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Does Spanish knowledge contribute to accurate English word spelling in adult bilinguals?

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Abstract

Correctly spelling an English word requires a high-quality orthographic representation. When faced with spelling a complex word without a high-quality representation, spellers often rely on other knowledge sources (e.g., incomplete stored orthographic forms, phonological to orthographic relationships) to spell it. For bilinguals, another potentially facilitative source is knowledge of a word's lexical and sublexical representations in another language. In the current study we considered simultaneous effects of word-level (e.g., frequency, cognate status) and person-level (e.g., English spelling skill, prompting, bilingual status) predictors on college students' complex English word spelling. Monolinguals (English; $n = 42$) significantly outperformed bilinguals (Spanish and English; $n = 76$) on non-cognate spelling; no group differences emerged for cognate spelling accuracy. Within bilinguals, significantly higher spelling performance on cognates compared to non-cognates suggests cognate facilitation, with no prompting effects. Findings expand an interdisciplinary framework of understanding bilinguals' activation and use of cross-linguistic representations in spelling.

Introduction

A growing number of individuals in the United States are tasked with learning to read and write in more than one language. In recent years, there has been increasing interest in exploring important questions about the structure and availability of orthographic and phonological representations across languages in bilingual individuals. Behavioral evidence suggests that linguistic knowledge from one language can be useful for acquiring and recalling word representations in another language (see Kaushanskaya & Marian, 2009; Poepsel & Weiss, 2016). For instance, the study of cross-linguistic activation during cognate processing indicates that bilinguals' language production and comprehension is language non-selective (see De Groot, 2011) and that cognates (i.e., words that are semantically, orthographically, and sometimes phonologically similar) are processed more quickly at the lexical level compared to non-cognates (see Lijewska, 2020). However, questions remain regarding the circumstances in which activation of sublexical units can facilitate or interfere with performance on tasks such as word recognition and spelling (Carrasco-Ortiz, Amengual & Gries, 2021; Martin & Nozari, 2021). In the current study we explored whether sublexical information from Spanish spelling can, and if so under what circumstances, aid the spelling of complex English cognate words in heritage speaking Spanish–English bilingual college students. To expand on the literature that has focused on cross-linguistic activation at the lexical level, we tested the likelihood of facilitation from transparent Spanish orthography-to-phonology relations in bilinguals' spelling of English words containing inconsistent orthography-to-phonology relations. Results are intended to shed light on how the quality of a lexical representation in one language of proficiency is impacted by sublexical representations in another language of proficiency that shares orthographic, phonological, and semantic features (e.g., cognates).

Sublexical representations in Spanish and English

To explore the possibility of cross-linguistic facilitation in isolated word spelling, we consider how the ease of establishing orthographic representations in alphabetic languages varies as a function of orthographic depth. Orthographic depth refers to the consistency of correspondences between graphemes (written letters) and their corresponding phonemes (spoken sounds) within a language (see Frost, Katz & Bentin, 1987; Seymour, Aro & Erskine, 2003; Ziegler & Goswami, 2005). In a deep orthography like English, the complexity of orthographic-phonological relations increases as words get longer and contain multiple syllables. Polysyllabic English words, both mono- and polymorphemic, are often more difficult to read and spell due to the added complexity of orthographic-phonological relations associated with complex syllable boundaries (Perry, Ziegler & Zorzi, 2010), word stress and vowel reduction (Ševa, Monaghan & Arciuli, 2009), vowel pronunciation ambiguities (Venezky, 1999), larger and more complex grapheme-phoneme units (Berninger, 1994), and morphological complexity (Carlisle & Stone, 2005; Nagy, Berninger & Abbott, 2006). Spanish, however, is a shallow orthography with highly consistent relationships that map graphemes directly onto phonemes with few exceptions and very little ambiguity at larger grain sizes. For example, in the Spanish word "casa" ("house" in English), one distinct mapping between each letter and its sound makes "casa" a completely transparent word. Compared to shallow orthographies, word reading and spelling acquisition in deep orthographies develop more slowly (Seymour et al., 2003), involve the formation of orthography-to-phonology connections at multiple grain sizes (Ziegler & Goswami, 2005), and require the establishment of representations for many "exception" words that never become fully decodable based on common grapheme-phoneme correspondences (GPCs; Frost et al., 1987). Thus, establishing fully specified word-specific representations takes longer in English, and there is likely greater variation in the quality of representations across individuals learning to read and spell in English (Perfetti, 1991, 1992; Seymour, 1997), including problems with spelling complex and infrequent English words, that persist into adulthood (Bosman & Van Orden, 1997; Burt & Fury, 2000).

According to Perfetti (1991, 1992, 1997), a fully specified orthographic representation in the reader's lexicon should develop over time with experiences leading to incremental increases in the representation's precision (i.e., the specific letters associated with that word) and redundancy (i.e., multiple stored phonological representations for a single word). With higher quality word representations comes a stronger relationship between a printed word and its spoken form, allowing for faster and more accurate reading and spelling (Perfetti & Hart, 2002). In the absence of fully specified representations, individuals often rely on other sources of information (e.g., phonology-to-orthography relationships) to aid in word spelling. However, in English, resorting to traditional phonology-to-orthography relationships of various sizes can still lead to error-filled spelling given the inconsistent nature of the orthography (particularly for vowels and larger, more complex, grapheme-phoneme units). While Perfetti (1997) argues that only one set of precise grapheme-phoneme connections is required for BUILDING the orthographic representation of a word, two sets of connections (e.g., /ɪnsepərəbəl/ and its decoded form /ɪnsepareɪbəl/ for "inseparable") provide a "safety net" by adding important redundancy to the representation, thus improving its lexical quality (see Perfetti & Hart, 2001, 2002), and boosting the probability of fluent word reading and more accurate spelling over time. Although this hypothesis focuses on redundant orthography-to-phonology relationships within one language of proficiency (i.e., storage of a word's mispronunciation based on English decoding rules in addition to the word's correct pronunciation), the same concept of storing two or more sets of orthography-to-phonology relationships for fluent reading and spelling could apply cross-linguistically. Over time, encounters with identical and non-identical cognates in spoken conversation, reading, and writing can support the application of linguistic knowledge, in this case sublexical orthography-to-phonology relations, from Spanish to English to create a "boosting" effect for bilinguals' sensitivity to mapping individual English sounds onto English print when constructing orthographic representations. This notion of a boosting effect in English sublexical sensitivity and knowledge suggests that bilinguals should be able to draw upon consistent sublexical connections activated in Spanish to aid English word spelling, but perhaps only for English words in which the sublexical connections are directly helpful (e.g., cognates; Perfetti & Hart, 2002). Consider the example of the irregular English word "inseparable", an orthographically identical cognate in Spanish and English. From a TRANSPARENCY standpoint each grapheme in the Spanish translation equivalent "inseparable" only corresponds to one phoneme, whereas each vowel grapheme in the English word corresponds to multiple phonemes, making the units in the Spanish word more transparent. Similarly in terms of CONSISTENCY, each "a" grapheme in the Spanish word corresponds to the same phoneme regardless of letter position, whereas each "a" grapheme in the English word is unstressed, corresponding to two different forms of the schwa /ə/ based on letter position, making the units less consistent than the Spanish word. Following the lexical quality hypothesis, we assume activation of Spanish sublexical units will be advantageous for bilingual adults when asked to spell irregular English words that are orthographically similar cognates in Spanish and English (e.g., "inseparable") and less advantageous for spelling non-cognate words that activate less overlapping cross-linguistic information. Additionally, this advantage should not be present in monolingual adults' cognate spelling since they lack knowledge of spelling-sound relationships in Spanish that could be activated and mapped onto English orthographic representations of cognates.

Range of cognate effects

There is substantial evidence that a bilingual individual's two languages are non-selectively activated in parallel when tasked with producing or comprehending a word in one language (De Groot, 2011; see Lijewska, 2020). Supporting evidence includes several reports of the cognate facilitation effect: the differential processing of cognates (words that are semantically and orthographically identical like "inseparable" in Spanish and English and near-identical words like "September" in English and "septiembre" in Spanish) compared to non-cognates (e.g., "overwhelmed" in English and "abrumado" in Spanish) that only share meaning across languages (Valente, Ferré, Soares, Rato & Comesaña, 2018). The cognate facilitation effect has been shown in word production (Colomé & Miozzo, 2010; Costa, Caramazza & Sebastián-Gallés, 2000; Hoshino & Kroll, 2008; Kroll, Dietz & Green, 2000; Sadat, Martin, Magnuson, Alario & Costa, 2016), as well as in visual and auditory word recognition, including lexical decision performance of bilingual adults who have similar first language (L1) and second language (L2) proficiency (Comesaña, Ferré, Romero, Guasch, Soares & García-Chico, 2015) and those with higher L1 proficiency compared to L2 (Dijkstra, Miwa, Brummelhuis, Sappelli & Baayen, 2010; Valente et al., 2018). These results also highlight how person-level factors like L2 proficiency, language dominance, and age of acquisition may moderate the size of observed cognate effects (Comesaña, Bertin, Oliveira, Soares, Hernández & Casalis, 2018; Lijewska, 2020; Soares, Oliveira, Ferreira, Comesaña, Macedo, Ferré & Fraga, 2019). For example, among bilinguals who varied in Welsh and English dominance, Broersma, Carter and Acheson (2016) report both facilitative and inhibitive cognate

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effects dependent on dominance and task demands. When tasked with switching between languages to name pictures, facilitative cognate effects were observed for Welsh-dominant and "equal-dominance" bilinguals while inhibitive cognate effects were only observed for English-dominant bilinguals when naming pictures in Welsh. Even within the same task, cross-linguistic activation occurs across different levels of processing, as shown by Muscalu and Smiley's (2019) results from bilinguals' typed word translations from L2 to L1 (see also Soares, Oliveira, Ferreira, Comesaña, Macedo, Ferré, Acuña-Fariña, Hernández-Cabrera & Fraga, 2019). Cognate facilitation was only observed in response onset latencies for typed whole word responses (i.e., lexical level), while spelling accuracy of cognates was significantly lower compared to non-cognates (i.e., sublexical inhibition). Similarly, Muylle, Van Assche and Hartsuiker (2022) recently reported cognate facilitation in onset latencies for Dutch–English bilinguals' picture naming in both spoken and typewritten modalities. Total latencies in the typewritten modality, however, were longer for cognates with less cross-linguistic overlap, suggesting that sublexical inhibition in typewritten production may only be expected for orthographically non-identical cognates.

