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Do Diacritics Entail an Early Processing Cost in the Absence of Abstract Representations? Evidence from Masked Priming in English

Manuel Perea
Universitat de València, Spain; Universidad Antonio de Nebrija, Spain

Pablo Gomez
California State University, San Bernardino, Palm Desert Campus, USA

Ana Baciero
Universidad Antonio de Nebrija, Spain; DePaul University, USA; Bournemouth University, UK

Abstract

Using the masked priming technique, word recognition experiments in various languages have shown slower response times for a target word like NEVEU (nephew, in French) when preceded by a diacritical prime like néveu than by the identity prime neveu. The most common account of this effect is linguistic: diacritical and non-diacritical vowels (e.g., é and e) activate different letter representations (e.g., compare neveu /nə.vø/ vs. néveu /ne.vø/). However, another explanation is that the reduced effectiveness of the diacritical primes is merely due to the perceptual salience of accent marks in the first moments of word processing. Here, we designed a masked priming experiment that tested this perceptual salience account by comparing the effectiveness of diacritical versus non-diacritical primes in a language where diacritics have no linguistic value, namely, English (e.g., nórth-NORTH vs. north-NORTH). We found a small but reliable cost due to the diacritical primes, thus revealing that perceptual salience reduced the effectiveness of the primes. However, the effect sizes were substantially smaller than in the experiments in languages with diacritical marks, thus suggesting that the néveu-NEVEU versus neveu-NEVEU difference relies on *both* linguistic and perceptual sources.

Keywords

Lexical access, masked priming, orthographic processing, visual similarity

Corresponding author:
Manuel Perea, Department of Methodology and ERI-Lectura, Universitat de València, Av. Blasco Ibáñez, 21, 46010 Valencia, Spain.
Email: mperea@uv.es

Introduction

Almost all Latin script languages have diacritical marks (also called diacritics or accent marks) on some or all vowels (see Wells, 2000, for review). These diacritical marks play different functions in each language (e.g., *vowel quality*: German; *lexical stress*: Spanish; *vowel length*: Czech; *vowel quality and lexical stress*: Catalan; *separation of two syllables* [hiatus]: Dutch; *vowel quality and tone*: Vietnamese). Notably, modern English is one of the very few languages written without diacritics. Of note, the influential magazine *The New Yorker* uses diacritical marks (namely, diereses) to delimit a hiatus in some prefixed words (e.g., coöperate, reëlect); however, these diereses are generally considered obsolescent in English (Fowler, 1965) and somewhat pedantic.

Given the near-monopoly of English-based research in word recognition and reading, researchers have paid a little attention to how the visual word recognition system represents diacritical vowels. Theorists have proposed elegant hierarchical models describing the flow from ink to abstract letter or word representations (e.g., Davis, 2010; Dehaene et al., 2005; Grainger & Jacobs, 1996; Grainger et al., 2008). This path includes layers of case-specific detectors (e.g., same activation to *a* and a, but not A) followed by layers of abstract case-independent detectors (e.g., same activation to *a*, a, and A) that lead to orthographic processing and, subsequently, to lexical access. However, neurally inspired and computational models of visual word recognition typically remain silent on how diacritical vowels are represented in the lexicon (see Grainger, 2018). One of the few exceptions is the multiple-trace model developed by Ans et al. (1998). This model assumes that diacritical vowels in French (e.g., â, à, ê, è, é, ë, etc.) and non-diacritical vowels have different letter representations. While Ans et al. did not offer a rationale for their choice, it is reasonable to assume that it is simply their position that the inclusion of a diacritic makes the vowel categorically different from its base letter. We must keep in mind that vowels with and without diacritics in French may indicate different grapheme-to-phoneme correspondences (e.g., the French word sévère [strict] is pronounced /se.vɛʁ/).

In an attempt to shed light on whether diacritical vowels and non-diacritical vowels share their representations in the mental lexicon, Chetail and Boursain (2019) conducted a lexical decision experiment in French using Forster and Davis' (1984) masked priming technique. They reasoned that if é and e activate the same abstract letter representations, the diacritic prime néveu would be as effective as the prime neveu for the target word NEVEU (nephew). Chetail and Boursain (2019) found that a non-diacritical target word like NEVEU was responded to faster when preceded by the identity prime neveu than by the diacritical pseudoword prime néveu. Furthermore, they found no differences between néveu-NEVEU and its orthographic control noveu-NEVEU. They concluded that, at least in French, diacritical and non-diacritical vowels activate distinct letter representations—note that the French word neveu is pronounced /nə.vø/ whereas néveu is pronounced /ne.vø/ (i.e., the vowels e and é have different grapheme-to-phoneme correspondences). To examine the generality of this finding, Perea et al., (2020) conducted a parallel lexical decision experiment in Spanish. Unlike French, diacritical vowels in Spanish indicate lexical stress with no phonemic value (e.g., cáscara → ['kas.ka.ra] shell). As a result, one could argue that diacritical and non-diacritical vowels in Spanish share the same letter units (Chetail & Boursain, 2019; Marcet & Perea, 2022). Perea et al. (2020) found that the response times to a non-diacritical target word like FELIZ (happy) were faster when preceded by the identity prime feliz than when preceded by the diacritic pseudoword prime féliz. In addition, féliz-FELIZ produced similar response times as its control fáliz-FELIZ. That is, the pattern of effects was similar to that in French. Thus, one tentative conclusion from these studies is that regardless of the different roles of accent marks in French and Spanish, the word recognition system encodes diacritical and non-diacritical vowels as separate letters.[1]

