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First language grapheme-phoneme transparency effects in adult second-language learning

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Abstract

The Spanish writing system has consistent grapheme-to-phoneme correspondences (GPC), rendering it more transparent than English. We compared first-language (L1) orthographic transparency on how monolingual English- and Spanish-readers learned a novel writing system with a 1:1 (LT) and a 1:2 (LO) GPC. Our dependent variables were learning time, decoding, and vocabulary. We found a main effect for transparency. Participants learned LT faster and decoded more words in LT than in LO. L1 reading characteristics influenced learning. English-readers decoded more words in the LO-LT sequence and Spanish-readers decoded more words in the LT-LO sequence. Spanish-readers had more difficulty recalling the meaning of LO than LT words; for English-readers there was no difference between the two word types. Our findings indicate that readers' L1 orthographic transparency or GPC type influences L2 decoding and the learning of L2 words from combined written-auditory teaching.

Keywords: transparency, writing, reading, orthographies, decoding, second language learning, English, Spanish

While reading requires extracting meaning from print, the cognitive processes by which meaning is extracted differ across different writing systems. Alphabetic writing systems range from transparent to more opaque, depending on how consistently they reflect phonetic or morphemic representation (Frost, Katz, & Bentin, 1987). In spite of such differences, cross-linguistic comparisons point to the crucial roles of phonological processing and word identification in reading (Hamada & Koda, 2008; Koda, 2004). The efficiency or automaticity of these processes has been shown to influence reading comprehension (Katzir, et al., 2006; Pikulski & Chard, 2005; Wolf, Bowers, & Biddle, 2000; Wolf & Katzir-Cohen, 2001). Consequently, research has focused on understanding how readers in different orthographies deploy reading strategies.

A long-standing question is whether reading is easier in orthographies considered transparent as compared to those considered more opaque. The ease or difficulty in learning to read is associated with the sound-to-symbol or meaning-to-symbol correspondences that readers must learn (Davies, Cuetos, & Glez-Seijas, 2007). The consistency with which these mappings are established in each writing system contributes to the constraints imposed on readers. For example, the size of the phonological unit (phoneme, syllable, morpheme, word), the consistency of the correspondences between sounds and orthographic units, the number of orthographic units, their combinations and their individual and bigraph frequency, all form part of the linguistic constraints imposed on readers of different orthographies (Koda, 2007; Wydell, 2012). Because English is considered a relatively opaque orthographic system, children learning to read in English may encounter more challenges in decoding and in building a sight vocabulary than children learning to read in a relatively transparent orthography like Spanish (Spencer, 2007).

At issue in the current study is how first-language (L1) reading strategies play a role when learning to read in a second language (L2). Artificial or novel orthographies can be used to elucidate cross-linguistic cognitive differences in reading (Hirshorn & Fiez, 2014). We assume that the influence of the L1 reading strategies on reading an L2 orthography is largely determined by the distance between the two writing systems on the transparency-opacity continuum (Frost et al., 1987). Readers of languages with writing systems that share more features benefit more from the application of reading strategies from L1 on L2. For example, Koda (2004, 2008) pointed out that orthographic distance between L1 and L2 determines decoding efficiency in L2 learners. By contrast, readers of languages with dissimilar writing systems may apply reading strategies from L1 to L2, but doing so may not always be successful.

In this study we compare English-readers and Spanish-readers on their ability to learn a more transparent and a more opaque novel script. To contextualize this study, our review of the literature considers research exploring: a) component skills of reading in English and Spanish; b) influence of transparency-opacity for reading in English and Spanish; and c) cross-language effects in reading for English-readers and Spanish-readers.

Component Skills of Reading in Different Writing Systems

A component skills approach to reading focuses on understanding the underlying cognitive processes involved in reading and their role in the overall task of reading (e.g., Carr, Brown, Vavrus, & Evans, 1990; Joshi, Tao, Aaron, & Quiroz, 2012). In the lexical quality hypothesis, Perfetti and Hart (2002) posit that knowledge about phonology, orthography, and the meaning of words account for variations in the quality of lexical representations. Moreover, the quality of lexical representations is also influenced by word frequency and practice in reading those words. The ability to readily assemble a word's meaning from its written representation and sound structure mediates comprehension at higher levels (Perfetti, Van Dyke, & Hart, 2001). When considering L2 learning, it is crucial to understand the interaction of cognitive processes from L1 and those involved in L2 reading (Koda, 2007; Sparks, Patton, Ganschow, Humbach, & Javorsky, 2006). That is, at the basic word level, reading involves extracting its phonological sound structure and obtaining a word's meaning—these processes are achieved by decoding, lexical identification, and by the extraction of meaning. Thus, whereas the simple view of reading primarily focuses on decoding and linguistic comprehension (Hoover & Gough, 1990), the lexical quality hypothesis incorporates processes of orthographic recognition. Perfetti et al. (2001) defined reading as the process by which linguistic meaning is extracted from written forms. As such, the acquisition of lexical representations and orthographic recognition become essential to reading comprehension. These two basic component skills, decoding and lexical or orthographic recognition, have been the bedrock in assessing reading and the relationship between oral language and written language abilities.

Being able to readily access a word's phonological form and its linguistic extraction is considered to be a universal principle of reading and constitutes unique variance in reading accuracy and in reading comprehension (Moll, et al., 2013; Perfetti & Dunlap, 2008; Perfetti & Liu, 2005). Even in non-alphabetic scripts deemed opaque (e.g., Mandarin), readers access written-word meanings through the spoken form of words (Koda, 2004). Learning to read in alphabetic writing systems with varying transparency levels, such as English and Spanish is characterized by phonological processing (Carrillo, 1994; Ziegler & Goswami, 2005). That is, efficient readers have the ability to manipulate phonemes within words, segment, decode, and recombine the sound structure of spoken words in print. In addition, decoding supports phonemic awareness and determines variance at the word reading level (Bar-Kochva & Breznitz, 2014; Carrillo, 1994; Jimenez-Gonzalez, 1997; Jimenez, 2012; Geva & Siegel, 2000; Valdivieso, 2002). Together, these studies point to the important role of efficient phonological processing in word reading across alphabetic writing systems, even in those at some distance in their degree of grapheme-to-phoneme consistency (GPC). Ultimately text integration and reading comprehension may depend on the efficiency and automaticity of phonological processes and orthographic recognition.