Given reports of cognate facilitation at the lexical level and inhibition at the sublexical level for typewritten tasks, it is critical to understand the roles of orthographic similarity (OS) and phonological similarity (PS) of a given word and its translation equivalent in cognate processing. Larger cognate facilitation effects have been reported for orthographically identical cognates compared to non-identical cognates in lexical decision (Comesaña et al., 2015; Guasch, Ferré & Haro, 2017; Vanlangendonck, Peeters, Rueschemeyer & Dijkstra, 2020), emphasizing OS effects in cognate recognition (Dijkstra et al., 2010). Cognates with high PS have also been shown to be facilitative of visual lexical decision when accounting for OS (Comesaña et al., 2015; Comesaña, Soares, Sánchez-Casas & Lima, 2012; Dijkstra et al., 2010) and without considering OS (Dimitropoulou, Duñabeitia & Carreiras, 2011). However, high PS was inhibitory in Dutch–English bilinguals' response latencies on a visual lexical decision task composed of English cognates and homographs varying in orthographic, phonological, and semantic overlap with Dutch words (Dijkstra, Grainger & Van Heuven, 1999). Among Spanish–English bilinguals, Carrasco-Ortiz et al. (2021) found evidence of independent contributions from OS and PS to word recognition latency. Facilitation was reported for cognates with higher PS and lower OS and cognates with lower PS and higher OS, but surprisingly, cognates with high PS and OS elicited slower responses. In contrast, Comesaña et al. (2012) reported that Portuguese–English bilinguals read higher PS cognates with high OS more quickly than low PS cognates, but no PS effects for cognates with low OS. Under the demands of both recognition and production, Schwartz, Kroll and Diaz (2007) found that bilinguals' word naming accuracy was facilitated for cognates when the Spanish and English translation equivalents of the word were both orthographically and phonologically similar, but response latency was inhibited for naming words with low PS. These results reveal a lack of consensus on expectations of cognate effects (i.e., inhibition versus facilitation) in word recognition and naming when accounting for a wide range of OS and PS in the cognate stimuli selection. Relatedly, lack of evidence for a facilitation effect in orthographically non-identical cognates compared to orthographically identical cognates suggests that the composition of stimuli lists can influence the direction of OS and PS effects on word recognition (Arana, Oliveira, Fernandes, Soares & Comesaña, 2022; Dijkstra et al., 2010). For example, Comesaña et al. (2015) report bilinguals' faster reaction times to orthographically identical and non-identical cognates compared to non-cognates in a Spanish lexical decision task, but when identical cognates were excluded, cognate inhibition and PS effects emerged, suggesting that identical and non-identical cognates of alphabetic orthographies are represented and processed differently, with stronger PS effects on processing of non-identical cognates with lower OS.

Despite the breadth of cognate processing studies that have examined various factors (i.e., participants' language history, task type, stimuli list composition) that influence the likelihood of cognate facilitation and inhibition effects, the mechanism for facilitative L1 activation in the recall and written production of L2 word representations is still not clearly understood, particularly in a context that requires both recognition of phonological representations and recall of orthographic representations in one language (i.e., English spelling). The Bilingual Interactive Activation+ model (BIA+; Dijkstra et al., 2010; Dijkstra & Van Heuven, 2002; Lam & Dijkstra, 2010; Van Hell, 2002) proposes that through non-selective lexical access and bottom-up processing, a given letter string automatically and subconsciously activates orthographically similar candidates, which then activate sublexical units and their corresponding phonological representations, followed by activation of orthographic and phonological representations at the lexical level, leading to faster recognition of cognates relative to non-cognates, regardless of the participants' expectations for language(s) of use in the task. Given the assumption that auditory word recognition follows a similar flow of activation as visual word recognition (Dijkstra & Van Heuven, 2002), this model is appropriate for considering cognate effects in the context of hearing a word before being asked to spell it in the same language. The contrastive analysis perspective assumes the possibility of cognate facilitation effects via conscious recognition of structural similarities between L1 and L2. When a learner recognizes similar features (e.g., phonological forms, orthographic forms, and cognates) across languages, formation of L2 representations can be facilitated (see Verhoeven, 2017), leading to easier storage and recall of lexical representations in an L2 that is closer to the L1 than a language that has a very different structure (Connor, 1996; Odlin, 1989). Taken together with supporting evidence of the cognate facilitation effect in other tasks and the concept of redundancy from the lexical quality hypothesis (Perfetti & Hart, 2002), the BIA+ model and contrastive analysis perspective suggest that the amount and type (phonological or orthographic) of cross-linguistic overlap between translation equivalents of a word should impact the extent to which activation of L1 sublexical and lexical representations facilitates L2 English spelling accuracy. Based on these frameworks, however, it remains unclear whether activation of L1 sublexical representations will result in facilitated or inhibited L2 word spelling and if the likelihood of facilitated spelling hinges on conscious and effortful recognition of structural similarities between a cognate's translation equivalents.

Complex word considerations

Features of the words and the speller's background experience in reading and spelling ability (in both languages for bilinguals) are critical to explaining a person's likelihood of representing a word's spelling with high quality. Adults need to be presented with challenging stimuli that balance frequency and familiarity to test the quality and activation of orthographic representations (i.e., the

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complex words to be spelled) for cognates and non-cognates. For this reason, the current study defines complex English words in the dependent spelling task as polysyllabic low frequency irregular words that most participants would likely recognize in their spoken forms (i.e., adequate familiarity) but seldom encountered in text (i.e., low frequency) prior to study participation. In addition to each person's item-specific familiarity with the words from the dependent spelling task, we tested each person's item-specific set for variability (SfV), which is the process of recognizing a word from its mispronunciation (based on English decoding rules) and correctly pronouncing it (see Gibson & Levin, 1975; Tunmer & Chapman, 2012; Venezky, 1999). SfV has been shown to be an important item-level predictor of irregular word reading accuracy in monolingual children (Steacy, Wade-Woolley, Rueckl, Pugh, Elliott & Compton, 2019; Tunmer & Chapman, 2012), as well as a general predictor of regular word reading in bilingual children (Elbro, de Jong, Houter & Nielsen, 2012), suggesting that this may be an important skill to consider in the recall of orthographic representations required for spelling of complex English words. Including these item-level measures of familiarity and SfV, the frequency of the target spelling words, and general English literacy skills (e.g., nonword reading, word reading, spelling, vocabulary) allows for interpreting the significant contributions of other relevant person-level variables (e.g., bilingual status) and word-level variables (e.g., cognate status) to spelling accuracy.

The current study

In the current study, we examined whether bilinguals show cognate facilitation effects in spelling accuracy of complex English words, and further whether prompting of the potential for cross-linguistic similarities in sublexical units influences spelling performance. To accomplish this, we assessed English word spelling performance in a sample of undergraduate students, including monolingual (English only) and bilingual participants (Spanish and English) who vary in acquisition history and dominance. We examined the role of word-level predictors (e.g., frequency, length, and cognate status) and person-level predictors (e.g., bilingual status, general English spelling and decoding, Spanish and English word reading, English vocabulary, prompting, and set for variability) in predicting item-level spelling performance of complex English words, including cognates ranging in OS and PS. We focused on spelling performance because spelling is considered a purer measure of an individual's orthographic representational quality of a word compared to reading (Perfetti, 1997). Echoing Anthony, Solari, Williams, Schoger, Zhang, Branum-Martin and Francis' (2009) methodological concerns with analytic approaches used in early bilingual research, our statistical approach explored individual differences using item-response based crossed random-effects models, which allow item-level variance in spelling accuracy to be partitioned between individual participants and words, permitting important person-by-word interactions to be explored.

We predicted that bilingual participants would a) show higher English spelling accuracy of complex cognate words compared to monolinguals and b) demonstrate this cognate facilitation effect regardless of whether they are prompted to consider Spanish spelling. This second prediction was tested to replicate an important assumption of the BIA+ model in the context of spelling complex words (outside of direct translation demands) that rely on precise sublexical information: participants' expectations of the language(s) used in a task should not influence the likelihood of cross-linguistic facilitation. Given the difference in demands of a spelling task compared to other language production and recognition tasks (Bosman & Van Orden, 1997; Muylle et al., 2022), no specific predictions for cognate type (identical vs non-identical) or direction of OS and PS effects on spelling accuracy were proposed in the current study. Ultimately, this study aimed to provide a unique perspective in understanding how a bilingual adult's activated representations (i.e., orthographic and phonological, lexical and/or sublexical) and word reading skills in both English and Spanish may potentially facilitate accurate spelling of complex English words (i.e., whole word orthographic representations), regardless of receiving the instruction to actively consider each word's sublexical units in Spanish.

