

The impact of consonant-vowel transpositions on masked priming effects in Italian and English

Lucia Colombo¹

Giacomo Spinelli²

and

Stephen J. Lupker²

¹University of Padua

²University of Western Ontario

Running Header: Consonant-Vowel Transpositions

Corresponding Author:

Stephen J. Lupker
Department of Psychology
University of Western Ontario
London, Ontario
N6A 5C2
Canada
phone: 519 661-2111 x84700
e-mail: lupker@uwo.ca

Abstract

There are now a number of reports in the literature that transposed-letter (TL) priming effects emerge when two consonants are transposed (e.g., caniso-CASINO) but not when two vowels are transposed (e.g., cinaso-CASINO) (e.g., Perea & Lupker, 2004). In the present paper, four masked priming lexical decision experiments, two in Italian, two in English, are reported in which TL priming effects involving the transposition of two adjacent consonants (e.g., atnenna-ANTENNA) were contrasted with those involving the transposition of a vowel and an adjacent consonant (e.g., anetnna-ANTENNA), a contrast not directly examined in the previous literature. In none of the experiments was there any indication that the priming effects were different sizes for the two types of transpositions, including Experiment 4 in which a sandwich priming paradigm (Lupker & Davis, 2009) was used. These results support the assumption of most orthographic coding models that the consonant-vowel status of the letters is not relevant to the nature of the orthographic code. The question of how to reconcile these results with other TL manipulations investigating vowel vs consonant transpositions is discussed.

Keywords: transposed-letter priming, orthographic code, consonant-vowel differences

The impact of consonant-vowel transpositions on masked priming effects in Italian and
English

Transposed letters effects: Consonant-vowel differences in masked priming lexical decision

In recent years, considerable research attention has been paid to “transposed letter” (TL) effects (Colombo, Sulpizio & Peressotti, 2017; Frankish & Turner, 2007; Guerrero & Forster, 2008; Johnson, Perea & Rayner, 2007; Kinoshita & Norris, 2009; Ktori, Kingma, Hannagan, Holcomb & Grainger, 2015; Lupker, Perea & Davis, 2008; Perea & Lupker, 2003a;

2003b; 2004; Schubert, Kinoshita & Norris, 2018). The basic phenomenon is that TL nonwords (e.g., jugde) appear to be perceived as being more similar to their base words (i.e., JUDGE) than are nonwords created by substituting different letters for the transposed letters (e.g., “substitution letter” (SL) nonwords such as jupte).

Although TL effects have been reported in a number of experimental paradigms, the focus of the present research is masked priming lexical decision (Forster & Davis, 1984) because we used this paradigm in the present experiments. In this paradigm, on each trial, a prime is initially presented for a very brief period of time (e.g., 50 ms), typically in lower case. Immediately following prime presentation, a (typically) upper case target is presented in the same location on the screen as the prime. The target serves as a backward mask for the prime with the result being that participants are rarely, if ever, aware of the prime’s existence. Participants then make a lexical decision to the target. With respect to TL effects, the specific phenomenon that is reported in this task is that responding to word targets is faster if the prime is a TL nonword than if it is a SL nonword.

As has been noted in most of the papers on this topic, this result is not one that was predicted by the older models of word recognition. Specifically, it was not predicted by models like McClelland and Rumelhart’s (1981) Interactive-Activation model, models that assume that letter positions are coded accurately and quickly. Partially in response to this situation, a number of newer models have emerged that do provide an explanation of TL effects (Adelman, 2011; Davis, 2010; Gómez, Ratcliff & Perea, 2008; Norris & Kinoshita, 2008, 2012; Grainger & Van Heuven, 2003; Whitney, 2001). What is important to note, however, is that essentially all of these models make no distinction between vowels and consonants. It was, therefore, somewhat of a surprise that Perea and Lupker (2004) were able to show that although transposing two

nonadjacent consonants (e.g., caniso vs caviro as primes for the target CASINO) produced a TL priming effect, transposing two vowels (e.g., cisano vs cesuno as primes for the target CASINO) did not. This null TL priming effect when transposing two vowels has now been replicated a number of times in Spanish (e.g., Carreiras, Vergara & Perea, 2009; Comesaña, Soares, Marcet & Perea, 2016; Perea & Acha, 2009). There has also been one published replication of this pattern in English (Lupker, Perea & Davis, 2008).

If the consonant-vowel TL priming difference is real, it poses a clear challenge for the models of orthographic coding that do not distinguish between vowels and consonants. Several attempts have, therefore, been made to try to explain this pattern within the context of those models. For example, Lupker et al. (2008) suggested that the speed of position coding for letters may be frequency dependent. More frequent letters may be more rapidly coded into their correct positions. Therefore, the “i” and the “a” in a nonword prime like cisano would be tagged into the second and fourth letter positions very early in processing because “i” and “a” are very frequent letters. As a result, the nonword cisano would be no more similar to the word CASINO than an SL nonword like cesuno would be because in both cases two letter positions would definitely contain different letters than in the word CASINO. In support of this idea, Lupker et al. showed that transposing two high frequency consonants (e.g., pterext-PRETEXT) produced a smaller priming effect than transposing two low frequency consonants (sibazle-SIZABLE).

Although letter frequency, in terms of how fast letters are assigned to positions, may play a role in producing the consonant-vowel difference, results reported by Duñabeitia and Carreiras (2011) suggest that the complete explanation is likely to be somewhat more complicated. In their experiment, the set of consonants contained in a word was used as a prime (e.g., nml-ANIMAL). Except in the case of the initial letter (for some pairs) all letters in the prime would,

as a result, be in a different letter position in the target. Therefore, if the more frequent letters were more likely to be assigned to their positions (positions 1, 2 or 3) in the orthographic code for the prime earlier than the less frequent letters were assigned to theirs, high frequency letter primes should be less effective primes than low frequency letter primes. Duñabeitia and Carreiras's results, however, were that equal priming effects emerged regardless of whether the letters in the prime were high or low frequency.

Transposing consonants and vowels in other tasks.

An alternative way of explaining the consonant-vowel TL priming difference in the framework of current orthographic coding models would be to suggest that the difference may not be an orthographic coding phenomenon at all (Perea & Acha, 2009). This alternative idea can be shown if we consider another paradigm that shows a consonant-vowel difference in TL effects. For, example, a TL effect also arises when TL versus SL nonwords are presented as nonword targets in a simple (i.e., unprimed) lexical decision task (Carreiras, Vergara & Perea, 2007; Colombo et al., 2017; Lupker, Perea & Davis, 2008; Perea & Lupker, 2004; Schubert et al., 2018). More importantly, however, a consonant-vowel TL difference does not arise in the masked priming same-different task (Perea & Acha, 2009), a task that seems to be mainly driven by the nature of orthographic codes while not involving higher-level processes such as lexical access.

In the masked priming same-different task (Norris & Kinoshita, 2008), a reference stimulus is initially presented, followed by a masked prime followed by a target. The task is to decide if the reference stimulus and target are the same. If the prime is a transposition of the reference stimulus/target (which are the same stimuli on "same" trials), responding is facilitated.

In three experiments, Perea and Acha (2009) demonstrated that the TL effects in that task did not show a consonant-vowel difference, that is, vowel TL nonwords produced just as large a priming effect as consonant TL nonwords. What these results suggest is that it is not the nature of the orthographic code that differs between vowel versus consonant TL nonword primes but how that code is used by higher-level processes.

An account that builds on this idea would be one based on the concept of lexical constraint, that is, the constraint that the prime provides concerning possible targets (Carreiras, Gillon-Dowens, Vergara & Perea, 2009; Duñabeitia & Carreiras, 2011; Perry, Lupker & Davis, 2008). In masked priming lexical decision experiments, the reason that there is orthographic (form) priming is that primes are assumed to activate lexical representations for targets that are orthographically similar to those primes. The degree of activation they provide is, to a large extent, assumed to be a function of the degree of prime-target similarity. A second factor that determines the size of the priming effects, however, is how many similar targets are activated by a given prime. That is, lexical processing models assume that activated lexical representations compete with one another during lexical processing (e.g., Davis, 2010) which slows down target activation. Therefore, to the extent that a prime can cause activation to flow mainly to the target (i.e., to the extent that the prime's activation is constrained to the target), there will be less competition and, hence, a larger priming effect.

The argument for how this idea could explain consonant-vowel differences in TL effects would be as follows. There are many more consonants than vowels in the alphabet. Thus, any identified consonants (e.g., during prime processing) provide much more useful information in terms of what lexical representations should be activated and what lexical representations should be inhibited. As a result, a SL prime like *caviro* would have the effect of not only providing

reduced activation for CASINO but also providing activation for competitors that contain either a “v” or an “r” (in contrast to the impact of the consonant TL prime caniso). Identifying a vowel would have much less impact on the overall pattern of lexical activation since both the “e” and the “u” in the vowel SL prime cesuno, and the “i” and the “a” in the TL prime cisano are contained in so many other words.

Essentially, the argument would be that, due to the nature of the lexicon, mismatching consonants in the prime (i.e., as with consonant SL primes) heighten the activation of more serious lexical competitors in comparison to consonant TL primes like caniso which do not contain mismatching consonants, producing a TL priming effect. Vowel TL and SL primes contain the same consonants (those contained in the target) and, therefore, activate essentially the same lexical representations. Hence, vowel TL and SL primes are equally effective primes. Thus, this type of account, which is a lexically-based account, could explain the fact that consonant TL nonwords prime while vowel TL nonwords do not (Perea & Lupker, 2004) within the context of current orthographic coding models, that is, within the context of models that do not propose any inherent differences in consonant versus vowel processing at the orthographic coding level.

This account would certainly be consistent with the data reported by New, Araújo and Nazzi (2008) and New and Nazzi (2014) in French, and Soares, Perea, and Comesaña (2014) in European Portuguese. Those authors showed that the primes containing the target’s consonant (e.g., what we are calling vowel SL primes, duvo-DIVA) produce a priming effect (in comparison to an unrelated prime condition) whereas primes containing the target’s vowels (e.g., what we are calling consonant SL primes, rifa-DIVA) do not.

Unfortunately, this lexical constraint idea makes an additional prediction that is unsupported by essentially all of the available data. That is, if consonants are more important to the lexical access process than vowels, primes that contain all the relevant consonants in the correct order (i.e., both vowel SL and vowel TL primes) should be the best primes in a lexical decision task (i.e., the New et al., 2008, New and Nazzi, 2014, and Soares et al., 2014, pattern should hold for both prime types). None of the available data sets (Carreiras, Vergara & Perea, 2009; Comesaña, Soares, Marcet & Perea, 2016; Lupker et al., 2008; Perea & Acha, 2009; Perea & Lupker, 2004), support this prediction. Rather, the consonant TL primes (e.g., caniso for CASINO) were the most effective primes in all these experiments. Therefore, it seems unlikely that the lexical constraint idea would be able to provide a complete explanation of why TL primes are better than SL primes when consonants are being transposed but not when vowels are being transposed.

Is consonant-vowel status encoded in the orthography?

What also needs to be noted is that there are other word recognition models that may be able to provide alternative explanations for consonant-vowel TL differences in terms of priming, models based on the idea that the inherent differences between vowels and consonants, which are, to a large degree, phonologically-based, are also coded *orthographically, or, are reflected at the orthographic level* (see Treiman, 1994, for this type of proposal).

Accounts of this sort note that consonants and vowels are phonological categories characterized by different systems of articulatory features (Caramazza et al., 2000). As Caramazza and Miceli (1990) argue, for example, “orthographic representations – the abstract mental representations of the spellings of words – include orthography-specific information

regarding the consonant/vowel identity of the individual letters that make up a word's spelling" (see also Buchwald & Rapp, 2003, 2006). This type of view suggests that, when we read words, the consonant-vowel status of the letters is encoded very early and is included in the orthographic representation that is formed from visual analysis, without the obligatory involvement of phonology.

The issue of there being different relative contributions of consonants and vowels in reading has been investigated a number of times although with contrasting results (see Berent and Perfetti, 1995; Colombo, 2000; Colombo, Cubelli, Zorzi & Brivio, 2003; Lee, Rayner & Pollatsek, 2001; New et al., 2008; New & Nazzi, 2014; Perry & Ziegler, 2002; Soares et al., 2014). For example, as noted, New et al. (2008) and Soares et al. (2014) reported priming for consonant-preserving primes (what we are calling vowel SL primes), but not for vowel-preserving primes (what we are calling consonant SL primes), compared to an unrelated prime condition, when the prime presentation time was 50 ms.