There is controversy among researchers as to whether linguistic meaning to a written word is achieved only through decoding its phonological structure or if the word's meaning can be accessed directly through whole-word and morphological processing, via visual-perceptual recognition (e.g., Beyersmann, Coltheart, & Castles, 2012). For English readers, research reviewed by Ehri (2005) supports the importance of extracting phonological information in building orthographic word-identification processes. Yet, the spelling of many irregularly spelled words in English must be memorized. Estimates on what percentage of words in English are irregularly spelled and must be memorized range from 13% (Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997) to 50% (Hanna, Hanna, Hodges, & Rudorf, 1966).

Inherent language-specific phonology/orthographic rules across languages may therefore constrain readers to combine cognitive strategies that mediate phonological processing and orthographic word recognition. For example, the orthographic system of Spanish supports the use of GPC mapping and decoding of those units, whereas the orthographic system of English entails GPC mappings of varying grain size (Davies et al., 2007; Ziegler & Goswami, 2005). In addition, from a developmental perspective, decoding efficiency is a good predictor of reading efficiency and word recognition among young readers in alphabetic writing systems such as those for English and Spanish (Carrillo, 1994; Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Ehri, 2005). Yet differences in orthographic constraints raise the question of whether readers of a more transparent writing system like Spanish (with consistent GPC) favor accessing a word's meaning through its phonological representation. By contrast, in more opaque writing systems like English (with varied GPC mappings), proficient readers may favor a more direct approach to accessing words' meanings, through the visual recognition of word units. Research exploring such questions has shown that beginning readers in Spanish initially rely on decoding and gradually increase word recognition, as they become efficient readers (Cuetos & Suarez-Coalla, 2009; Diuk & Borzone, 2006; Marin, Cuadro, & Pagan, 2007; Suárez-Coalla, Ramos, Álvarez-

Cañizo, & Cuetos, 2014).

The highly reliable phonological mediation in Spanish favors the use of decoding among poor readers. Defior, Martos, and Cary (2002) compared Spanish- and Portuguese-readers from 1st through 4th grades on various reading tasks that included non-word decoding. They found that whereas all children improved with increased school experience, the Portuguese-readers took longer time and were less accurate in reading than the Spanish-readers. This difference was attributed to the less transparent orthography of Portuguese than Spanish, constraining Portuguese-readers to rely more on whole-word reading strategies. In contrast, studies arising from reading in transparent orthographies reveal that less efficient readers tend to rely on decoding, thus reading at a slower rate and with less accuracy when compared to more efficient readers (e.g., Bar-Kochva & Breznitz, 2014; Landerl & Wimmer, 2000; Tressoldi, Stella, & Faggella, 2001; Serrano & Defior, 2008).

Influence of Transparency-Opacity for Reading in English and Spanish

Varying grain sizes of the phonological unit in different writing systems can place dissimilar cognitive-linguistic processing demands on their readers (Seymour, Aro, & Erskine, 2003; Wydell, 2012). For example, in an alphabetic orthography such as English, individual letters may represent more than one phoneme and more than one letter may represent one phoneme. Efficient English-readers master complex spelling pronunciation rules and learn regularities in the representation of grammatical morphemes, which may facilitate word recognition. In contrast to its GPC irregularities, English maintains systematic grapheme-to-morpheme relationships for inflectional processes, such as tense and plurality. These spelling regularities may be maintained across different pronunciations for each morpheme. For example, the '-ed' morpheme in the word "walked" is spelled the same way for all persons and numbers (e.g., I walked, they walked, we walked), but the pronunciation of the '-ed' morpheme changes across words based on the preceding consonant (e.g., for "walked" /t/, "called" /d/ and "waited" /Id/). Morpheme-size spelling similarities such as these may help beginning readers in English who are learning to read a language they can already speak. However, the pronunciation changes may be confusing for learners of English as a second language (ESL) who do not have such rules linking the orthographic and morphemic systems in their L1. For example, Kieffer and Lesaux (2008) found that morphological awareness was strongly correlated with reading comprehension in Spanish-speaking children in 4th and 5th grade learning English.

In spite of its consistent grapheme-to-morpheme inflectional characteristics, the low GPC consistency in English presents more reading challenges to beginning readers than Spanish (Cuetos & Suárez-Coalla, 2009; Serrano & Defior, 2008). In contrast to English, the pronunciation of most words in Spanish can be easily derived from their written form. Spanish-readers face few challenges, with the exception of a few letters (i.e., v, b, c, and ll) that can correspond to two phonemes each or to dialectical variations (Nash, 1977). In addition, the number of syllables, final consonants, and placement of diacritic accents in words help to determine the rules for stress and pronunciation (Nash, 1977). Thus, Spanish presents with more consistent GPC mappings than English, which may account for the lower estimates of reading problems reported in the literature for readers in transparent orthographies (e.g., Serrano &

Defior, 2005; Seymour, Aro, & Erskine, 2003; Wydell, 2012). Likewise, poor readers in Spanish have been noted to decode slowly but accurately, whereas accuracy ratings markedly decrease in less transparent writing systems, such as English (e.g., Carrillo, 1994; Carrillo & Alegría, 2009; Carrillo, Alegría, Miranda, Sanchez, 2011).

Cross-Language Effects in Reading for English-Readers and Spanish-Readers

A broad view of cross-language effects posits that language knowledge developed in the L1 contributes to L2 learning. Cummins (1979, 1991) proposed the interrelationship between L1 and L2, whereby reading competence in L1 would facilitate reading competence in L2. Conversely, inefficient reading in L1 would inhibit the acquisition of reading skills in L2. This global view of cross-language effects or transfer has been increasingly challenged in favor of a better understanding of how L1 linguistic processes not only influence L2 learning, but also constrain the cognitive processes used in L2 reading (e.g., Geva & Siegel, 2000; Koda, 2004; Koda, 2007; Pritchard & O'Hara, 2008; Sparks, Humbach, Patton, & Ganschow, 2011). Such a language-specific perspective of cross-language effects in reading focuses on the reader's language competencies across several processes, including decoding, morphological analysis, syntactic parsing and discourse. Koda (2007) defined transfer as "the automatic activation of well-established L1 competencies (mapping patterns) triggered by L2 input" (p. 17). By her analysis, transfer is automatic and ongoing, though transferred competencies will evolve through the readers' experience with reading in L2.