Methods

Participants

Over the course of nine months, data were collected from 120 undergraduate students in the psychology subject pool of a large public university in the Southeast region of the U.S. Prior to the study's initiation, ethical approval was obtained from the university's ethics committee for human subject research, in compliance with the U.S. Federal Policy for the Protection of Human Subjects. Individual consent was obtained in person for each participant before the first study session began. Bilingual participants were randomly assigned to either receive prompting or no prompting for thinking about the Spanish spelling of the complex English words before attempting to spell them in the dependent spelling task. A monolingual comparison group was recruited for contrast purposes. Participating subjects completed two separate one-hour sessions and were compensated with extra credit for selected courses.

Demographic data for 115 participants are presented in Table 1[1], and person-level descriptive statistics for the full sample are displayed in Table 2. Hispanic/Latino student populations were intentionally oversampled to recruit eligible bilinguals with Spanish and English fluency. Between prompted bilingual, unprompted bilingual, and monolingual groups, there were no significant group differences on any independent measures of English oral vocabulary, word reading, or standardized spelling. The participants' ages ranged from 18 to 25 years. Monolingual participants self-identified as primarily English-speaking with no fluency in or prolonged exposure to Spanish. Bilingual participants self-identified as fluent in both Spanish and English with no fluency in or significant exposure to a third language. They were also required to reach a minimum proficiency on the Woodcock-Muñoz Language Survey III (Woodcock, Alvarado, Ruef & Schrank, 2017) Spanish word identification task (> 45 out of 70 words correctly read, equivalent to reading proficiency at 8 years of age). The heterogeneity of the sample of mainly heritage Spanish speakers (i.e., informal L1 learners of Spanish language with less developed Spanish literacy skills) is reflected in the wide range of Spanish word reading scores and the majority reporting English dominance with primarily Spanish home language exposure. Two participants' data were removed from the final set of analyses due to their reports of trilingual fluency in

[1]Demographic data were missing for 3 participants on ethnicity, gender, race, and/or home and dominant languages and therefore not included in final analyses.

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Table 1. Demographic characteristics of participants.

Variable	Full sample $N = 115$*	Monolingual $n = 40$*	Bilingual $n = 75$*	Chi square tests of independence
Age (Years)	*M* = 19.57 *SD* = 3.07	*M* = 19.50 *SD* = 1.30	*M* = 19.60 *SD* = 3.69	
Sex (%)				χ^2 (4) = 5.96
Female	63.48	65.00	36.00	*p* = .202
Male	35.65	35.00	62.67	
No answer	0.87	–	1.33	
Ethnicity (%)				χ^2 (2) = 76.76
Hispanic/Latino	68.70	10.00	100.00	*p* < .001
Non-Hispanic/Latino	31.30	90.00	–	
Home Language (%)				
Spanish	46.09	–	70.67	
English	44.34	100.00	14.67	
Both	9.57	–	10.66	
Other	–	–	4.00	
Dominant Language (%)				
Spanish	15.65	–	24.00	
English	84.35	100.00	76.00	
Race (%)				χ^2 (12) = 15.38
American Indian/Alaskan Native	0.87	–	1.33	*p* = .22
Asian	1.74	5.00	–	
Black/African American	1.74	5.00	–	
Caucasian	81.74	87.50	78.67	
Multiracial	3.48	2.50	4.00	
No answer	6.10	–	9.33	
Other	4.35	–	6.67	

Note. *Demographic data is only reported for 115 participants (instead of the full sample of 118 participants) due to incomplete survey responses from three participants (2 monolingual, 1 bilingual) on the relevant variables.
M and *SD* are used to represent mean and standard deviation, respectively.

Russian and Slovenian (see Hoshino & Kroll, 2008, for evidence of cross-script cognate facilitation effects).

Procedures

Participants were assessed on reading, spelling, word familiarity, oral vocabulary, and set for variability (SfV) performance across two 30–40 minute sessions. In the first testing session, SfV was administered first, followed by English and Spanish familiarity, standardized English spelling, English word reading, English reading fluency, and Spanish word reading (bilinguals only). In the second testing session (at least 3 days after the first session), dependent spelling was administered first, followed by English oral vocabulary and the online demographics survey. All tasks were taken from pre-existing standardized tests, except for the SfV and familiarity tasks, which were adapted from measures used by Steacy et al. (2019) and Kearns, Rogers, Koriakin and Al Ghanem (2016). Raw total scores for each Woodcock-Johnson III (Schrank, 2005) measure were used in the main analyses, as well as raw total scores for the Woodcock-Muñoz Language Survey III (Woodcock et al., 2017) Spanish word identification task in an exploratory analysis.

Dependent measure

Spelling

The spelling task consisted of 40 English words; 20 cognates and 20 matched non-cognates (see Appendix). The 20 cognates were chosen from NTC's Dictionary of Spanish Cognates (Nash, 1997) for having identical (i.e., no difference in spelling) or near identical (i.e., 1–3 letters different) spellings between Spanish and English translation equivalents. The 20 non-cognates were selected from the English Lexicon Project (Balota, Yap, Hutchison, Cortese, Kessler, Loftis & Treiman, 2007) and matched to the cognates in length, frequency, number of morphemes and phonemes, lexical decision reaction time, and reading accuracy. After study completion, two items that were originally

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Table 2. Descriptive statistics of person and word-level variables by group.

	Prompted Bilingual ($n = 38$)		Unprompted Bilingual ($n = 38$)		Monolingual ($n = 42$)			
	M	*SD*	*M*	*SD*	*M*	*SD*	$F(2, 115)$	*p*
Outcome variable								
Dependent spelling	23.23	6.82	22.05	6.52	23.81	6.52	0.87	.42
Person-level variables								
Standardized spelling	51.18	3.36	50.53	3.57	50.77	3.65	.17	.85
Oral vocabulary	30.18	5.61	28.32	4.93	31.53	3.13	3.85	.12
Decoding (PDE)	55.31	7.65	51.61	8.95	55.00	7.73	2.58	.08
English familiarity	30.03	5.26	28.63	4.72	30.81	4.55	1.29	.28
SfV (Total)	23.36	5.73	21.74	5.02	24.05	5.61	1.56	.22
Spanish familiarity	15.26	2.43	15.03	2.62	5.21	3.90	155.20	<.001
Spanish reading (AE)	16.87	4.41	16.88	4.38	–	–		
Spanish word reading	63.49	4.97	61.95	5.52	–	–		
			Cognate ($n = 22$)		Non-cognate ($n = 18$)		$F(1, 40)$	*p*
Word-level variables			*M*	*SD*	*M*	*SD*		
Length			9.68	1.99	9.72	2.02	<.01	.95
LD reaction time (s)			808.30	97.60	775.90	89.26	1.17	.29
LD reading accuracy			.86	.14	0.87	0.14	.05	.83
Log HAL frequency			6.25	1.04	6.31	1.17	.02	.88
Morphemes			2.09	.75	2.44	1.15	1.37	.25
OS			.29	.08	.23	.15	288.70	<.001
Phonemes			8.59	1.84	8.06	1.83	.84	.37
PS			.29	.08	.06	.07	91.80	<.001
Syllables			3.59	.91	2.89	.90	5.96	.02

Note. M and *SD* are used to represent mean and standard deviation, respectively. ANOVA Bonferroni correction was conducted to correct for multiple comparisons at the person level (3 groups) and word level (2 groups).
OS = orthographic similarity; PDE= phonemic decoding efficiency subtest from the TOWRE-2 (Torgesen et al., 2012); SfV = Set for Variability; AE = age equivalent scores; HAL = Hyperspace Analogue to Language corpus; LD = lexical decision (based on data available from the English Lexicon Project, Balota et al., 2007); PS = phonological similarity.

coded as non-cognates were determined to be more comparable in orthographic similarity between Spanish and English translation equivalents to other cognates (range = .70–1.00) compared to non-cognates (range = 0–.50); therefore, the words were recoded as cognates and the final spelling list consisted of 22 cognates (7 identical, 15 near identical) and 18 non-cognates. Between cognates and non-cognates, only number of syllables was significantly different ($p = .02$) while all other lexical features were not significantly different ($p > .05$; see Table 2). The administration procedures for the spelling task were adapted from the Woodcock-Johnson III (Schrank, 2005) standardized spelling task, in which participants heard each word read aloud on a recording, used in a sentence, and then repeated in isolation before being asked to spell it on paper. Cronbach's alpha was .92.

Independent word-level measures

Cognate status

This is a dichotomous categorization of the 40 spelling words as non-cognate (0) or cognate (1) based only on orthographic and semantic overlap between Spanish and English translation equivalents.

Frequency

The 40 spelling words' log-transformed HAL frequency values, based on the Hyperspace Analogue to Language corpus, were taken from the English Lexicon Project (Balota et al., 2007). The corpus consists of approximately 131 million words gathered from 3,000 newsgroups during 1995. The log transformed HAL frequency reported for the 40 spelling words ranges from 4.52 to 8.34.

Orthographic similarity (OS)

This measure of spelling (i.e., orthographic) overlap between the 40 English spelling words and their Spanish translation equivalents was calculated with normalized Damerau-Levenshtein distance (NDLD) values on a scale of 0 to 1 (0 = no operations required to match spelling across language). Values were reverse coded to represent similarity values with higher values indicating higher similarity rather than distance.

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Number of morphemes

This measures the number of morphemes in each word based on data from the English Lexicon Project (Balota et al., 2007). The range reported for the 40 spelling words is 1 to 4 morphemes.