As is often the case in cognitive science, the story is more complicated than what the studies outlined earlier might suggest. For diacritical target words (e.g., FÁCIL [easy in Spanish]), Perea et al. (2020) found that the responses to the identity pair fácil-FÁCIL were not faster than to facil-FÁCIL. Even more revealing is that, in Finnish, Perea, Hyönä and Marcet (2022) found that the identity pair pöytä-PÖYTÄ (table) was not responded faster than poytä-PÖYTÄ—note that the vowels o and ö in Finnish correspond to different phonemes (/o/ and /ø/, respectively). If á and a (or ö and o) had activated separate letter representations, one would have expected faster responses to pöytä-PÖYTÄ than poytä-PÖYTÄ (or fácil-FÁCIL vs. facil-FÁCIL). Instead, a simpler explanation of the latter findings is in the context of letter similarity effects in masked priming. As shown by Marcet and Perea (2017, 2018), a visually similar pair (e.g., obiect-OBJECT) produces response times nearly as close as the identity pair (e.g., object-OBJECT) and shorter than its orthographic control (e.g., obaect-OBJECT). The usual explanation of these letter similarity effects is that the encoding of letter identity is subject to perceptual uncertainty in the first moments of word processing, as assumed in noisy channel models (see Norris & Kinoshita, 2012). However, an unresolved issue is why the masked primes néveu (for NEVEU; in French) or féliz (for FELIZ; in Spanish) were not particularly effective.

One potential explanation of the above dissociation (e.g., a → á, but á ↛ a) is not linguistic but perceptual ("perceptual salience" account; see Kinoshita et al., 2021; Perea et al., 2021). As first discovered by Tversky (1977) and Treisman and Souther (1985), the perceptual similarity between two visually similar objects that share all features except for one extra part (e.g., F vs. E) is asymmetric: the letter F is perceptually more similar to the letter E than vice versa. Indeed, it is much easier to find the letter E in an array of letters F, and the letter F in an array of letters E. Recently, Kinoshita et al. (2021) showed that the idea of asymmetric similarities fits well with a noisy channel model of visual word recognition (see Norris & Kinoshita, 2012). When applied this notion to diacritics in a masked priming scenario, the letter a would be initially interpreted as more perceptually similar to á than vice versa. Specifically, a non-diacritical vowel like a would initially activate the representations of a and á, thus resulting in similar response times for facil-FÁCIL and fácil-FÁCIL (e.g., a → á). In contrast, the word recognition system would quickly interpret the diacritical mark from a prime (e.g., the mark ´ in néveu or fácil) as different from its non-diacritical counterpart (see Perea et al., 2021). As a result, the primes néveu and féliz would be less effective than neveu and feliz for the target words NEVEU and FELIZ (e.g., é ↛ e, á ↛ a). Interestingly, Marcet et al. (2020) found this dissociation with consonants (moñeda-MONEDA [coin] slower than moneda-MONEDA, but muneca-MUÑECA [doll] as fast as muñeca-MUÑECA; that is, ñ ↛ n, n → m) and Kinoshita et al. (2021) found this dissociation using katakana characters in a letter matching task (e.g., サ → ザ, but ザ ↛ サ).

This perceptual salience account can also accommodate, at a qualitative level, the findings with non-diacritical target words reported in French and Spanish (Chetail & Boursain, 2019; Perea et al., 2020). However, the perceptual salience cannot easily explain why the difference between néveu-NEVEU and neveu-NEVEU in French was larger than between féliz-FELIZ and feliz-FELIZ in Spanish (50 vs. 17 ms, respectively). While one might argue that the stimuli and the languages were different, the above discrepancy could have also been due to the activation of orthographic–phonological information from the diacritical primes, especially for the French vowels (i.e., a linguistic explanation). Nevertheless, the experiments conducted in languages with diacritical vowels cannot disentangle the role of linguistic and perceptual factors.

To directly test the feasibility of the perceptual salience hypothesis during visual word recognition, it is necessary to examine the effect of diacritical versus non-diacritical primes in a language where accent marks play no linguistic role: English. Such examination is the aim of the present study. The English language does not contain words with diacritics except for a few

foreign ones (e.g., café, naïve); hence, it is unlikely that these diacritical letters have any linguistic function. Therefore, a diacritical mark on the letter o, as in nórth, would essentially add a non-functional sign for English readers with no linguistic value (see Wiley et al., 2016). For comparison purposes with previous studies, we employed the masked priming technique combined with a lexical decision task. The manipulation in the experiment was straightforward. For an English target word like NORTH, we created a lowercase prime that was identical (i.e., non-diacritical, north) or the same except for an added diacritic (an acute mark) in an internal vowel (e.g., nórth). We also included diacritical and non-diacritical form-related primes that differed on that vowel (e.g., narth vs. nárth). The reason for having form-related pairs was to examine whether the effect from the diacritical prime was specific to the critical vowel (i.e., o in the above example).

The perceptual salience hypothesis would predict a cost due to the accent marks in identity primes. The diacritical mark on the letter ó in the prime nórth would be interpreted as different from the letter o, thus slowing down the processing of the target NORTH when compared to the non-diacritical, identity prime north. That is, the diacritical vowel ó would be less effective at activating the letter o in NORTH. While this was the primary comparison of the experiment, we also added the same manipulation with form-related pairs (e.g., nárth vs. narth). The inclusion of form-related pairs informs us of whether the potential cost from the diacritical marks in the primes extends to other letters (i.e., is nárth less effective than narth despite not sharing the letter o in NORTH?).

In sum, if diacritical primes (e.g., nórth for the target NORTH) are less effective than identity primes (e.g., north) in English, we would need to qualify the conclusions from earlier reports in French and Spanish (Chetail & Boursain, 2019; Perea et al., 2020). Conversely, the lack of a difference between nórth-NORTH and north-NORTH in English would favor the idea that the cost from the diacritical primes is not perceptual. Hence, by *reductio ad absurdum*, the cost from the diacritical primes would be mainly linguistic.