New and Nazzi's (2014) results in a follow up investigation were a bit more complex but still suggestive of a vowel-consonant difference. With a 33 ms prime presentation time, consonant- and vowel-preserving primes did not differ from each other and nor did either differ from an unrelated prime condition (i.e., there was no priming). With a 66 ms presentation time the advantage for consonant-preserving primes over vowel-preserving primes re-emerged. Unfortunately, the interpretation of this contrast is complicated by the fact that that difference was mainly due to there being inhibition for vowel-preserving primes compared to an unrelated condition, whereas no significant facilitation for consonant-preserving primes was observed (again, compared to the unrelated prime condition).

A second way of trying to establish the importance of the letter's nature in the orthographic

code can be found in experiments investigating the CV structure of the prime and target. For example, in a lexical decision task in Spanish, Perea, Marcet and Acha (2018) contrasted masked SL primes preserving the consonant-vowel (CV) structure of the target word (e.g., *alusno-ALUMNO*), masked SL primes not preserving the CV structure (e.g., *alueno-ALUMNO*) and masked identity primes (e.g., *alumno-ALUMNO*). Expectedly, Perea et al. found a cost for both SL primes compared to the identity prime condition, however, the nature of the letter being replaced mattered, to at least some degree. When the letter being replaced was a consonant (as in the examples above in which the “m” is the letter being replaced), the cost was the same when that letter (i.e., “m”) was replaced by a consonant as when it was replaced by a vowel. However, when a vowel was replaced (e.g., the “u” in *ALUMNO*), the cost was less when the “u” was replaced by another vowel (i.e., the CV structure was maintained as in *alemno-ALUMNO*) in comparison to being replaced by a consonant (i.e., the CV structure was not maintained as in *alsmno-ALUMNO*). The latter result (the vowel-consonant difference when a vowel is the letter being replaced in the prime) would be consistent with the idea that establishing the target’s CV structure by means of the prime is important. The former result (no vowel-consonant difference when a consonant is being replaced in the prime) is not. Hence, Perea et al. conclusion was that what is activated in the early stages of word activation may not be the CV structure, but rather something like a consonant grid.

Research by Chetail and collaborators (Chetail & Content, 2012, 2013, 2014; Chetail, Drabs & Content, 2014), however, would appear to make an even stronger case for the idea that vowel-consonant status is important early in processing. In their view, vowels and vowel clusters (i.e., a cluster of two or more vowels, as in the word *bouquet*) form early pre-lexical perceptual (vowel-centered) units in word recognition. They found evidence in support of their view in a

number of paradigms: syllable counting, cross-case matching, estimating the physical length of stimuli. Chetail et al., (2014), for example, used the unprimed same-different task and examined situations in which the reference stimulus and target did or did not share vowel-centered units (i.e., “different trials”). For example, transposing two letters (u and r) in FOUREIL (FORUEIL) preserves the number of vowel –centered units, while transposing those same two letters in BOUDLET (BODULET) does not. Their results indicated that detecting a mismatch between the reference stimulus and target was much faster in the latter case, i.e., when the number of vowel-centered units is not preserved. Based on these results, they argued that orthographic processing involves initially identifying abstract letter identities followed by a pre-lexical process that requires parsing the letter string into vowel-centered units. When a reference stimulus does not respect the CV organization of the target based on this principle, it should, therefore, be easier to decide that the two stimuli are not identical.

To sum up, the literature on this subject presents a rather complex picture, although it does contain support for the ideas that: a) there is a different status for consonants and vowels and b) the status of letters as either consonants or vowels may be relevant in the orthographic code.

The present study.

The goal of the present research was to provide a further examination of these issues. One point to note is that the transpositions used in most of the prior experiments investigating consonant-vowel differences, particularly those experiments using the masked priming lexical decision task, inevitably involved nonadjacent transpositions. In some sense this is an odd choice since the original TL effects in masked priming involved adjacent transpositions (Forster, Davis, Schoknecht & Carter, 1987; Perea & Lupker, 2003a; 2003b), as did the earlier work on

TL effects using other paradigms (e.g., Andrews, 1996; Chambers, 1979; Holmes & Ng, 1993; O'Connor & Forster, 1981; Taft & van Graan, 1998). On the other hand, one of the reasons for researchers being hesitant to use nonadjacent transpositions, at least in English experiments, may be that adjacent vowel-vowel transpositions inevitably involve a graphemic change that creates a change in phonology (i.e., “ae” is virtually always pronounced qualitatively differently than “ea”). Note, however, that Lupker, Acha, Davis and Perea (2012) have reported that transpositions that involved breaking up a grapheme behaved no differently than transpositions that altered any two other letters.

The specific contrast investigated here was between CC transpositions and both consonant-vowel (CV) transpositions and vowel-consonant (VC) transpositions. In Experiment 1 (in Italian), CC transpositions were contrasted with transpositions involving one consonant and one vowel. To create the latter condition, both CV and VC transpositions were used. In Experiments 2 (in Italian) and 3 (in English), a balanced number of targets were used in CC, VC and CV priming conditions. In Experiment 4 (in English), a sandwich priming paradigm (Lupker & Davis, 2009) was used with the primes and targets from Experiment 3 in order to increase the sizes of the priming effects for the three prime types, and consequently, the likelihood of finding differential priming effects.

Based on previous results, it is likely that CC transpositions will prime the corresponding target words (in comparison to SL primes). However, it is not clear whether either CV or VC transpositions will prime to any measurable degree. For example, based on the premise that the consonant-vowel status is established early in processing and is crucially important as a guide for lexical access (e.g., Caramazza & Miceli, 1990), CV and VC transpositions would create primes that are different from their targets in terms of consonant-vowel structure, while CC

transpositions would not change it. Thus, models based on the assumption that consonant-vowel status is assigned very early in processing would seem to predict that VC and CV transpositions would create less effective primes than CC transpositions. If so, it should be the case that, because both related and unrelated primes involving CV and VC transpositions create an (identical) change of CV structure, responses to targets primed by those primes might be slower overall than responses to targets primed by both related and unrelated CC primes (i.e., primes that do not alter the target's CV structure). That is, there would be an overall letter type effect. Whether this pattern emerges or not, there may still be TL priming effects from CV and VC primes (measured against the SL prime condition). In contrast, it is also possible that the prime must maintain the CV structure of the target in order for any priming effects to emerge. Thus, unlike CC transpositions that maintain the target's CV structure, CV and VC transpositions, transpositions that disrupt that structure could, in theory, produce a complete lack of priming.

At present, there appears to be only one investigation (in English) in which CV, VV and CC transpositions were contrasted (Blythe, Johnson, Liversedge & Rayner, 2014). Blythe et al.'s Experiment 2 involved the contrast between CC, VV and CV adjacent letters (sytsem from system, faeture from feature, and fromat from format, respectively). The stimuli were either included in a reading task with a sentence context in which the TL letter strings were presented in the periphery before changing to the correct spelling when the word was fixated (a boundary technique), or presented in isolation in a misspelling decision task. In the reading task, Blythe et al. found evidence in total reading times and in number and duration of regressions for a greater difficulty with CV than with CC and VV transpositions. In the misspelling decision task, longer latencies were associated with CV strings than the other two stimulus types. As only CV transpositions changed the CV structure of the word, those authors concluded that there is

evidence for an influence of CV structure.

What should be noted, however, is that in their reading task, while an overall effect of letter transposition (peripheral presentations involving transpositions versus those involving no transpositions) was apparent in early measures of processing (e.g., first fixation durations) the relative difference between CC, VV and CV was not. Those differences only emerged on later measures of processing. Blythe et al. (2014) concluded, therefore, that the effect of CV status only emerges at the phonological level.

If Blythe et al.'s (2014) conclusion is correct, we may observe no differences among the three primes types. In any case, the existence of prime type differences of the sort investigated in the present experiment is an empirical question and, to this point, there have been no investigations of this question using adjacent transpositions in masked priming, lexical decision experiments. The present experiments were an effort to begin filling this gap.

Experiment 1

The goal of Experiment 1 was to determine whether not only adjacent CC transpositions (e.g., *puslante-PULSANTE*; *button*) but also adjacent transpositions involving one consonant and one vowel (either CV transpositions, e.g., *pulasnte-PULSANTE*, or VC transpositions, e.g., *pulsnate-PULSANTE*) produce priming effects in a masked priming lexical decision task in Italian and, if so, whether those priming effects differ in magnitude.

Method

Participants

Forty students (22 males) from the University of Padua participated in this experiment (age 19-32, $M = 22$) for course credit. All were native speakers of Italian and had normal or corrected-to-normal vision.

Materials

Sixty-four Italian words were extracted from PhonItalia (Goslin, Galluzzi, & Romani, 2014) to serve as target words. Nine of them had to be removed from the analyses due to typos in the primes associated with them (see below), so we report the characteristics of the remaining 55. Their mean length is 7.65 letters (range = 6-9) and their mean word frequency (per million) is 48.69 (range = 1.21-349.11). Four nonwords were created to serve as their primes. TL primes based on the target words were created in two ways, by: 1) transposing two adjacent consonants (e.g., *puslante*-PULSANTE, the CC transposition condition); 2) transposing a consonant and a subsequent adjacent vowel or a vowel and a subsequent adjacent consonant (e.g., *pulasnte*- or *plusante*-PULSANTE, the CV/VC transposition condition). In the original list of 64 targets, 26 were in the CV prime condition and 38 were in the VC prime condition. SL primes based on the TL primes were created in two ways, by: 1) replacing the transposed consonants in the CC transposition primes with other consonants (e.g., *purmante*-PULSANTE, the CC substitution condition); 2) replacing the transposed vowel and consonant in the CV/VC transposition primes with another vowel and another consonant, respectively (e.g., *pulucnte*-PULSANTE, the CV/VC substitution condition). Transpositions never involved the first or the last letter of the word, and CC and CV/VC transpositions were matched on the position of the first transposed/substituted letter ($M = 3.87$ and $M = 3.80$, respectively). The word targets and their primes in all experiments are listed in the Appendix.

Sixty-four orthographically legal nonwords were created to serve as nonword targets. CC and CV/VC transposition and substitution primes were created for the nonword targets in the same way as they were created for the word targets.

The targets were divided into four sets of 16 and each set was primed by primes from one of the four prime conditions. Four lists, with 64 target words and 64 target nonwords each, were created for an appropriate counterbalancing and participants were randomly (and equally) assigned to one of those lists.

Procedure

Participants were tested individually in a quiet room. E-prime 2.0 (Psychology Software Tools, Pittsburgh, PA; see Schneider, Eschman, & Zuccolotto, 2002) was used for stimulus presentation and data collection. Each trial began with a lower-case prime presented for 60 ms followed by the target, which was presented in upper case for 2000 ms or until a response was made. All stimuli were presented in Courier New-18 centered on the screen. Participants were instructed to respond as quickly and as accurately as possible as to whether the upper-case letter string was a real Italian word or not by pressing the “M” and “Z” keys, respectively. Participants were not informed of the presence of the primes. Participants completed 24 practice trials followed by a randomized list of all of the experimental trials.

Results

Data from nine word targets were removed due to typos in one or more of their primes, leaving 55 word targets that were primed by CC primes (all 55) and either CV (21) or VC (34) primes. In this and the following experiments, nonword data were not analyzed. Incorrect responses (3.07%) and response latencies below 250 ms or above 1750 ms (0%) were removed from the latency analyses. Latency and error analyses were conducted using generalized linear mixed-effects modeling in R version 3.5.1 (R Core Team, 2018), treating subjects and items as random effects and treating Letter type (CC vs. CV/VC) and Prime type (transposition vs. substitution) as within-subject and within-item fixed effects (Baayen, 2008; Baayen, Davidson,

& Bates, 2008). Prior to running the model, R-default treatment contrasts were changed to sum-to-zero contrasts (i.e., `contr.sum`) to help interpret lower-order effects in the presence of higher-order interactions (Levy, 2014; Singmann & Kellen, 2018). The model was fit by maximum likelihood with the Laplace approximation technique. The `lme4` package, version 1.1-18-1 (Bates, Mächler, Bolker, & Walker, 2015) was used to run the generalized linear mixed-effects model. The function `Anova` in the `car` package version 2.1-2 (Fox & Weisberg, 2016) was used to obtain estimates and probability values for the fixed effects.