There is limited research focused on such specific aspects of transferred skills among L2 learners. Phonological awareness has been identified as a common underlying ability that is not only related to oral proficiency but is also shared cross-linguistically (Durgunoglu et al., 1993). Among young Spanish-readers, phonological awareness in the L1 has been found to be a good predictor of word recognition and reading ability in English (Dickinson, McCabe, Clark-Chiarelli, & Wolf, 2004; Durgunoglu et al., 1993; Goswami, Gombert, & Fraca de Barrera, 1998; Paéz & Rinaldi, 2006). Research with Spanish-speaking children in bilingual Spanish-English programs in the United States reveal strong correlations between performance in phonological awareness tasks in Spanish and English and also between performance on these tasks and on word reading in both languages (Branum-Martin, et al., 2006). These findings suggest that phonological awareness and its relationship to print are skills that carry cross-linguistic influence for English-readers and Spanish-readers.

There is scant research on how adult Spanish-readers' L1 phonological processes would influence their reading ability in English. Likewise, there is limited work on how adult English-readers' L1 phonological processes and inconsistency of English GPC rules would influence their reading ability in Spanish. Considering that adult readers have years of experience in reading in their L1s, and that there is much structural similarity between English and Spanish at the syntactic, lexical and alphabetic levels, a likely prediction would be that L1 decoding and word recognition strategies would be applied by both groups English-readers when learning Spanish and Spanish-readers when learning English. In that case, we might expect that extensive experience in reading their L1 would predispose adult readers to apply L1 reading strategies when reading in an L2. However, given the different constraints imposed by English and Spanish, adult Spanish- and English-readers may engage different strategies when learning to read a new script. That is, Spanish-readers would rely on consistent GPC mapping, while English-readers would rely more on multiple GPC mappings and larger-grain strategies.

In this study we aim to compare the influence of L1 orthographic transparency on how monolingual English- and Spanish-readers learn a novel L2 script with a 1:1 or 1:2 GPC. Thus, we pose the following research questions:

1. Is it easier for typical adult English- and Spanish-readers to learn GPC mappings in a more transparent written script than in a more opaque one?
2. How do L1 reading constraints of English and Spanish influence word decoding in a more transparent and in a more opaque written script?
3. How does GPC transparency influence Spanish-readers and English-readers on recalling the meaning of words learned in a new script?

Method

Procedures

To address the research questions, we created a novel script with two different GPC types to be learned by Spanish-readers and by English-readers. We called these written codes "Lingo Transparent" (LT) and "Lingo Opaque" (LO). The former consisted of a set of 10 symbols corresponding univocally with ten phonemes (seven consonants and three vowels). The latter only differed in that the three vowels each had two different pronunciations. The words used in both written code versions were monosyllabic, with CVC structure and phonotactic constraints common to both English and Spanish.

To ensure the two groups included good L1 readers, participants were administered two pretests to check for decoding and spelling ability. For decoding, participants completed a GPC learning task. They had to memorize five symbols and their five corresponding phonemes. They were then asked to decode by reading aloud these five symbols in 10 different combinations. Neither the actual symbols nor their GPC and combinations were included in the later LT and LO experiment learning tasks. All participants learned the task in less than four minutes, and achieved 100 percent accuracy in decoding the GPC combinations. To test for spelling, a one-page written autobiographical sketch was elicited in each language. The autobiographical summaries were checked for spelling errors that could be indicative of reading/writing problems. All participants achieved 95-100% spelling accuracy in these writing samples.

The training/testing protocol included four parts: a) participants learned the 10 letters/phonemes of the Lingo script they were to learn on a given day (LT or LO); b) they were then tested on decoding 10 LT or LO words; c) they were instructed on the meanings of the words they had learned to decode; d) they were tested on their ability to recall the LT or LO word meanings when they heard the spoken words.

Participants

Two groups of monolingual adult participants balanced for gender made up our sample. One group consisted of 20 monolingual Spanish-speakers living in Salto, Uruguay (aged $M = 25.6$ years, $R = 19–30$, years of education $M = 13$, $R = 11–16$). The second group consisted of 20 monolingual English-speakers living in New Jersey, United States (aged $M = 20.5$ years, $R = 18–25$, years of education $M = 13.4$, $R = 12–16$). Recruiting was conducted by posting flyers at community centers and by word of mouth. None of the participants had any reported history of reading and/or learning problems, sensory deficits, or medical history that might interfere with the learning task. Among the English-speakers, five were seniors in high school, 11 were attending college, and four had completed high school and were working. Among the Spanish-speakers, 14 were attending college, two worked, and four had completed high school. One Spanish participant was home-schooled from 6th through 10th grade, attended high school for two years, and worked as a journalist. Another participant completed 10 years of education, two years of vocational schooling, and worked as an administrator. All Spanish-speaking participants came from families where Spanish was the only language spoken. Similarly, English-speaking participants came from English-only households.

To ensure comparability between the groups, we selected middle-class adults of college-age in each country. We considered socioeconomic status (SES) by asking participants to report on their living conditions and professions. Of those living in Uruguay most lived at home with their families (16 participants) and described their SES as middle-class. Their parents had professional degrees or worked. The two older participants (aged 28 and 30) were employed (journalist and manager). Participants living in the United States described their SES as middle-class; 16 were still living at home or attending college, and four worked.

Participants were interviewed individually and completed a written questionnaire to obtain information on SES, language-learning history and reading habits. The questionnaire focused on five aspects: elements of comfort (i.e., having a telephone, internet access, or car), living independently or having individual space at home, parents' education or profession, participants' history of language and/or learning problems, access to consistent and uninterrupted education (see Appendix C).

The main criteria for participation in this study were to be monolingual and to have received consistent education. Monolingual was defined as only having proficiency in the native language (English or Spanish). Consistent education was defined as having uninterrupted learning opportunities. Responses on this written questionnaire were scored on a scale of 1–3 (maximum total score = 15) to quantify information in order to compare the groups: English-readers, $M = 14.35$ (SD .81) and Spanish-readers, $M = 13.95$ (SD 1.09). Paired samples t tests did not yield differences between the groups, $F(1, 19)$ p = .189. See Appendix C for Measuring Scale for Living Conditions and Education History.