Phonological similarity (PS)

This measure of pronunciation overlap between the 40 English spelling words and their Spanish translation equivalents was calculated by transcribing the word pairs to International Phonetic Alphabet (completed by an experienced speech language pathologist, with consideration of the mainstream Spanish dialect of Latin American Spanish and mainstream English dialect of General American English). After converting the IPA forms to SAMPA[2], NDLD values on a scale of 0 to 1 were calculated for each pair of words and reverse coded to represent similarity values ranging from 0 to 0.46 with higher values indicating higher similarity.

Word length

This measures the number of letters in each of the 40 spelling words, ranging from 6 to 13 letters.

Independent person-level measures

Bilingual status

This is a dichotomous categorization of participants as monolingual (0; English only) or bilingual (1; Spanish and English) based on participants' self-identification of being monolingual or bilingual and (for bilinguals only) reading more than 45/70 words correctly on the Woodcock-Muñoz Language Survey III (Woodcock et al., 2017) Spanish word identification task.

Prompting

Half of the bilingual participants ($n = 38$) were randomly assigned to receive an additional instruction before hearing the first spelling word (i.e., "think of the words in Spanish prior to attempting to spell them"). The unprompted bilinguals ($n = 38$) and monolinguals ($n = 42$) did not hear this additional instruction.

English and Spanish familiarity

These measures were adapted from Kearns et al.'s (2016) measure to include the complete list of 40 spelling words and 5 foil words, and a list of the Spanish translation equivalents of the same 45 words. After hearing a recording of each English word in isolation, participants provided a yes/no response for whether the word sounded familiar or not (based on having heard or encountered the word in text prior to the testing session). Following the same instructions, the Spanish list was presented to all participants to account for any Spanish exposure that monolingual participants may have had prior to the study and proxy for bilingual participants' Spanish vocabulary. Cronbach's alpha was .79 for English familiarity[3].

Oral vocabulary

The Woodcock-Johnson III (Schrank, 2005) English vocabulary subtest required participants to identify pictures with single word descriptions for up to 44 items. The authors report split-half reliability of .81.

Word and nonword reading fluency

The English reading fluency tasks were the sight word efficiency (for real words) and phonological decoding efficiency (for nonwords) subtests from the TOWRE-2 (Torgesen, Wagner & Rashotte, 2012). Participants were asked to read a list of 108 sight words and a list of 66 nonwords as quickly and accurately as possible within the span of 45s for each list. The authors report an alternate forms reliability of .91 for sight word efficiency and .92 for phonemic decoding efficiency.

Set for variability (SfV) mispronunciation task

Based on the work of Tunmer and Chapman (1998, 2012) and Steacy et al. (2019) with elementary-aged students, SfV was evaluated by participants' ability to derive the correct pronunciation from spoken English words that are "mispronounced" based on decoding rules, as if they were regular words or partially decoded (e.g., /brikfəst/ for / brɛkfəst/). This is an experimental measure aimed at capturing adult participants' phonological flexibility and the strength of lexical representations for the 40 spelling words. Cronbach's alpha was .90.

Standardized spelling

The Woodcock-Johnson III (Schrank, 2005) spelling subtest was used to measure general spelling ability of increasingly difficult English words ($N = 59$) appropriate for the sample's specific age range. The authors report split-half reliability of .90.

Word identification

The word identification subtests from the Woodcock-Johnson III (Schrank, 2005) were used to measure their ability to read 76 words across difficulty levels in English. Only self-identified bilingual participants completed the Spanish word identification subtest of the Woodcock-Muñoz Language Survey III (Woodcock et al., 2017) to confirm that they had an appropriate minimum Spanish proficiency to be considered "bilingual" for this study. This subtest helped highlight a small group of students who had self-identified as bilingual based on some high school or undergraduate course experience with oral and written comprehension, but who displayed very low reading proficiency. For those who did not reach a minimum proficiency on the test (> 45 out of 70 words correctly read, equivalent to reading proficiency at 8 years of age), testing was discontinued and their data was not included in the final sample. The authors report split-half reliability of .94 for the English subtest and .95 for the Spanish subtest.

Fidelity

A fidelity-of-implementation checklist was developed based on the testing scripts for the Woodcock-Johnson III (Schrank, 2005), Woodcock-Muñoz Language Survey III (Woodcock et al., 2017), Test of Word Reading Efficiency 2 (TOWRE-2; Torgesen et al., 2012), and researcher-created scripts for the remaining measures. Graduate and undergraduate assistants were trained to administer testing sessions with fidelity, including weekly training sessions over the course of two months, after which each research assistant was required to practice administering each measure to either the primary investigator or the trainer. Finally, research assistants completed mock test administration sessions with the trainer, who gave targeted feedback in the rare

[2] We transformed double characters that represented a single consonant sound in the SAMPA transcription into single unique characters (e.g., dZ for the /dʒ/ phoneme in "discouraging" transformed to 9 in the final SAMPA transcription).

[3] Cronbach's alpha is not reported for the Spanish familiarity task here due to our lack of item-level data available for this task.

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event that fidelity of implementation was less than 80%. Subsequently, research assistants were asked to practice more and required to complete another mock testing session with fidelity above 80%. During the data collection period, the trainer met with assistants after their first testing sessions to address any unplanned complications with subjects and answer questions. Fidelity estimates were maintained at >80% across participants in these preliminary trials to ensure greater confidence in fidelity over the course of data collection.

All testing sessions were audio-recorded and, following the completion of each data collection period (three total), 15% of the recordings were randomly selected for fidelity checks of test administration. All tests were triple-scored by three team members and double-entered; a separate researcher was asked to resolve any discrepancies between each set of scores and entries. The REDCap (Research electronic data capture) tool hosted at Vanderbilt University (Harris, Taylor, Thielke, Payne, Gonzalez & Conde, 2009) was used to enter and manage data throughout the study period.

Data Analysis

Item-response based crossed random-effects models were used to account for the roles of person-level, word-level, and item-specific predictors of complex word spelling variance while identifying significant interactions between person- and word-level predictors. These cross-classified models were used to predict the participants' spelling accuracy of the specific word (e.g., "macabre") coded as a dichotomous response (correct or incorrect) using person-level (e.g., bilingual vs. monolingual status, prompted vs. non-prompted, vocabulary total score), word-level (e.g., frequency, length, cognate vs. non-cognate status), item-specific predictors (e.g., indivdual response to a specific word on the SfV mispronunciation task – correctly identifying "macabre" from /mækʌbɜː/), and interactions (e.g., bilingual status by cognate status). Modeling these random effects simultaneously decreases the probability of unbiased estimates, which may have been more problematic with separate analyses at only the person or item level due to "ignored dependencies" within the data (Gilbert, Compton & Kearns, 2011).

These analyses were conducted using a binomial distribution with a logit link, available through the glmer function (Bates & Maechler, 2009) in the lme4 package from R programming (R Development Core Team, 2012). All continuous person- and word-level predictors were grand mean-centered to aid in interpreting the intercept and coefficients.

Results

Word-level descriptive statistics for cognates and non-cognates are presented in Table 2 along with zero-order correlations for word features in Table 3. Only orthographic and phonological similarity were significantly correlated with cognate status at .94 and .84, respectively, confirming that the three measures are capturing a similar lexical feature of "cognateness." Additionally, person-level descriptive statistics are presented in Table 2 along with zero-order correlations for person features in Table 3. The only person-level predictors that were significantly correlated with bilingual status were Spanish familiarity (.85) and oral vocabulary (−.21), but prompted bilinguals, unprompted bilinguals, and monolinguals did not significantly differ by group in oral vocabulary ($p = .12$). All person-level predictors apart from bilingual status were significantly correlated with standardized spelling, including a small association with Spanish familiarity (.06), moderate associations with oral vocabulary (.34), English decoding (.43), and English familiarity (.54), and the largest association with set for variability (.68).

Unconditional model

A series of crossed random-effects models (see Table 4) were run to decompose and model item-level spelling variance associated

Table 3. Person & word-level feature correlations in the full sample (N = 118).

Person-level variables	*M*	*SD*	1	2	3	4	5	6
1. Bilingual Status	–	–						
2. Standardized Spelling	50.79	3.53	.001					
3. Oral Vocabulary	30.19	4.78	−.21*	.34**				
4. Decoding (PDE)	53.95	8.35	−.10	.43**	.14			
5. English Familiarity	29.97	4.92	−.11	.54**	.55**	.26*		
6. Spanish Familiarity	11.52	5.72	.85**	.06*	−.21*	−.12	.07	
7. SfV (Total)	23.06	5.62	−.12	.68*	.57**	.49**	.73**	.01
Word-level variables	*M*	*SD*	1	2	3	4	5	
1. Cognate Status	–	–						
2. Orthographic Similarity	.59	.35	.94**					
3. Log HAL Frequency	6.28	1.09	−.03	.07				
4. Length	9.70	1.98	−.02	.06	.26			
5. Morphemes	2.25	.95	−.19	−.12	.30	.57**		
6. Phonological Similarity	.19	.14	.84**	.84**	−.08	.17	−.05	

Note. M and *SD* are used to represent mean and standard deviation, respectively.
* indicates $p < .05$. ** indicates $p < .001$.
Bilingual status is coded as 0 for monolingual, 1 for bilingual. Cognate status is coded as 0 for non-cognate, 1 for cognate.
PDE = phonemic decoding efficiency; SfV = set for variability.

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Table 4. Fixed effects predicting probability of correct word spelling responses on dependent spelling task.

