Effects of orthography and cognate status on second language Spanish lexical encoding

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Abstract

This study examined the accuracy of English-speaking learners of Spanish in storing L2 sounds within cognates and noncognates, specifically in words containing <g> and <h>, which have differing cross-linguistic phoneme-grapheme correspondences. In the first task, participants heard Spanish words with target-like pronunciations of <g> and <h> or inaccurate pronunciations with an English-like phonemic substitution for these graphemes, and they decided whether or not they were words. The second task had participants decide between the two pronunciations of each Spanish word and select the accurate pronunciation. The findings in both tasks showed that for L2 learners, <h> cognate words had less accurate phonological representations compared to all other conditions, possibly due to the greater consistency in phoneme-grapheme correspondence for <h> in English. These results show that cognate status and orthographic (in)congruity interact to influence the accuracy of L2 lexical encoding.

Keywords: lexical encoding, cognates, orthography, Spanish, lexical decision

1. Introduction

Remembering how words sound in a second language (L2) can be an arduous task for students, especially in the presence of sounds which are not native to the learner's first language (L1). Research on the perception and production of these foreign sounds indicates that this difficulty likely stems from "fuzzy" encoding into the mental lexicon, in that the sounds within words are not specified precisely in long-term memory (e.g., Amengual, 2015; Barrios & Hayes-Harb, 2021; Darcy, Daidone, & Kojima, 2013). This is often due to the fact that sounds themselves are not perceived accurately, but research has indicated that this imprecision can emerge with L2 sounds that are not considered difficult to perceive and/or produce (Gor, Cook, Bordag, Chrabaszcz, & Opitz, 2021). Cognates – words in two languages that have similar orthographic and/or phonological forms and similar semantics – have also been shown to contribute to fuzziness by increasing L1 influence compared to noncognates (e.g., Amengual, 2012; Schepens, Dijkstra, Grootjen, & Van Heuven, 2013). With cognates between Spanish and English in particular, there tends to be high orthographic overlap and high phonological overlap. However, while these languages share many phonemes and use of the Latin alphabet, there are still deviations in phoneme-grapheme correspondences that may cause confusion for L2 speakers (Rafat, 2016). In this study we investigate whether orthography and cognate status contribute to the acceptance of non-target-like forms of Spanish words by American English-speaking learners. Specifically, there may be confusion arising in cognates with high orthographic overlap but phoneme-grapheme correspondences that differ across the languages, even with sounds that are not perceptually difficult for learners.

2. Literature Review

The mental lexicon contains representations of words in three forms: the phonological, the orthographic, and the semantic (see Ramus, Peperkamp, Christophe, Jacquemot, Kouider, & Dupoux, 2010, for an in-depth description). These three components are all readily accessible and highly specified for literate speakers since all three forms need to be known in order to recognize and/or articulate a given word. However, the average language learner often has considerable difficulties in discriminating and memorizing phonemes not found in their native language, which can affect their representations of words. Thus, L2 learners can exhibit faulty lexical encoding, primarily by way of fuzzy or non-target-like phonological representations in the L2 mental lexicon. These imprecise or inaccurate phonological representations of words can lead to inefficient lexical processing, such as added lexical competition due to confusable phonemes, stronger activation of illegitimate competitors, and difficulty inhibiting competitors, as well as confusion between words in recognition and production (e.g., Barrios & Hayes-Harb, 2021; Bassetti, 2017; Broersma & Cutler, 2011; Cook, Pandža, Lancaster, & Gor, 2016; Gor et al., 2021; Pallier, Colomé, & Sebastián-Gallé, 2001).

Pallier et al. (2001) observed that Spanish-dominant speakers of Catalan, whose first language was Spanish, were primed by hearing /ɛ/-/e/ minimal pairs such as *néta* [netə] "granddaughter" and *neta* [nɛtə] "clean" as if they were a repetition of the same word, unlike Catalan-dominant native speakers of Catalan who did not show this effect. The authors interpret the results from the Spanish-dominant bilinguals as their possible non-target-like storage of /ɛ/ and /e/ minimal pairs as homophones. Similarly, L1 Dutch learners of English in Broersma and Cutler (2011) struggled to inhibit the competing sounds of /ɛ/ and /æ/, since the latter is not found in Dutch. When hearing a word like *daffodil* /dæfədɪl/, the participants showed evidence of strongly activating a competing [ɛ] word such as *deaf* [dɛf] in place of the first syllable. The tendency to favor L2 phonological categories with L1 equivalents like /ɛ/ over novel L2 sounds like /æ/ speaks to the fact that L2 lexical encoding can be asymmetrical. The L2 category that is phonetically closest to the L1, i.e., the dominant category, may be encoded more accurately or stored in place of the L2 category that is more phonetically distant, i.e., the non-dominant category (e.g., Darcy, Daidone, & Kojima, 2013). In other words, encoding L2 phonemes in words may not be equally difficult for all L2 sounds; specifically, those L2 sounds without close L1 equivalents may be stored less accurately.

As Barrios and Hayes-Harb (2021) show, these asymmetries in the L2 mental lexicon and the source of fuzziness also differ by L1. In their study, the researchers tested the accuracy in lexical encoding of two different L2 English contrasts by Korean and Mandarin native speakers, in particular, /æ/-/ɛ/ and /l/-/ɹ/. The findings indicated that, while both groups were highly accurate with the words containing /æ/-/ɛ/, they were less accurate at rejecting /æ/-/ɛ/ nonwords, especially the nonwords containing /ɛ/. In contrast, the findings for /l/-/ɹ/ differed by group. For the Mandarin natives, there seemed to be difficulty at the perceptual coding level, such that their prelexical, phonetic representation was not target-like. Meanwhile, the Korean natives seemed to have difficulty at the lexical coding level, meaning that they likely had errors in how they stored these L2 sounds in words. These results show that errors can be found either in the process of perception or in the representations stored in the mental lexicon, both resulting in difficulty when recognizing or recalling L2 words.

The previous examples all pertain to the learning of nonnative contrasts that are perceptually difficult, often resulting in non-target-like phonological representations. However, Gor et al. (2021) state that faulty lexical encoding of any lexical level (semantic, orthographic, phonological) can have consequences on lexical storage and retrieval. Therefore, another important aspect in the acquisition of words in an L2 is the relationship between orthography and the phonological categories of an L1. Specifically, the use of orthography can be a source of confusion for the learner if the graphemes are similar between languages yet represent different phonemes across languages.

Bassetti, Masterson, Cerni, and Mairano (2021) demonstrated how differences in phoneme-grapheme correspondence could affect the accuracy of phonological representations in a study with L1 Italian learners of English in Italy and Italian-English sequential bilinguals in England. Their experiments looked at the auditory perception of homophones containing either a consonant or vowel that is spelled with one or two letters in English, such as *finish* vs. *Finnish* and *morning* vs. *mourning*. When audio stimuli were accompanied by visual information such as a Finnish flag, both the bilingual and learner groups misperceived the homophones as having different sounds. The researchers deduced that these L1 Italian learners and bilinguals recode the L2 written forms according to their L1 grapheme-phoneme correspondences, thus resulting in perceptual illusions of differences in length in the L2 speech.