Materials

For learning the letters, LT/LO consisted of ten letter symbols (#, Π, ¶, Ω, §, Δ, ≈, ∫, [], ∑) corresponding to ten phonemes. These symbols were selected based on their visual distinctiveness and on their limited novelty. The aim was to include symbols that were easily recognizable, distinct from one another, and with which readers would have some basic familiarity. In a pilot study, a selection of 50 symbols was presented to 10 undergraduate college students in the United States (five Spanish native-speakers and five English-speakers). They were asked to circle 12 symbols that were best differentiated from each other and with which they felt they had some familiarity. The 10 symbols employed in the current study were selected by nine of the 10 students.

The seven consonant phonemes: /s/, /tʃ/, /p/, /t/, /k/, /l/, /n/, and three vowel phonemes: /æ/, /ɛ/, /u/ used in this study are present in English and Spanish. The phoneme combination /tʃ/ was included as a consonant, because it is a phoneme in both languages. LO had the same consonants as LT but each of the vowels had two possible pronunciations (/æ/ or /o/, /ɛ/ or /i/ and /u/ or /au/). The letter symbols with their corresponding phonemes and a word example can be found in Appendices A and B.

Three different sets of 10 test-words were created. One set was used for decoding and one each for testing word meanings for the LT and the LO versions. The words consisted of CVC syllables following legal phonotactic constraints of both English and Spanish. The consonant phonemes /t/, /p/, /tʃ/, and /k/ only occurred in syllable-initial position. In syllable-final position, only the consonants, /s/, /n/, and /l/ were used, as these are the only legal consonants for word endings in Spanish.

Each of the 10 phonemes and 30 words were recorded on magnetic-phonic cards that could be played in a Califone CardMaster Card Reader (2014). This instrument is often used as an audio-visual multisensory aid in the teaching of reading, in classes for ESL, and in speech-language therapy. It can record up to 12 seconds of teacher track for modeling exercises. In this study, the magnetic-phonic cards with pre-recorded phonemes and words were provided for self-guided practice in learning the symbols, their corresponding phonemes, and the stimuli words.

In order to teach meanings, high-frequency nouns (objects and animals) were selected from basal reading texts in each language. All items were concrete nouns that were well known in each culture (e.g., fan, cat, or banana). The corresponding picture for each noun was affixed to each magnetic-phonic recorded card for quick access to meaning. Each time a magnetic-phonic card containing a word was played, the picture corresponding to its assigned meaning was visible on the right uppermost corner of the magnetic-phonic card, as indicated in Appendices A and B.

General Instructional Procedures

Participants worked individually with the first author, who is bilingual and served as instructor while speaking English or Spanish with the respective groups. Participants were told there were two Lingo versions, LT and LO, one of which they would learn that day, and the other one the following day. The order of teaching (LT-LO and LO-LT) was counterbalanced across participants in each group. To minimize crossover effects, participants learned one Lingo version on each of two consecutive days. Thus, one-half of each language group (*N*=10) learned LT (1:1 GPC) one day followed by LO (1:2 GPC) on the second day, and the second half of each language group (*N*=10) learned LO on the first day, followed by LT on the second day.

For each Lingo version, participants were instructed that they should first practice the pronunciation of each symbol and they would be timed to measure how rapidly they could learn. Learning time was recorded when participants indicated knowing the 10 Lingo symbols and phonemes. They were then given 10 printed Lingo words and were tested for decoding aloud. Their correct responses were scored for this variable.

Next, participants learned the Lingo words' meanings and pronunciation by playing the magnetic-phonic recorded cards, which included a picture to depict the meaning. For the LT version, participants read each word and the instructor confirmed its pronunciation. For the LO version, participants read each of two possible pronunciations and the instructor indicated which pronunciation was correct and should be remembered. Once participants indicated knowing the words' meanings, they had to identify each spoken Lingo word from a visual array containing 20 pictures and their scores were again recorded.

Phase I Instruction

We used a structured multisensory approach based on explicit teaching of the letter symbols, phonemes and their combinations (e.g., Sparks, Ganschow, Kenneweg & Miller, 1991; Sparks et al., 2000; Ritchey & Goeke, 2006). Structured multisensory instruction relies of repeated practice of GPC through visual, auditory, and kinesthetic/tactile learning (Ritchey & Goeke, 2006). The learning of LT and LO followed the same teaching procedure. Each consonant was first taught individually, followed by vowels to be combined in medial position between two consonants. For LT, each written word had only a single pronunciation given by the 1:1 GPC of the vowel. For LO, each written word had two possible pronunciations given by the 1:2 GPC of the vowel, but only one of these pronunciations was indicated as the correct one. Confirmation of the correct pronunciation was elicited by asking participants to repeat the correct pronunciation to be memorized.

In order to learn GPC, participants played the magnetic-phonic recorded cards, listened to the phoneme, practiced its pronunciation, and then matched it with the corresponding symbol. Participants were reminded that learning was timed, and they should learn as quickly as possible. Following a sequential multisensory approach, consonants were introduced first, followed by vowels. This allowed participants to combine consonants and vowels to form syllables and to decode them. Learning time was measured in minutes/seconds with a stopwatch and recorded. When participants reported they had learned the GPC mappings for the 10 symbols, they were given 10 Lingo words to decode aloud in the Lingo version just learned, LT or LO. These scores were recorded on an answer sheet.

Phase II Instruction

After the 10-item Lingo word decoding test, we turned to the meaning-learning task to master vocabulary in each Lingo version. Participants learned word meanings by playing the recorded magnetic-phonic cards that had a picture of the noun associated with each word. The word meanings were practiced by engaging participants in two conversational turns: posing a question about the target item and providing a response that included the target item. This was achieved by holding each printed card displaying a picture of the signified object with the Lingo word, and asking the participant to pose questions using the Lingo word, as in this example: "Do you have a favorite *tʃæs*? Do you like to wear *tʃæs*?" The examiner responded by using the target word again in a sentence and posing a similar question, e.g., "Yes, I wear *tʃæs*. What about you? Do you wear *tʃæs*?" The participant was in turn required to provide a response using the target word, e.g., "My favorite *tʃæs* is brown." Following this brief conversational practice for each of the 10 items, participants were tested on their knowledge of each word's meaning. For example, they had to identify the spoken word *tʃæs* from an array of 20 pictures. Whereas the vowel pronunciations were different in each Lingo version, the consonants for the same meanings were the same (e.g., *tʃæs* and *tʃos* both referred to "hat"). A score for the correct number of identified spoken Lingo words to pictures was recorded.

