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Spanish Heritage Bilingual Perception of English-Specific Vowel Contrasts

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ABSTRACT

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Theories of lexical storage differ in how entries are encoded in the lexicon. Exemplar-based accounts posit that lexical items are stored with detailed acoustic information, while abstract accounts argue that fine acoustic detail is removed and an item is stored in more basic phonological units.

These separate accounts make distinct predictions about cross-linguistic and bilingual perception. Studies asking participants to compare non-native vowels have shown that people tend to associate multiple non-native phonemes to a single L1 phoneme when the contrast between the two does not exist in the L1. However, several studies have shown that the ability to discriminate sounds is never lost.

A line of research has focused on how bilinguals perceive contrasts in their second language. One such study, Pallier et al. (2001) looked at early bilinguals of Spanish and Catalan, testing whether the native Spanish speakers, who were highly proficient in Catalan, perceived certain Catalan minimal pairs as homophones. Importantly, the contrasts of these minimal pairs were exclusive to Catalan. The native Spanish bilinguals heard pairs such as /neta/-/nɛta/ in an audio-only lexical decision task (LDT), and showed responses to the second item that were not significantly different from actual item repetitions (i.e., /neta/-/neta/). These results were taken as evidence in favor of abstractionist models of lexical storage.

This study was based on Pallier et al, (2001), examining instead the perceptions of heritage speakers of Spanish (HSSs) in the U.S., children of native Spanish speakers who get early and sustained exposure to their second language, English. Unlike the bilinguals studied in Pallier et al., heritage bilinguals receive little linguistic or social support for development of their first language. The L1 proficiency of adult heritage bilinguals varies considerably. In this study, a group of these HSSs participated in an LDT testing their perception of English-exclusive phonemic vowel contrasts (i.e., *peak-pick*). It was hypothesized that, like Pallier et al.'s highly proficient bilinguals, HSSs would show responses to the second item of these minimal pairs as if it were a repetition of the first.

Results of the LDT did not confirm the hypothesis. The heritage Spanish speakers did not perform significantly differently from the native English controls on English-specific contrasts ($p = .065$), and it was found that the native English speakers showed higher priming on these minimal pairs than HSSs. These results run counter to those of previous studies, and may disfavor an abstract account of lexical storage. At the very least, the construct validity of this methodology is questionable when the control and experimental participants reverse hypothesized behavior.

Keywords: perception, lexical storage, bilingualism, heritage bilinguals

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INTRODUCTION

Current lexical theories differ in one important aspect: whether lexical items are stored with acoustic detail or in an abstracted form. Following the former assumption, when humans learn a word we make a sort of mental recording every time we hear it. These mental recordings are stored as exemplars of the word in question, containing specific phonetic detail. As we perceive speech, we match what we pick up in the signal to these exemplars. If the latter theories are correct, then a different process occurs, in which the speech signal is abstracted pre-lexically, stripped of all unnecessary acoustic/phonetic detail, and stored as a string of L1 phonemes. If lexical items are stored this way, then when we perceive speech, the signal is turned into basic phonological units of our native language, which are then matched to lexical items.

Previous research has shown that bilinguals, even early-age onset bilinguals, tend to associate two or more L2 phones to one L2 phoneme. Evidence of this can be found in studies looking at conscious vowel perception tasks, in which bilinguals consciously rate two vowels as more similar than native L2 speakers do. Other studies have looked at how this assimilation may percolate into the mental lexicon of bilinguals, influencing how they respond to minimal pairs whose contrast only exists in the L2. Results have consistently supported the notion that such minimal pairs are stored in the lexicon as homophones. One such study (Pallier, Colomé & Sebastián-Gallés, 2001), looked at adult early Spanish-Catalan bilinguals. The study made use of a Lexical Decision Task (LDT) to test how these Spanish-dominant bilinguals responded to Catalan minimal pairs whose contrasts are not phonemic in Spanish (e.g., /neta/ vs. /nɛta/). The bilinguals, despite being highly proficient in both languages, showed a significant tendency to treat the second item of a Catalan minimal pair as if it were a repetition of the first item. The

control subjects, similar bilinguals except for being Catalan-dominant, showed no such effects, indicating that they perceived the second item of the minimal pair as novel. As in similar bilingual studies, Pallier et al. say that these results favor lexical theories in which lexical entries are phonologically abstracted before they are stored. Otherwise, they reason, L2 minimal pairs would not show such priming effects.