In the latency analysis, a generalized linear mixed-effects model was used instead of a linear mixed-effects model because generalized linear models, unlike linear models, do not assume a normally distributed dependent variable and can, therefore, better accommodate the typically positively skewed distribution of RT data (Balota, Aschenbrenner, & Yap, 2013; Lo & Andrews, 2015). We decided to use the generalized linear mixed-effects model and analyze raw RTs rather than the more common practice of using linear mixed-effects models and normalizing raw RTs with a reciprocal transformation (e.g., $\text{invRT} = -1000/\text{RT}$). The reason is that nonlinear transformations systematically alter the pattern and size of interaction effects, rendering such transformations inappropriate when the research interest lies in interactions, as in the present case (Balota et al., 2013; Cohen-Shikora, Suh, & Bugg, in press; Yang, Chen, Spinelli, & Lupker, in press). (note 1)

A Gamma distribution was used to fit the raw RTs, with an identity link between fixed effects and the dependent variable (Lo & Andrews, 2015). Note that, in the current version of `lme4`, convergence failures for generalized linear mixed-effects models, especially more complex models, are frequent, although many of those failures reflect false positives (Bolker, 2018). To limit the occurrence of convergence failures, for this and for the following analyses we kept the

random structure of the model as simple as possible by using only random intercepts for subjects and items. (note 2) The statistical model for the latency analysis was: $RT = \text{glmer}(RT \sim \text{letter_type} * \text{prime_type} + (1|\text{subject}) + (1|\text{item}), \text{family} = \text{Gamma}(\text{link} = \text{"identity"}))$. The statistical model for the error rate analysis was: $\text{Accuracy} = \text{glmer}(\text{accuracy} \sim \text{letter_type} * \text{prime_type} + (1|\text{subject}) + (1|\text{item}), \text{family} = \text{"binomial"})$. (note 3)

As noted, our main research interest concerns whether priming for CC transpositions might differ from priming for CV/VC transpositions, i.e., a Letter type by Prime type interaction. However, null-hypothesis significance testing does not allow one to draw strong conclusions if the effect of interest is not statistically significant. Thus, we also conducted a Bayes Factor analysis to quantify the statistical evidence in favor or against a Letter type by Prime type interaction. This analysis was conducted using the Bayesian Information Criterion (BIC) approximation of the Bayes Factor (Wagenmakers, 2007). Specifically, the Bayes Factor BF_{01} was computed using the BIC values obtained for the model without the interaction (interpreted as the null hypothesis H_0) and for the model with the interaction (interpreted as the alternative hypothesis H_1) using the formula $BF_{01} = \exp((\text{BIC}(H_1) - \text{BIC}(H_0))/2)$ (Wagenmakers, 2007, p. 796). Note that $BF_{01} < 1$ would suggest evidence in support of H_1 (i.e., the presence of the interaction), whereas $BF_{01} > 1$ would suggest evidence in support of H_0 (i.e., the absence of the interaction) ($BF_{01} = 1$ would suggest equal evidence for the two hypotheses). Jeffreys's (1961) classification (as reported in adjusted form by Lee and Wagenmakers, 2013) was used to help interpret the size of the Bayes Factor.

The mean response times and error percentages based on the by-subject data are presented in Table 1. For this and for the following experiments, the raw data and the scripts used for the analyses are publicly available at <https://osf.io/7dgyh/>.

The latency data revealed a main effect of Letter type, $\chi^2 = 9.25$, $p = .002$, with faster responses to targets preceded by CC primes (591 ms) than to targets preceded by CV/VC primes (607 ms). The main effect of Prime type was significant as well, $\chi^2 = 49.94$, $p < .001$, with faster responses to targets preceded by transposition primes (583 ms) than to targets preceded by substitution primes (616 ms). The two factors, however, did not interact, $\chi^2 = .001$, $p = .97$. The Bayes Factor for the comparison between the model with and the model without the interaction was $BF_{01} = 46.15$, meaning that the data were 46.15 times more likely to occur under the hypothesis of no interaction than under the hypothesis of an interaction. In Jeffreys's (1961) classification scheme, this value would suggest "very strong" evidence for the absence of the interaction.

In the error data, the main effect of Letter type did not reach significance, $\chi^2 = 2.75$, $p = .097$. The main effect of Prime type was significant, $\chi^2 = 8.28$, $p = .004$, indicating that error rates were lower when targets were preceded by a transposition (1.98%) than a substitution prime (4.09%). Again, the two factors did not interact, $\chi^2 = 1.11$, $p = .29$, with the Bayes Factor, $BF_{01} = 26.51$, indicating "strong" evidence for the absence of the interaction.

Discussion

As expected, a standard TL priming effect was obtained. Targets were responded to more rapidly when preceded by TL primes than by SL primes. More centrally, however, there was no evidence that this effect was larger for CC primes than for CV/VC primes, a finding that may seem a bit surprising when contrasted with previous research on consonant-vowel differences in Spanish (e.g., Carreiras et al., 2009; Comesaña et al., 2016; Lupker & Perea, 2004; Perea & Acha, 2009), a language that is much like Italian. That research, showing no priming for nonadjacent VV transpositions, might suggest that CV/VC transpositions (i.e., transpositions

involving a vowel) would produce smaller priming effects than CC transpositions (i.e., transpositions not involving a vowel).

Note that in Experiment 1, we did not differentiate between CV and VC transpositions, because no extant model of letter position coding suggests that the two types of transpositions should differ in any respect. However, there is some evidence that suggests that the magnitude of TL effects might be sensitive to the specific nature and context of the letters being transposed (Schubert et al., 2018). For example, although not directly related to the present situation, Schubert et al. found that in the unprimed same-different task, nonwords created by transposing nonadjacent consonants were harder to reject on “different” trials if one of the transposed consonants was involved in a consonant cluster (e.g., alhocol from ALCOHOL) than if neither of them was (e.g., lutanic from LUNATIC). Therefore, a reasonable question to ask is whether the more specific nature of the transposed letters mattered, that is, whether the magnitude of the TL priming effect was equivalent for CV and VC primes.

It should be noted, of course, that the present experiment was not designed to contrast CV and VC transpositions because one set of targets was associated with CV primes and another set of targets was associated with VC primes. Thus, any potential difference between the two conditions might simply reflect differences in the priming effects for the two different sets of targets. Nonetheless, we conducted a post-hoc analysis breaking down the CV/VC condition into CV and VC primes as an initial step in exploring this question.

Out of the 55 targets being analyzed, 21 were primed by CV primes and 34 were primed by VC primes. The two target sets did not differ on length, position of the first transposed/substituted letter or word frequency. The mean response times and error percentages from the subject analyses are presented in Table 1. Both dependent variables were submitted to a

generalized linear mixed-effects model with Letter type (CV vs. VC) as a within-subject and between-item fixed effect, and Prime Type (transposition vs. substitution) as a within-subject and within-item fixed effect.

In the latency analyses, no main effect of Letter type was obtained, $\chi^2 = .08, p = .77$, whereas a main effect of Prime type was obtained, $\chi^2 = 22.77, p < .001$. Importantly, the interaction between Letter type and Prime type did not reach significance, $\chi^2 = 2.11, p = .15$. In addition, the Bayes Factor analysis still suggested “strong” evidence for the model without the interaction, $BF_{01} = 11.91$. (None of the effects reached significance in the error data (all $ps > .10$.) Therefore, statistically, the evidence suggests that there is no difference between CV and VC primes. Numerically, however, the TL priming effect was noticeably smaller for CV primes (20 ms) than for VC primes (39 ms), a result that at least raises the question of whether such differences might emerge in a situation where the difference between CV and VC primes is examined in a more controlled fashion.

A final point to note is that there was a Letter type effect. Overall, targets in the CC condition were responded to 16 ms faster than those in the CV/VC condition. This result is consistent with the idea that primes are better primes when their CV structure matches that of the target. As with the CV vs VC contrast discussed above, Experiment 2 allowed for a more controlled examination of this issue.

Experiment 2

Experiment 1 showed that TL priming effects are equivalent for transpositions involving two consonants and transpositions involving one consonant and one vowel. At the same time, there was a clear tendency in the data suggesting a potential difference between CV and VC transpositions, the former producing a numerically smaller TL priming effect than the latter, as

well as a significant overall latency difference favoring the CC condition over the CV/VC condition. The aim of Experiment 2 was to provide a further examination of these issues by using the same set of targets for all primes – CC, CV, and VC. Because each target was primed by all three prime types across participants, this manipulation allows one to draw stronger conclusions about the relative magnitude of TL priming effects and about any overall latency differences produced by the three different types of transpositions.

Method

Participants

Thirty-six students (10 males) from the University of Padua participated in this experiment (age 21-38, $M = 24$) for course credit. All were native speakers of Italian and had normal or corrected-to-normal vision.

Materials

Ninety-six Italian words were selected from PhonItalia (Goslin et al., 2014) to serve as target words. Their mean length is 8.03 letters (range = 7-10) and their mean word frequency (per million) is 47.91 (range = 0-579.64). TL and SL primes were created in the same manner as in Experiment 1, except that six, rather than four, different nonword primes were created for each target word: 1) CC transposition (puslante-PULSANTE); 2) CC substitution (purmante-PULSANTE); 3) CV transposition (pulasnte-PULSANTE); 4) CV substitution (pulucnte-PULSANTE); 5) VC transposition (plusante-PULSANTE); 6) VC substitution (prosante-PULSANTE). As in Experiment 1, transpositions never involved the first or the last letter of the targets words, and CC, CV, and VC transpositions were matched on the position of the first transposed/substituted letter ($M = 4.73$, $M = 4.67$, and $M = 4.72$, respectively). Orthographic neighborhood size (Coltheart, Davelaar, Jonasson & Besner, 1977) and bigram frequency were

also matched across all six primes to rule out the possibility of an influence of ease of prime processing on the magnitude of priming effects.

Ninety-six orthographically legal nonwords were created to serve as nonword targets. They were associated with CC, CV, and VC transposition and substitution primes created in the same way as was done in the parallel conditions for the word targets.

The targets were divided into six sets of 16 and each set was primed by primes from one of the six prime conditions. Six lists were created to complete the counterbalancing, and participants were randomly (and equally) assigned to one of those lists.

Procedure

Although there is no reason to believe participants in Experiment 1 were aware of the existence of the primes, the masking procedure used in that experiment did deviate slightly from the conventional masked priming procedure in word recognition research (Forster & Davis, 1984). To ensure that the primes were effectively masked in Experiment 2, we adopted the conventional masking procedure developed by Forster and Davis (1984) by applying two changes to the stimulus presentation sequence. First, the prime was preceded by ten hashtags centered on the screen and displayed for 500 ms and, second, the prime duration was reduced slightly to 50 ms. The procedure was the same as that of Experiment 1 in all other respects.

Results

Incorrect responses (6.42%) and response latencies below 250 ms or above 1750 ms (0.20%) were removed from the latency analyses. The mean response times and error percentages from the subject analyses are presented in Table 2. The analyses were conducted in the same way as for Experiment 1, the only difference being that Letter type was a within-subject and within-item fixed effect with three levels (CC vs. CV vs. VC). Post hoc analyses, when

necessary, were conducted using the emmeans package, version 1.3.1 (Lenth, 2018), with Tukey's HSD adjustment for multiple comparisons.

In the latency analyses, there was a main effect of Prime type, $\chi^2 = 11.26, p < .001$, with faster responses to targets preceded by transposition primes (605 ms) than to targets preceded by substitution primes (619 ms). The main effect of Letter type was not significant, $\chi^2 = 1.55, p = .46$, and neither was the interaction, $\chi^2 = 3.67, p = .16$. Indeed, the Bayes Factor, $BF_{01} = 648.23$, indicated "extreme" evidence for the absence of the interaction. (note 4) None of the effects reached significance in the error data (all $ps > .1$).

Discussion

The data pattern most relevant to the present issues was replicated. As in Experiment 1, there was a significant TL priming effect, although it was a bit smaller than the parallel effect in Experiment 1. More importantly, its magnitude did not vary as a function of the letters involved in the transposition.

It is worth noting that the tendency suggested by the post-hoc analysis of Experiment 1 (i.e., a smaller priming effect for CV than VC transpositions) was not confirmed here, as priming for CV transpositions was in fact numerically *larger* than priming for VC transpositions. It is also worth noting that the Letter type effect observed in Experiment 1 (i.e., faster overall latencies following CC primes) was not replicated here. In sum, there is no convincing evidence up to this point that transpositions of adjacent consonants and transpositions of one vowel and an adjacent consonant differ in terms of the magnitude of the priming effects, or the overall latencies, that they produce.