Procedural Reliability for Instruction

Implementation of the instruction procedures followed the same order for all participants (see below). Once each step was completed, the instructor proceeded to the next step. In this way, all participants completed the same number of steps in the same sequence for both the LT and the LO versions:

1. Modeling of consonant phonemes and presentation of associated Lingo symbol.
2. Self-practice in associating consonant phonemes with Lingo symbols by playing recordings on magnetic-phonic cards.
3. Modeling of vowel phonemes and presentation of associated Lingo symbols.
4. Self-practice in associating vowel phonemes with corresponding Lingo symbols by playing recording on magnetic-phonic cards.
5. Self-practice in combining Lingo consonant and vowel symbols for decoding.
6. Decoding test for 10 Lingo words in the LT or LO version learned that day.
7. Practicing the Lingo words in conversation to review and establish meaning for each word.
8. Testing recall for meaning on LT or LO words by identifying spoken Lingo word from an array of 20 pictures.

Design

We used a 2 X 2 design and multilevel crossed random effects modeling (CREM) to measure participants' performance under two transparency conditions (LT and LO). The independent variables were group (English-readers [N = 20], Spanish-readers [N = 20]), and sequence of presentation (LT/LO [N = 20], LO/LT [N = 20]). The dependent variables were learning time for LT and LO GPC mappings, accuracy in decoding LT and LO words, and accuracy in recalling meaning for LT and LO words. The CREM used to fit data for LT and LO was set up with group and sequence as fixed effects. Variation in participants, variation in test items, and their interaction were set up as random effects.

To determine random effects on each of the dependent variables, we first present an "empty" model that only carries the general intercept (γ_o). The random effects were then added in the following CREM formula: $\Upsilon_{si} = \gamma_o + \mu o_s + \nu o_i + \varepsilon_{si}$, where the random effects (participant variation) (μo_s), item variation (νo_i) and a certain amount of random error (ε_{si}) helped explain the participants' observed responses (Υ_{si}).

To determine fixed effects on each of the dependent variables, the predictor model included group (English-readers and Spanish-readers) and sequence of transparency as factors that helped explain the observed responses. Predictors were entered one at a time to test their contribution to the model. We only present the results of the final model: $\Upsilon_s^i = \gamma_o + \gamma_{1group} + \gamma_{2sequence} + \mu o_s + \nu o_i + \varepsilon_{si}$. This model states that in addition to the general intercept (γ_o), the random effect of participants (μo_s), the random effect of item variation (νo_i), and the random error (ε_{si}), the observed responses can be predicted by the participants' L1 group (γ_{1group}) and by the sequence of transparency during teaching ($\gamma_{2sequence}$). In order to determine an estimated effect size, we calculated the proportion of variance explained by the predictor model. To calculate the effect size of the model we used the following formula:

$$\frac{\sigma^2 \text{ “empty” model - } \sigma^2 \text{ predictor model}}{\sigma^2 \text{ “empty” model}}$$

Results are presented for each of the dependent variables, beginning with descriptive statistics and followed by results from the CREM analysis, including effect size for each model. The results of each "empty" model and their predictor models are summarized in Tables 1, 2, and 3. See Tables 4 and 5 for response scores and standard deviations on learning time, accuracy in decoding, and accuracy in recalling meaning.

Results

Learning Time for LT and LO GPC Mappings

Descriptive statistics indicate that time to learn LT and LO varied among participants. English-readers took *M* = 14.8 min (*SD* 7.6) and Spanish-readers took *M* = 12.35 min (*SD* 5) to learn LT. For LO, English-readers took *M* = 15.08 min (*SD* 7.5) and Spanish-readers took *M* = 14.4 min (*SD* 5.1). Overall, LT took less time to learn (*M* = 13.59, *SD* 7.49) than LO (*M* = 15.08, *SD* 7.44). Sequence influenced the time to learn whichever Lingo version was taught first when compared with the subsequent Lingo version. This discrepancy was greater for LO than for LT, showing the effects of transparency. For those who learned LO first, learning time was *M* = 18.38 minutes (*SD* 6.94) and for those who learned it second, learning was *M* = 11.78 minutes (*SD* 6.30). For those who learned LT first, learning time was *M* = 15.64 min (*SD* 8.37) and for those who learned it second, learning time was *M* = 11.55 (*SD* 6.02) (See Figure 1).

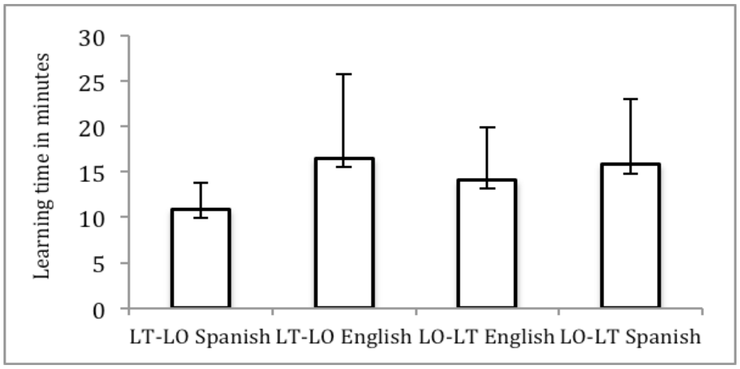

Figure 1. Learning time according to sequence
Note. Error bars are based on standard deviations due to small sample size.

Using CREM, we examined whether transparency predicted the time to learn 1:1 and 1:2 GPC Lingo mappings for English- and Spanish- readers. We included random effects of both participants and word items. The two-predictor variables (group and sequence) were grand mean centered. We first used the CREM to test whether group and sequence of transparency helped predict the participants' observed learning time. Results of the model are summarized in Table 1, Model 2. Sequence of transparency was significant, F (1, 43), p = .002. Group was not significant, F (1, 29), p = .228 in differentiating participants' responses. Covariance components (random effects) were significant for LT items, Z = 3.01, p = .003, but not for LO items, Z = 1.22, p = .219. The intercept for participant variation + items was significant, Z = 2.75, p = .006. The estimated effect size for the predictor model was .84 or 84% of the variance. We therefore conclude that transparency influenced learning time across participants in both groups; regardless of each group L1's reading characteristics. Item transparency and variation among participants helped to explain the observed responses.