2 Method

2.1 Participants

Fifty-two DePaul University undergraduates took part in the experiment in exchange for course credit. This choice of sample size follows Brysbaert and Stevens' (2018) recommendation for small-sized effects in masked priming (i.e., at least 1,800 observations per cell; 2,600 in this study). Participants were native English speakers with normal or corrected vision and no history of reading problems. While it is unavoidable that university students in English-speaking countries have some exposure to a foreign language, none rated their knowledge of foreign languages as intermediate or advanced. The Institutional Review Board of DePaul University approved this experiment, and all participants signed a consent form before the experiment.

2.2 Materials

We selected 200 English words of five and six letters ($M = 5.08$) from the stimuli used by Adelman et al. (2014). The CELEX word-frequency per million was 53.14 (range: 0.84–745.53), the mean log bigram frequency was 2.81 (range: 1.75–3.50), and the mean number of orthographic neighbors was 3.41 (range: 0–14) in the N-Watch database (Davis, 2010). For each target word (e.g., NORTH), we created the following four priming conditions in lowercase: (1) an identity prime (north), (2) a diacritical identity prime in which a vowel had an added acute accent mark (nórth), (3) a form-related prime created by replacing one internal vowel with another vowel (narth), and

Table 1. Mean Response Times (in ms) and Accuracy (Proportion) for the Target Words in the Experiment.

	Identity pairs		Form-related pairs	
Target: NORTH	Response time	Accuracy	Response time	Accuracy
Diacritical prime	605 Prime: nórth	0.955	615 Prime: nárth	0.943
Non-diacritical prime	598 Prime: north	0.960	613 Prime: narth	0.953

Note. The mean RTs and accuracy for the nonword targets were 730 ms and 0.901, respectively.

(4) a diacritical form-related prime parallel to (3) except that the vowel had an acute accent mark (nárth). We also created 200 orthographically legal pseudowords for the lexical decision task, one for each word using Wuggy (Keuleers & Brysbaert, 2010). These pseudowords were matched on the number of letters, mean log bigram frequency, and number of neighbors with the word stimuli. The manipulation of the prime-target relationship was the same as that for word trials (e.g., FLARM: flarm, flárm, flurm, flúrm). We created four lists to counterbalance the various prime-target conditions following a Latin square design. Each list was composed of 200 word trials (100 non-diacritical primes [50 identity, 50 form-related], 100 diacritical primes [50 identity, 50 form-related]), and 200 nonword trials word trials (100 non-diacritical primes [50 identity, 50 form-related], 100 diacritical primes [50 identity, 50 form-related]). All the stimuli are provided in the Appendix.

2.3 Procedure

The experiment was run on DMDX (Forster & Forster, 2003) on Windows computers connected to cathode-ray tube (CRT) monitors in individual cabins. When participants arrived at the laboratory, they were given the standard lexical decision instructions where speed and accuracy were stressed. A pattern mask (a series of #'s) was presented for 500 ms on each trial. This forward mask was immediately replaced by a prime, in lowercase, for 50 ms (three refresh rates), which was replaced by the target stimulus, in uppercase, until the participant's response—there was a 2,500 ms deadline for responding. Participants were instructed to press "M" when the stimulus was a word and "Z" when the stimulus was not a word. The stimuli were presented in a monospaced font (14-pt Courier New) in black on a white background and in a random order to each participant. There were two breaks in the experiment, and 16 practice trials preceded the 400-trial experimental phase. The duration of the experiment was around 20 minutes.

3 Results

In the latency data for word targets, we excluded incorrect responses (4.7%) and all response times faster than 250 (0.13%) or beyond 2.5 standard deviations from the participant's mean (2.7%). Lack of response before the 2,500 ms deadline was automatically encoded as an error. The mean Response Time (RT, in ms) and accuracy for each condition are displayed in Table 1.

We created Bayesian linear mixed-effects models with the *brms* package (Bürkner, 2016) in *R* (R Core Team, 2021) to analyze the latency and accuracy of word trials.[2] The fixed factors were Prime-Target Relationship (identity vs. form-related; encoded as –0.5 and 0.5) and Type of Prime (non-diacritical vs. diacritical; encoded as –0.5 and 0.5). We used the maximal models in terms of random-effect structure:

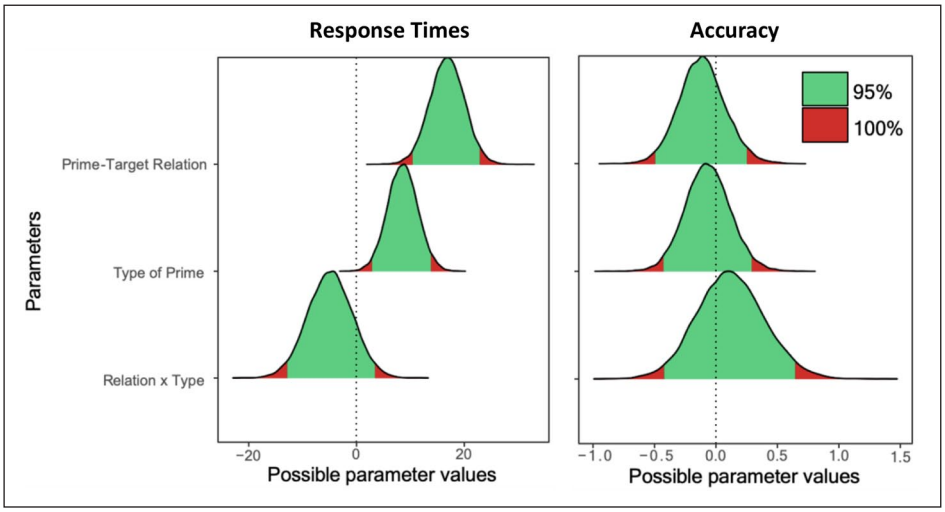

Figure 1. Posterior distributions of the estimates of the models of the response times (left panel) and accuracy (right panel) in the experiment.
The green area represents the 95% credible interval for each parameter.