Another example of this phenomenon of orthography inducing confusion can be seen in Hayes-Harb, Nicol, and Barker (2010), where researchers examined English monolinguals' auditory perception of pseudowords (e.g., the auditory form [kɑməd]). Participants were divided into three groups: those who were presented orthographic forms consistent with English spelling conventions (e.g., <kamad>), those who were presented orthographic forms inconsistent with English spelling conventions (e.g., <kamand>), and those who were not presented with any orthographic forms. All groups were given associated "meanings" and images to memorize with these pseudowords. The results revealed that the group presented with the incongruent word forms created lexical representations containing /n/, despite the fact that this sound was not in the input. Parallel findings were reported by Showalter (2018), but for an unfamiliar script. In her study, groups of English speakers learned Russian pseudowords through auditory forms and 1) no orthography, 2) Cyrillic forms congruent with L1 orthography (e.g., <KOM>-[kom]), 3) Cyrillic forms incongruent with L1 orthography (e.g., <PAT>-[rɑt]), or 4) completely unfamiliar Cyrillic forms (e.g., <ФИЛ>-[fil]). She found that the participants presented with incongruent orthography were less accurate than the other groups on a word-picture matching task. Both of these studies illustrate that even when learning words that only contain familiar sounds, incongruent phoneme-grapheme correspondences can lead to inaccurate representations.

Rafat (2016) similarly focused on phonological transfer due to orthography. She investigated the effects of a wide variety of grapheme-phoneme correspondences on L1 Canadian English speakers learning new Spanish words. Participants were randomly assigned to one of four between-subjects conditions: 1) no orthographic input in either the training phase or production phase, 2) orthographic input in the training phase only, 3) orthography input in the production phase only, and 4) orthographic input in both the training and production phases. The data showed that the conditions with no orthographic exposure had the least L1-based phonological transfer, followed by the condition with the exposure to written forms exclusively in the production phase. Being presented earlier with the orthography in each condition resulted in non-target-like pronunciation of the Spanish sounds, most prominently when the phoneme-grapheme correspondence had a differing value across languages. The results indicated that incongruent correspondences across Spanish and English, such as <s> vs. <z> and <h> vs. ∅, greatly impacted the accuracy of L2 production.

Melnik and Peperkamp (2019) also examined the <h> vs. ∅ contrast, but with L1 French learners of English, whose tendency is to omit the pronunciation of the letter <h> at the onset of a word due to the <h> being silent in French. Participants completed a lexical decision task by listening to speakers say words and nonwords, with the nonwords being either words originally beginning with /h/ and removing that sound, or words originally beginning with vowels but with an added /h/ at the onset of the word. The participants had more misses on real /h/ words (e.g., *holiday*) and more false alarms on vowel-initial nonwords (e.g., *usband*), meaning that participants accepted these auditory forms as words. This research corroborates the results of Hayes-Harb et al. (2010) and Rafat (2016) that learners can struggle with encoding the presence or absence of a sound when it is represented with a new orthographic convention.

Other research suggests that the presence of orthography may be helpful in establishing more accurate L2 phonological representations, but only under particular conditions. Escudero, Simon, and Mulak (2014) found that a group of L1 Spanish participants who were exposed to Dutch orthographic forms in addition to the auditory forms outperformed an audio-only group on a picture-matching task with Dutch pseudowords, but only for those words where the Dutch graphemes had phoneme correspondences that would lead to a similar L1 phonemic contrast (e.g., Dutch <i>-<u> = /ɪ/-/y/ vs. Spanish <i>-<u> = /i/-/u/). For words with novel phoneme-grapheme correspondences (e.g., Dutch <u>-<uu> = /ʏ/-/y/ vs. Spanish <u> = /u/), the orthography group had less accurate performance than the audio-only group. Simon, Chambless, and Alves (2010) also used a picture-matching task to investigate how well L1 English speakers could learn groups of words contrasting French /u/ and /y/. A group that learned words such as [styg], [stug], and [stig] through sound only performed as well as a group that also had access to orthographic forms (e.g., <stûgue>, <stougue>, <stigue>), indicating that the novel grapheme correspondences provided no benefit in establishing lexical representations containing novel phonemes. Similar results were obtained by Showalter and Hayes-Harb (2015), where the presence of Arabic script did not have any impact on the accuracy of encoding the /k/-/q/ contrast, even when the researchers used arrows to draw learner's attention to the specific graphemes marking the distinction. In general, orthography appears to only be helpful when it aligns with L1 phoneme-grapheme correspondences (cf., Showalter & Hayes-Harb, 2013).

In the process of encoding orthographic and phonological forms, there is an additional phenomenon that can create confusion for L2 learners. This is the occurrence of cognates, which Schepens et al. (2013) define as “translation equivalents with large spelling and/or sound similarities across languages.” The authors give the example of the English-Dutch translation equivalents *wheel* and *wiel*, which have a high spelling and sound overlap. Cognates are more frequent depending on how closely related the languages in question are.

Carrasco-Ortiz, Amengual, and Gries (2021) looked at how bilinguals, one group of English-dominant speakers and another of Spanish-dominant speakers, performed on a visual lexical decision task with written cognates that had differing levels of phonological and orthographic overlap. They found that participants exhibited quicker word recognition of the Spanish words that had greater orthographic similarity to their English cognate counterparts, and vice versa, but phonological similarity led to quicker word recognition for solely Spanish words. Thus, word processing is seen to be modulated by orthographic and phonological overlap in both dominant and non-dominant languages. Also concerning cognates found between English and Spanish, Brown and Harper (2009) investigated the speech of bilinguals and their use of /s/ at the end of a word, occasionally weakened in some dialects of Spanish, in order to test the exemplar model of lexical representation (e.g., Bybee, 2001). The results revealed that speakers exhibited less reduction (i.e., aspiration or deletion) of word-final /s/ in Spanish when the equivalent word in English ended in /s/. These results illustrate that individual segments are susceptible to cognate effects, a finding also supported by Amengual (2012). In this study, cognate status had a significant effect on the production of Spanish VOT by Spanish-English and English-Spanish bilinguals, such that these bilinguals produced /t/ with longer (more English-like) VOT values in the Spanish production of cognates compared to noncognate words. Amengual (2016) similarly reported that the Catalan mid-vowels /o/ and /ɔ/ produced by Spanish-Catalan bilinguals overlapped more for cognate words, especially for Spanish-dominant participants. In an auditory lexical decision task, these Spanish-dominant speakers also were more likely to accept cognate nonwords with the incorrect mid-vowel (e.g., *[flo] instead of [flɔ] "flower") compared to noncognate nonwords, suggesting that their lexical representations for cognate words were highly influenced by their L1 equivalents. In sum, research on cognate effects shows that cross-linguistic overlap, both phonological and orthographic, can affect the representation, processing, and pronunciation of words. This lends support to the idea that it is possible for cognates to introduce serious conflicts for L2 learners if the words are orthographically similar but are pronounced differently across languages.