Experiment 3

Because letter transposition effects do not generalize across all languages (Velan & Frost, 2010), one obvious question is whether the results reported so far would replicate in a different language. Experiment 3 was aimed at investigating this question by using the same design as used in Experiment 2 with English, a language in which there is some evidence for a consonant-vowel difference in TL priming (Lupker et al., 2008).

Method

Participants

Seventy-seven students (36 males) from the University of Western Ontario participated in this experiment (age 17-23, $M = 19$) for course credit. All were native speakers of English and had normal or corrected-to-normal vision.

Materials

Ninety-six English words from the CELEX database (Baayen, Piepenbrock, & van Rijn, 1993) were selected to serve as target words (see the Appendix). Their mean length is 7.63 letters (range = 7-8) and their mean word frequency (per million) is 11.87 (range = 0-101.23). Six nonword primes were created for each of word targets in the same way as Experiment 2. CC, CV, and VC transposition and substitution primes were again matched on the position of the first transposed/substituted letter ($M = 3.99$, $M = 4.01$, and $M = 3.99$, respectively), as well as orthographic neighborhood size (Coltheart et al., 1977) and bigram frequency. Ninety-six orthographically legal nonwords and their transposition and substitution primes were created as well.

The targets were again divided into six sets of 16 and each set was primed by primes from one of the six prime conditions. The participants whose data were included in the analyses were randomly (and equally) assigned to one of the six lists.

Procedure

The procedure was the same as that of Experiment 2, except that the forward mask consisted of eight hashtags and the target stimulus was presented for 2500 ms or until a response was made. In addition, all stimuli were presented in Courier New-10 and responses to words and nonwords were made by pressing the right and the left shift keys, respectively. The experiment was run using the DMDX (Forster & Forster, 2003) software.

Results

Five participants were removed from the analyses because their error rates were above 25%, leaving 72 participants. Incorrect responses (4.44%) and response latencies below 250 ms or above 1750 ms (1.07%) were removed from the latency analyses. The mean response times and error percentages from the subject analyses are presented in Table 3. The same generalized linear mixed-effects model was used to analyze the results as in Experiment 2. For both the latency and the error analyses, the model failed to converge. However, convergence was obtained once model estimation was restarted from the apparent optimum (see footnote 1). We report the results from the restarted model.

In the latency analyses, there was a main effect of Letter type, $\chi^2 = 8.55$, $p = .014$, as overall latency in the VC condition (626 ms) was faster than the latency in the CV condition (638 ms), $\beta = 10.98$, $SE = 3.89$, $z = 2.82$, $p = .013$, and marginally faster than the latency in the CC condition (636 ms), $\beta = 8.23$, $SE = 3.80$, $z = 2.16$, $p = .078$. There was a main effect of Prime type, $\chi^2 = 36.69$, $p < .001$, with faster responses to targets preceded by transposition

primes (623 ms) than targets preceded by substitution primes (643 ms). There was again no interaction, $\chi^2 = 1.82$, $p = .40$. The Bayes Factor, $BF_{01} = 3053.75$, suggested that there was “extreme” evidence for the absence of the interaction.

None of the effects reached significance in the error data, although the interaction between Letter type and Prime type was marginal, $\chi^2 = 5.67$, $p = .059$. This latter result was due to the fact that the TL effect in the error data was numerically larger in the VC condition than in the CC or CV conditions. However, in this case as well, the Bayes Factor favored the model without the interaction, suggesting that there was, in fact, “extreme” evidence for the absence of the interaction, $BF_{01} = 390.75$.

Discussion

In English as well as in Italian, no significant differences were found in the magnitude of TL priming effects across CC, CV, and CC transposition conditions. The data from these two languages thus provide converging evidence that prime transpositions involving two adjacent consonants and transpositions involving one consonant and one adjacent vowel provide equivalent benefits in terms of speed of word recognition. In addition, as in Experiment 2, there was no evidence that overall latencies were shorter in the CC conditions.

A potential concern about the findings reported so far is that the magnitude of the priming effects might be too small to generate appreciable differences across transposition types. Indeed, overall TL priming effects were somewhat smaller than it is generally reported in the masked priming literature, at least in Experiments 2 (14 ms) and 3 (20 ms). Experiment 4 was designed to address this concern by using the sandwich priming technique (Lupker & Davis, 2009) in order to increase the sizes of the TL priming effects.

The sandwich priming technique was created by Lupker and Davis (2009) with the specific goal being to allow the orthographic relationship between the prime and target to have a stronger impact on the observed priming effect. The task involves inserting a very brief (imperceptible) presentation of the target just before the prime of interest on all trials. According to Davis's (2010) Spatial-coding model, doing so produces two benefits. The first is that, by pre-activating the target, the impact of lexical competition on target processing is diminished. The second is that target decay is slowed after the target's initial pre-activation by the presentation of an orthographically similar prime (see Davis, 2003, for a more complete explanation of the processes that are presumed to be affected in a masked priming situation). This task has now been used to investigate a number of form/orthographic priming effects that are small in size in the conventional task with the inevitable result being a noticeable increase in the size of those priming effects in the sandwich priming task (e.g., Davis & Lupker, 2017; Lupker, Zhang, Perry & Davis, 2015).

Experiment 4

Method

Participants

Sixty-two students (22 males) from the University of Western Ontario participated in this experiment (age 17-21, $M = 18$) for course credit. All were native speakers of English and had normal or corrected-to-normal vision.

Materials

The materials were the same as in Experiment 3.

Procedure

Each trial consisted of a sequence including an eight-hashtag forward mask displayed for 500 ms, the (upper case) target displayed for 33 ms, the (lower case) prime displayed for 50 ms, and the (upper case) target displayed for 2500 ms or until the participant responded. All stimuli were centered on the screen. The procedure was otherwise identical to that of Experiment 3.

Results

One participant was removed from the analyses because her error rate was above 25% and another participant was removed due to an equipment malfunction, leaving 60 participants. Incorrect responses (4.11%) and response latencies below 250 ms or above 1750 ms (1.41%) were removed from the latency analyses. The mean response times and error percentages from the subject analyses are presented in Table 4. The same generalized linear mixed-effects model used in Experiments 2 and 3 was used to analyze the results. The model for the latency analysis failed to converge, but convergence was obtained when model estimation was restarted from the previous fit (see footnote 1). We report the results from the restarted model.

The latency analyses showed a main effect of Prime type, $\chi^2 = 90.74$, $p < .001$, with faster responses to targets preceded by transposition primes (648 ms) than to targets preceded by substitution primes (681 ms). The main effect of Letter type was not significant, $\chi^2 = .40$, $p = .82$, and neither was the interaction, $\chi^2 = .37$, $p = .83$. Once again, the Bayes Factor, $BF_{01} = 4695.61$, suggested that there was “extreme” evidence for the absence of the interaction.

The error data mirrored the latency data. There was a main effect of Prime type, $\chi^2 = 12.04$, $p < .001$, with fewer errors to targets preceded by transposition primes (3.72%) than to targets preceded by substitution primes (5.56%). Neither the main effect of Letter type nor the interaction was significant (all $ps > .10$).

Discussion

The sandwich priming technique succeeded in increasing the magnitude of the TL priming effect, which was now 33 ms compared to the 20 ms of Experiment 3. However, just like in the previous experiments, the TL priming effect was not modulated by transposition type. Priming effects were once again equivalent for CC, CV, and VC transpositions. Further, there was no evidence that overall latencies were shorter following CC primes.

General Discussion

The goal of the present experiments was to investigate the impact in a masked priming lexical decision task of transposing an adjacent vowel and consonant in comparison to the transposition of two adjacent consonants. Previous research (Carreiras et al., 2009; Comesaña et al., 2016; Lupker et al., 2008; Perea & Acha, 2009; Perea & Lupker, 2004) has suggested that, when transposing nonadjacent letters, consonant-consonant transpositions (e.g., caniso) produce priming effects whereas vowel-vowel transpositions (e.g., cinaso) do not. This result appears to have no obvious explanation in the context of most current models of orthographic coding. More specifically, because most models do not distinguish between vowel and consonant letters, there would be no reason for one type of prime to be effective when the other type of prime is not.

In the Introduction we reviewed several potential accounts of this pattern while noting that none were able to successfully explain it. Therefore, the question of whether and how consonant-vowel status affects masked priming appeared to need additional investigation. In the present experiments, we examined this general issue by comparing priming effects when one letter is a consonant and the other is a vowel versus when both letters are consonants (with the transpositions involving adjacent letters).

In four experiments, two in Italian and two in English (one of those experiments involving the sandwich priming paradigm), the priming effects produced by CV and VC transpositions were identical to those produced by transposing two adjacent consonants. These results would be quite consistent with the predictions of most of the current models of orthographic coding, models that do not distinguish between vowel and consonant letters. For example, in the open-bigram model of Schoonbaert and Grainger (2004) the letters of the prime activate the appropriate open bigrams and those bigrams activate the lexical representation of the target. The priming effect is produced by the overlap in the open bigrams between prime and target irrespective of the consonant-vowel status of the transposed letters. In the spatial-coding model (Davis, 2010) input letters are matched to the whole word representations, and no role of consonant-vowel status is assumed. Given that the priming effects were essentially the same size for CC, CV and VC transposition primes in the present experiments, the apparent conclusion is that, consistent with these models, little, if any, role is being played by consonant-vowel status in the processes producing adjacent TL priming effects.

We also should note that these equivalent priming effects, per se, would also not necessarily be inconsistent with models that are based on the notion that the consonant-vowel structure of the letter string being read is represented in the orthographic code. Transposing a consonant and its adjacent vowel alters that consonant-vowel structure. However, our control (i.e., SL) primes experienced the same structural alteration. Therefore, these models would not necessarily predict that CV or VC primes would show a smaller TL priming effect than CC primes (in which the target's structure is maintained in both TL and SL primes).

What would, potentially, be more relevant for these models would be the comparison between primes involving a CC transposition and those same primes involving a CV/VC

transposition. The former type of prime (both TL and SL) maintains the consonant-vowel structure of the target whereas the latter type (both TL and SL) does not. Therefore, one might expect that overall latencies in the CC condition might be faster than in the CV/VC conditions due to the CC primes establishing/activating the correct consonant-vowel structure of the target. The data from the present Experiment 1 are consistent with this expectation, however, there is not even a hint of this pattern in the other three experiments.

Another account based on the idea that consonants and vowels have a different status is the hypothesis put forward by Chetail and colleagues (Chetail et al., 2014, 2018) that vowel-cluster units are a main determinant of orthographic similarity. We already noted that CV and VC transpositions change the CV structure of the primes, in some cases producing a change in the nature of vowel cluster units and in some cases not. In particular, in Experiment 2, whereas all the CC primes (both TL and SL) matched their target in terms of vowel-cluster units, 43% of the CV primes and 21% of the VC primes (both TL and SL) did not do so. Similarly, in Experiments 3 and 4, all CC primes (both TL and SL) matched their targets in terms of vowel-cluster units, whereas 25% of the CV primes and 31% of the VC primes did not do so. If a match in vowel-cluster units matters in that target recognition is facilitated when such a match occurs, we would have expected faster latencies following CC primes (both TL and SL) than following VC or CV primes. As noted, such was not the case in either experiment.

What must be noted is that none of the studies reported by Chetail and collaborators used a masked priming lexical decision task. It's likely, therefore, that the different results may be attributable to different processes involved in the different experimental paradigms. The overall conclusion, however, seems to be that although the consonant-vowel structure of the letter string being processed is undoubtedly represented at some level, the present data provide no evidence

for the idea that that structure is represented at the level of the orthographic code (see also Perea et al., 2018).

Given that the present experiments produced no evidence that the type of TL priming investigated here varied as a function of the transposed letters' consonant-vowel status, what implications can one draw concerning the lack of priming from VV TL primes in masked priming lexical decision tasks (e.g., Carreiras et al., 2009; Comesaña et al., 2016; Perea & Acha, 2009 in Spanish; Lupker et al., 2008 in English)? The most basic conclusion offered by the present results, of course, is that because both VC and CV transpositions involved vowels and yet they produced the same size priming effect as that generated by CC transpositions, it would appear that it is not the involvement of a vowel in the prime, per se, that prevents priming effects from emerging.

What's also worth noting, however, is that the consonant-vowel distinction is not an unimportant one in word recognition, as both the results of Chetail and colleagues (Chetail et al., 2014, 2018) and those of Perea et al. (2018), just to mention the most recent ones, demonstrate, although in apparently contrasting directions. That is, the results in the former papers suggest that the important units are vowels, while the results in the latter paper suggest what is crucial is the consonant grid. Also worth noting is that Perea and Lupker (2004), using Spanish stimuli, reported that while both consonant (caniso) and vowel (cisano) TL nonwords were harder to reject than SL nonwords (i.e., both showed a TL effect) in an unprimed lexical decision task, the effect was larger for consonant TL nonwords than vowel TL nonwords. Importantly, Lupker et al. (2008) replicated this pattern using English stimuli and Schubert et al. (2018) have replicated Lupker et al.'s results (using Lupker et al.'s stimuli), indicating that that pattern is not language dependent.