$$\begin{aligned}\text{Response\_Time (or Accuracy)} \sim\ & \text{primetarget\_relation} \times \text{primetype} + \\ & (1 + \text{primetarget\_relation} \times \text{primetype} \mid \text{subject}) + \\ & (1 + \text{primetarget\_relation} \times \text{primetype} \mid \text{item})\end{aligned}$$

We modeled the RT data with the ex-Gaussian distribution (family = exgaussian) and the accuracy data (1 = *correct*, 0 = *incorrect*) with the Bernoulli distribution (family = bernoulli).[3] For each model, we employed 5,000 iterations (1,000 as a warm-up) with four chains. All chains converged successfully, and this was corroborated by $\hat{R} = 1.00$ for all estimates. Bayesian linear mixed-effects models do not provide an estimate of *p* values; instead, they indicate the value of each estimate, its standard error, and its 95% credible interval (95% CrI) of their posterior distributions. We interpreted as evidence for an effect when the 95% CrI of its estimate did not cross zero.

The analyses of the latency data showed that target words were responded faster when preceded by an identity prime than when preceded by a form-related prime, $b = 16.88$, $SE = 3.20$, 95% CrI = [10.60, 23.12]. Also, target words were responded faster when preceded by a non-diacritical prime than when preceded by a diacritical prime, $b = 8.63$, $SE = 2.79$, 95%CrI = [3.21, 14.19]. The cost of a diacritical prime was slightly larger for identity than for form-related pairs. While the 95% credible interval of the estimate of the interaction crossed zero, $b = -4.85$, $SE = 4.14$, 95% CrI = [–13.05, 3.17] (see Figure 1 for the posterior distribution estimates), the 95% credible interval of the difference between diacritical and non-diacritical pairs did not contain zero for the identity pairs [–13.90, –2.98]—it did contain zero for the form-related pairs [–10.20, 2.44].

The analysis of the accuracy data did not show any significant effects (see Figure 1 for the posterior distribution estimates).

4 Discussion

In masked priming experiments with non-diacritical words in French or Spanish, identity primes with an added diacritical mark (e.g., néveu-NEVEU [French], féliz-FELIZ [Spanish]) are less

effective than their non-diacritical counterparts (neveu-NEVEU or féliz-FELIZ; Chetail & Boursain, 2019; Perea et al., 2020). Researchers have usually advocated for a linguistic explanation (e.g., the letters é and e activate separate letter representations; see Chetail & Boursain, 2019). However, an alternative, simpler explanation is that the perceptual salience of the diacritical marks in the prime makes the stimulus less similar to the target word (Kinoshita et al., 2021; Perea et al., 2021). To examine the feasibility of the latter hypothesis, we compared the effect of diacritical versus non-diacritical primes on target processing in English. We chose English because it lacks diacritical marks, thus minimizing any issues regarding the function of diacritics in the language. The masked primes could share all the base letters with the target (identity pairs, for example, north-NORTH, nórth-NORTH) or differ in the critical vowel (form-related pairs, for example, narth-NORTH, nárth-NORTH). Leaving aside the expected advantage of identity pairs over form-related pairs (see Forster et al., 1987; Perea & Rosa, 2000, for similar evidence), we found a small but significant cost due to the presence of an accented vowel in the prime. This difference occurred mainly for identity pairs: a target word like NORTH was responded, on average, 7 ms more rapidly when preceded by the identity prime north than when preceded by the diacritical prime nórth. This finding offers empirical support to the perceptual salience hypothesis in a scenario where diacritics have no linguistic role.

While our findings demonstrate the feasibility of the perceptual salience hypothesis in masked priming, they are not conclusive as to whether this effect occurs exclusively for the critical vowel. A straightforward interpretation of this hypothesis is that the prime nórth would disrupt the processing of the target NORTH when compared north. In contrast, the primes narth and nárth would behave similarly—bear in mind that neither the non-diacritical vowel a nor the diacritical vowel á would be consistent with the vowel o in NORTH. We did not find sufficient evidence for an interaction between Prime-Target Relationship and Type of Prime; however, the cost from the diacritical primes for form-related pairs was minimal (i.e., 2 ms). Notably, a significant interaction would not have changed the central message of the present experiment. There is a small but genuine cost due to the diacritical marks in English (i.e., nórth-NORTH slower than north-NORTH).

The present experiment also has other theoretical implications on how the cognitive system represents accented vowels. Previous research showing slower responding to pairs like néveu-NEVEU when compared to neveu-NEVEU (French: Chetail & Boursain, 2019; see also Perea et al., 2020, for a similar finding in Spanish) interpreted this difference as being due to é and e activating different letter representations in the mental lexicon. Critically, in the present experiment, we found the same pattern (e.g., nórth-NORTH slower than north-NORTH) in a language (English) with no internal representations of diacritical letters. Therefore, any differences between diacritical and non-diacritical identity priming conditions must be due to the perceptual processes caused by the diacritical marks in the primes. At the same time, the reading cost from the diacritical primes was quite small: around 7 ms. In French, Chetail and Boursain (2019) found a difference of 50 ms between néveu-NEVEU and neveu-NEVEU. This difference was smaller but still sizable in a language in which diacritics do not alter vowel quality (Spanish): the disadvantage of féliz-FELIZ over feliz-FELIZ was 17 ms (Perea et al., 2020). Therefore, an explanation purely in terms of perceptual salience cannot be the whole story. Instead, a more realistic conclusion is that the difference between néveu-NEVEU versus neveu-NEVEU (French) and féliz-FELIZ versus feliz-FELIZ (Spanish) reflects a combination of the following two underlying elements: (1) an effect of perceptual salience from the diacritical primes and (2) an effect due to linguistic factors such as a mismatch in vowel quality (see Perea, Labusch, & Marcet, 2022, for cross-linguistic differences [German vs. Spanish] when processing diacritical vs. non-diacritical vowels).