Table 1. *Regression coefficient estimates and variance-covariance estimates for cross random effects models predicting time to learn lingo GPC mappings*

Parameters TIME variable	Model 1	Model 2
Regression coefficients		
(Fixed effects)		
Intercept	14.42*** (1.04)	2.34 (3.39)
Group		2.73 (2.20)
Sequence		5.74*** (1.76)
Variance components		
(Random effects)		
Covariance: Item 1	23.23*** (8.36)	33.07*** (10.96)
Item 2	18.40* (8.03)	9.09 (7.40)
Intercept ID + items	33.40*** (10.06)	.088*** (.032)
Model summary		
Deviance statistic (-2LL)	527.26	523.21
# of estimated parameters	4 4	8 6

Note. Parameter estimate standard errors listed in parentheses.
* p < 0.05 *** p < 0.001

Accuracy in Decoding LT and LO Words

Descriptive statistics suggest differences in accuracy for decoding LT and LO words. English-readers decoded M = 8.6 (SD 1.29) and Spanish-readers decoded M = 9.25 (SD .55) LT words. For LO, English-readers decoded M = 6.9 (SD 1.15) and Spanish-readers decoded M = 7.05 (SD 1.25). Overall, more words were decoded in LT (M = 8.92, SD .85) than LO (M = 6.97, SD 1.2). In the LT, LO sequence Spanish-readers decoded more words (M = 8.8, SD .55) than English-readers (M = 7.1, SD 1.5). In contrast, with the LO, LT sequence, English-readers decoded more words (M = 8.4, SD .89) than Spanish-readers (M = 7.5, SD 1.2). See Figure 2.

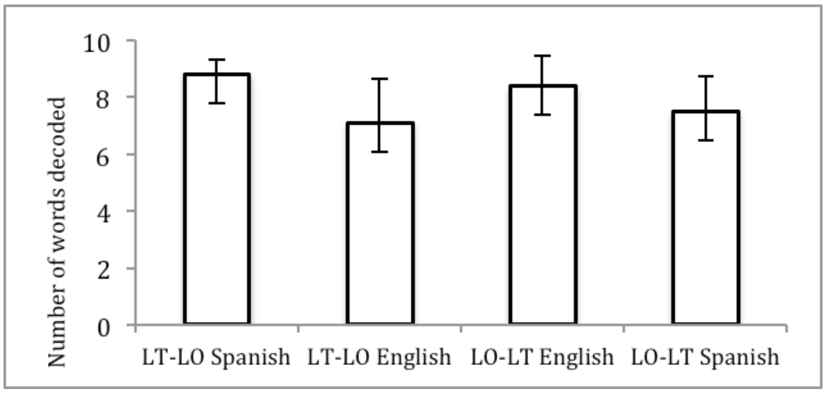

Figure 2. Number of words decoded according to sequence
Note. Error bars are based on standard deviations due to small sample size.

The CREM was used to determine if transparency influenced the accuracy of decoding 1-1 and 1-2 GPC Lingo mappings in English- and Spanish-readers. Random effects were set up for participants and word items. The two-predictor variables (group and sequence) were grand mean centered. The results of the predictor model are summarized in Table 2, Model 2. Group was significant, F (1, 24), p = .040, and sequence of transparency was also significant, F (1, 35), p = .001. Covariance components (random effects) were significant for LT items, Z = 2.55, p = .011, and for LO items, Z = 3.35, p = .001. The intercept for participant variation + items was significant, Z = 2.11, p = .035. The estimated effect size for the predictor model was .56 or 56% of the variance. Our findings suggest that transparency and sequence of presentation influenced the accuracy of decoding in different ways for English- and Spanish-readers, as there were significant group differences. However, random effects associated with item variation and participant variation helped to explain the observed responses.

Table 2. *Regression coefficient estimates and variance-covariance estimates for cross random effects models predicting decoding of lingo GPC mappings*

Parameters READ variable	Model 1	Model 2
Regression coefficients		
(Fixed effects)		
Intercept	7.73*** (.18)	12.10*** (.58)
Group		-.822* (.38)
Sequence		1.95*** (.20)
Variance components		
(Random effects)		
Covariance: Item 1	3.27 (1.07)***	.824* (.32)
Item 2	2.07* (.91)	.914*** (.27)
Intercept ID + items	.069 (.45)	.002* (.00)
Model summary		
Deviance statistic (-2LL)	306.413	258.93
# of estimated parameters	4 4	8 6

Note. Parameter estimate standard errors listed in parentheses.
* $p < 0.05$ *** $p < 0.001$

Recalling Meaning for LT and LO Words

Descriptive statistics indicate that overall, English-readers recalled $M = 15.8$ (SD 1.35) word meanings and Spanish-readers recalled $M = 13.2$ (SD 2.25). In addition, Spanish-readers recalled fewer LO words than English readers in both, the LT-LO and LO-LT sequences. In the LO-LT sequence, Spanish-readers recalled ($M = 6$, SD 2.7) and English-readers recalled ($M = 8.3$, SD 1.0). In the LT-LO sequence, Spanish-readers recalled ($M = 6.3$, SD 2.2) and English-readers recalled ($M = 7.8$, SD 1.1).

The CREM was used to determine if transparency influenced the accuracy of English- and Spanish-readers in recalling meaning for Lingo words with 1-1 and 1-2 GPC mappings. Again, random effects were set up in the model for participants and word items. The two-predictor variables (group and sequence) were grand mean centered. The results of the predictor model are summarized in Table 3, Model 2. Group was significant, F (1, 29), $p = .009$; and sequence of transparency was not significant, F (1, 34) = $p < .392$. Covariance estimates for random effects were significant for LT items, $Z = 2.92$, $p = .003$, and for LO items, $Z = 3.80$, $p = .001$. The intercept for participant variation + items was $Z = .618$, $p = .537$. The estimated effect size for the predictor model was .19, or 19%. Our findings suggest that our groups behaved differently in their ability to recall word meanings with 1-1 or 1-2 GPC transparency. Random effects related to the transparency of the items helped to explain the observed responses.