Perhaps the, apparently, reliable consonant-vowel difference in those unprimed lexical decision tasks is the place to start in thinking about these issues. Although what produces the consonant-vowel difference in those tasks is not entirely clear, a reasonable possibility is that it is due to the impact of phonology (Colombo et al., 2017; Frankish & Barnes, 2008; Frankish & Turner, 2007). That is, virtually by definition, the consonant-vowel status of a word is a distinction that would be represented at the phonological level, and the phonological level would be likely to influence responding when discriminating words from nonwords (i.e., in a lexical decision task), particularly when those nonwords are orthographically similar to known words (i.e., TL nonwords). The masked priming paradigm, in contrast, taps into processing that arises during the first 50 ms or so after stimulus presentation, a time at which phonological information is only weakly represented (see also Ferrand & Grainger, 1992; 1993). Hence, much less evidence of an impact of phonology in masked priming experiments should be expected.

This line of reasoning, however, does not necessarily provide an answer the question of why consonant-vowel differences have been reported in the masked priming lexical decision task, in particular, the different patterns of priming effects for consonant- and vowel-preserving primes obtained in the studies by New and colleagues (New et al., 2008; New & Nazzi, 2014) and Soares et al. (2014) discussed in the Introduction and, more central to the present research, the absence of priming from VV TL primes in Spanish studies (e.g., Carreiras et al., 2009; Comesaña et al., 2016; Perea & Acha, 2009) as well as one English study (Lupker et al., 2008). As noted, results from masked priming tasks are presumed to mainly reflect the nature of the orthographic code, not the nature of phonological representations. Therefore, the CC vs VV TL priming difference does seem to imply that consonant-vowel status is somehow relevant to the nature of the orthographic code, an idea that appears to be inconsistent with the present data.

What should also be noted, however, is that a number of attempts to replicate the only English study showing that pattern of results (Lupker et al., 2008) have been unsuccessful even when Lupker et al.'s original stimuli were used (Yang & Lupker, submitted). Potentially, therefore, the null VV TL priming effect is idiosyncratic to Spanish, a language that has a very shallow orthography (in fact, one that appears to be at least as shallow as Italian). As a result, potentially, Spanish readers are able to activate phonology sufficiently rapidly that phonology comes to play a larger role in masked priming lexical decision tasks than that experienced by even Italian readers. Hence, the Spanish pattern in masked priming lexical decision may be one that is also due to the impact of phonology. Before drawing any definitive conclusions, however, and given the similarity between Spanish and Italian, it would be useful to replicate the conditions of the Spanish experiments in Italian, using nonadjacent letters.

In conclusion, the present results are generally inconsistent with the idea that consonant-vowel status affects the orthographic level of processing, the level that appears to be tapped by masked priming. This conclusion is consistent with the basic assumptions made by most of the present models of orthographic coding. The impact of consonant-vowel status and other phonologically-based factors are, however, clearly important to the reading process. How and where in the process their effects arise, therefore, remain crucial issues for subsequent research.

References

Adelman, J. S. (2011). Letters in time and retinotopic space. *Psychological Review*, *118*, 570-582. <http://dx.doi.org/10.1037/a0024811>

Andrews, S. (1996). Lexical retrieval and selection processes: Effects of transposed-letter confusability. *Journal of Memory and Language*, *35*, 775-800.
<https://doi.org/10.1006/jmla.1996.0040>

Baayen, R. (2008). *Analyzing Linguistic Data: A Practical Introduction to Statistics Using R*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511801686>

Baayen, R., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390-412.
<https://doi.org/10.1016/j.jml.2007.12.005>

Baayen, R., Piepenbrock, R., & van Rijn, H. (1993). The CELEX lexical database [CD-ROM]. Philadelphia: Linguistic Data Consortium, University of Pennsylvania.

Balota, D., Aschenbrenner, A., & Yap, M. (2013). Additive effects of word frequency and stimulus quality: The influence of trial history and data transformations. *Journal of Experimental Psychology: Learning Memory and Cognition*, *39*, 1563-1571.
<https://doi.org/10.1037/a0032186>

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*, 255-278. <https://doi.org/10.1016/j.jml.2012.11.001>

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*, 1-48.

<https://doi.org/10.18637/jss.v067.i01>

Berent, I., & Perfetti, C. A. (1995). A rose is a REEZ: The two-cycles model of phonology assembly in reading English. *Psychological Review*, *102*, 146-184.

<https://doi.org/10.1037/0033-295x.102.1.146>

Blythe, H. I., Johnson, R. L., Liversedge, S. P., & Rayner, K. (2014). Reading transposed text: Effects of transposed letter distance and consonant-vowel status on eye movements.

Attention, Perception, & Psychophysics, *76*, 2424-2440. <http://dx.doi.org/10.3758/s13414-014-0707-2>

Bolker, B. (2018). *GLMM FAQ*. Retrieved from <https://bbolker.github.io/mixedmodels-misc/glmmFAQ.html>

Buchwald, A. & Rapp, B. (2003). The orthographic representation of consonant–vowel status: Evidence from two cases of acquired dysgraphia. *Brain and Language*, *87*, 120-121.

[https://doi.org/10.1016/s0093-934x\(03\)00228-1](https://doi.org/10.1016/s0093-934x(03)00228-1)

Buchwald, A., & Rapp, B. (2006). Consonants and vowels in orthographic representations. *Cognitive Neuropsychology*, *23*, 308–337.

<https://doi:10.1080/02643290442000527>

Caramazza, A., Chialant, D., Capasso R. & Miceli, G. (2000). Separable processing of consonants and vowels. *Nature*, *403*, 428–430. <http://dx.doi.org/10.1038/35000206>

Caramazza, A. & Miceli, G. (1990). The structure of graphemic representations. *Cognition*, *37*, 243-297. [https://doi.org/10.1016/0010-0277\(90\)90047-n](https://doi.org/10.1016/0010-0277(90)90047-n)

Carreiras, M., Gillon-Dowens, M., Vergara, M. & Perea, M. (2009). Are vowels and consonants processed differently? ERP evidence with a delayed letter paradigm. *Journal of Cognitive Neuroscience*, *21*, 275-288. <https://doi.org/10.1037/e512682013-233>

Carreiras, M., Vergara, M. & Perea, M. (2007). ERP correlates of transposed-letter similarity effects: Are consonants processed differently from vowels? *Neuroscience Letters*, *419*, 219-224. <https://doi.org/10.1016/j.neulet.2007.04.053>

Carreiras, M., Vergara, M., & Perea, M. (2009). ERP correlates of transposed-letter priming effects: The role of vowels versus consonants. *Psychophysiology*, *46*, 34-42. <https://doi.org/10.1111/j.1469-8986.2008.00725.x>

Chambers, S. M. (1979). Letter and order information in lexical access. *Journal of Verbal Learning and Verbal Behavior*, *18*, 225–241. [https://doi.org/10.1016/s0022-5371\(79\)90136-1](https://doi.org/10.1016/s0022-5371(79)90136-1)

Chetail, F., & Content, A. (2012). The internal structure of chaos: Letter category determines visual word perceptual units. *Journal of Memory and Language*, *67*, 371-388. <https://doi.org/10.1016/j.jml.2012.07.004>

Chetail, F., & Content, A. (2013). Segmentation of written words in French. *Language and Speech*, *56*, 125-144. <https://doi.org/10.1177/0023830912442919>

Chetail, F., & Content, A. (2014). What is the difference between OASIS and OPERA? Roughly five pixels: Orthographic structure biases the perceived length of letter strings. *Psychological Science*, *25*, 243-249. <https://doi.org/10.1177/0956797613500508>

Chetail, F., Drabs, V., & Content, A. (2014). The role of consonant/vowel organization in perceptual discrimination. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*, 938-961. <https://doi.org/10.1037/a0036166>

Chetail, F., Ranzini, M., De Tiège, X., Wens, V., & Content, A. (2018). The consonant/vowel pattern determines the structure of orthographic representations in the left fusiform gyrus. *Cortex*, *101*, 73-86. <https://doi.org/10.1016/j.cortex.2018.01.006>

Cohen-Shikora, E. R., Suh, J., & Bugg, J. M. (in press). Assessing the temporal learning account of the list-wide proportion congruence effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. <https://doi.org/10.1037/xlm0000670>

Colombo, L. (2000). The assembly of phonology in Italian and English: Consonants and vowels. In A. Kennedy, R. Radach, D. Heller, & J. Pynte (Eds.), *Reading as a perceptual process* (pp. 377-398). Amsterdam: North-Holland. <https://doi.org/10.1016/b978-008043642-5/50018-8>

Colombo, L., Sulpizio, S. & Peressotti, F. (2017). Serial mechanism in transposed letters effects: A developmental study. *Journal of Experimental Child Psychology*, *161*, 46-62. <http://dx.doi.org/10.1016/j.jecp.2017.04.002>

Colombo, L., Zorzi, M., Cubelli, R., & Brivio, C. (2003). The status of consonants and vowels in phonological assembly: Testing the two-cycles model with Italian. *European Journal of Cognitive Psychology*, *15*, 405-433. <https://doi.org/10.1080/09541440303605>

Coltheart, M., Davelaar, E., Jonasson, J. F. & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and Performance VI* (pp. 535-555). Hillsdale, N.J.: Erlbaum.

Comesaña, M., Soares, A. P., Marcet, A., & Perea, M. (2016). On the nature of consonant/vowel differences in letter position coding: Evidence from developing and adult readers. *British Journal of Psychology*, *107*, 651–674. DOI: 10.1111/bjop.12179

Davis, C. J. (2003). Factors underlying masked priming effects in competitive network models of visual word recognition. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art* (pp. 121–170). Philadelphia, PA: Psychology Press.

<https://doi.org/10.4324/9780203502846>

Davis, C. J. (2010). The spatial coding model of visual word identification. *Psychological Review*, *117*, 713–758. <https://doi.org/10.1037/a0019738>

Davis, C. J. & Lupker, S. J. (2017). A Backwards Glance at Words: Using Reversed-Interior Masked Primes to Test Models of Visual Word Identification. *PLoS One*. *12*: e0189056. <https://doi.org/10.1371/journal.pone.0189056>

Duñabeitia, J. A. & Carreiras, M. (2011). The relative position priming effect depends on whether letters are vowels or consonants. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *37*, 1143-1163. <http://dx.doi.org/10.1037/a0023577>

Ferrand, L., & Grainger, J. (1992). Phonology and orthography in visual word recognition: Evidence from masked non-word priming. *The Quarterly Journal of Experimental Psychology*, *45A*, 353-372. <https://doi.org/10.1080/02724989208250619>

Ferrand, L., & Grainger, J. (1993). The time course of orthographic and phonological code activation in the early phases of visual word recognition. *Bulletin of the Psychonomic Society*, *31*, 119-122. <https://doi.org/10.3758/bf03334157>

Forster, K. I. & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *10*, 680-698. <http://dx.doi.org/10.1037/0278-7393.10.4.680>

Forster, K. I., Davis, C., Schoknecht, C. & Carter, R. (1987). Masked priming with graphemically related forms: Repetition or partial activation? *Quarterly Journal of Experimental Psychology*, 39A, 211-251. <https://doi.org/10.1080/14640748708401785>

Forster, K. I. & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, 35, 116-124. <http://dx.doi.org/10.3758/bf03195503>

Fox, J., & Weisberg, S. (2011). *An {R} Companion to Applied Regression*. Second Edition. Thousand Oaks, California: Sage. <http://socserv.socsci.mcmaster.ca/jfox/Books/Companion>

Frankish, C. & Barnes, L. (2008). Lexical and sub-lexical processes in the perception of transposed-letters anagrams. *Quarterly Journal of Experimental Psychology*, 61, 381–391. <https://doi.org/10.1080/17470210701664880>

Frankish, C. & Turner, E. (2007). SIHGT and SUNOD: The role of orthography and phonology in the perception of transposed letter anagrams. *Journal of Memory and Language*, 56, 189–211. <https://doi.org/10.1016/j.jml.2006.11.002>

Gómez, P., Ratcliff, R., & Perea, M. (2008). The overlap model: A model of letter position coding. Psychological. *Psychological Review*, 115, 577–600. <https://doi.org/10.1037/a0012667>

Goslin, J., Galluzzi, C. & Romani C. (2014). PhonItalia: a phonological lexicon for Italian. *Behavioral Research Methods*, 46, 872-886. <https://dx.doi.org/10.3758/s13428-013-0400-8>

Grainger, J. & van Heuven, W. J. B. (2003). Modeling letter position coding in printed word perception. In P. Bonin (Ed.), *The mental lexicon* (pp. 1-23). New York: Nova Science.