Thus, our findings have a non-trivial implication for understanding the mechanism underlying the masked priming effects. The first few moments of word processing can be affected by an

extra feature added to one of the letters (e.g., the mark) and by phonological or prosodic information. Another methodological take-home message is that we should also be cautious at making firm conclusions when comparing diacritical and non-diacritical identity pairs to examine whether they share the letter representations. The reason is that these effects are conflated with the effects of visual similarity (e.g., obiect-OBJECT is responded as fast as object-OBJECT, Marcet & Perea, 2017, 2018 see also Gutiérrez-Sigut et al., 2019, for ERP evidence of these effects).

In sum, the present masked priming experiment has revealed an early detrimental effect from diacritical marks in a language (English) lacking these marks (e.g., nórth-NORTH slower than north-NORTH). Therefore, researchers should be cautious at attributing an entirely linguistic source to a comparison involving diacritical versus non-diacritical identity items. We believe that this study opens an avenue for further research on this topic using more precise estimates of the time course of these effects, such as recording event-related potentials in word recognition task (see Massol et al., 2010) and using parafoveal previews in sentence reading (see Angele et al., 2016).

Authors' note

The stimuli used in the experiment are given in the Appendix. The data and script are presented in the following OSF link: https://osf.io/c3txr/

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ORCID iD

Manuel Perea https://orcid.org/0000-0002-3291-1365

Notes

1. Chetail and Boursain (2019) and Perea et al. (2020) also conducted masked priming experiments with individual vowels with an alphabetic decision task. The pattern of findings paralleled those of the lexical decision experiments.
2. Although masked priming effects are typically unreliable for pseudoword data, we also conducted parallel analyses of the pseudoword data for completeness. Unsurprisingly, all the estimates were minimal, and their 95% credible intervals crossed zero.
3. While the ex-Gaussian distribution typically offers good fits to Response Time (RT) data, it is important to assess the generality of the findings. To that end, we modeled the data with the Gaussian distribution after a standard –1000/RT transformation. Note that the –1000/RT transformation reduces the skew of the RT distributions and, at the same time, it is easy to interpret: it reflects the number of words per second. This analysis, which is presented in detail in the OSF link, revealed exactly the same pattern of data as that given in the text (Prime-Target Relationship: $b = 0.05$, $SE = 0.01$, 95%CrI = [0.03, 0.07]; Type of Prime: $b = 0.03$, $SE = 0.01$, 95%CrI = [0.01, 0.05]; interaction: $b = –0.02$, $SE = 0.01$, 95%CrI = [–0.04, 0.01]). Furthermore, the same pattern occurred when using frequentist linear mixed-effects models (Prime-Target Relationship: $t = 4.31$, $SE = 0.015$, $p < .001$: Type of Prime: interaction: $t = 2.99$, $SE = 0.0094$, $p = .004$; interaction: $t = 1.158$. $SE = 0.0134$. $p = .25$). Thus, the cost of nórth-NORTH over north-NORTH in English is robust to data transformations.

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Appendix

List of Prime-Target pairs in the experiment

The items are presented in quintuplets: identity prime; (diacritical) identity prime; form-related prime; (diacritical) form-related prime, and TARGET.

Word trials. north, nórth, narth, nárth, NORTH; focus, fócus, facus, fácus, FOCUS; burst, búrst, barst, bárst, BURST; smoke, smóke, smeke, sméke, SMOKE; tasty, tásty, tusty, tústy, TASTY; purse, púrse, porse, pórse, PURSE; spare, spáre, spere, spére, SPARE; human, húman, haman, háman, HUMAN; demon, démon, damon, dámon, DEMON; small, smáll, smull, smúll, SMALL; acute, acúte, acete, acéte, ACUTE; broth, bróth, brath, bráth, BROTH; smoky, smóky, smaky, smáky, SMOKY; crumb, crúmb, cremb, crémb, CRUMB; crawl, cráwl, crewl, créwl, CRAWL; prove, próve, prave, práve, PROVE; wrong, wróng, wrang, wráng, WRONG; grove, gróve, greve, gréve, GROVE; stamp, stámp, stemp, stémp, STAMP; truth, trúth, trath, tráth, TRUTH; score, scóre, scure, scúre, SCORE; drama, dráma, droma, dróma, DRAMA; crack, crácк, creck, créck, CRACK; cards, cárds, cerds, cérds, CARDS; crave, cráve, creve, créve, CRAVE; alert, alért, alart, alárt, ALERT; crane, cráne, crene, créne, CRANE; chore, chóre, chure, chúre, CHORE; exact, exáct, exect, exéct, EXACT; straw, stráw, strow, strów, STRAW; scale, scále, scule, scúle, SCALE; thumb, thúmb, thomb, thómb, THUMB; crowd, crówd, crewd, créwd, CROWD; dusty, dústy, dosty, dósty, DUSTY; scrap, scráp, scrup, scrúp, SCRAP; shore, shóre, shere, shére, SHORE; throw, thrów, thraw, thráw, THROW; block, blóck, bleck, bléck, BLOCK; alarm, alárm, alorm, alórm, ALARM; glare, gláre, glore, glóre, GLARE; parent, párent, purent, púrent, PARENT; trash, trásh, trush, trúsh, TRASH; serve, sérve, sarve, sárve, SERVE; short, shórt, shart, shárt, SHORT; grade, gráde, grode, gróde, GRADE; world, wórld, warld, wárld, WORLD; cramp, crámp, cromp, crómp, CRAMP; track, tráck, trock, tróck, TRACK; nurse, núrse, narse, nárse, NURSE; crude, crúde, crade, cráde, CRUDE; direct, diréct, diract, dirácт, DIRECT; nerve, nérve, narve, nárve, NERVE; thorn, thórn, tharn, thárn, THORN; snore, snóre, snere, snére, SNORE; clock, clóck, cleck, cléck, CLOCK; share, sháre, shere, shére, SHARE; brown, brówn, brewn, bréwn, BROWN;