As previously described, researchers have examined the effects of both orthography and cognate status on L2 lexical encoding, but there is still not much known about the extent of the interaction between these two variables. In order to determine the impact of both of these factors, the present study investigates the accuracy of English-speaking learners' encoding of Spanish words containing the graphemes <g> and <h> in cognates and noncognates. These graphemes were chosen because <g> and <h> differ in the consistency of their phoneme-grapheme relationship within and across Spanish and English. Additionally, these graphemes represent sounds that are not perceptually difficult for English-speaking learners, and hence any findings cannot be explained as an inability to accurately perceive the sounds in question.

The Spanish <g> represents two possible phonemes, which follow clear orthographic conventions: <g> in most contexts represents /ɡ/ as in *gato* [ˈɡa.to] “cat”; this phoneme is produced as an approximant [ɣ̞] when not after a pause or a nasal, e.g. *lago* [ˈla.ɣ̞o] “lake”. When <g> appears before <e> or <i> it represents /x/ as in *gente* [ˈxen.te] “people”.[i] On the other hand, English <g> can be pronounced [d͡ʒ], [ʒ], or [ɡ], but phoneme-grapheme correspondences are not consistent, as can be seen in the words *gem* [ˈd͡ʒɛm], *genre* [ˈʒɑn.ɹə], and *get* [ˈɡɛt], in addition to exceptions such as when <g> is silent (e.g., *night* [ˈnaɪt]). Cognates often contain /x/ in Spanish but /d͡ʒ/ in English. A cognate example of this cross-language variation would be the Spanish *agente* [a.ˈxen.te] and the English *agent* [ˈeɪ.d͡ʒənt]. Meanwhile, <h> has less variation in its pronunciation in both languages. The letter <h> in English is typically pronounced [h], as in *hotel* [hoʊ.ˈtɛl], although many loanwords exist in which the <h> is not pronounced, such as *honest* [ˈɑ.nɪst] and *hour* [ˈaʊ.əɹ]. This is compared to Spanish where pronunciation of <h> is omitted, as in *hotel* [o.ˈtel], except in rare loanwords like *Hawái* [ha.ˈwaj].

This variation between languages in the pronunciation of <g> and <h> may cause L2 Spanish learners to confuse the sounds and thus encode inaccurate representations into their mental lexicon. The added factor of cognates may cause L2 learners to assume that words can retain their L1 pronunciations. By pairing the phenomenon of cognates with differing phoneme-grapheme relationships across languages, the phonological representations of words may become fuzzier, therefore leading to faulty L2 lexical encoding.

3. Research Questions & Predictions

In the present study, the research questions are as follows:

1. Does the accuracy of lexical encoding of L2 Spanish words by L1 English learners differ between the graphemes <g> and <h>?
2. Does the accuracy of lexical encoding of L2 Spanish words by L1 English learners differ between cognates and noncognates?

We predict that there will be an interaction of these variables on L2 lexical encoding. Firstly, since in English <g> has more variability while <h> is mostly consistent in its pronunciation, participants may have stronger connections between <h> and /h/ in their mental lexicon. This is supported by L1 research suggesting that as individuals learn to read, words with orthographically consistent patterns develop more detailed and robust phonological representations (see Zieglar, Petrova, & Ferrand, 2008). In contrast, since <g> is specified on a word-by-word basis rather than a consistent orthographic convention in English, there is likely not a strong connection between <g> and any one phoneme, leading to weaker interference from the L1 phoneme-grapheme correspondences with <g> and more flexibility in its associations. The fact that <g> in Spanish has two possible pronunciations may also lead learners to incorrectly assume <g> must be specified on a word-by-word basis in Spanish as well. Secondly, noncognates in Spanish may be learned with greater accuracy since they have no direct English counterpart, therefore requiring more cognitive effort to acquire than cognates. At the same time, cognates might experience additional interference from English orthography and phonology, thereby having less accurate lexical representations in L2 Spanish.

4. Method

4.1. Participants

We recruited two groups of participants: native English speakers learning Spanish and native Spanish speakers. For the English-speaking learners of Spanish, we tested intermediate to advanced L2 Spanish learners, specifically students who were enrolled in 5th semester university-level Spanish classes or higher. The recruitment was primarily completed through the University of North Carolina Wilmington. This study tested a total of 76 participants (58 L2 Spanish, 18 Native Speakers), and after making exclusions based on information in the background questionnaire, there were a total of 56 participants (46 L2 and 10 Native Speakers) included in the analyses. We excluded individuals from either group of participants if they reported exposure to more than one language in the home (n=14), were enrolled in a language immersion program in primary school (n=2), or reported a hearing impairment (n=2). We also excluded L2 Spanish learners who spent extensive time in a Spanish-speaking country as a child (n=2); one of these learners was the child of missionaries and lived in multiple Spanish-speaking countries from age 10 to 15, while the other had spent 3 months in Nicaragua every year since age 10. The demographic information of this study's participants can be found in Table 1.

Table 1. Participant Demographics

	L2 Learners (n=46)	**Native Speakers (n=10)**
Gender	5 Male, 1 Nonbinary	2 Male
Dominant Hand	6 left-handed	1 left-handed
Age at Testing	21.0 (3.2)	33.8 (14.2)

Age of Onset for L2* Learning	13.7 (3.8)	10.1 (7.1)
Self-rated L2 speaking ability (0-6)	3.1 (1.4)	5 (1.6)
Self-rated L2 listening ability (0-6)	3.6 (1.3)	5.3 (1.3)
Self-rated L2 reading ability (0-6)	4.2 (1.3)	5.3 (1.6)
Self-rated L2 writing ability (0-6)	3.7 (1.3)	4.2 (1.5)
Experience in Spanish-Speaking Countries		
Yes, Study Abroad	8	NA
Yes, Other	3	NA

Note. For the Age at Testing, Age of Onset, and the Self-rated L2 abilities, the data presented reflect the mean with the standard deviation indicated in the parentheses. *For "L2 Learners", "L2" refers to Spanish, and for "Native Speakers", "L2" refers to English.