While bilingual studies like Pallier et al. have presented consistent results, the general question of how words are stored mentally (especially how to reconcile bilingual results with monolingual results) remains unanswered, since previous research has supported an exemplar-based account. Research on this subject looking at heritage bilinguals (i.e., early-onset bilinguals who in many cases are dominant in their second language) is relatively new. Since heritage bilinguals receive early input in their second language, which input often overtakes first-language input, exemplar and abstract accounts make different predictions about how these bilinguals will store second language lexical items. Studying heritage bilinguals may give new insights into understanding how the mental lexicon is encoded and formed.

The current study used the Pallier et al. (2001) study as a model, and sought to replicate with heritage bilinguals the results with bilinguals in which L2 minimal pairs primed one another, indicating perceptual and lexical association. As to the question of whether heritage bilinguals treat the second item in a minimal pair as if it were a repetition of the first, it was hypothesized that they would, since an abstract account predicts that when L2 words are learned, they are stored in the lexicon in the form of L1 phonemes. This study looked at how heritage Spanish bilinguals respond to minimal pairs from their second language, English. Two English vowel contrasts, /i/-/ɪ/ and /æ/-/ɑ/, were used to create minimal pairs (e.g., /lid/-/lɪd/) to be tested in an LDT.

Results confirming the hypothesis would strongly support the case for bilinguals perceptually associating L2 contrasts, and would also support abstract accounts of lexical storage.

Results of the study were mixed. The crucial hypothesis, that heritage Spanish speakers would treat the second item as if it were a repetition of the first, was not confirmed. Additionally, the results did not support other important assumptions: for example, that native English speakers treat the second item in a minimal pair as a novel item. Not only was the hypothesis not confirmed, but these negative results raise questions about the validity of this methodology as it pertains to questions about perception and phonological aspects of the mental lexicon.

Research Questions

Ultimately, this study sought to contribute an answer to the question of whether a person's L1 phonology influences perception even in cases where the L2 has come to dominate in terms of linguistic proficiency.

1. Do L1-Spanish L2-English heritage speakers demonstrate facilitation effects (priming) on English minimal pairs differing in contrasts that do not exist in Spanish? (i.e., Do we get similar results to Pallier et al. (2001) even with heritage speakers?)

2. Do real word + pseudoword mixed pairs behave similarly to real+real pairs in terms of priming effects?

    a. On pairs showing the real word first (i.e., ***weed***...*wid*), do we see any change in reaction times on the second member of the pair?

    b. On pairs showing the pseudoword first (i.e., ***wid***...*weed*), do we see any change

in reaction times (facilitation effects) on the second member of the pair?

This study was based on Pallier et al. (2001), who sought to verify by new means the previous results these authors had obtained. That is, they had shown in other studies on the same groups that Spanish-to-Catalan early bilinguals perceive Catalan-specific vowel contrasts as the same despite early and prolonged exposure to their L2, Catalan.

In answering question one, it was hypothesized that:

1. The heritage speakers as a group would show significant priming on minimal pairs on which their English-L1 peers show none (pairs of the type *teak*/*tick*).
2. The heritage speakers' repetition priming on English minimal pairs would be significantly higher than pairs differing in contrasts common to both English and Spanish.
3. The heritage speakers' repetition priming on English minimal pairs would not significantly differ from their own response times on the actual repetition of an item.

Confirmation of these hypotheses would lend support to and extend the conclusion of Pallier et al. that words are stored mentally in abstract phonemic form, since it would indicate that heritage speakers perceive and store L2 words in basic phonological L1 units.

In answering question two, it was hypothesized that:

1. The pseudoword/real word minimal pairs would show results confirming the hypothesis that heritage speakers perceive L2 sounds through their L1 filter.
2. On pseudoword/real word pairs, significant priming would be observed (similar to real+real pairs), indicating a facilitation effect.