clerk, clérk, clork, clórk, CLERK; scent, scént, scont, scónt, SCENT; craft, cráft, creft, créft, CRAFT; grate, gráte, grote, gróte, GRATE; porch, pórch, purch, púrch, PORCH; grasp, grásp, grosp, grósp, GRASP; chart, chárt, chert, chért, CHART; check, chéck, chack, chák, CHECK; taste, táste, toste, tóste, TASTE; erase, eráse, erose, eróse, ERASE; upset, upsét, upsat, upsát, UPSET; herbs, hérbs, harbs, hárbs, HERBS; grace, gráce, gruce, grúce, GRACE; force, fórce, ferce, férce, FORCE; grand, gránd, grond, grónd, GRAND; female, fémale, famale, fámale, FEMALE; party, párty, perty, pérty, PARTY; crest, crést, crast, crást, CREST; press, préss, prass, práss, PRESS; truce, trúce, troce, tróce, TRUCE; sector, séctor, sactor, sáctor, SECTOR; front, fróntt, frant, frántt, FRONT; escape, escápe, escupe, escúpe, ESCAPE; rusty, rústy, rosty, rósty, RUSTY; large, lárge, lorge, lórge, LARGE; fresh, frésh, frash, frásh, FRESH; place, pláce, ploce, plóce, PLACE; curse, cúrse, carse, cárse, CURSE; award, awárd, awerd, awérd, AWARD; formal, fórmal, farmal, fármal, FORMAL; drugs, drúgs, drogs, drógs, DRUGS; flash, flásh, flosh, flósh, FLASH; scrub, scrúb, scrob, scrób, SCRUB; shame, sháme, shome, shóme, SHAME; scene, scéne, scane, scáne, SCENE; forest, fórest, ferest, férest, FOREST; glory, glóry, glury, glúry, GLORY; truck, trúck, trock, tróck, TRUCK; screw, scrém, scraw, scráw, SCREW; trend, tréndt, trand, tránd, TREND; spray, spráy, sproy, spróy, SPRAY; crash, crásh, cresh, crésh, CRASH; story, stóry, stary, stáry, STORY; store, stóre, sture, stúre, STORE; scarf, scárf, scorf, scórf, SCARF; truly, trúly, traly, trály, TRULY; scary, scáry, scery, scéry, SCARY; flame, fláme, flome, flóme, FLAME; scope, scópe, scepe, scépe, SCOPE; knock, knóck, knuck, knúck, KNOCK; frame, fráme, frume, frúme, FRAME; chest, chést, chast, chást, CHEST; abuse, abúse, abose, abóse, ABUSE; brand, bránd, brond, brónd, BRAND; scalp, scálp, scolp, scólp, SCALP; elect, eléct, elact, elácte, ELECT; frost, frósst, frast, frást, FROST; worth, wórth, warth, wárth, WORTH; smart, smárt, smort, smórt, SMART; border, bórder, barder, bárder, BORDER; grape, gráp, grepe, grépe, GRAPE; waste, wáste, woste, wóste, WASTE; amend, aménd, amand, amánd, AMEND; vocal, vócal, vacal, vácal, VOCAL; flask, flásk, flusk, flúsk, FLASK; stare, stáre, sture, stúre, STARE; prose, próse, prase, práse, PROSE; mural, múral, maral, máral, MURAL; blame, bláme, blome, blóme, BLAME; basic, básic, bosic, bósic, BASIC; crush, crúsh, crosh, crósh, CRUSH; broken, bróken, braken, bráken, BROKEN; cured, cúred, cered, céred, CURED; blast, blást, blost, blóst, BLAST; bored, bóred, bured, búred, BORED; drunk, drúnk, dronk, drónk, DRUNK; strong, stróng, strang, stráng, STRONG; fumes, fúmes, fomes, fómes, FUMES; plumb, plúmb, plamb, plámb, PLUMB; sword, swórd, swerd, swérd, SWORD; scare, scáre, scere, scére, SCARE; charm, chárm, chorm, chórm, CHARM; travel, trável, trevel, trével, TRAVEL; broke, bróke, breke, bréke, BROKE; lemon, lémon, lamon, lámon, LEMON; nasty, násty, nosty, nósty, NASTY; camel, cámel, comel, cómel, CAMEL; aware, awáre, awere, awére, AWARE; blush, blúsh, blesh, blésh, BLUSH; stock, stóck, steck, stéck, STOCK; grant, grántt, gront, grónt, GRANT; black, bláck, bleck, bléck, BLACK; pocket, pócket, pecket, pécket, POCKET; decor, decór, decar, decár, DECOR; horse, hórse, harse, hárse, HORSE; branch, bránch, bronch, brónch, BRANCH; trust, trúst, trast, trást, TRUST; worse, wórse, warse, wárse, WORSE; grave, gráve, gruve, grúve, GRAVE; crops, cróps, crups, crúps, CROPS; draft, dráft, druft, drúft, DRAFT; brush, brúsh, brosh, brósh, BRUSH; start, stárt, stort, stórt, START; theme, théme, thome, thóme, THEME; local, lócal, lacal, lácal, LOCAL; paste, páste, puste, púste, PASTE; sharp, shárp, shorp, shórp, SHARP; bacon, bácon, bocon, bócon, BACON; shock, shóck, sheck, shéck, SHOCK; apart, apárt, apert, apért, APART; tract, tráct, troct, tróct, TRACT; basil, básil, busil, búsil, BASIL; basin, básin, bosin, bósin, BASIN; storm, stórm, starm, stárm, STORM; charge, chárge, chorge, chórge, CHARGE; demand, demánd, demond, demónd, DEMAND; grown, grówn, grawn, gráwn, GROWN; shark, shárk, shork, shórk, SHARK; lucky, lúcky, lecky, lécky, LUCKY; clash, clásh, clush, clúsh, CLASH; amuse, amúse, amase, amáse, AMUSE; decay, decáy, decey, decéy, DECAY; brave, bráve, brove, bróve, BRAVE; tramp, trámp, tremp, trémp, TRAMP; trace, tráce, troce, tróce, TRACE; crown, crówn, crawn, cráwn,