	Main effects model (*N* = 118)				Main interaction model (*N* = 118)				Interaction OS model (*N* = 118)				Interaction PS model (*N* = 118)			
Fixed effects	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*
Intercept	.27	.32	.85	.40	–.58	.32	–1.81	.07	–.45	.42	–1.06	.29	–.43	.37	–1.18	.24
Person-by-word factors[a]																
SfV	–	–	–	–	**.59**	**.11**	**5.55**	**<.001**	**.59**	**.11**	**5.55**	**<.001**	**.59**	**.11**	**5.51**	**<.001**
English Familiarity	–	–	–	–	**.91**	**.12**	**7.36**	**<.001**	**.91**	**.12**	**7.36**	**<.001**	**.91**	**.12**	**7.40**	**<.001**
Bilingual x Cognate	–	–	–	–	**.54**	**.16**	**3.33**	**<.001**	–	–	–	–	–	–	–	–
Bilingual x OS	–	–	–	–	–	–	–	–	**.72**	**.24**	**3.02**	**<.01**	–	–	–	–
Bilingual x PS	–	–	–	–	–	–	–	–	–	–	–	–	**1.61**	**.59**	**2.74**	**.01**
Person factors[b]																
Bilingual	–.08	.10	–.74	.46	**–.40**	**.14**	**–2.87**	**<.01**	**–.53**	**.18**	**–2.97**	**<.01**	–.41	.15	–2,63	.30
Decoding (PDE)	**.01**	**.01**	**2.08**	**.04**	**.02**	**.01**	**2.20**	**.03**	**.02**	**.01**	**2.20**	**.03**	**.02**	**.01**	**2.19**	**.03**
English Familiarity	.01	.01	.41	.68	–.02	.02	–1.10	.27	–.02	.02	–1.10	.27	–.02	.02	–1.13	.26
Oral Vocabulary	.02	.01	1.45	.15	.02	.01	1.60	.11	.02	.01	1.59	.11	.02	.01	1.57	.12
SfV	**.07**	**.02**	**4.45**	**<.001**	**.06**	**.02**	**3.29**	**.001**	**.06**	**.02**	**3.29**	**<.001**	**.06**	**.02**	**3.32**	**<.001**
Spelling	**.15**	**.02**	**7.93**	**<.001**	**.16**	**.02**	**7.99**	**<.001**	**.16**	**.02**	**7.99**	**<.001**	**.16**	**.02**	**8.00**	**<.001**
Word factors[c]																
Cognate	.64	.42	1.53	.13	.31	.40	0.77	.44	–	–	–	–	–	–	–	–
Length	.03	.13	.26	.79	–.07	.12	–0.60	.55	–.07	.13	–.57	.57	–.08	.13	–.62	.53
Log HAL Frequency	**1.01**	**.20**	**5.08**	**<.001**	**.86**	**.19**	**4.61**	**<.001**	**.85**	**.19**	**4.43**	**<.001**	**.88**	**.19**	**4.58**	**<.001**
Morphemes	–.04	.27	–.14	.88	–.07	.25	–0.26	.77	–.11	.26	–.41	.68	–.12	.26	–.48	.63
OS	–	–	–	–	–	–	–	–	.08	.59	.13	.89	–	–	–	–
PS	–	–	–	–	–	–	–	–	–	–	–	–	.18	1.53	.12	.91
Intercepts	Variance		Variance Explained		Variance		Variance Explained		Variance		Variance Explained		Variance		Variance Explained	
Person	.10		91.22%		.10		91.07%		.10		91.18%		.10		91.07%	
Word	1.58		44.99%		1.36		51.50%		1.43		50.08%		1.44		49.88%	

Note. Each of the predictors and respective estimates represent the results from predicting probability of word spelling accuracy from all variables simultaneously (i.e., in the presence of all other word- and person-level predictors in the model). Est. = parameter estimate; *SE* = standard error; SfV = set for variability; PDE = phonemic decoding efficiency; OS = orthographic similarity; PS = phonological similarity; Morphemes = number of morphemes.
[a]Person-by-word factors include item-specific performance and interactions of person- and word-level variables; [b]Person factors represent aggregate performance by the individual on the measure, except for bilingual status, which is coded as 0 for monolingual, 1 for bilingual. [c]Word factors represent fixed characteristics of each specific word on the dependent spelling measure.

Table 5. Fixed effects predicting bilinguals' probability of correct word spelling responses on dependent spelling task.

	Prompting model ($n = 76$)				OS Prompting model ($n = 76$)				PS Prompting model ($n = 76$)				Spanish Reading model ($n = 76$)			
Fixed effects	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*	Est.	*SE*	*z*	*p*
Intercept	**−.95**	**.32**	**−2.97**	**<.01**	**−.95**	**.42**	**−2.26**	**.02**	**−.82**	**.37**	**−2.20**	**.03**	**−.92**	**.32**	**−2.89**	**<.01**
Person-by-word factors[a]																
SfV (Item-Level)	**.49**	**.13**	**3.72**	**<.001**	**.49**	**.13**	**3.72**	**<.01**	**.49**	**.13**	**3.71**	**<.001**	**.49**	**.13**	**3.68**	**<.001**
English Familiarity	**1.00**	**.15**	**6.49**	**<.001**	**.99**	**.15**	**6.48**	**<.001**	**.99**	**.15**	**6.47**	**<.001**	**.10**	**.15**	**6.50**	**<.001**
Person factors[b]																
Prompting	−.11	.12	−.88	.38	−.11	.12	−.88	.38	−.11	.12	−.88	.38	−.17	.12	−1.37	.17
Spelling	**.17**	**.02**	**6.78**	**<.001**	**.17**	**.02**	**6.78**	**<.001**	**.17**	**.02**	**6.78**	**<.001**	**.16**	**.02**	**6.89**	**<.001**
Oral Vocabulary	.02	.02	1.26	.21	.02	.02	1.26	.21	.02	.02	1.27	.21	.03	.02	1.88	.06
Decoding (PDE)	.01	.01	1.75	.08	.01	.01	1.75	.08	.01	.01	1.75	.08	.01	.01	1.76	.18
English Familiarity	−.03	.02	−1.60	.11	−.03	.02	−1.60	.11	−.03	.02	−1.60	.11	−.03	.02	−1.65	.10
SfV (Total)	**.07**	**.02**	**3.21**	**<.01**	**.07**	**.02**	**3.21**	**<.01**	**.07**	**.02**	**3.22**	**<.01**	**.06**	**.02**	**2.66**	**.01**
Spanish Reading	–	–	–	–	–	–	–	–	–	–	–	–	**.03**	**.01**	**2.49**	**.01**
Word factors[c]																
Cognate	**.87**	**.39**	**2.24**	**.02**	–	–	–	–	–	–	–	–	**.87**	**.39**	**2.23**	**.03**
Length	−.08	.12	−0.68	.50	−.08	.13	−.65	.51	−.10	.13	−.75	.46	−.08	.12	−.67	.50
Log HAL Frequency	**.85**	**.19**	**4.56**	**<.001**	**.83**	**.19**	**4.30**	**<.001**	**.88**	**.19**	**4.53**	**<.001**	**.85**	**.19**	**4.55**	**<.001**
Morphemes	−.05	.25	−0.19	.85	−.09	.26	−.35	.72	−.12	.26	−.44	.66	−.05	.25	−.19	.85
OS	–	–	–	–	.81	.57	1.41	.16	–	–	–	–	–	–	–	–
PS	–	–	–	–	–	–	–	–	1.87	1.49	1.26	.21	–	–	–	–
Intercepts	Variance		Variance Explained		Variance		Variance Explained		Variance		Variance Explained		Variance		Variance Explained	
Person	.10		91.53%		.10		91.42%		.10		91.53%		.07		93.44%	
Word	1.30		55.63%		1.41		52.08%		1.43		51.51%		1.31		55.46%	

Note. Each of the predictors and respective estimates represent the results from predicting probability of word spelling accuracy from all variables simultaneously (i.e., in the presence of all other word- and person-level predictors in the model). Est. = parameter estimate; *SE* = standard error; SfV = set for variability; PDE = phonemic decoding efficiency; OS = orthographic similarity; PS = phonological similarity; Morphemes = number of morphemes.
[a]Person-by-word factors include item-specific performance and interactions of person- and word-level variables; [b]Person factors represent aggregate performance by the individual on the measure, except for bilingual status, which is coded as 0 for monolingual, 1 for bilingual. [c]Word factors represent fixed characteristics of each specific word on the dependent spelling measure.