- Guerrera, C. & Forster, K. (2008). Masked form priming with extreme transposition. *Language and Cognitive Processes*, 23, 117-142.
<http://dx.doi.org/10.1080/01690960701579722>
- Holmes, V. M. & Ng, E. (1993). Word-specific knowledge, word recognition strategies, and spelling ability. *Journal of Memory and Language*, 32, 230–257.
<https://doi.org/10.1006/jmla.1993.1013>
- Jeffreys, H. (1961). *The Theory of Probability*. Third Edition. Oxford: Clarendon Press.
- Johnson, R. L., Perea, M., & Rayner, K. (2007). Transposed-letter effects in reading: Evidence from eye movements and parafoveal preview. *Journal of Experimental Psychology: Human Perception and Performance*, 33, 209-229. <https://doi.org/10.1037/0096-1523.33.1.209>
- Kinoshita, S. & Norris, D. (2009). Transposed-letter priming of prelexical orthographic representations. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35, 1-18. <http://dx.doi.org/10.1037/a0014277>
- Ktori, M., Kingma, B., Hannagan, T., Holcomb, P.J., Grainger, J. (2014). On the time-course of adjacent and non-adjacent transposed-letter priming. *Journal of Cognitive Psychology*, 26, 491–505. <http://dx.doi.org/10.1080/20445911.2014.922092>
- Lee M. D., Wagenmakers E. J. (2013). *Bayesian Cognitive Modelling: A Practical Course*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9781139087759>
- Lenth, R. (2018). emmeans: Estimated Marginal Means, aka Least-Squares Means.
<https://CRAN.R-project.org/package=emmeans>
- Levy, R. (2014). Using R formulae to test for main effects in the presence of higher order interactions. *arXiv:1405.2094*.

Lo, S., & Andrews, S. (2015). To transform or not to transform: Using generalized linear mixed models to analyse reaction time data. *Frontiers in Psychology*, 6, 1171.

<https://doi.org/10.3389/fpsyg.2015.01171>

Lupker, S. J., Acha, J., Davis, C.J. & Perea, M. (2012). An investigation of the role of grapheme units in word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, 38, 1491-1516. <https://doi.org/10.1037/e512592013-024>

Lupker, S. J. & Davis, C. J. (2009). Sandwich priming: A method for overcoming the limitations of masked priming by reducing lexical competitor effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 35, 618-639. <http://dx.doi.org/10.1037/a0015278>

Lupker, S. J., Perea, M. & Davis, C.J. (2008). Transposed letter priming effects: Consonants, vowels and letter frequency. *Language and Cognitive Processes*, 23, 93-116. <https://doi.org/10.1080/01690960701579714>

Lupker, S. J., Zhang, Y., Perry, J. R. & Davis, C. J. (2015). Superset versus substitution-letter priming: An evaluation of open-bigram models. *Journal of Experimental Psychology: Human Perception and Performance*, 41, 138-151. <http://dx.doi.org/10.1037/a0038392>

McClelland, J. L. & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review*, 88, 375-407. <http://dx.doi.org/10.1037/0033-295X.88.5.375>

New, B., Araújo, V., & Nazzi, T. (2008). Differential processing of consonants and vowels in lexical access through reading. *Psychological Science*, 19, 1223-1227. <https://doi.org/10.1111/j.1467-9280.2008.02228.x>

New, B., & Nazzi, T. (2014). The time course of consonant and vowel processing during word recognition. *Language, Cognition and Neuroscience*, 29, 147-157.

<https://doi.org/10.1080/01690965.2012.735678>

Norris, D. & Kinoshita, S. (2008). Perception as evidence accumulation and Bayesian inference: Insights from masked priming. *Journal of Experimental Psychology: General*, 137, 433-455. <http://dx.doi.org/10.1037/a0012799>

Norris, D. & Kinoshita, S. (2012). Reading through a noisy channel: Why there's nothing special about the perception of orthography. *Psychological Review*, 119, 517-545. <http://dx.doi.org/10.1037/a0028450>

O'Connor, R. E. & Forster, K. I. (1981). Criterion bias and search sequence bias in word recognition. *Memory & Cognition*, 9, 78-92. <https://doi.org/10.3758/bf03196953>

Perea, M. & Acha, J. (2009). Does letter position coding depend on consonant/vowel status? Evidence with the masked priming technique. *Acta Psychologica*, 130, 127-137. <https://doi.org/10.1016/j.actpsy.2008.11.001>

Perea, M. & Lupker, S. J. (2003a). Does judge activate COURT? Transposed-letter similarity effects in masked associative priming. *Memory & Cognition*, 31, 829-841. <http://dx.doi.org/10.3758/BF03196438>

Perea, M. & Lupker, S. J. (2003b). Transposed-letter confusability effects in masked form priming. In S. Kinoshita and S. J. Lupker (Eds.), *Masked priming: State of the art* (pp. 97-120). Hove, UK: Psychology Press. <https://doi.org/10.4324/9780203502846>

Perea, M. & Lupker, S. J. (2004). Can caniso activate casino? Transposed letter similarity effects with nonadjacent letter positions. *Journal of Memory and Language*, 51, 231-246. <http://dx.doi.org/10.1016/j.jml.2004.05.005>

Perea, M., Marcet, A. & Acha, J. (2018). Does consonant-vowel skeletal structure play a role early in lexical processing? Evidence from masked priming. *Applied Psycholinguistics*, *39*, 169-186. <https://doi.org/10.1017/s0142716417000431>

Perry, C., & Ziegler, J. C. (2002). On the nature of phonological assembly: Evidence from backward masking. *Language and Cognitive Processes*, *17*, 31-59. <https://doi.org/10.1080/01690960042000157>

Perry, J. R., Lupker, S. J. & Davis, C. J. (2008). An evaluation of the interactive-activation model using masked partial-word priming. *Language and Cognitive Processes*, *23*, 36-68. <http://dx.doi.org/10.1080/01690960701578112>

R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>

Schneider, W., Eschman, A. & Zuccolotto, A. (2002). E-Prime: User's guide. Psychology Software Incorporated.

Schoonbaert, S., & Grainger, J. (2004). Letter position coding in printed word perception: Effects of repeated and transposed letters. *Language and Cognitive Processes*, *19*, 333-367. <https://doi.org/10.1080/01690960344000198>

Schubert, T., Kinoshita, S. & Norris, D. (2018). What causes the greater perceived similarity of consonant-transposed nonwords? *Quarterly Journal of Experimental Psychology*, *71*, 642-656. <https://doi.org/10.1080/17470218.2016.1271444>

Singmann, H., & Kellen, D. (2018). An Introduction to Mixed Models for Experimental Psychology. In D. Spieler, & E. Schumacher (Eds.), *New Methods in Cognitive Psychology*. New York: Routledge.

Soares, A. P., Perea, M., & Comesaña, M. (2014). Tracking the emergence of the consonant bias in visual-word recognition: Evidence with developing readers. *PLoS ONE*, *9*, e88580. <https://doi.org/10.1371/journal.pone.0088580>

Taft, M. & van Graan, F. (1998). Lack of phonological mediation in a semantic categorization task. *Journal of Memory and Language*, *38*, 203-224. <https://doi.org/10.1006/jmla.1997.2538>

Treiman, R. (1994). To what extent do orthographic units in print mirror phonological units in speech?. *Journal of psycholinguistic research*, *23*, 91-110. <https://doi.org/10.1007/bf02143178>

Velan, H. & Frost, R. (2003). Cambridge University Vs. Hebrew University: The impact of letter transposition on reading English and Hebrew. *Psychonomic Bulletin & Review*, *14*, 913–918. <https://doi.org/10.3758/bf03194121>

Wagenmakers, E. J. (2007). A practical solution to the pervasive problems of *p* values. *Psychonomic bulletin & review*, *14*, 779-804. <https://doi.org/10.3758/bf03194105>

Whitney, C. (2001). How the brain encodes the order of letters in a printed word: The SERIOL model and selective literature review. *Psychonomic Bulletin & Review*, *8*, 221–243. <https://doi.org/10.3758/BF03196158>

Yang, H., Chen, J., Spinelli, G., & Lupker, S. J. (in press). The impact of text orientation on form priming effects in four-character Chinese words. *Journal of Experimental Psychology. Learning, Memory, and Cognition*. <https://doi.org/10.1037/xlm0000655>

Yang, H. & Lupker, S. J. (submitted). A re-examination of the consonant-vowel difference in TL priming effects with English words.

Footnotes

1. Following the suggestion of an anonymous reviewer, we also log-transformed RTs to normalize the distribution and analyzed them using linear mixed-effects models. These analyses were conducted for all of the experiments using both a simple random effects structure (i.e., random intercepts only) or the maximal random effect permitted by the design and by convergence constraints (Barr, Levy, Scheepers, & Tily, 2013). The results were the same as those of the generalized linear mixed-effects models reported in the article and can be found at <https://osf.io/7dgyh/>.
2. Even with a simple model, convergence warnings were returned for some of the analyses presented in this article, specifically, the latency and error analyses for Experiment 3 and the latency analysis for Experiment 4. The troubleshooting process for those convergence problems followed the recommendations made by the lme4 authors (see “convergence” help page in R), including restarting the fit from the apparent optimum position. The R syntax for the troubleshooting process can be found in the R scripts for Experiments 3 and 4 at <https://osf.io/7dgyh/>. Following the suggestion of an anonymous reviewer, we conducted another set of analyses using the BOBYQA optimizer, an optimizer that is known to produce fewer convergence warnings than lme4’s default optimizer (Bolker, 2019). In these analyses, we used the maximal random structure allowed by the design and by convergence constraints (Barr et al., 2013). The results were equivalent to those of the simple generalized linear mixed-effects models reported in the article, the single exception being that the main effect of Prime Type did not reach significance in Experiment 2 (see footnote 4).

3. Traditional ANOVAs based on subject and item means were also performed for all experiments. Except for some discrepancy of minor importance, the results were essentially the same as those of the generalized linear mixed-effects models reported in the article and can be found at <https://osf.io/7dgyh/>.
4. The main effect of Prime Type did not reach significance in the generalized linear mixed-effects model with untransformed RTs as the dependent variable when the model included the near-maximal random structure (by-subject random slope for the main effect of Prime Type and by-item random slopes for the two main effects and their interaction), $\chi^2 = 2.51, p = .11$. However, that effect was significant in the linear mixed-effects model with log-transformed RTs as the dependent variable both when the model included a simple random structure (random intercepts only), $\chi^2 = 10.28, p = .001$, and when it included the near-maximal random structure (by-subject random slopes for the two main effects and their interaction and by-item random slope for the main effect of Prime Type), $\chi^2 = 6.49, p = .011$.

Author Note

This research was partially supported by Grant DOR (Dotazione Ordinaria per Ricerca, Università degli Studi di Padova - 2017) to Lucia Colombo, Natural Sciences and Engineering Research Council of Canada Grant A6333 to Stephen J. Lupker and the Ontario Trillium Scholarship to Giacomo Spinelli.

Correspondence concerning this article may be addressed to: Lucia Colombo, Dipartimento di Psicologia Generale, [Università degli Studi di Padova](http://www.unipd.it), via Venezia 8, 35131 Padova, Italy (email: lucia.colombo@unipd.it), Giacomo Spinelli, Department of Psychology, University of Western Ontario, London, Ontario, N6A 5C2, Canada (e-mail: gspinel@uwo.ca) or Stephen J. Lupker, Department of Psychology, University of Western Ontario, London, Ontario, N6A 5C2, Canada (e-mail: lupker@uwo.ca).

Table 1

Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in Experiment 1

Letter type	Prime type		
	TL	SL	TL priming
CC (elefatne/elefamce)	574 (1.17)	609 (3.66)	35 (2.49)
CV/VC (elefnate/elefmote)	591 (2.73)	623 (4.49)	32 (1.76)
CV	598 (2.81)	618 (5.38)	20 (2.57)
VC	586 (2.69)	625 (4.19)	39 (1.50)

Note: TL = transposed letter prime; SL = substituted letter prime; CC = consonant-consonant transposition; CV = consonant-vowel transposition; VC = vowel-consonant transposition. Examples of TL and SL primes for the target word ELEFANTE ‘elephant’ are reported in parentheses.