CROWN; crust, crúst, crost, cróst, CRUST; plump, plúmp, plamp, plámp, PLUMP; space, spáce, spoce, spóce, SPACE; close, clóse, clase, cláse, CLOSE; trade, tráde, trode, tróde, TRADE; torch, tórch, tarch, tárch, TORCH; phase, pháse, phose, phóse, PHASE; harsh, hársh, horsh, hórsh, HARSH; ghost, ghóst, ghast, ghást, GHOST; verse, vérse, varse, várse, VERSE; smash, smásh, smesh, smésh, SMASH; exert, exért, exart, exárt, EXERT; profit, prófit, prafit, práfit, PROFIT; trunk, trúnk, tronk, trónk, TRUNK; prone, próne, prane, práne, PRONE; chase, cháse, chese, chése, CHASE; sport, spórt, spart, spárt, SPORT

Nonword trials. edrape, edrápe, edrepe, edrépe, EDRAPE; nombs, nómbs, nambs, námbs, NOMBS; fomos, fómos, femos, fémos, FOMOS; burfs, búrfs, berfs, bérfs, BURFS; smole, smóle, smale, smále, SMOLE; fosty, fósty, fasty, fásty, FOSTY; purns, púrns, parns, párns, PURNS; slare, sláre, slore, slóre, SLARE; husen, húsen, hasen, hásen, HUSEN; desin, désin, dasin, dásin, DESIN; wrall, wráll, wrull, wrúll, WRALL; asuse, asúse, asase, asáse, ASUSE; brort, brórt, brart, brárt, BRORT; snuky, snúky, snoky, snóky, SNUKY; crusp, crúsp, crasp, crásp, CRUSP; crask, crásk, crosk, crósk, CRASK; pronk, prónk, prenk, prénk, PRONK; smong, smóng, smang, smáng, SMONG; grone, gróne, grane, gráne, GRONE; stame, stáme, steme, stéme, STAME; trult, trúlt, tralt, trált, TRULT; prore, próre, prare, práre, PRORE; claca, cláca, cluca, clúca, CLACA; crars, crárs, crers, crérs, CRARS; sarks, sárks, serks, sérks, SARKS; sraws, sráws, srews, sréws, SRAWS; aterd, atérd, atard, atárd, ATERD; brame, bráme, breme, bréme, BRAME; churo, chúro, chero, chéro, CHURO; emacs, emács, emocs, emócs, EMACS; strar, strár, strer, strér, STRAR; scate, scáte, scute, scúte, SCATE; thurl, thúrl, thorl, thórl, THURL; croif, cróif, creif, créif, CROIF; rosty, rósty, rosty, rósty, ROSTY; thrap, thráp, thrup, thrúp, THRAP; shoms, shóms, shems, shéms, SHOMS; scrow, scrów, scraw, scráw, SCROW; drock, dróck, dreck, dréck, DROCK; alorn, alórn, alurn, alúrn, ALORN; wrare, wráre, wrere, wrére, WRARE; rarell, rárell, rorell, rórell, RARELL; trare, tráre, trore, tróre, TRARE; terve, térve, torve, tórve, TERVE; shome, shóme, sheme, shéme, SHOME; gramp, grámp, gromp, grómp, GRAMP; worne, wórne, warne, wárne, WORNE; crale, crále, crule, crúle, CRALE; scack, scáck, scuck, scúck, SCACK; nuced, núced, neced, néced, NUCED; crume, crúme, crume, crúme, CRUME; direve, diréve, dirave, diráve, DIREVE; nerse, nérse, narse, nárse, NERSE; quorn, quórn, quern, quérn, QUORN; snove, snóve, snave, snáve, SNOVE; grock, gróck, grack, grák, GROCK; shast, shást, shust, shúst, SHAST; brorn, brórn, brarn, brárn, BRORN; clern, clérn, clorn, clórn, CLERN; scews, scéws, scaws, scáws, SCEWS; braft, bráft, breft, bréft, BRAFT; grake, gráke, groke, gróke, GRAKE; pombs, pómbs, pembs, pémbs, POMBS; grair, gráir, groir, gróir, GRAIR; chace, cháce, choce, chóce, CHACE; chers, chérs, churs, chúrs, CHERS; tacts, tácts, tocts, tócts, TACTS; esose, esóse, esese, esése, ESOSE; udsat, udsát, udset, udsét, UDSAT; hects, hécts, hacts, hácts, HECTS; crace, cráce, croce, cróce, CRACE; fonse, fónse, fanse, fánse, FONSE; grale, grále, grole, gróle, GRALE; temacs, témacs, tamacs, támacs, TEMACS; marby, márby, marby, márby, MARBY; cregs, crégs, crogs, crógs, CREGS; pruss, prúss, pross, próss, PRUSS; trume, trúme, trome, tróme, TRUME; muctor, múctor, mactor, máctor, MUCTOR; trosh, trósh, trush, trúsh, TROSH; roshy, róshy, reshy, réshy, ROSHY; larms, lárms, lorms, lórms, LARMS; frere, frére, frare, fráre, FRERE; swace, swáce, swoce, swóce, SWACE; curns, cúrns, carns, cárns, CURNS; agacs, agács, agecs, agécs, AGACS; fornel, fórnel, farnel, fárnel, FORNEL; drull, drúll, drell, dréll, DRULL; flump, flúmp, flomp, flómp, FLUMP; scruy, scrúy, screy, scréy, SCRUY; shamp, shámp, shomp, shómp, SHAMP; scesh, scésh, scash, scásh, SCESH; turest, túrest, torest, tórest, TUREST; phosy, phósy, phesy, phésy, PHOSY; pruck, prúck, preck, préck, PRUCK; screr, scrér, scror, scrór, SCRER; trond, tróndt, trand, tránd, TROND; sprab, sprább, spreb, spréb, SPRAB; crare, cráre, crore, cróre, CRARE; shomy, shómy, shumy, shúmy, SHOMY; stoms, stóms, stums, stúms, STOMS; scact, scáct, scoct, scóct, SCACT; sruty, srúty, sraty, sráty, SRUTY; drany, drány, drony, dróny, DRANY; flace, fláce, flece, fléce, FLACE; scode, scóde, scude, scúde, SCODE; wrock, wróck, wruck, wrúck, WROCK; frade, fráde, frede,