4.2. Materials

4.2.1. Stimuli for Lexical Tasks

The stimuli used in this study were 160 recordings of Spanish words and nonwords. The list of test words was gathered by the researchers by first searching for both cognate and noncognate Spanish words that had the letters <g> and <h>. In addition, for all of the selected cognate words, <g> was pronounced as /dʒ/ in English and /x/ in Spanish, and <h> was pronounced as /h/ in English but was not pronounced in Spanish. For this study, a cognate word was defined as having similar meaning and use in both English and Spanish with at most two orthographic changes (i.e., differences in spelling by the addition, deletion, or substitution of a grapheme). Each orthographic change was coded as 1 difference, while we coded an accent mark to be a 0.5 difference. Cognates in both the <g> and <h> conditions had, on average, 0.6 of an orthographic difference. After gathering these lists of the four conditions (<h> cognate, <h>

noncognate, <g> cognate, <g> noncognate), the words were then ranked in order of word frequency per million as assessed with EsPaL (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013). The top ten most frequent words in each condition were kept and the remaining were discarded, resulting in a total of forty words. We chose the most frequent words that fit our criteria rather than controlling for word frequency or other factors such as position of the target phoneme, part of speech, neighborhood density, or word length because native Spanish measures of frequency or neighborhood density would likely be different for our learners, who were acquiring Spanish mainly in a classroom setting and had smaller vocabulary sizes than native speakers. Also, given their limited vocabulary, controlling for various factors would likely result in many unknown words as stimuli. Thus, we prioritized the likelihood that a stimulus would have a lexical representation for our L2 participants over other considerations.

In addition to these test words, a total of eighty filler words were added to the list of stimuli, forty that were real Spanish words unrelated to the targeted phonemes (e.g., *cabeza* “head”; *primero* “first”) and forty that were Spanish pseudowords that followed the phonotactic constraints of Spanish (e.g., *guafo*; *leto*). The test stimuli for the <h> condition are displayed in Table 2 and the test stimuli for the <g> condition are displayed in Table 3. The word familiarity measure included in these tables is explained in section 4.2.5.

Table 2. Test Stimuli in <h> Condition

Spanish Ø - English /h/ (spelled with <h>)						
cognates:	**Freq**	**Fam**	**O**	**noncognates:**	**Freq**	**Fam**
alcohol	34.49	5.71 (0.87)	0	ahora	2510.54	5.98 (0.15)
hábitat	2.07	5.70 (1.07)	0.5	hablar	749.86	6.00 (0.00)
hábito	7.69	5.41 (0.93)	1.5	hacer	1790.92	6.00 (0.00)

habitual	11.29	5.80 (0.50)	0	hasta	1027.75	5.91 (0.00)
helicóptero	26.71	5.82 (0.80)	1.5	hay	2466.74	5.96 (0.21)
historia	310.77	6.00 (0.00)	2	hecho	861.02	5.78 (0.59)
horror	13.69	5.87 (0.40)	0	hermano	369.15	6.00 (0.00)
hospital	150.24	6.00 (0.00)	0	hola	1367.24	6.00 (0.00)
hotel	117.35	6.00 (0.00)	0	hombre	1138.55	6.00 (0.00)
humano	82.34	5.87 (0.40)	1	hoy	558.59	6.00 (0.00)

Note. Freq = word frequency per million. Fam = mean self-rated word familiarity (1-6) for the L2 learners. O = orthography changes for cognates.

Table 3. Test Stimuli in <g> Condition

Spanish /x/ - English /dʒ/ (spelled with <g>)						
cognates:	**Freq**	**Fam**	**O**	**noncognates:**	**Freq**	**Fam**
agente	157.94	4.91 (1.40)	1	elegir	38.89	5.57 (1.00)
ángel	42.94	5.74 (0.83)	0.5	escoger	15.55	5.07 (1.53)
digital	6.68	5.89 (0.31)	0	exigir	6.46	5.15 (1.33)
general	165.82	5.96 (0.29)	0	gemelo	3.91	3.30 (1.96)
imagen	51.69	5.87 (0.50)	1	gente	861.98	5.98 (0.15)
origen	14.86	5.93 (0.25)	1	gerente	3.56	3.91 (1.96)
original	32.21	5.96 (0.21)	0	girar	30.70	2.96 (1.78)
región	12.76	5.65 (0.92)	0.5	girasol	2.05	2.46 (1.52)
religión	19.29	5.91 (0.46)	0.5	ligero	10.89	2.57 (1.49)
urgente	23.99	5.47 (1.17)	1	recoger	34.58	5.24 (1.08)

Note. Freq = word frequency per million. Fam = mean self-rated word familiarity (1-6) for the L2 learners. O = orthography changes for cognates.

A phonetically-trained female native Spanish speaker from Argentina recorded the stimuli. For the test stimuli, the cognates and noncognates containing <g> and <h> were recorded twice, once with an accurate Spanish production of the targeted phonemes, that is, <h> as silent and <g> as /x/, as well as another pronunciation of the Spanish words using an English-like variation of <h> and <g>, with <h> pronounced as [h~x] and <g> as [d͡ʒ], for example, *digital* [di.xi.ˈtal] and *humano* [u.ˈma.no], with the target-like pronunciations, and *digital* [di.d͡ʒi.ˈtal] and *humano* [hu.ˈma.no], with English-like pronunciations. The speaker's productions, with the exception of the English-like pronunciations of <g> and <h>, exhibited standard Latin American Spanish pronunciation, such as that which learners would hear in the classroom.[ii]

4.2.2. Standard Lexical Decision (SLD) Task

In the Standard Lexical Decision (SLD) task, participants heard a stimulus and then had to indicate whether each word was a real or fake Spanish word depending on how they perceived each pronunciation. As described in the previous section, the stimuli included cognates and noncognates with both of the targeted phonemes' pronunciations (e.g., <g> as [x] and as [d͡ʒ]) as well as filler words and pseudowords. In each trial, participants had four seconds to decide if the word was real or fake. The instructions for right-handed individuals read: "In this task, you will decide if what you hear is a real word of Spanish or not: If what you hear is a fake Spanish word, press A. If what you hear is a real Spanish word, press L. Respond as quickly as you can without making mistakes." The use of the A and L keys used in this task varied depending on the dominant hand of each participant. Participants used their dominant hand to indicate a real word and their non-dominant hand to indicate a fake word. Initially, participants were given ten practice trials with feedback ("Correct!", "Incorrect", or "Too slow!") before the actual task in order to become comfortable with the keys. However, in the actual SLD task, they did not receive feedback. There was always a researcher present via a Zoom call guiding each participant through the practice round specifically saying "Use your [dominant hand] if you think the word is correct, real, or accurate, and your [nondominant hand] if you think the word is incorrect, fake, or inaccurate." In each trial, participants saw a fixation cross on the screen; they did not see any orthographic forms. With eighty test stimuli and eighty filler stimuli, there were a total of 160 trials in this task. For the test stimuli, participants made decisions on both the word and nonword versions; for example, they heard both *hermano* [eɾ.ˈma.no] "brother" and the nonword [heɾ.ˈma.no] with the <h> pronounced. This task was administered through jsPsych (de Leeuw, 2015) and took approximately ten minutes.

4.2.3. Forced Choice Lexical Decision (FCLD) Task

In the Forced Choice Lexical Decision (FCLD) task, participants heard only the test stimuli, meaning the two possible pronunciations of each Spanish word. One recording was that of the accurate Spanish pronunciation with its corresponding phoneme, and the other recording contained the English-like pronunciation of <h> or <g>. For example, in one trial, participants heard the word *hermano* [eɾ.ˈma.no] "brother" and the nonword [heɾ.ˈma.no] with the <h> pronounced.