Pseudoword + real word pairs were included in this study to answer the question of

whether a pseudoword like *wid* can activate a lexical item like *weed*. Confirmation of these hypotheses would lend further support to the conclusion that heritage speakers perceive their L2 through their L1 phonology. If native Spanish speakers consistently neutralize an English contrast such as /i/-/ɪ/ perceptually, then it is expected that a pseudoword such as *wid* will, through this neutralization, activate the word *weed*. This activation would then lead to priming when *weed* is eventually heard. These hypotheses were chosen because assuming that Pallier et al.'s conclusions are true, we ought to expect that even minimally contrasting pseudowords, once stripped of phonetic detail prelexically, will at least activate their real-word partner, even if this activation is eventually disregarded. Since we expect the subject to correctly answer that these pseudowords aren't real words, the lexical item is never beaten out by a competing item. The real word subsequently heard should then show evidence of its earlier activation. Inversely, if the real word is heard first and successfully activates, we ought to see evidence of that in stronger activation levels when the pseudoword comes up. Again, assuming the subject eventually reaches the conclusion that the pseudoword is not real, this should take longer than normal since the real word has been activated. Any significant results will likely illuminate this intriguing concept.

REVIEW OF LITERATURE

Speech Perception Theories

Questions about speech perception lead many researchers to the question of how lexical items are stored in the mind, since many researchers regard continuous speech perception essentially as a task of word recognition. Theories about the interface between perception and the lexicon differ in one important way: some posit that lexical entries are stored in some abstract form, while others put forward that words are stored in precise phonetic detail (McQueen, 2005). The former imply that a word is stored in the mind as a code of abstract pieces. Whether the pieces are phonemes, syllables, features, or some other unit is a matter of further debate. The latter imply that a word is stored with fine phonetic detail. The former are referred to as prototype or abstractionist models, while the latter are often referred to as exemplar models (Pallier et al., 2001). The answer to which of these accounts is more accurate has implications for how humans perceive speech.

Under an exemplar approach to lexical storage, speech perception is essentially a matter of continuously matching chunks of the speech signal to the best candidate stored in memory (McQueen, 2005). It is assumed that the closest match found in the lexicon will be an episodic memory connected to the intended word.

Under an abstractionist approach, speech perception is facilitated by a pre-lexical abstraction of the speech signal. Before the lexicon is consulted, the speech signal is assumed to be stripped of all phonetic detail and converted into the abstract code of the lexicon. As stated earlier, the unit of this abstract code is another matter of disagreement, some candidates being

the phoneme and the syllable (among others). Whatever the unit used, the lexicon is stored in this form, and thus each lexical entry, or word, is stored as one form. Once the speech signal has been put into this abstract form, a similar process of finding the closest match occurs, though under this account, this step ought to be cognitively much less intensive. When different acoustic signals appear in different contexts, humans are able to correctly interpret them as the same underlying phoneme; when the same acoustic signal appears in different contexts, humans are able to correctly interpret them as different phonemes. Facts such as these lend support to there being an abstraction away from the speech signal (McQueen, 2005).

This study seeks to determine if data collected from heritage bilinguals has anything to contribute to the debate. Heritage bilinguals have a strong command of the (sequentially) second language, implying this language's dominance over the L1. If the results of the current study agree with those of Pallier et al. (2001) and the hypotheses are confirmed, the results may be said to favor abstractionist theories.

Cross-linguistic Perception

Research has verified that when a person hears a language they don't know, an apparent filtering effect can be observed, as if the foreign speech signal passed through the native phonology on its way to perception (Best, 1994; Best, 1995; Best & Tyler, 2007; Flege, Munroe & Fox, 1994). For example, when a native Spanish speaker begins learning English, several vowel pairs that may feel clearly distinct to a native English speaker are often perceived by the Spanish speaker as one and the same. One such pair, /i/-/ɪ/, causes a great amount of difficulty, and at times even fear, since a native Spanish speaker often feels s/he cannot know whether s/he

is saying an innocent word such as *beech* or *sheet*, or accidentally uttering their taboo counterparts (Zuengler, 1988; Barkov, 2013; Kirylo, Thirumurthy & Spezzini, 2010). This filtering effect often makes learning the pronunciation of a foreign language particularly difficult, especially for later learners. However, this first-language (L1) filtering effect is not absolute, and native speakers can be trained to distinguish difficult non-native contrasts (Lively, Pisoni, Yamada, Tohkura, & Yamada, 1994).