fréde, FRADE; chere, chére, chure, chúre, CHERE; amose, amóse, amese, amése, AMOSE; brant, bránt, bront, brónt, BRANT; scafe, scáfe, scefe, scéfe, SCAFE; eterd, etérd, etard, etárd, ETERD; fronk, frónk, frenk, frénk, FRONK; worch, wórch, wurch, wúrch, WORCH; wrart, wrárt, wrort, wrórt, WRART; bumder, búmder, bemder, bémder, BUMDER; grart, grárt, grort, grórt, GRART; wacts, wácts, wocts, wócts, WACTS; amete, améte, amute, amúte, AMETE; joral, jóral, jural, júral, JORAL; flarm, flárm, flurm, flúrm, FLARM; stase, stáse, stese, stése, STASE; prote, próte, prute, prúte, PROTE; musel, músel, mesel, mésel, MUSEL; flart, flárt, flert, flért, FLART; basop, básop, bosop, bósop, BASOP; grush, grúsh, gresh, grésh, GRUSH; frojen, frójen, frajen, frájen, FROJEN; rured, rúred, rered, réred, RURED; blams, bláms, blums, blúms, BLAMS; bomps, bómps, bamps, bámps, BOMPS; drush, drúsh, drash, drásh, DRUSH; strote, stróte, strate, stráte, STROTE; furts, fúrts, ferts, férts, FURTS; pluct, plúct, plact, pláct, PLUCT; swork, swórk, swark, swárk, SWORK; scank, scánk, scenk, scénk, SCANK; chask, chásk, chusk, chúsk, CHASK; provel, próvel, prevel, prével, PROVEL; brole, bróle, brele, bréle, BROLE; luson, lúson, loson, lóson, LUSON; gacty, gácty, gecty, gécty, GACTY; basel, básel, busel, búsel, BASEL; afure, afúre, afere, afére, AFURE; scush, scúsh, scosh, scósh, SCUSH; stors, stórs, stors, stórs, STORS; grase, gráse, grose, gróse, GRASE; prack, prácк, preck, préck, PRACK; rucket, rúcket, recket, récket, RUCKET; docal, docál, dacal, dacál, DOCAL; hurle, húrle, herle, hérle, HURLE; braffs, bráffs, breffs, bréffs, BRAFFS; trurs, trúrs, trars, trárs, TRURS; worge, wórge, warge, wárge, WORGE; grare, gráre, grere, grére, GRARE; brops, bróps, braps, bráps, BROPS; draze, dráze, droze, dróze, DRAZE; brunk, brúnk, bronk, brónk, BRUNK; stace, stáce, stoce, stóce, STACE; thech, théch, thoch, thóch, THECH; losal, lósal, lesal, lésal, LOSAL; parps, párps, porps, pórps, PARPS; sharf, shárf, shorf, shórf, SHARF; basan, básan, bosan, bósan, BASAN; brack, bráck, bruck, brúck, BRACK; asave, asáve, aseve, aséve, ASAVE; trarf, trárf, trorf, trórf, TRARF; bamit, bámit, bemit, bémit, BAMIT; bamon, bámon, bomon, bómon, BAMON; stosk, stósk, stesk, stésk, STOSK; chasks, chásks, chosks, chósks, CHASKS; demeps, deméps, demups, demúps, DEMEPS; groil, gróil, gruil, grúil, GROIL; shace, sháce, shece, shéce, SHACE; fecky, fécky, focky, fócky, FECKY; grash, grásh, grush, grúsh, GRASH; amund, amúnd, amand, amánd, AMUND; demey, demév, demoy, demóy, DEMEY; brase, bráse, brese, brése, BRASE; dramp, drámp, dramp, drámp, DRAMP; trart, trárt, trort, trórt, TRART; croil, cróil, creil, créil, CROIL; crugs, crúgs, cregs, crégs, CRUGS; drump, drúmp, dremp, drémp, DRUMP; slace, sláce, sloce, slóce, SLACE; crose, cróse, crase, cráse, CROSE; trale, trále, trele, tréle, TRALE; torth, tórth, tarth, tárth, TORTH; dwase, dwáse, dwuse, dwúse, DWASE; hamse, hámse, homse, hómse, HAMSE; ghoms, ghóms, ghams, gháms, GHOMS; verms, vérms, varms, várms, VERMS; wrash, wrásh, wrosh, wrósh, WRASH; emech, emécн, emoch, emóch, EMECH; prebit, prébit, prabit, prábit, PREBIT; trung, trúng, treng, tréng, TRUNG; pronk, prónk, prunk, prúnk, BLONE; shase, sháse, shuse, shúse, SHASE; flort, flórt, flart, flárt, FLORT