Table 3. *Regression coefficient estimates and variance-covariance estimates for cross random effects models predicting recalling meaning of lingo words*

Parameters RECALL variable	Model 1	Model 2
Regression coefficients		
(Fixed effects)		
Intercept	7.32*** (0.26)	5.94*** (.84)
Group		1.19*** (.42)
Sequence		-.325 (.37)
Variance components		
(Random effects)		
Covariance: Item 1	1.20* (.56)	2.48*** (.85)
Item 2	2.42*** (.74)	3.14*** (.83)
Intercept ID + items	1.86*** (1.85)	.000 (.00)
Model summary		
Deviance statistic (-2LL)	317.68	319.45
# of estimated parameters	4 4	8 6

Note. Parameter estimate standard errors listed in parentheses.
* $p < 0.05$ *** $p < 0.001$

Table 4. *Means and standard deviations for learning time, decode, and recall*

Sequence	LT First	LO Second	LT-LO Total	LO First	LT Second	LO-LT Total
English-readers	19.5	13.5	16.5	18.1	10.1	14.1
Learning Time	(10.2)	(8.4)	(9.3)	(6.6)	(5)	(5.8)
Spanish-readers	11.7	10.1	10.9	18.7	13	15.8
Learning Time	(3.2)	(2.6)	(2.9)	(7.6)	(6.8)	(7.2)
Total Learning	15.6	11.8	13.7	18.4	11.5	14.9
Time	(6.7)	(5.5)	(6.1)	(7.1)	(5.9)	(6.5)
English-readers	7.8	6.4	7.1	7.4	9.4	8.4
Decode	(1.9)	(1.2)	(1.5)	(1.1)	(.69)	(.89)
Spanish-readers	10	7.6	8.8	6.5	8.5	7.5
Decode	(.00)	(1.1)	(.55)	(1.4)	(1.1)	(1.2)
Total Decode	8.9	7	7.9	6.9	8.9	7.9
Scores	(.96)	(1.1)	(1)	(1.2)	(.88)	(1)
English-readers	7.1	7.8	7.4	8.3	8.5	8.4
Recall Meaning	(1.8)	(1.1)	(1.5)	(1)	(1.4)	(1.2)
Spanish-readers	7.1	6.3	6.7	6	7	6.5
Recall Meaning	(1.8)	(2.2)	(2)	(2.7)	(2.2)	(2.5)
Total Recall	7.1	7	7	7.1	7.7	7.4
Scores	(1.8)	(1.7)	(1.8)	(1.9)	(1.8)	(1.8)

Note. Lingo Transparent (LT) and Lingo Opaque (LO). Learning time scores are provided in minutes/seconds; LT-LO and LO-LT Total scores are provided as Means; numbers within parentheses are standard deviations.

Table 5. *Total LT and LO scores for time, decode, recall*

Combined Scores	LT/Time	LO/Time	LT/Decode	LO/Decode	LT/Recall	LO/Recall
English-readers	14.8	15.8	8.6	6.9	7.8	8
	(7.6)	(7.5)	(1.3)	(1.1)	(1.6)	(1)
Spanish-readers	12.4	14.4	9.2	7	7	6.1
	(5)	(5.1)	(.55)	(1.3)	(2)	(2.5)
Total	13.6	15.1	8.9	7	7.4	7.1
	(6.3)	(6.3)	(.93)	(1.2)	(1.8)	(1.8)

Note. Lingo Transparent (LT) and Lingo Opaque (LO). Time, Decode, and Recall include Mean for sum of LT or LO in the LT-LO and LO-LT sequence: (LT1+LT2)/2 and (LO1+LO2)/2; numbers within parentheses are standard deviations.

Discussion

In this study we set out to compare the influence of L1 orthographic transparency on how monolingual English- and Spanish-readers learned a novel L2 orthographic system with a 1:1 or a 1:2 GPC. We first asked whether orthographic transparency would facilitate the learning of GPC mappings or not. Consistent with other research (e.g., Spencer, 2007; Ziegler et al., 2010) we found that for the participants in this study, it was easier to learn an orthographic code with a 1:1 GPC than a code with a 1:2 GPC. The transparency effects were evident for the learning time, the accuracy in decoding, and in participants' ability to recall LT and LO word meanings.

We found that LT was learned faster than LO and that sequence of transparency influenced learning time across participants. There were group differences in the accuracy of decoding LT and LO words among participants. These differences were influenced by sequence of transparency, which matched the participants' L1 reading systems. There were also group differences in recalling word meanings for LT and LO words. Spanish-readers had more difficulty than English-readers in recalling LO words. Random effects associated with item transparency and participant variation also helped to explain the observed learning time, accuracy in decoding, and recall for word meanings among the participants in our study.

Readers in transparent orthographies need to master fewer speech-to-print associations than readers learning to read more opaque writing systems. Therefore, learning to read in a transparent orthography imposes fewer constraints than learning to read in a more opaque writing system. These findings are consistent with estimates of decreased reading problems in transparent orthographies, such as Spanish, Italian, and German (e.g., Alegría & Morais, 1991; Carrillo, 1994; Serrano & Defior, 2008; Tressoldi et al., 2001) and increased challenges for children learning to read in a more opaque orthography, such as English (e.g., Seymour, Aro, & Erskine, 2003). The importance of efficient GPC learning on decoding cannot be underestimated. Readers must be able to readily access sounds from letters and integrate this information to efficiently decode words. The automaticity of this process is what determines the ease or difficulty encountered in decoding and ultimately in building orthographic word recognition, not only in alphabetic writing systems, but also in less transparent writing systems (e.g., Perfetti & Hart, 2002; Perfetti et al, 2001). Ehri (2005) pointed out that extracting phonological information is crucial in building word identification processes for reading in English. Likewise, efficient phonological extraction is crucial in decoding and word identification when reading in Spanish (Cuetos & Suárez-Coalla, 2009).

A second likely explanation for the advantages that readers experience when decoding in transparent orthographies is that phonological awareness is reinforced by the regularity of the speech-to-print associations. This regularity may help readers to establish lexical quality representations or word-specific orthographic recognition through increased practice (Perfetti & Hart, 2002; Share, 1995). The strong interaction between phonological processing and decoding has been shown in monolingual research, both in English and in Spanish (e.g., Defior, 2004; Durgunoglu et al., 1993; Goswami et al., 1998). Phonological decoding is such a strong and reliable strategy in Spanish that the slow reading rate through decoding of Spanish-speaking children with dyslexia has been described as delayed rather than symptomatic of dyslexia (Davies et al., 2007).