Bilingual Perception

The Perceptual Assimilation Model (PAM model) (Best, 1994) suggests that perception and discrimination are connected to the relationship between the inventories of the first and second languages. That is, the perceptual similarity of the sound systems of the two languages determines the difficulty or ease with which the second language will be acquired and perceived.

Evidence has shown that perception of second-language (L2) contrasts changes with experience in the L2 (Fox et al., 1995; Flege et al., 1997; Morrison, 2008). That is, even without explicit training, it seems that our minds make gradual adjustments to our perceptions as we become more and more accustomed to a new language. And these adjustments may translate into greater ability to distinguish non-native contrasts, even in later bilinguals. Some studies have shown, however, that early bilinguals retain, at least to some degree, non-discrimination of L2 contrasts to L1 phonemes at the lexical level (Pallier, Colomé, & Sebastián-Gallés, 2001). This type of evidence seems to favor models of speech perception in which the speech signal is stripped of phonetic detail and perceived in an abstract form. Otherwise, non-native contrasts would be readily accessible to the perceiver.

In a study reported in a 2012 presentation, Maria-Josep Solé examined the perception of Spanish and Catalan advanced learners of English using an experiment similar to that used here, a medium-term (i.e., with test items spaced 8-20 items apart) auditory repetition priming LDT (Solé, 2012). Solé reported "no facilitation effects for words differing in an English-specific contrast for L2 speakers." These results suggest that the advanced learners perceived the words as separate and unique. Although the results were described as "preliminary", they are opposite the hypothetical expectations here. As if to add to the puzzle, a priming effect was observed for pseudoword minimal pairs (e.g., /brib/ primed /brɪb/). Pseudoword minimal pairs are expected not to trigger priming, since they don't activate lexical items. Although both Solé's study and Pallier et al.'s study examined two linguistically distinct groups, their respective results seem to run in direct contradiction. Solé indicates that her results suggest that "the sound categories may only be abstracted from lexical contrasts at a later stage" of acquisition. If it can be established that late bilinguals and early bilinguals consistently obtain opposite results, this may provide further evidence that early bilinguals are fundamentally different from late bilinguals in the way they perceive novel sound contrasts.

Despite contrary results, other studies, such as that of Cutler and Otake (2004), show LDT results consistent with this study's hypothesis of bilinguals showing priming on contrasts not existing in their L1. Cutler and Otake looked at Dutch and Japanese native speaker perception of English phonemic contrasts (/æ/-/ɛ/ for Dutch speakers; /r/-/l/ for Japanese speakers), and found significant priming effects (i.e., /æ/ primed /ɛ/ and vice versa). In later studies (Weber & Cutler, 2004; Cutler, Weber & Otake, 2006), however, it was shown that Lexical Decision Tasks may hide what is really going on in perception. These studies used eye tracking to get a window into lexical competition. With the same Dutch and Japanese

populations, participants were given audio stimuli (words) indicating which of two images to click on. The first halves of these words were minimal pairs (e.g. *panda-pencil*, *rocket-locker*), giving a clue into how the two images may compete in the listener's mind before the word is recognized as one or the other. The English /æ/-/ɛ/ contrast is known to assimilate to Dutch /ɛ/. The Dutch listeners were not distracted by the panda image when they heard the first syllable of the word *pencil* (that is, hearing the beginning of *pencil* didn't trigger the idea of a panda). Interestingly, however, they were distracted by the image of a pencil when hearing the first syllable of *panda*. This asymmetry, the authors suggest, indicates that perhaps while the dominant phoneme (/ɛ/) is always passed on to the lexicon at the moment of perception, the words must be encoded in different ways such that only a word truly containing /ɛ/ could be activated by /ɛ/ in the input. Results with Japanese listeners (2006) further confirmed the account of an asymmetric phonemic assimilation and provided evidence that orthography is not to blame.