Much like the SLD task, the participants then had to indicate using the A and L keys which pronunciation was real depending on how they perceived the sounds. The instructions presented on screen for the FCLD task were as follows: "In this task, you will decide which of the two words you hear is a real word of Spanish. If the first word you hear is the real Spanish word, press A. If the second word you hear is the real Spanish word, press L. Respond as quickly as you can without making mistakes." There was a five-second time limit per trial and there were a total of 80 trials (see Tables 2 and 3 for explanation of stimuli used in this task), with all trials presented in a random order. As in the SLD task, participants were first given ten practice trials with feedback (“Correct!”, “Incorrect”, or “Too slow!”). However, in the actual FCLD task, they did not receive feedback nor see the orthography of the word; participants only heard the recordings of the words. This task was administered through jsPsych and took approximately six minutes.

4.2.4. Headphone Check

To test the hearing ability of our participants as well as to see if their headphones were functional before completing any tasks, a bilateral headphone check was completed with 1000 Hz, 2000 Hz, and 4000 Hz pure tones at 20 dB HL. In order for an individual to participate in the experiment, they needed to pass the headphone check with 100% accuracy. This was the same headphone check found in Daidone (2020). The pulsed tones were presented in a random order in one ear at a time, and the participants would then indicate that they heard each tone by pressing the spacebar. If a participant missed a tone, all of the tones were repeated. If they missed any of the second iteration of tones, the test indicated on the screen that the participant failed to pass. They were given a maximum of five attempts to pass the headphone check, if necessary, after explaining the instructions again and having participants check their equipment and reduce any external noise that could have been interfering. This task was administered through jsPsych and lasted approximately two minutes.

4.2.5. Background Questionnaire

A background questionnaire was used to gather demographic information about the participants, such as their gender, handedness, age, birthplace, history of residence, as well as their language learning history and current use of languages. This section included questions about their native language and that of their parents and what language or languages were spoken in their home and by whom. Participants also reported the age at which they acquired Spanish (for the native English speakers), English (for the native Spanish speakers), and any additional language(s). For Spanish or English and any additional language(s), they indicated how they learned that language (i.e., at home, at school, living where the language is spoken, in an intensive language program, or other), and they self-rated their proficiency in reading, writing, speaking, and listening on scales from 0 to 6, with 0 indicating "not well at all" and 6 indicating "very well". The native English speakers were also asked to describe any study abroad or other travel experience in a Spanish-speaking country for more than 3 weeks.

Additionally, there was a section of the questionnaire that assessed the Spanish L2 participants' familiarity with the Spanish words found in the tasks, specifically the filler words and the test words containing the <h> and <g> graphemes in both the cognates and noncognates. Following Daidone (2020), the L2 participants rated how familiar they were with a word among six options ranging from "I don't know this word." to "I know this word well, can provide a translation in English, and can use this word while speaking Spanish." This self-report data was used to determine what exclusions from the analyses were needed on a trial-by-trial basis for unknown words. For each participant, a word and its corresponding nonword (if applicable) were only included in analyses if the word was rated by that participant as one of the top three options: "I recognize this word and know more or less what it means", "I know this word and can provide a translation in English", or "I know this word well, can provide a translation in English, and can use this word while speaking Spanish".

Finally, there was also a section dedicated to having the L2 Spanish participants explain how to pronounce <h> and <g> in Spanish to see if any exclusions were necessary. The first item was as follows: “Describe how the letter <h> is pronounced in Spanish, as in *hola*. If you don't know, please indicate that.” The second item in this section was: “Describe how the letter <g> is pronounced in Spanish before <e> or <i>, as in *gente* or *elegir*. If you don't know, please indicate that.” All participants accurately stated that the <h> is not pronounced and described <g> as making an /h/-like sound. The background questionnaire was administered through Qualtrics and took between five and ten minutes.

4.3. Procedure

This experiment was conducted remotely over scheduled Zoom meetings between the first author and a participant. Participants used their own computer to complete the tasks while the researcher acted as a proctor. The participants were primarily proctored in English and the instructions on the tasks and background questionnaire were solely in English. However, some translating was done by the researcher for the native Spanish-speaking participants that needed the assistance. After consenting to be in the study, participants were given a participant ID number and the researcher then sent the links to each task. The participants first completed the headphone check to make sure they would be able to hear all of the audio in the lexical decision tasks. The SLD and then FCLD followed, and the background questionnaire was the last task completed. In total, participation in the experiment took between thirty and forty minutes.

5. Results

5.1. Standard Lexical Decision Task

This task measured the willingness of participants to accept real Spanish words as well as reject nonwords that exhibited non-target-like use of the English phonemes for the graphemes <g> and <h>. In addition to grapheme, the effect of cognate status (whether the word was a cognate or noncognate) was also in question. All data from two L2 learners were excluded from the analyses for this task due to having timeouts on more than 5% of trials, and the data from one native Spanish speaker was not saved due to an online server malfunction. In total, data from 44 L2 learners and 9 native Spanish speakers were analyzed. For these participants, individual trials were excluded from the analyses if the participant timed out (n = 48; 0.6% of trials) or if they did not know the word based on the word familiarity section of the background questionnaire (n = 389; 4.6% of trials). Figure 1 shows the accuracy for words and nonwords in each test condition. In this figure, the diamond symbol (◆) indicates the mean. For the filler condition, L2 learners had a mean accuracy of 92.6% (SD = 4.6) for words and 59.3% (SD = 19.0) for nonwords; for native Spanish speakers, mean accuracy was 95.8% (SD = 4.3) for words and 92.7% (SD = 4.3) for nonwords.

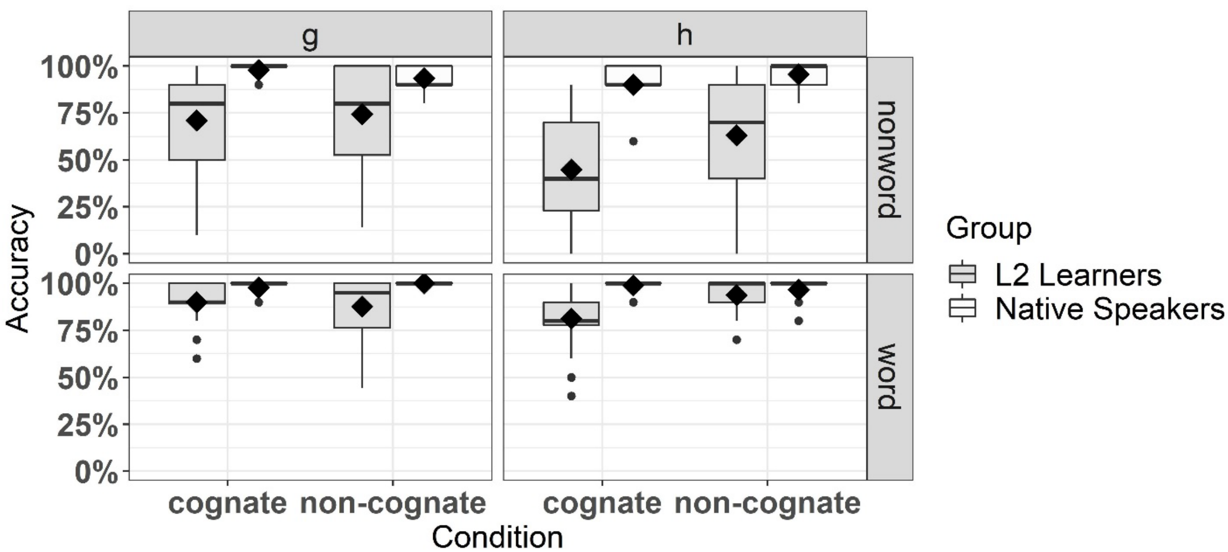

Figure 1. Accuracy by Condition and Lexical Status in the Standard Lexical Decision Task