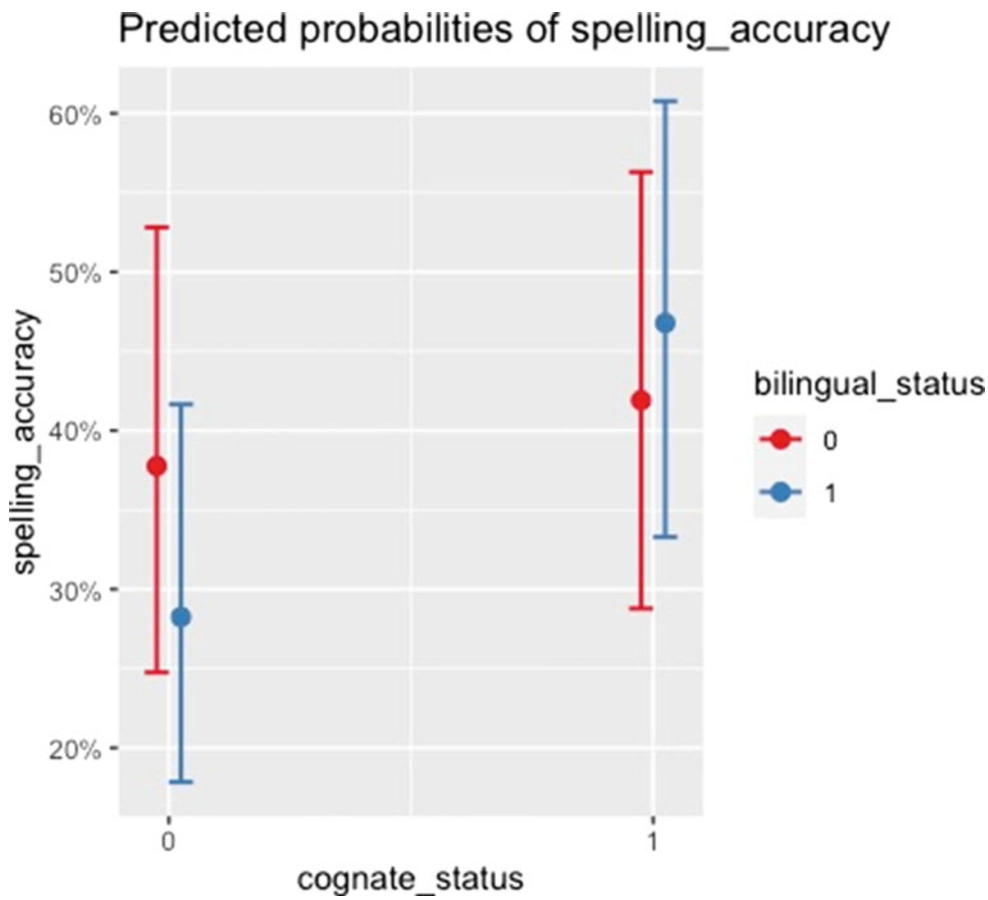

Fig. 1. Interaction of bilingual status and cognate status in dependent spelling task.
Note. Error bars represent 95% confidence intervals.
On the x-axis, 0 = non-cognate, 1 = cognate. In the legend, 0 = monolingual, 1 = bilingual.

with persons and words for all participants ($N = 118$). Probabilities were calculated based on logit estimates from each respective model. The unconditional model intercept indicated that the average probability of a correct response across words and participants on the target spelling task was .64. Variance estimates at the person-level (1.12) and word-level (2.87) suggested that there was significant variance to be explained at both levels in subsequent models.

Main effects models

All person- and word-level predictors were entered into the models simultaneously to predict item-level spelling performance (see Table 4). Across all words, controlling for person-level variables (bilingual status and total scores for English spelling, vocabulary, decoding, familiarity, set for variability [SfV]) and word-level variables (cognate status, frequency, length, number of morphemes), bilinguals and monolinguals did not differ in the likelihood of correctly spelling a word. At the person level, significant contributions from total SfV, standardized English spelling, and English decoding indicated that participants had a higher likelihood of spelling accuracy if they were generally better at being flexible with phonological representations of English words, English spelling, and English decoding. At the word level, only frequency significantly predicted item-level spelling accuracy, indicating that higher frequency words were more likely to be spelled correctly, regardless of length, number of morphemes, or cognate status.

An additional set of models estimated the contribution of each predictor alone in predicting the probability of correct spelling (see supplemental Table S1). In the presence of no other predictors in each respective model, all person-level variables significantly predicted item-level spelling accuracy ($p < .001$), except for bilingual status and Spanish familiarity, indicating that in isolation, neither of these factors significantly accounted for variance in participants' spelling accuracy. At the word level, only frequency significantly predicted item-level spelling accuracy.

Main interaction model

The main interaction model was run with the full sample ($N = 118$) to investigate the specific relationship between the participant's bilingual status and a word's cognate status (i.e., the bilingual by cognate interaction term) in predicting item-level spelling performance, while controlling for other item-specific, person-level, and word-level variables (see Table 4). The significant crossover interaction (see Figure 1) indicates that bilinguals had a significantly higher probability of correctly spelling cognates compared to non-cognates. Analysis of the simple slopes in the main interaction model revealed that across groups, however, bilinguals did not significantly differ from monolinguals in likelihood of spelling cognates accurately, which does not support our first hypothesis that bilinguals would outperform monolinguals in cognate spelling accuracy. The interaction also shows that monolinguals had a significantly higher probability of correctly spelling non-cognates compared to bilinguals, suggesting that the significant (negative) main effect of bilingual status on spelling accuracy in this model may have been driven by significant group differences in non-cognate spelling. This model accounted for 91.07% of person-level variance and 51.50% of word-level variance in spelling accuracy. To probe the likelihood of identical cognates driving this cognate effect in bilingual spelling, we ran a separate model with 7 identical cognates excluded, leaving only 19 non-cognates and 14 non-identical cognates. Interaction results ($\gamma = .49$, $z = 2.72$, $p = .01$) replicated the significant cognate status by bilingual status interaction effect reported for the whole sample of 40 words, with bilinguals exhibiting a higher likelihood of accurate non-identical cognate spelling compared to non-cognates and monolinguals showing a smaller difference in likelihood of correct spelling between non-identical cognates and non-cognates.

As expected, the significant effects of English standardized spelling and decoding indicated that participants with higher English spelling and decoding performance had a slightly higher probability of accurate spelling across words on the target spelling task. Interestingly, SfV performance significantly predicted item-level spelling accuracy at both the person and item levels, indicating that a) participants with generally more flexible phonological representations of English target spelling words had a higher probability of accurately spelling each target word and b) an individual who correctly identified and pronounced a specific target word after hearing its mispronunciation had a probability of .51 of accurately spelling that word (compared to a .24 probability of spelling accuracy for those who did not provide a correct response to the word's mispronunciation in the SfV task). Also at the item level, a participant's familiarity with a target spelling word in English was a strong predictor of accurately spelling that particular word (.58 for those familiar with the word, .19 for those unfamiliar with the word) in contrast to the insignificant contributions of total scores on English familiarity and oral vocabulary to item-level spelling accuracy. The only significant word-level predictor was frequency, similar to the main effects model.

Exploratory interaction models

To further explore the crossover interaction between bilingual status and cognate status, two separate models replaced the dichotomous cognate variable with orthographic similarity (OS) and phonological similarity (PS) as alternative continuous "cognateness" measures (see Table 4). In their respective models, and consistent with the previous interaction model, neither OS nor PS uniquely accounted for any significant variance in item-level spelling accuracy when competing with other item-specific, person-level, and word-level predictors. For bilinguals, the significant interactions in both exploratory interaction models show a trend towards higher OS and PS being associated with a higher probability of accurate word spelling. However, analysis of the simple slopes in each model confirmed that neither monolinguals' nor bilinguals' likelihood of spelling accuracy was significantly impacted by OS or PS. Considerations for future cognate stimuli selection representing a wider range of OS and PS are offered in the Discussion.

Prompting models

Next, an unconditional model was conducted including only bilingual participants ($n = 76$), showing that the average probability of a correct response across words and bilinguals on the target spelling task was .62, with variance estimates of 1.14 at the person level and 2.94 at the word level (similar to estimates reported in the unconditional model with the full sample). To explore the role of prompting in bilingual spelling accuracy, a model of only bilingual participants included similar item-specific, person-level, and word-level predictors from the main interaction model, with bilingual status replaced by prompting (see Table 5). As hypothesized, there was no significant effect of prompting indicating that there was no difference in the likelihood of spelling accuracy between bilingual participants who were prompted to think of the words in Spanish before attempting to spell in English and unprompted bilinguals. Notably, English decoding was a significant person-level predictor in the main interaction model, but not significant in the prompting model when only bilinguals were included. In contrast to the previous models, cognate status significantly predicted bilinguals' item-level spelling accuracy in the prompting model. Significant contributions of all other item-specific, person-level, and word-level predictors to item-level spelling accuracy were similar between the main interaction and prompting models. Similar to the exploratory results reported for the full sample, when cognate status was replaced with OS or PS as a continuous word-level predictor in the prompting model, very little additional word-level variance was accounted for in bilinguals' spelling accuracy (see Table 5). Another exploratory analysis revealed that performance on Spanish word reading, among other item-specific, person-level, and word-level predictors, did significantly predict bilinguals' likelihood of spelling accuracy, indicating that higher performance on Spanish word reading was predictive of higher spelling accuracy.

Discussion

With a growing interest in bilingual populations and a lack of understanding regarding the different word- and person-level features that can contribute to adult spelling accuracy, this study aimed to explore the unique effects of cognates and bilingualism in complex English word spelling performance. The primary analysis included an interaction of bilingual status and cognate status predicting item-level complex word spelling. Bilingual status, along with total scores on English standardized spelling, decoding, vocabulary, familiarity, and set for variability (SfV) were included as predictors to represent general person-level English language skills. Cognate status, word length, frequency, and number of morphemes were included as predictors to represent word features that may influence a participant's ability to correctly spell each target word in English. Participants' item-specific familiarity and SfV of the spelling words were also included as predictors. Together, these predictors were included in the models to create a layered interpretation that captures the roles of general person skills (person-level), fixed word characteristics (word-level), item-specific performance, and person-by-word interactions in accurate word spelling.