Table 2

Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in Experiment 2

	Prime type		
	TL	SL	TL priming
Letter type			
CC (elefatne/elefable)	603 (5.21)	610 (7.30)	7 (2.09)
CV (eleafnte/eleolnte)	600 (6.42)	621 (7.12)	21 (.70)
VC (elefnate/elefmote)	599 (6.25)	611 (6.60)	12 (.35)

Note: TL = transposed letter prime; SL = substituted letter prime; CC = consonant-consonant transposition; CV = consonant-vowel transposition; VC = vowel-consonant transposition. Examples of TL and SL primes for the target word ELEFANTE 'elephant' are reported in parentheses.

Table 3

Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in Experiment 3

	Prime type		
	TL	SL	TL priming
Letter type			
CC	629	642	13 (.52)
(elehpant/eletrant)	(4.95)	(5.47)	
CV	626	649	23 (-.43)
(elepahnt/elepinnt)	(4.77)	(4.34)	
VC	613	638	25 (2.34)
(elpehant/elzuhant)	(3.82)	(6.16)	

Note: TL = transposed letter prime; SL = substituted letter prime; CC = consonant-consonant transposition; CV = consonant-vowel transposition; VC = vowel-consonant transposition. Examples of TL and SL primes for the target word ELEPHANT are reported in parentheses.

Table 4

Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in Experiment 4

Letter type	Prime type		
	TL	SL	TL priming
CC (elehpant/eletrant)	648 (4.17)	681 (5.52)	33 (1.35)
CV (elepahnt/elepinnt)	647 (3.54)	686 (4.79)	39 (1.25)
VC (elpehant/elzuhant)	649 (3.44)	675 (6.35)	26 (2.91)

Note: TL = transposed letter prime; SL = substituted letter prime; CC = consonant-consonant transposition; CV = consonant-vowel transposition; VC = vowel-consonant transposition. Examples of TL and SL primes for the target word ELEFANTE 'elephant' are reported in parentheses.

Appendix

Target	Stimuli in Experiment 1					
	CC-SL	CC-TL	CV-SL	CV-TL	VC-SL	VC-TL
ALBERGO	ablergo	acmergo	alebrgo	alidrgo		
AMBIENTE	abmiente	adniente			ambinete	ambitate
ANTENNA	atnenna	ablenna	anetnna	anolnna		
ARBITRO	abritro	acsitro	aribtro	aragtro		
ARMADIO	amradio	ansadio	aramdio	aripdio		
ARROSTO	arrotso	arrolbo	arorsto	arigsto		
ASCIUTTO	acsiutto	abriutto	asicutto	asovutto		
ATTENTO	attetno	attemco	atetnto	atirnto		
ATTORNO	attonro	atolso	atotrno	atamrno		
CAMPIONE	capmione	cangione			campinoe	campidae
CANTANTE	catnante	caplante			cantnate	cantrute
CASTAGNA	catsagna	cardagna			csatagna	cnotagna
CONQUISTA	coquista	codcuista			conquisita	conqudeta
CONTAGIO	cotnagio	covragio	contaigo	contaifo		
CONTROLLO	cotnrollo	cossrollo			contrlolo	contrcelo
COPERTA	copetra	copesga			cpoerta	craerta
DENTISTA	detnista	deldista			dentsita	dentfota
DISCORSO	dicsorso	dibrorso			discroso	disccaso
ELEFANTE	elefatne	elefamce			elefnate	elefmote
ENTRATA	etnrata	eclrata			entrtaa	entria
ESTATE	etsate	epmate			esttae	estroe
FAMIGLIA	familgia	faminzia	famigila	famigema		
FANTASMA	fatnasma	fadmasma			fantsama	fantpema
FASTIDIO	fatsidio	fabridio	fastiido	fastiumo		
FINESTRA	finesrta	finespda	fienstra	fiulstra		
GIGANTE	gigatne	gigalde			ggiante	groante
INCENDIO	icnendio	iglendio	incenido	incenuto		
INDIETRO	idnietro	imtietro			inditero	indisuro
INFINITO	ifninito	imlinito			infintio	infinvuo
INSALATA	isnalata	irlalata	insaalta	insaepa		
INVERNO	ivverno	idlerno	inevrno	inutrno		
LEOPARDO	leopadro	leopatso			leoprado	leoptedo
MERENDA	meredna	merelba			mreenda	msuenda
OSPEDALE	opedale	obredale	ospedale	ospeolle		
PAZIENTE	pazietne	paziebre			pazinete	pazimute
POLENTA	poletna	polembe			ploenta	praenta
PULSANTE	puslante	purmante			plusante	prosante
QUARANTA	quaratna	quaralca			quarnata	quartota
RACCONTO	raccotno	raccompo			rcaconto	rpoconto
RICORDO	ricodro	riconbo			rciordo	rnaordo

Consonant-Vowel Transpositions 56

RIMPIANTO	ripmianto	rictianto			rimpinato	rimpigito
RISPOSTA	ripsosta	ricrosta			rsiposta	rtaposta
RITORNO	ritonro	ritoflo			rtiorno	rbuorno
ROBUSTO	robotso	roburdo			rbousto	rpausto
ROTONDO	rotodno	rotolbo			rtoondo	rpeondo
SDRAIATO	srdaiato	sfbaiato			sdraitao	sdraipuo
SEGUENTE	seguetne	seguesce			sgeuente	stiunte
SERVIZIO	sevrizio	sefnizio	serviizo	serviaso		
STUPENDO	stupedno	stupemso	sutpendo	socpendo		
TEDESCO	tedesco	tedefbo			tdeesco	traesco
TRAMONTO	tramotno	tramobro	tarmonto	tesmonto		
TREMENDO	tremedno	tremebso	termendo	tafmendo		
TURISTA	turitsa	turilca	tuirsta	tuogsta		
UNIVERSO	univesro	univetfo			univreso	univviso
VACANZA	vacazna	vacaflo			vcaanza	vrianza
*COLOMBO	colobmo	colopmo	coolmbo	coevmbo		
*DISTANZA	ditsanza	diptanza			distnaza	distriza
*INCROCIO	icnrocio	iplocio	incroico	incroudo		
*INTANTO	itnanto	iclanto	inatnto	inapnto		
*INTORNO	itnorno	ivlorno	inotrno	inoclno		
*ISTITUTO	itsituto	ibrituo	istiutto	istianto		
*LEGGENDA	leggedna	leggelta			leggneda	leggsinda
*POTENTE	potetne	ponelde			ptoente	pdiente
*PROBLEMA	pbrolema	psdolema			prbolema	prsulema

*removed

Stimuli in Experiment 2

Target	CC-SL	CC-TL	CV-SL	CV-TL	VC-SL	VC-TL
ACCANTO	accatno	accasdo	acacento	acesnto	accnato	accpoto
ALLARME	allamre	allaspe	alalrme	alidrme	allrame	allsime
ANARCHIA	anacrhia	ananshia	anarciha	anarcala	anrachia	anbochia
ANGOSCIA	angocsia	angotgia	angosica	angosoda	angsocia	angnacia
ARBITRO	arbirto	arbipto	aribtro	arottro	arbtiro	arbdoro
ARMADIO	amradio	ansadio	aramdio	arubdio	armdaio	arntaio
ASSURDO	assudro	assumno	asusrdo	asiprdo	assrudo	assgedo
ATTENTO	attetno	attemco	atetnto	atidnto	attneto	atffoto
AUTOGRAFO	autorgafo	autolbafo	autogarfo	autogetfo	autgorafo	autsirafo
BALCONE	baclone	bargone	balocne	balevne	balcnoe	balcrie
BLOCCHETTO	blochcetto	blocrtetto	bloccehtto	bloccafftto	blocchteto	blocchrato
BOCCAGLIO	boccalgio	o	boccalgilo	boccalgapo	bocccaglio	bocccselio
BOTTIGLIA	bottiglia	bottistia	bottigila	bottigema	bottiglia	bottbalia

Consonant-Vowel Transpositions 57

BRILLANTE	brillatne	brillatre	brilalnte	briletnte	brillnate	brillcete
CANTANTE	cantatne	cantalre	canatnte	canicnte	cantnate	cantrute
CEMENTO	cemetno	cemesfo	ceemnto	ceodnto	cemneto	cemrato
CENTRALE	cenrtale	cencnale	centarle	centusle	centrlae	centrpue
CESPUGLIO	cepsuglio	cenvuglio	cespugilo	cespugaso	cespgulio	cesppalio
COLOMBO	colobmo	cololso	coolmbo	coirmbo	colmobo	colnibo
CONTAGIO	cotnagio	cosgagio	contaigo	contaero	contgaio	contciio
CONTROLLO	conrtollo	congfollo	contorllo	contubllo	contrlolo	contrmelo
COPERTA	copetra	copenca	coeprta	coicrta	copreta	copsota
CORTESIA	cotresia	cosbesia	corteisa	corteoha	cortseia	cortloia
CRISTALLO	critsallo	crifgallo	crisatllo	crisibllo	cristlalo	cristmilo
DENTISTA	dentitsa	dentirva	denitsta	denofsta	dentsita	dentfota
DISCIPLINA	dicsiplina	ditmiplina	discipilna	discipobna	discpilina	disctolina
DISTANZA	distazna	distarta	disatnza	disinnza	distnaza	distriza
DISTURBO	distubro	distucno	disutrbo	disanrbo	distrubo	distcabo
ELEFANTE	elefatne	elefable	eleafnte	eleolnte	elefnate	elefmote
ELEMENTO	elemetno	elemepso	elemnto	eleisnto	elemneto	elemrato
ELETTRICO	eletrtico	eletcnico	elettirco	elettagco	eltetrico	elpatrico
ESEMPIO	esempio	esengio	esemipo	esemudo	esempio	esgupio
ESEMPLARE	esemplare	esesclare	esempalre	esempuvre	esemplare	esgoplare
FAMIGLIA	familgia	famisdia	famigila	famigona	famgilia	famsolia
FANTASMA	fantamsa	fantadfa	fanatsma	fanersma	fantsama	fantpema
FASCISMO	fascimso	fasciglo	fasicsmo	fasugsmo	fascximo	fasctamo
FASTIDIO	fatsidio	fanmidio	fastiido	fastiumo	fastdiio	fastleio
FORMAGGIO	fomraggio	fotcaggio	formagigo	formagolo	formgagio	formpeggio
FRESCHEZZA	freshcezza	fresrtezza	frescehzza	frescirzza	freschzeza	freschtaza
FURBIZIA	fubrizia	fudsizia	furbiiiza	furbiora	furbziia	furbilaia
GIGANTE	gigatne	gigapse	giagnte	giosnte	gignate	gigrete
GORGONZOL	gogronzol	goplonzol	gorgonozl		gorgnozol	
A	a	a	a	gorgonitla	a	gorglizola
GRANCHIO	gracnhio	gralghio	granciho	grancego	grnachio	grlichio
IMPEGNI	impengi	impechi	imepgni	imurgni	impgeni	impcani
IMPOSTA	impotsa	impodna	imopsta	imitsta	impsota	impdita
INCENDIO	incednio	incerpio	incenido	incenuto	incnedio	inctodio
INCROCIO	inrcocio	inplocio	incroico	incroudo	incrcoio	incrteio
INFERNO	infenro	infelso	inefrno	inaprno	infreno	infcino
INGORGO	ingogro	ingopbo	inogrgo	inisrgo	ingrogo	ingfago
INSULTO	insutlo	inumno	inuslto	iniblto	insluto	insdato
INTORNO	intonro	intotgo	inotrno	inulrno	introno	intfeno
LEGGENDA	leggedna	leggevra	legegnda	legornda	leggneda	leggsida
LEOPARDO	leopadro	leopapco	leoaprdo	leoitrdo	leoprado	leoptedo
MACIGNO	macingo	macipro	maicgno	maomgno	macgino	macnano
MAGNESIO	mangesio	mabvesio	magneiso	magneado	magnseio	magnuio