For our STD statistical analyses, we did not want to combine accuracy rates for words and nonwords since combined accuracy rates do not show the nature of response patterns. It is possible for a participant to score with 50% accuracy by accepting all nonwords, rejecting all words, or by randomly guessing. To account for this, *d'* ("d-prime"), a measure of sensitivity was computed (Stanislaw & Todorov, 1999). The *d'* measure takes into account participants' ability to say "yes" to word trials (a "hit") and say "no" to nonword trials (a "correct rejection"). Generally, a *d'* score of below about 0.75 estimates that participants cannot distinguish between words and nonwords and that their answers are essentially by random chance. A *d'* score between .75 and 1.5 suggests weak discrimination between words and nonwords, and scores between 1.5 and 3 indicate strong ability to discriminate. Any score above 3 shows (near) ceiling performance, meaning that their discrimination is near an accuracy score of 100%. In order to avoid infinite values in the case that a participant exhibited ceiling or floor performance, *d'* corrections were added that were proportional to the number of word and nonword trials remaining for each participant in each condition, excluding trials with timeouts and unknown words. For a participant with no missing trials, this would be .50 for word trials and .50 for nonword trials. Figure 2 displays the *d'* scores in the SLD for each test condition and each group. The diamond symbol (◆) indicates the mean score of each condition. For the filler trials, the mean *d'* was 1.71 (SD = 0.58) for L2 learners and 3.21 (SD = 0.65) for native Spanish speakers.

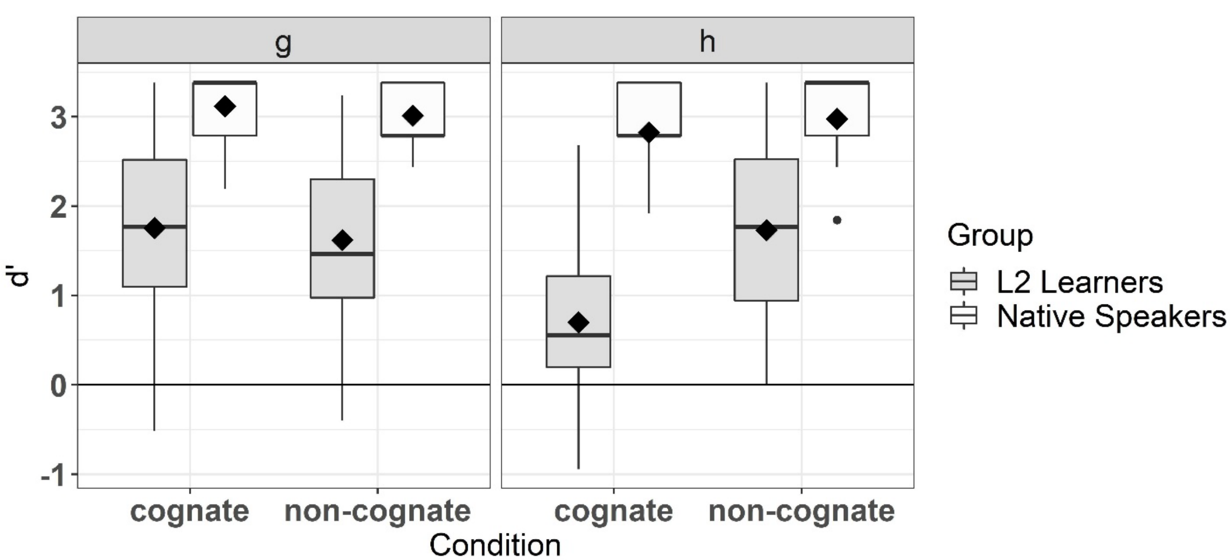

Figure 2. d' Scores for the Standard Lexical Decision Task

A three-way mixed measures ANOVA was run in RStudio using the *rstatix* package v.0.3.1 (Kassambara, 2019) with *d'* as the dependent variable, cognate status (cognate or noncognate) and grapheme (<h> or <g>) as the within-subject independent variables, and group (L2 learners or native Spanish speakers) as the between-subject independent variable.[iii] The filler condition was not included in this analysis. The p-values in post-hoc tests were adjusted for multiple comparisons using the Bonferroni correction method.

The ANOVA yielded a significant three-way interaction between cognate status, grapheme, and group, $F(1, 51) = 4.501$, $p = .039$. A two-way ANOVA at each group level revealed that this interaction was driven by the fact that L2 learners displayed a significant interaction between cognate status and grapheme ($F(1, 43) = 37.300$, $p < .001$), but there was no such interaction for the native speakers ($F(1, 8) = 3.790$, $p = .087$). While the native speakers' scores did not differ based on cognate status ($F(1, 8) = 0.058$, $p = .816$) or grapheme ($F(1, 8) = 0.528$, $p = .488$), there was an effect of both cognate status ($F(1, 43) = 26.000$, $p < .001$) and grapheme for the L2 learners ($F(1, 43) = 20.700$, $p < .001$). Post-hoc tests showed that for the L2 learner group, only the cognate condition exhibited a difference between graphemes ($p < .001$), and only the <h> grapheme displayed a difference between cognates and noncognates ($p < .001$). Moreover, the L2 learners were less accurate than the native speakers across all conditions (all $p < .001$). In other words, while the native speaker group performed accurately across all conditions, regardless of whether the word was a cognate or contained <h> or <g>, the L2 learners performed less accurately overall and had lower scores specifically in the <h> cognate condition compared to all other conditions.

5.2. Forced Choice Lexical Decision Task

This task measured the ability of participants to choose the words containing the Spanish phonemes associated with <g> and <h> when directly contrasted with nonwords containing the non-target-like use of the English phonemic counterparts for these graphemes. Effects of both grapheme and cognate status were of interest. Like for the SLD data, trials in which the participant timed out (n = 13; 2.9% of trials) and trials for which participants did not know the word based on the word familiarity section of the background questionnaire (n = 374; 8.3% of trials) were excluded from the analyses. The data from 46 L2 learners and 10 native Spanish speakers were included in the analyses for this task. Figure 3 displays the accuracy scores of participants in the FCLD task.