In our study, orthographic transparency influenced GPC learning and decoding across participants in both groups. Our findings indicate the relevance of considering orthographic transparency when teaching an L2 to adults and even in developmental reading instruction. Further research is needed on applications of orthographic transparency in foreign language teaching and in literacy instruction with dual-language learners.

Our second question was whether L1 reading constraints influence word decoding in a more transparent or a more opaque L2 written system. We found differences between the groups denoting the influence of the participants' L1 reading characteristics on their ability to decode LT and LO Lingo words according to the sequence of presentation. Spanish-readers read more words in the LT, LO sequence and English-readers read more words in the LO, LT sequence. Thus, the influence of the L1 had an effect on how efficiently each group decoded the Lingo words presented. Our findings are consistent with studies that show that specific L1 linguistic processes not only influence L2 acquisition, but also constrain the cognitive processes engaged in L2 reading (e.g., Geva & Siegel, 2000; Koda, 2004; Koda, 2007). It appears likely that the Spanish-readers in our study expected to decode using a 1:1 GPC strategy, whereas the English-readers expected more variety in decoding and word recognition, using a 1:many GPC strategy. Given the strong role of phonological processing in reading across languages (Perfetti & Liu, 2005; Perfetti & Dunlap, 2008), more research is needed in this area to understand cross-linguistic effects on L2 reading.

Our third question focused on whether orthographic transparency influenced vocabulary or recalling the meaning for Lingo words learned in the LT and LO versions. Our findings revealed group differences that were not sufficiently explained by random effects, such as variation among participants and variation in the test items used in this study. Orthographic transparency had an effect on how English- and Spanish-readers in this study recalled the meaning of the Lingo words learned. Spanish-readers recalled more LT words than LO words, whereas English-readers recalled similar numbers of LT and LO Lingo words. Monolingual research with school-age children shows a relationship between decoding ability and vocabulary building (e.g., Biemiller, 1999; Nation, 2001; Ouellete, 2006; Share, 1995). Less is known about decoding ability and vocabulary learning when learning a second language in adults. Phonological coding skills are linked to word learning ability in foreign language research (Sparks et al., 2006). Efficient phonological processing is also a key predictor in word learning and in reading comprehension during the school years. Future research should explore the relationships of transparency, decoding, and word building in learning a foreign language, particularly in adult learners.

Two main limitations constrain generalization in our study: its small sample size and the lack of a double blind method. Because participants worked individually with the first author, it is possible that research outcomes were influenced by experimenter bias rather than the independent variables. In addition, our participants were not matched on cognitive skills that could have influenced their reading performance. Our results must therefore be interpreted with caution. Future studies in this area should be conducted with larger groups where the participants are also matched on cognitive measures and double blind procedures are implemented.

In spite of these shortcomings, our data suggests that constraints associated with readers' L1 GPC type influence learning to read in an L2. That is, a tighter, more univocal bond between GPC mappings facilitates learning to decode in an L2. Further research is needed to explore how readers' L1 orthography-phonology mappings influence vocabulary learning in an L2. Explicit teaching of these relationships may be of particular value to English-readers learning Spanish and to Spanish-readers learning English as an L2.

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Appendix A

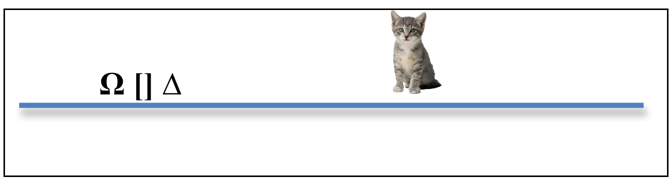
Lingo Symbols and Phonemes

Lingo Transparent (LT)		Lingo Opaque (LO)	
#	/s/	#	/s/
P	/k/	P	/k/

¶	/t/	¶	/t/
Ω	/n/	Ω	/n/
§	/tʃ/	§	/tʃ/
Δ	/l/	Δ	/l/
≈	/p/	≈	/p/
∫	/u/	∫	**/u/** **/au/**
[]	/e/	[]	**/e/** **/i/**
∑	/a/	∑	**/a/** **/o/**

Appendix B

Example of Lingo word on magnetic-phonic cards



Note: Magnetic-phonic card for the word /nel/ or /nil/ (cat). Blue strip holds recording to be played on Califone CardMaster Reader.

Appendix C

Measuring scale for responses on living conditions and education history

3 point scale based on 5 questions

1. Eight elements of comfort at home (circle all the ones that apply). At home I have:
   Air conditioner, washing machine, computer, internet-access, television, telephone or cell-phone, car or motorcycle, dishwasher.
   i. Score 3 (7-8 elements of comfort)
   ii. Score 2 (5-6 elements of comfort)
   iii. Score 1 (3-4 elements of comfort)

2. Living at home:
   a. Having own bedroom or having office space at home
   b. Sharing bedroom and having an office space at home

   c. Sharing bedroom and not having any office space at home
      i. Score 3 (own bedroom/office)
      ii. Score 2 (shared bedroom/no office)
      iii. Score 1 (shared bedroom and no office)

3. Parents' education and profession/occupation
   a. Completed college/some college
   b. Completed high school/some high school
   c. Completed elementary school or less
      i. Score 3 (college/some college)
      ii. Score 2 (high school/some high school)
      iii. Score 1 (elementary school/some elementary)

4. Language and learning history
   a. No history of any language or learning problems
   b. Needed some tutoring during school
   c. Repeated one grade or more / failed any college classes
      i. Score 3 (no history of language or learning problems)
      ii. Score 2 (needed some tutoring)
      iii. Score 1 (repeated one grade/failed college class)

5. Received consistent and uninterrupted education
   a. Never stopped attending school. Number of years of education_____
   b. Brief interruption due to illness or other causes (two months or less)
   c. Long interruption for various causes (three months or longer)
      i. Score 3 (never stopped attending school)
      ii. Score 2 (interruption of 2 months or less)
      iii. Score 1 (interruption of 3 months or longer)

Total score:

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