Consonant-Vowel Transpositions 58

MARMELLAT	mamrellat	masnellat	marmelalt	marmelozt	marmlelat	marmzolat
A	a	a	a	a	a	a
MERENDA	meredna	merespa	meernda	meimnda	merneda	mervada
MURAGLIA	muralgia	muratpia	muragila	muragona	murgalia	murfilia
OFFERTA	offetra	offespa	ofefrta	ofotrta	offreta	offsita
PASTICCIO	patsiccio	papficcio	pasticico	pasticopo	pastcicio	pastzecio
PETROLIO	pertolio	pecpolio	petroilo	petrouco	petrloio	petrfeio
PIASTRELLA	piatsrella	pialprella	piasterlla	piastonlla	pisatrella	pinetrella
PILASTRO	pilastro	pilanfro	pialstro	piesstro	pilsatro	pilvitro
POLENTA	poletna	polerca	poelnta	poornata	polneta	polputa
		promnem				
PROBLEMA	prolbema	a	probelma	probatma	problmea	problzia
PROVVISTO	provvitso	provvigho	provivsto	provutsto	provvsito	provvrato
PULSANTE	pulsatne	pulsasce	pulasnte	pulucnte	pulsnate	pulstute
		quamnun				
QUALCUNO	quacluno	o	qualucno	qualadno	qualcnuo	qualcleo
QUARANTA	quaratna	quarapda	quaarnta	quaulnta	quarnata	quartota
RACCONTO	raccotno	raccopro	racocnto	racignto	raccnoto	raccvito
REGISTA	regitsa	regigla	reigsta	reozsta	regsitata	regrota
		rimbarmi				
RISPARMIO	ripsarmio	o	risparimo	risparofio	rispramio	rispsomio
RISPOSTA	rispotsa	risponfa	risopsta	risivsta	rispsota	rispgeta
RITORNO	ritonro	ritoglo	riotrno	riecrno	ritrono	ritfino
ROBUSTO	robotso	robungo	roubsto	roissto	robsuto	roblito
ROTONDO	rotodno	rotosgo	rootndo	roinndo	rotnodo	rotrado
SALSICCIA	salsiccia	satriccia	salsicica	salsicega	salscicia	salsgucia
SCAMBIO	scabmio	scalsio	scamibo	scamolo	scmabio	sclbio
SCHERMATA	schemrata	schebvata	scheramta	schereasta	schermata	schermsea
SCHERZARE	schezrare	schendare	scherezare	scherefre	schertzare	schertzoe
SECONDO	secodno	secotvo	seocndo	seisndo	secnodo	secrido
SERVIZIO	sevrizio	sedsizio	servizio	serorzio	servizio	servteio
	sghingazz		sghiganzz		sghignazz	
SGHIGNAZZO	o	sghistazzo	o	sghigorzzo	o	sghignazio
SPLENDORE	splendore	splecbore	splendore	splenuzre	splendroe	splendrie
STARNUTO	stanruto	staltuto	starunto	starogto	starntuo	starnzio
STRINGERE	strignere	stribrere	strinegre	strininre	stringree	stringsae
STUPENDO	stupedno	stupetzo	stuepndo	stuosndo	stupnedo	stupsado
TEDESCO	tedesco	tedetro	teedscio	teicsco	tedseco	tedraco
TRAMONTO	tramotno	tramopso	traomnto	trauvnto	tramnoto	tramcato
TRAPUNTA	traputna	trapudca	traupnta	traolnta	trapnuta	traptata
TREMENDO	tremedno	trememco	treemndo	trealndo	tremnedo	trepnado
TRIANGOLO	triagnolo	triabtolo	trianoglo	trianivlo	trinagolo	trivigolo
TURISTA	turitsa	turicma	tuirsta	tuopsta	tursita	turdeta
UNIVERSO	univesro	univepto	unievrsio	uniigrso	univreso	univsiso

VACANZA	vacazna	vacadla vempagli	vaacnza	vaernza	vacnaza	vacniza
VENTAGLIO	vetnaglio	o	ventagilo	ventaguzo	ventgalio	ventzelio

Stimuli in Experiment 3 and 4

Target	CC-SL	CC-TL	CV-SL	CV-TL	VC-SL	VC-TL
ADVANCE	advacne	advatfe	adavnce	adornce	advnace	advrece
ADVISORY	avdisory	agrisory	adviosry	adviefry	advsiory	advgeory
AIRBORNE	aibrone	aiskorne	airobrne	airagne	airbrone	airbsane
ALLERGIC	allegric	allepic	alelrgic	alosrgic	allregic	alltigic
ALMIGHTY	almihgty	almitrty	alimghty	alecghty	almgihty	almbahty
AMNESTY	amnetsy	amnepny	amensty	amotsty	amnsety	amntoty
ANAGRAM	anargam	analtam	anagarm	anagidm	angaram	ancyram
ANTENNA	atnenna	agmenna	anetnna	anobnna	antnena	anthina
ASPHALT	ashpalt	asrlalt	aspahlt	asporlt	asphlat	asphcot
ATTEMPT	attempt	attehrt	atetmpt	atonmpt	attmept	attfopt
ATTORNEY	attonrey	attombey	atotrney	ataprney	attroney	attbuney
AUGMENT	aumgent	aurent	augemnt	augadnt	augmnet	augmcut
BACTERIA	batceria	bagneria	bacetria	bacovria	bactreia	bacthaia
BALANCE	balacne	balarve	baalnce	baesnce	balnace	balrece
BERSERK	besrerk	beplerk	beresrk	berotrk	bersrek	bersbak
BIBLICAL	bilbical	birtical	bibilcal	bibescal	biblcial	bibldeal
BLANKET	blaknet	blarmet	blanekt	blanaft	blnaket	blcyket
BONANZA	bonazna	bonacha	boannza	boiknza	bonnaza	bondoza
BUNGALOW	bugnalow	bumpalow	bunaglow	bunorlow	bunglaow	bungreow
CALENDAR	calednar	calesgar	caelndar	caomndar	calnedar	calpadar
CAPTIVE	catpive	calzive	capitve	caponve	captvie	captlye
CARDINAL	cadrinal	cashinal	caridnal	carubnal	cardnial	cardwual
CEREBRAL	cererbal	cereclal	ceerbral	ceobbral	cerberal	cermiral
CHIMNEY	chinmey	chikpey	chimeny	chimicy	chminey	chconey
COINCIDE	coicinide	coiskide	coinicde	coinolde	conicide	cobacide
COMMENCE	commecne	commefve	comemnce	comornce	commnece	commbace
CONFETTI	cofnetti	codretti	coneffti	conadtti	confteti	confpiti
CRESCENT	crecsent	creldent	cresecnt	cresasnt	crsecent	crdocent
CRYSTAL	crytsal	crychal	crysatl	crysiml	crsytal	crnutal
CUCUMBER	cucubmer	cuculper	cuucmber	cuabmber	cucmuber	cucceber
DEADLOCK	dealdock	deaqwock	deadolck	deademck	dedalock	derelock
DELIGHT	delihgt	deliblt	deilght	deepght	delgiht	delmaht
DIAGNOSE	diangose	diakrose	diagonse	diagafse	diganose	ditunose

Consonant-Vowel Transpositions 60

DISASTER	disatser	disacler	diasster	dienster	dissater	diszoter
DISCIPLE	dicsiple	dibriple	disicple	disufple	discpile	dischole
DISPATCH	dipsatch	divdatch	disaptch	disuftch	disptach	dispgoch
DYNASTY	dynatsy	dynachy	dyansty	dyopsty	dynsaty	dyntity
ELEPHANT	elehpant	eletrant	elepahnt	elepinnt	elpehant	elzuhant
FEEDBACK	feebdack	feegfack	feedabck	feedonck	fedeback	feliback
FESTIVAL	fetsival	fekgival	fesitval	fesovval	festvial	festpual
FOOTNOTE	foontote	foolcote	footonte	footeste	fotonote	fosenote
FORGIVEN	fogriven	fomdiven	forigven	foresven	forgvien	forgroen
FRAGMENT	framgent	fransent	fragemnt	fragovnt	frgment	frpoment
GUARDIAN	guadrian	guaplian	guaridan	guarozan	guradian	gulodian
HANDICAP	hadnicap	hafsicap	hanidcap	hanoncap	handciap	handpaap
HOSTAGE	hotsage	hophage	hosatge	hoserge	hostgae	hostsoe
IMPLICIT	implicit	imgficit	impilcit	imponcit	implciit	implpait
IMPULSE	impusle	impuzte	imuplse	imoflse	impluse	impdase
INSTINCT	intsinct	inqcinct	insitnct	insognct	instnict	instmact
INTENSE	intesne	intelme	inetnse	inarnse	intnese	intlose
INTRIGUE	inrtigue	innfigue	intirgue	intuhgue	intrgiue	intrneue
JOURNAL	jounral	joumbal	jouranl	jourohl	journal	jowenal
LISTENER	litsener	limdener	lisetner	lisopner	listneer	listfuer
MARATHON	marahon	maracwon	maarthon	mainthon	martahon	marzyhon
MEALTIME	meatlime	meacsime	mealitme	mealelme	melatime	mepotime
METAPHOR	metahpor	metacgor	meatphor	meirphor	metpahor	metcehor
MOUNTAIN	moutnain	mouwgain	mounatin	mounenin	monutain	mopotain
MUSTARD	mutsard	mudmard	musatrd	musofrd	mustrad	mustlid
NEUTRAL	neurtal	neunpal	neutarl	neutesl	netural	nepiral
OBSERVE	obsevre	obsebne	obesrve	obodrve	obsreve	obsmave
OUTRAGE	ourtage	ouhpage	outarge	outunge	outrgae	outrrye
OVERCAST	ovecrast	oveldast	overactst	overidst	ovrecast	ovcocast
OVERLAP	ovelrap	ovexzap	overalp	overemp	ovrelap	ovcalap
PHANTOM	phatnom	phalfom	phanotm	phanusm	phnatom	phdutom
PHARMACY	phamracy	phadlacy	pharamcy	pharorcy	phramacy	phlimacy
PRESTIGE	pretsige	preblige	presitge	presuhge	prsetige	prtutige
PROPHET	prohpet	prorset	propeht	propabt	prpohet	prdehet
RESEMBLE	resebmlle	resedsle	reesmble	reotmble	resmeble	restoble
SADISTIC	saditsic	sadiwric	saidstic	saogstic	sadsitic	sadletic
SCORPION	scoprion	scovtion	scoripon	scorydon	scorpion	scypion
SCRATCH	scracth	scrazph	scartch	scegtch	scrtach	scrfech
SENTENCE	setnence	sembence	senetnce	senognce	sentnece	sentlace
SENTINEL	setninel	selqinel	senitnel	seneznel	sentniel	sentwael
SHAMPOO	shapmoo	shawfoo	shamopo	shamavo	shmapoo	shbupoo
SHEPHERD	shehperd	shegzerd	shepehrd	shepolrd	shpeherd	shcaherd
SINCERE	sicnere	sidmere	sinecre	sinadre	sincree	sinctye

Consonant-Vowel Transpositions 61

SINGULAR	signular	sitpular	sinuglar	sinadlar	singluar	singzoar
SINISTER	sinitser	sininfer	siinster	siamster	sinsiter	sinboter
SPLENDID	splendnid	spletgid	spelndid	spohndid	splnedid	splvudid
SPRINKLE	spriknle	sprimple	spirnkle	spotnkle	sprnikle	sprsakle
STANDARD	stadnard	stapsard	stanadr	stanomrd	stnadard	stjodard
STRANGLE	stragnle	strapmle	starngle	stesngle	strnagle	strsygle
SUPREME	surpeme	sulteme	superme	supolme	suprnee	suprsye
SYMPATHY	sypmathy	sytnathy	symapthy	symonthy	symptahy	sympfihy
TAPESTRY	tapetsry	tapemzry	taepstry	taagstry	tapsetry	tapgatry
TEASPOON	teapsoon	teabzoon	teasopon	teasenon	tesapoon	tedipoon
TENTACLE	tetnacle	telbacle	tenatcle	tenidcle	tentcale	tentlyle
TRANQUIL	traquuil	tralmuil	tranuqil	tranatil	trnaquil	trkuquil
TRANSIT	trasnit	trampit	tranist	tranyrt	trnasit	trlusit
TRESPASS	trepsass	trercass	tresapss	tresotss	trsepass	trzypass
TURNOVER	tunrover	tubvover	turonver	turelver	turnvoer	turngeer
UPRIGHT	uprihgt	uprint	upirght	upenght	uprgiht	uprpoht
UPSURGE	upsugre	upsutne	upusrge	upitrge	upsruge	upstege
VEHICLE	vehilce	vehibne	veihcle	veancle	vehcile	vehmale
WATERWAY	watewray	watekmay	waetrway	waiprway	watreway	watlaway
WHISPER	whipser	whimner	whisepr	whisydr	whsiper	whdaper