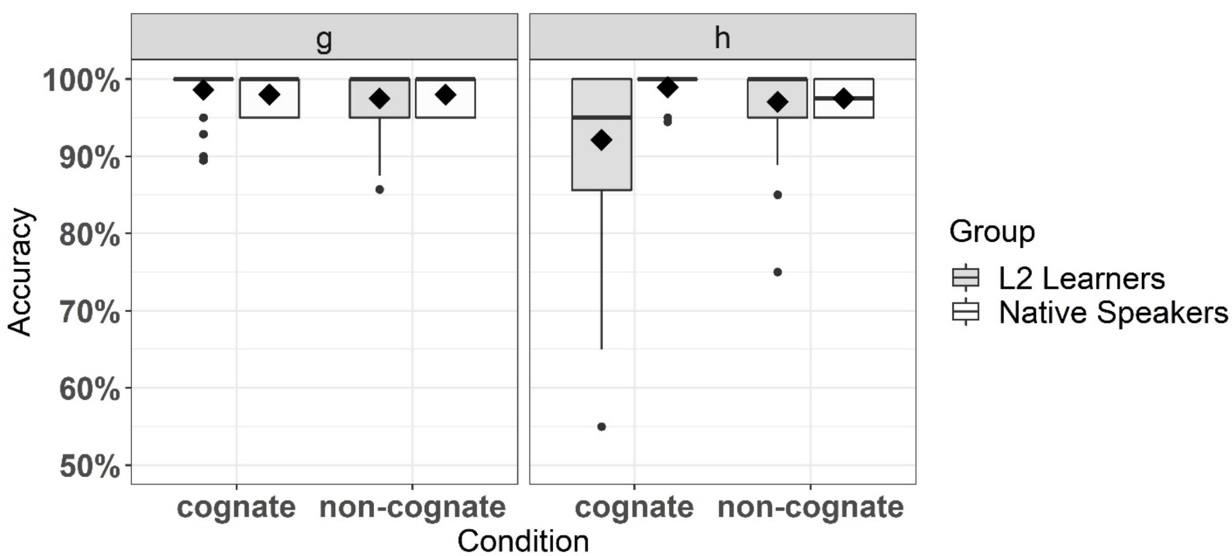

Figure 3. Accuracy Scores in the Forced Choice Lexical Decision Task

Similar to the SLD analysis, a three-way mixed measures ANOVA was run with accuracy as the dependent variable, cognate status (cognate or noncognate) and grapheme (<h> or <g>) as the within-subject independent variables, and group (L2 learners or native Spanish speakers) as the between-subject independent variable.[iv] The Bonferroni correction method was used to correct for multiple comparisons in post-hoc tests.

Results of the ANOVA showed that there was a significant three-way interaction between cognate status, grapheme, and group, $F(1, 54) = 5.810$, $p = .017$. A two-way ANOVA at each group level revealed the same findings as for the SLD results, in that L2 learners exhibited a significant interaction between cognate status and grapheme ($F(1, 45) = 18.500$, $p < .001$), but the interaction was not significant for the native speakers ($F(1, 9) = 0.918$, $p = .363$). For the native speaker group, their scores did not differ by cognate status ($F(1, 9) = 0.617$, $p = .452$) or grapheme ($F(1, 9) = 0.053$, $p = .823$). In contrast, the L2 learners' scores differed by both cognate status ($F(1, 45) = 7.180$, $p = .010$) and grapheme ($F(1, 45) = 17.400$, $p < .001$). Specifically, only the cognate condition was different by grapheme ($p < .001$), and only the <h> grapheme was different based on cognate status ($p = .003$). In sum, the L2 learners performed less accurately in the <h> cognate condition compared to all other conditions. This was also the sole condition in which they differed from the native speakers ($p = .031$).

Overall, these analyses show that for the L2 learners, the <h> cognate condition was more difficult than other conditions in both the SLD and FCLD tasks, while the native Spanish speakers were equally as accurate across all conditions.

6. Discussion

The current study sought to understand the extent to which phonological representations are encoded in a non-target-like form in an L2, specifically in Spanish by L1 English speakers. Knowing that both the occurrence of cognate words and use of orthography can individually affect the storage of these representations, in this experiment we wanted to ascertain the extent to which these linguistic features together can affect L2 lexical encoding. As predicted, L2 participants were significantly less sensitive to and less accurate in selecting target-like <h> pronunciations compared to the <g> pronunciations, but this was only true for cognate words. Additionally, cognate words were more difficult than noncognate words, but only for those with <h>. Therefore, the hypotheses of the current study, that the Spanish <h> representation would be less accurate compared to the <g> and that cognates would have less accurate representations compared to noncognates, were supported. However, the data demonstrated that each of these linguistic features affected the accuracy of participant representations only for one specific combination of grapheme and cognate status. This suggests that learners' phonological representations are particularly susceptible to L1 influence when confronted with cognate words that contain <h>. This is true even for the fairly advanced L2 learners examined in this study, who were enrolled in 5th semester Spanish classes or higher and could articulate how <h> and <g> are pronounced in Spanish. Despite their explicit knowledge, these L2 learners occasionally struggled to accurately remember cognate words containing <h> in Spanish, even to the extent that they rejected the actual pronunciation in favor of the non-target-like one in the forced choice task. In contrast, the native speaker group had near ceiling performance in both tasks, and they did not differ by grapheme or cognate status. Thus, it appears that their L2 English did not affect their L1 representations to the extent that the L2 learners' Spanish representations were affected by their L1.

That learners' L1 phonological representations continue to dominate in their L2 is evident in the current study's <h> category, with the English phonemic representations still overriding in Spanish words. This result corroborates the findings of Melnik and Peperkamp (2019) in that the dominant representation prevails, with the dominant category in this study being the pronunciation of <h> over the Spanish omission, similar to the French omission but the inverted effect. This is also in line with other research on fuzzy L2 lexical representations (e.g., Broersma & Cutler, 2011; Darcy, Daidone, & Kojima, 2013). However, in the case of the current study, the L2 learners did not have difficulty distinguishing the presence or absence of /h/, as evidenced by their high accuracy in the noncognate category. Therefore, L1 categories can lead to non-target-like L2 representations even when perception is not difficult.

The results of the current study add additional support to the models related to the mental lexicon found in both Ramus et al. (2010) and Brown and Harper (2009). The mental lexicon is portrayed as clusters of orthographic, phonological, and semantic forms of words. The processes involved in the lexical encoding of phonological forms were particularly in question, especially in terms of how faulty representations arise. Ramus et al. (2010) discussed how L1 phonemic categories appear to be activated seemingly automatically, even when it is actually the L2 being produced. Furthermore, Brown and Harper (2009) mentioned that the more interwoven the phonological, orthographic, and semantic aspects of a cognate are, the more difficulties bilinguals will have in associating and storing the target-like L2 phonemes. This was supported by this study's findings, which displayed that cognate accuracy scores were significantly lower compared to noncognate scores. Some of these difficulties probably arose because noncognates are exclusive to their respective language and likely garnered more careful attention during encoding. Cognates, on the other hand, have considerable overlap, and L2 learners of Spanish might have assumed during the initial encoding that English phonemes were applicable since the L1 categories dominate automatically and the words resembled each other in some of their pronunciation, though especially their orthographic forms. However, additional explanation is needed as to why there was lower accuracy in cognate words only for the <h> condition in this experiment.