As predicted by the lexical quality hypothesis (Perfetti & Hart, 2002), item-specific English familiarity significantly predicted word spelling accuracy across participants and words in all interaction models. Given that the less frequent target words would be less likely to be heard or practiced in an undergraduate student's oral vocabulary range, the variance that general oral vocabulary may normally account for in spelling accuracy (Ocal & Ehri, 2017) may have been absorbed by the familiarity measure that includes the 40 spelling words as individual items, making familiarity closer in proximity and more highly correlated at .54 ($p < .001$) to total target spelling scores than the general oral vocabulary task, which was moderately correlated with total spelling at .34 ($p < .001$). Also supporting the lexical quality hypothesis is a consistently significant contribution from general SfV (i.e., total number of dependent spelling words correctly recognized from their decoded pronunciation) and item-specific SfV (i.e., ability to correctly recognize a specific word from its decoded pronunciation) to spelling accuracy in all interaction models. This finding aligns with Perfetti and Hart's (2001) assumption that formation of a high-quality representation relies on storing redundant phonological representations, including at least one that is recoverable from regular orthographic-to-phonological mappings (see Edwards, Steacy, Siegelman, Rigobon, Kearns, Rueckl & Compton, 2022; Elbro, 1998; Elbro & Jensen, 2005; Goswami, 2000). For the whole sample, the SfV contributions can be interpreted as a more highly skilled speller having a higher quality orthographic representation of a given familiar spelling word that allows for recognition of that word's decoded pronunciation heard in the SfV task (i.e., a second plausible pronunciation based on orthographic-to-phonological mappings), likely as a result of an item-specific encounter (i.e., having successfully decoded the specific word before) given the low frequency of the spelling words tested in this sample. If SfV can be understood as a measure of redundancy for a specific lexical representation (see Rigobon, Gutierrez, Edwards, Marencin, Borkenhagen, Steacy & Compton, under review) and accurate English spelling relies heavily on high-quality lexical entries that are only influenced by highly constrained sources within the lexicon (Perfetti & Hart, 2001), it still remains unclear how available sources of phonological redundancy in the bilingual lexicon may be influenced by phonological and orthographic representations in both languages of proficiency. In other words, the relationship between performance on SfV and spelling, while not significantly different between prompted bilingual, unprompted bilingual, and monolingual groups in this sample, may be influenced by a different set of highly constrained sources in the bilingual lexicon (e.g., a word's decoded pronunciation in English, direct translation in Spanish, and cross-linguistic orthographic and phonological neighbors) from the sources of phonological redundancy available in the monolingual lexicon.

Based on the main interaction model's results, the primary hypothesis was not supported: bilingual participants did *not* show a significantly higher probability of spelling cognate words correctly compared to their monolingual peers. Bilinguals and monolinguals did, however, differ significantly on non-cognate spelling, with monolinguals outperforming bilinguals (i.e., a crossover interaction). Importantly, this finding was still supported even with English standardized spelling and familiarity (item-specific and person-level) in the model, suggesting that broader English spelling skills and familiarity with these specific items cannot account for all unique variance in the likelihood of target word spelling. Bilinguals did, however, show significantly higher spelling performance on cognates compared to non-cognates, supporting prior findings of cognate facilitation effects among bilingual adults (Comesaña et al., 2015; Dijkstra et al., 2010; Hoshino & Kroll, 2008; Muscalu & Smiley, 2019; Valente et al., 2018). This result presents initial evidence of a cognate facilitation effect on a task of English spelling that does not include the additional demand of direct translation. Given the importance of precise position coding and sublexical mappings in accurate spelling (Perfetti, 1997), the BIA+ model (Dijkstra et al., 2010; Dijkstra & Van Heuven, 2002; Lam & Dijkstra, 2010) of visual word recognition is best suited to account for the cross-linguistic activation of lexical and sublexical units that boosted bilinguals' likelihood of cognate spelling accuracy above non-cognate spelling accuracy.

The finding of facilitative cross-linguistic activation in bilinguals' spelling reported in the main interaction model (and a separate model excluding identical cognates) differs from Muscalu and Smiley's (2019) findings of sublexical cognate inhibition in typewritten word translation, demonstrating that sublexical activation from orthographically identical and non-identical cognates is not always inhibitory in cognate processing. The significant two-way interactions of bilingual status by OS and bilingual status by PS in the exploratory models also suggest that bilinguals' likelihood of spelling is potentially positively associated with increasing OS and PS, although neither OS nor PS significantly impacted bilinguals' spelling accuracy in the model. This positive trend and lack of a significant inhibition effect in spelling orthographically non-identical cognates is incongruent with Muylle et al.'s (2022) finding of sublexical interference for processing cognates with less cross-linguistic overlap. Relatedly, the significant interaction between PS and bilingual status showed that bilinguals and monolinguals had a similar likelihood of correctly spelling cognates with lower PS, indicating little to no cognate facilitation in bilinguals' spelling of more phonologically discrepant cognates. Furthermore, the non-significant effect of PS on bilinguals' spelling accuracy suggests that cognate processing was not inhibited by higher phonological discrepancy, differing from reports of low PS inhibiting cognate processing in Comesaña et al. (2012) and Schwartz et al. (2007). While our main interaction results certainly support the small facilitative effect of cross-linguistically activated lexical and sublexical units in bilinguals' cognate processing compared to non-cognates, it is important to note that non-significant differences between monolinguals and bilinguals in OS and PS effects on spelling accuracy may be explained by a limitation in the study's cognate stimuli selection. We intentionally chose cognates for being identical or near-identical (i.e., restricted range of high OS) to answer the first primary research question, but we did not intentionally choose cognates that represent a wide range of PS between Spanish and English (i.e., restricted range of low PS), and values of OS and PS between the 40 spelling words' translation equivalents were only calculated for post-hoc exploratory interaction models. In future investigations, authors should determine whether the findings reported here generalize to other samples of words and participants when cognate stimuli have been selected more systematically to represent wider ranges of both OS and PS between translation equivalents.

From the main interaction model, we acknowledge that the differences between monolingual and bilingual non-cognate spelling performance are likely responsible for group differences in overall spelling accuracy, rather than our hypothesis that bilinguals' significantly higher cognate spelling accuracy would drive these differences. The finding of bilinguals' significantly lower likelihood of correctly spelling non-cognates compared to monolingual peers can be interpreted in at least two different ways. First, it is assumed that monolinguals encounter words in English nearly twice as frequently as bilinguals, who divide

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their language usage between Spanish and English – see Gollan et al.'s weaker-links hypothesis (Gollan, Montoya & Werner, 2002; Gollan, Montoya, Fennema-Notestine & Morris, 2005; Gollan, Montoya, Cera & Sandoval, 2008). Therefore, bilinguals' lower non-cognate spelling performance compared to monolinguals is consistent with findings of slower lexical retrieval (see Cop, Keuleers, Drieghe & Duyck, 2015; Diependaele, Lemhöfer & Brysbaert, 2013). Similarly, it is possible that following simultaneous activation of phonological representations in Spanish and English for non-cognates, more distinct orthographic neighbors from both the non-target language (Spanish) and target language (English) were activated. Consequently, bilinguals could have experienced inhibition in recalling the most precise orthographic representation that maps onto the word they heard, while monolinguals' probability of accurate non-cognate spelling benefitted from a smaller pool of activated orthographic neighbors. This explanation supports prior evidence of inhibition effects from non-target language orthographic neighbors (Meade, Midgley, Dijkstra & Holcomb, 2018; Van Heuven, Dijkstra & Grainger, 1998). Another consideration stems from evidence of non-target language frequency effects in bilingual adults' cognate processing during a lexical decision task (Peeters, Dijkstra & Grainger, 2013). Using log frequency values of the spelling words' Spanish translations equivalents from Alonso, Fernandez and Díez's (2011) Spanish oral frequency norms, a set of post-hoc item-level analyses revealed non-significant effects of Spanish frequency as a single and competing predictor of English target word spelling accuracy (see supplemental Table S2). Given the non-significant contributions, we do not believe that lower frequency values of the non-cognates' Spanish translation equivalents are responsible for bilinguals' lower non-cognate spelling accuracy.

Our second hypothesis, that there were no significant effects of prompting bilinguals to think of the target English words in Spanish prior to spelling them, was supported in the bilingual only prompting models. Because spelling is such an effortful task (Bosman & Van Orden, 1997) that requires the most precise information about individual letters and their order, it is possible that after the automatic co-activation of cross-linguistic phonological representations, bilinguals in both prompted and unprompted groups began CONSCIOUSLY recruiting sublexical units in Spanish to aid with English spelling in an untimed task, regardless of whether they were prompted to consider the structural similarities between Spanish and English orthographic forms. Following the lexical quality hypothesis (Perfetti & Hart, 2002), actively reflecting on multiple phonological representations of a given word (e.g., regularized English pronunciation, Spanish pronunciation) can be helpful for recalling the orthographic units that make up a word as precisely and accurately as possible, particularly in the case of a word for which a high-quality orthographic representation is absent. This conscious level of processing also aligns with the contrastive analysis perspective's assumption that conscious cognate recognition facilitates recall of L2 lexical representations and the BIA+ model's distinction of a task system that requires active attention from an automatic identification system immediately following visual input (Dijkstra & Rekké, 2010).

