasta	broimsta	bormista	brounsta	banmista
algodonoso	anhosolozo	algodoonso	alogdonoso	algodoarso	alapdonoso
tesorero	becocera	tesoerro	teosrero	tesoinro	teamrero
afilador	amesadar	afildaor	afliador	afilteor	aftaador
respiratorio	teslecacorio	respirtaorio	respriatorio	respirdoorio	respsoatorio
medidor	pevador	meddior	mdeidor	medloor	mtoidor
vistoso	tustoco	visotso	vsitoso	visedso	vmotoso
amplificador	ancragicadar	amplificdaor	ampilficador	amplificteor	ampatficador
contenedor	coscicedor	contendeor	conetnedor	contentoor	conulnedor

TL, transposed letters; RL, replaced letters

Appendix B: Regression analyses

We examined whether some critical properties of polymorphemic words could have covaried with the magnitude of the between-morpheme and within-morpheme TL effects for each of the two groups (i.e., faster and slower participants). To this end, we computed the magnitude of the TL effect (replaced-letter condition minus transposed-letter condition) for the averaged responses to each individual word separately for each group and place of manipulation. Given that the materials were selected to ensure (1) a sufficient degree of generalization of the results to the item population (n = 420), and (2) adequate representativeness of the heterogeneity of each individual factor explored (see the ranges and *SD*s presented in Table 1), it can be confidently expected that if any of the factors under investigation were directly responsible for the modulation of the magnitude of the TL effects, on top of the speed and strategy of response of the participants (and the cognitive processes associated with this speed), such a result would emerge in these regression analyses.

The factors included in the regression models were Word, Base, and Suffix Length (e.g., the numbers of letters in "violinista," "violín," and "ista"), the Frequency of the words and bases and their Orthographic Neighborhood Sizes, the Levenshtein Distance between the base and the stem (the number of edits needed so that the string corresponding to the base would exactly match the string corresponding to the stem; see Yarkoni, Balota, & Yap, 2008), the Morphological Family Size of the bases and the suffixes (individually computed for each item, considering the lexicon included in B-Pal and the SCOGEME morphological management computational system for Spanish developed at the ULPGC), the Cumulative Frequency of the morphological family of the bases and suffixes (see Ford, Marslen-Wilson, & Davis, 2003), and the Frequency of the Bigrams constituting the morphemic boundary (e.g., the frequency of "ni" in "violi**ni**sta"; see the bigram trough hypothesis proposed by Seidenberg, 1989).

The results of the regression analyses were clear cut. With the exception of the regression model of the between-morphemes TL effects for the faster participants ($p = .04$) (see the Supplementary Table), none of the other models reached significance ($ps > .50$). The model fitted to the between-morpheme TL effect for the faster participants showed that the base word frequency and orthographic neighborhood of the whole word accounted for a significant portion of the variance (both $ps = .04$). Hence, the magnitude of the between-morpheme TL effects was modulated by these two lexical properties of the words in the group of faster participants.

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