The findings for the <g> and <h> cognates showed only significant effects in <h> words, the condition where the phoneme-to-grapheme relationship consistency was higher. Learners were likely initially unsure of how to pronounce <g> in Spanish, especially given its inconsistency in English, and, therefore, may have focused more attention on the pronunciation of words with this grapheme. In contrast, they may have wrongly assumed that <h> was clearly pronounced /h/ as it almost always is in English and paid less attention to auditory examples of these words, especially for cognate words that required less effort to learn. Thus, the strength of the association for <h> to /h/ is presumably greater for English speakers than the association of <g> to any phoneme, since <g> is variably pronounced in English. For these learners, it is perhaps difficult to ignore this very strong connection between <h> and /h/, especially for cognate words. In sum, these findings suggest that the consistency within the phoneme-grapheme relationship in a language might be affecting phonemic storage in the mental lexicon, and that the application of a consistent L1 phoneme-grapheme correspondence is harder to disregard for L2 cognate words.

7. Conclusion

Future research could proceed in several directions when reflecting on the findings of this study. One aspect to pursue could be the effects of cognate status and other grapheme-phoneme relationships, in Spanish or other second languages. First of all, it is possible that the specific sounds chosen for the current study highly influenced the results. There is a greater degree of acoustic difference between the English phoneme /d͡ʒ/ and the Spanish phoneme /x/ compared to the English /h/ versus silence in Spanish. Thus, if an English speaker was expecting <g> to sound like [d͡ʒ], [h~x~χ] would be quite perceptually distinct from this expected realization. In contrast, silence would be less perceptually distinct from an expected [h] for <h>. Perhaps this would lead to more awareness of the cross-linguistic differences in the realization of <g> compared to <h> and to quicker learning of the phoneme-grapheme correspondences for <g>. Also, participants in our study may have perceived [d͡ʒ] in stimuli to be less Spanish-like than [h~x] and, therefore, were less likely to indicate that those pronunciations were real words, although [d͡ʒ], or more specifically the palatal affricate [ɟ͡ʝ], is a variant of the palatal phoneme in Spanish in many dialects, represented with <y> or <ll> (Hualde, 2005, p. 165). In addition, the distribution of the graphemes differed between <g> and <h> words in our study. Almost all of the <h> cognate and noncognate words began with <h> and most of the <g> noncognate words began with <g>, but most of the <g> cognate words contained <g> in the second or third syllable. While this is an artifact of what cognates exist and which words the participants were likely to know, it is possible that these differences, along with factors such as neighborhood density or stress position also influenced the results. Future studies should examine additional phoneme-grapheme correspondences, for both cognates and noncognates, in order to ascertain the generalizability of these findings. It would also be important to test learners with a higher proficiency level than those tested in this study so that additional factors like the position of stress and graphemes within words could be controlled.

Another possibility is to investigate the effects of grapheme and cognate status on learners at various proficiency levels. It may be that both cognate and noncognate words are initially stored with phonemes according to L1 phoneme-grapheme relationships, and while these representations are eventually corrected for noncognate words to be more target-like, the representations for cognate words are more difficult to alter due to their tight connections with L1 representations.

An alternative direction could be in gaining greater understanding of the effects of cognate status and orthography on heritage speakers. Researchers could analyze the extent to which heritage speakers with different language dominance patterns are influenced by these factors at varying stages in their language development and/or schooling.

Ultimately, there are pedagogical implications that result from insights into the relationship between L2 orthography and phonology. The findings of the current study steer us to agree with Hayes-Harb and Barrios (2021) and Rafat (2016) that perhaps orthography might be used sparingly when first exposing learners to new vocabulary and that it is important to provide explicit pronunciation instruction on new or opaque phoneme-grapheme correspondences. Additionally, we suggest that language programs incorporate lessons in pronunciation sooner in the timeline of students' instruction. Language learners may also benefit from more careful attention to the accuracy of cognate words due to their confusability with L1 phonological categories.

In sum, the current study has analyzed grapheme-phoneme relationships in a new way, and it opens the door to more linguistic and pedagogical research pertaining to phonology and the impact that both orthography and cognate words can have together on the encoding of words in the L2 mental lexicon.

Data Availability Statement

The task files, data, and analyses for this experiment are available on Open Science Framework at https://osf.io/7sczq/.

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[i] Depending on the dialect, this phoneme can have a range of pronunciations, such as [h], [x], and [χ] (Hualde, 2005, pp. 154-155). For the purposes of this article, we will refer to this phoneme as /x/ as is standard in Hispanic linguistics.

[ii] Words with <ll> and <y> were avoided since these graphemes represent [ʒ~ʃ] in Argentine Spanish, while a palatal [j] is their most common realization cross-dialectally (Hualde, 2005, pp. 165-166).

[iii] The data was judged to be approximately normal by examining the QQ plots. Mauchly's Test of Sphericity showed that the assumption of sphericity was also met ($p > .05$). However, Levene's tests revealed that the SLD data violated the assumption of homogeneity of variances in the <g> cognate ($p = .008$), <g> noncognate ($p = .020$), and <h> noncognate conditions ($p = .035$). Furthermore, the data also violated the assumption of homogeneity of covariances as assessed by Box's M-test ($p < .001$). In this case, Wilcox (2012) suggests that a three-way mixed ANOVA with Robust Estimation be run. However, no R package was available to perform this analysis, including the one recommended by Wilcox. Because of this, a two-way mixed ANOVA with Robust Estimation were run using the R package WRS2 v1.0-0 (Mair, 2019) with group and condition (coded as <g> cognate, <g> noncognate, <h> cognate, and <h> noncognate) as the independent variables. In this analysis, there was a significant interaction between group and condition, as well as main effects of group and condition, reproducing the findings for the traditional ANOVA.

[iv] Mauchly's Test of Sphericity showed that the assumption of sphericity was met ($p > .05$). However, the assumption of normality was violated as seen in the QQ plots of the data for the <h> cognate condition for both groups and for the <g> cognate and <h> noncognate conditions for the L2 learners. Levene's tests revealed that the SLD data violated the assumption of homogeneity of variances in the <h> cognate condition ($p = .018$). Box's M-test showed that the data also violated the assumption of homogeneity of covariances ($p < .001$). Due to these violations of assumptions, a two-way mixed ANOVA with Robust Estimation were run using the R package WRS2 v1.0-0 (Mair, 2019) with group and condition (coded as <g> cognate, <g> noncognate, <h> cognate, and <h> noncognate) as the independent variables. Results showed there was a significant interaction between group and condition, and main effects of both group and condition, as expected from the findings for the traditional ANOVA.

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