Importantly, the operationalized definition of "bilingual" varies across experimental studies, as well as the implications of different cut points and identification criteria. In this study, bilingual students were self-identified and then "confirmed" as bilingual by meeting a preset minimum score on the Woodcock-Muñoz Language Survey III Spanish word-identification task (Woodcock et al., 2017). The exploratory finding of Spanish reading skill significantly predicting likelihood of accurate English spelling suggests that, in general, having high-quality lexical representations in Spanish is beneficial for recalling and producing lexical representations in English. Alternatively, given that the word-identification task is not timed, bilinguals who reached the more difficult and unfamiliar items could have relied on slower, more effortful decoding skills to read the words correctly. Therefore, it can be argued that the Spanish word reading measure may be capturing bilinguals' knowledge of Spanish orthography-phonology connections instead of their general Spanish reading ability, supporting the role that sublexical units of activated Spanish representations may have played in facilitating cognate spelling among bilinguals. Together, the information gained from the Spanish reading task and the demographics survey question about language dominance partly justifies our decision to omit Spanish spelling assessment from the testing battery, which would have been an exceedingly difficult task for our sample of primarily English-dominant heritage Spanish speakers given their lack of formal instruction in Spanish reading and writing skills and low exposure to Spanish orthographic code (i.e., high likelihood of floor effects on Spanish spelling). Additionally, bilinguals on average reported familiarity with approximately one third of the spelling words' Spanish translation equivalents (see Table 2), suggesting that they had some existing phonological representations in Spanish that could aid English spelling. However, we acknowledge that in addition to familiarity and reading skill, measuring Spanish spelling ability in a sample of bilinguals who report exposure to formal Spanish literacy instruction would be valuable for analyzing predictive effects of their Spanish orthographic knowledge in English spelling. Lastly, it is also worth noting that no test of lexical decision or written proficiency in English or Spanish was administered. Lexical decision measures like the online LEXTALE (Lemhöfer & Broersma, 2012) could shed light on speed of language-specific word processing, while measures of written skills like the Woodcock-Muñoz Tests of Written Language Expression (Muñoz-Sandoval, Woodcock, McGrew, Mather & Ardoino, 2009) can offer a more holistic understanding of reading- and spelling-related skills in each language of proficiency.

Conclusion & future directions

This study explored item-specific, person-level, and word-level variables in the context of adult spelling to demonstrate how bilingual L1 experience with a shallow orthography (i.e., Spanish) may facilitate L2 complex word spelling in a deep orthography (i.e., English) through the activations of cross-linguistic sublexical information. Given the multiple gaps in educational, linguistics, and psychological research literature regarding factors that contribute to adult bilinguals' spelling performance on difficult, unfamiliar words, and more specifically, cognates, this study demonstrated that bilingual adults do show a higher probability of spelling cognate words correctly compared to non-cognate words, a finding that only begins to address the "fuzziness of the phonological system" (Dijkstra, Wahl, Buytenhuijs, Van Halem, Al-Jibouri, De Korte & Rekké, 2019, p. 709) among bilingual speakers with limited L1 literacy. While results suggest cross-linguistic sublexical facilitation from Spanish to the spelling of complex English words in bilingual participants, the evidence does not support a significantly higher

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probability of bilinguals correctly spelling cognates compared to monolinguals. We look forward to asking more nuanced questions about other person-level features, such as age and context of language acquisition, and adding measures of written and oral fluency to create a more holistic definition of bilingual proficiency in future investigations while continuing to use item-response based crossed random-effects models for capturing individual differences across heterogeneous profiles of language proficiency (Van Hell & Tanner, 2012).

This study also supported the notion that adult bilinguals do not rely on explicit prompting to draw on phonological and orthographic representations from both Spanish and English, a finding that supports the BIA+ model's assumption that auditory word recognition follows a similar flow of activation as visual word recognition (Dijkstra & Van Heuven, 2002) in the context of effortful word spelling. Ultimately, this study demonstrated how bilingual university students with proficiency in both Spanish and English could benefit from cross-linguistic co-activation when tasked with spelling English cognate words that are typically difficult to spell accurately. There is a cognate facilitation effect within bilingual spelling performance that exists under very specific conditions, and the findings reported here encourage further investigation of the person-, task-, and word-level factors that influence cognate processing in bilingual individuals.

Supplementary Material. For supplementary material accompanying this paper, visit https://doi.org/10.1017/S1366728923000093.

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Appendix

MATERIALS						
	Dependent Spelling Words (*N* = 40)				Cross-Linguistic Similarity*	
	English	*Phonetic Transcription*	*Spanish*	*Phonetic Transcription*	*Orthographic*	*Phonological*
Cognates (*n* = 22)	ambidextrous	ˌæ̃mbəˈdɛkstɹəs	ambidextro	ambi'ðekst̪ɾo	0.83	0.43
	commendable	kəˈmendəbl̩	recomendable	rekomenˈdable	0.75	0.46
	dimensional	dəˈmɛnːʃənəl̩	dimensional	ðimensio'naːl	1.00	0.27
	dogmatic	dɑgˈmæɾɪk	dogmático	ðɔg'mat̪iko	0.89	0.22
	enigmatic	ˌɛnɪgˈmæɾɪk	enigmático	eniɣ'mat̪iko	0.90	0.40
	facilitate	fəˈsɪləte͡ɪt	facilitar	faːsili't̪aɾ	0.80	0.27
	grandiose	ˈgɹæ̃ndio͡ʊːs	grandioso	gɾan'd̪ijoso	0.89	0.31
	inseparable	ɪnˈsɛpɚəbəl̩	inseparable	iːnsepaˈɾaβle	1.00	0.33
	irrefutable	ˌɪ͡ɚəˈfjuːtəbəl̩	irrefutable	irefu'taːβle	1.00	0.29
	macabre	məˈkɑːb	macabro	mã'kaβɾo	0.86	0.29
	malign	məˈla͡ɪn	maligno	ma'liɣno	0.86	0.29
	manifestation	mænɪfɛˈsteɪʃən	manifestación	manifest̪aˈsijoːn	0.92	0.23
	nausea	ˈnɔːsʒə	náusea	'na͡ʊsea	1.00	0.14
	neutralize	ˈnuːtɹəla͡ɪz	neutralizar	neutɾali'saɾ	0.82	0.25
	ostracism	ˈɑstɹəsɪːzəm	ostracismo	ostɾa'sismo	0.90	0.33
	panacea	ˌpæ̃nəˈsɪə	panacea	pana'seːa	1.00	0.25
	primordial	pɹɪˈmɔ͡ɚdiəl	primordial	pɾimoɾ'ðijaːl	1.00	0.25
	promulgate	ˈpɹɒməlge͡ɪt	promulgar	pɾomul'ɣaɾ	0.80	0.33
	reprisals	ɹɪˈpɹa͡ɪzəlz	represalias	repɾe'salijas	0.73	0.15
	sterilization	ˌstɛ͡ɛɹələˈze͡ɪʃɪn	esterilización	est̪eɾilisaˈsijoːn	0.84	0.19
	superficial	ˌsuːpɚˈfɪʃəl	superficial	supeɾfi'sijaːl	1.00	0.31
	tumultuous	təˈmʌltʃʊəs	tumulto	tu'mulːto	0.70	0.33
Non-Cognates (*n* = 18)	admittedly	ædˈmɪɾɪdli	ciertamente	ˌsjieɾt̪a'ment̪e	0.18	0.08
	behemoth	bəˈhiːmɪθ	gigante	xiː'gant̪e	0.12	0.00
	blithely	ˈblaɪðli	alegremente	aˌlegɾe'ment̪e	0.18	0.09
	chartreuse	ʃɑ͡ɚˈt̪ɹuːs	cartujo	kaɾ'tuxo	0.50	0.20
	discouraging	dɪsˈkɝədʒɪŋ	desalentador	ðeːsalent̪a'ðoːɾ	0.17	0.07
	ensconced	ɛnˈskɑnst	acomodado	akomo'ðaðo	0.11	0.00
	equivocal	əˈkwɪvəkl̩	ambiguo	am'biːɣwo	0.11	0.00
	forgiveness	fɚˈgɪvnɪs	perdón	peɾ'ðoːn	0.18	0.00
	hierarchical	ˌhɑ͡ɪɚˈɑ͡ɚkəkl̩	jerárquico	xeˈɾaɾkiko	0.50	0.15
	landowners	ˈlæ̃ndo͡ʊnɚz	terratenientes	terat̪e'njieːnt̪es	0.21	0.13
	marauders	məˈɹɔːdɚz	sakeadores	sakea'ðoɾes	0.36	0.00
	nostrils	ˈnɑstɹɪlz	fosas	fosas	0.37	0.11
	overwhelmed	ˌovɚwɛːlmd	abrumada	aβɾu'maːðo	0.18	0.00
	plunge	plʌndʒ	inmersión	immeɾ'sijoːn	0.00	0.00
	rambunctious	ɹæ̃mˈbʌŋkʃəs	bullicioso	buʝi'sijoːso	0.25	0.00
	reimbursement	ˌɹiɪmˈbɝsmɪnt	reembolso	reem'boːlso	0.38	0.17
	remembrance	ɹəˈmembɹɪnts	recuerdo	re'kweɾðo	0.27	0.08
	umbrage	ˈʌmbɹɪdʒ	ofensa	o'fensa̧	0.00	0.00

Note. All participants were presented with an audio recording of the target English spelling words in randomized order for the English familiarity and target spelling tasks, as well as in their decoded (i.e., regularized) forms for the set for variability task. All participants were also presented with an audio recording list of the original Spanish cognate words in randomized order for the Spanish familiarity task.

*Values for both orthographic and phonological similarity were reverse coded from Normalized Damerau-Levenshtein Distance (NDLD) to represent similarity values with higher values indicating higher similarity rather than distance. NDLD values were calculated based on the minimum number of operations required to transform the Spanish character string into the English character string. Accented letters in Spanish were not treated as different characters in calculating the orthographic NDLD values, and a transposition (i.e., two letters appearing consecutively but in different letter positions between translation equivalents) is calculated as only one operation rather than two (unlike Normalized Levenshtein Distance [NLD] values that consider a transposition to be two operations and result in slightly larger distance values, such as those provided by Guasch et al.'s 2013 NIM software). Phonological NDLD values were calculated by first converting IPA transcriptions to SAMPA, including recoding of consonant phonemes that were originally represented with 2 characters to only be represented by 1 character in the SAMPA transcription.