Early Spanish-English Bilinguals

Of interest here is the lexical representation and perception of L2 words in the minds of heritage Spanish speakers (HSSs): that is, adults whose language spoken in the home was Spanish, but who began learning English at or before the age of six, and who after continue using English predominantly. Spanish possesses five monophthong vowels, /i/, /e/, /a/, /o/, and /u/, a much simpler spread than that of the English vowel inventory, which, while it varies much depending on regional variety, contains at least eleven contrasts in the phonology of General American English (/i/, /ɪ/, /e/, /ɜ/, /æ/, /ʌ/, /ə/, /ɑ/, /ɔ/, /u/, and /ʊ/). The difference in complexity of these two phonologies creates the potential for phonemic vowel contrasts in English to be neutralized in the mind of the native Spanish- L2 English speaker. If this neutralization reaches

the depths of lexical storage, the expected result is that minimal pairs representing an English-only vowel contrast will be stored and retrieved (perceived) as if homophones.

Pallier et al. investigated a group of 64 experienced, "highly fluent" Catalan-Spanish bilinguals looking for evidence of influence of the dominant language on perception of the second language (Pallier et al., 2001). The control and experimental groups were essentially identical to each other in every way but one: the ordering of Spanish and Catalan as their L1 and L2. The control group were Catalan-to-Spanish bilinguals. They had come from Catalan-speaking homes, and had started learning Spanish in kindergarten. The experimental group were the inverse. Both groups had received bilingual education, and had apparently reached identical or near-identical proficiency (as determined by interviews for previous studies) in both languages.

The item list used by Pallier et al. consisted of 64 Catalan minimal pairs, 24 with Catalan-specific contrasts, 8 with contrasts common to both Catalan and Spanish, and 32 consisting of pseudowords. Three contrasts were used: /e/-/ɛ/ (***n****é**ta-n**e**ta*), /o/-/ɔ/ (***o****ssos-**ó**ssos*), and /s/-/z/ (***c****inc-**z**inc*). The pairs were counterbalanced across four lists, such that for every pair *a*-*b* (*cinc-zinc*), one list contained a repetition of *a* (*cinc...cinc*), one a repetition of *b* (*zinc...zinc*), one both in the order *cinc...zinc*, and one both in the order *zinc...cinc*. Repeating one word from a minimal pair gives pure repetition priming data to which to compare priming effects between both words in a pair. When a minimal pair contrast is common to both languages (i.e., ***p****ala-**b**ala*), the expectation is that both groups of participants will show no priming effects. The key condition are those minimal pairs with Catalan-specific contrasts (described above). As expected, the Catalan control participants showed no priming effects for these pairs, while their experimental counterparts showed significant priming. Additionally, the priming effects seen on these minimal

pairs was no different from that seen in the repeated word condition, favoring the interpretation that the Spanish-dominant bilinguals perceived the Catalan minimal pairs as homophones. The pseudoword minimal pairs showed no repetition priming for either group, importantly lending strength the fact that only the real words tap lexical knowledge.

As an extension of the Pallier et al. study, the present study included minimal pairs consisting of a real word paired with a pseudoword. Although it was unclear at the outset what the results of including such pairs would be, they were used to test the hypothesis that pseudowords could be shown to prime real words, if the pseudowords differ minimally from the real word they are priming.

Pallier et al. seem to go as far as implying that the crucial priming effect demonstrated by the experimental group was due to their perceiving the minimal pairs as homophones. They never explicitly state whether this perception is merely subconscious, or if it extends to more careful, conscious differentiation tasks. If it extends to conscious discrimination, we would expect control participants to mistakenly say that *wid* is a word (hearing *weed*). If indeed these minimal pairs are perceived as homophones, we can expect that error rates will be higher for pseudowords that are members of these special pairs, since they ought to be perceived as the other member of the pair.

Beyond testing the error rates of pseudowords in mixed pairs, it is unclear what effects, if any, should be expected. It is hypothesized that pseudowords ought to prime real words. If these pseudowords produce consistently high error rates (i.e. if the experimental group thinks they are real words), we should expect simply that these pairs show the same priming effects as the real-real minimal pairs. The expectation is, however, that the experimental participants' error rates for these words will be the same as that of the controls. If this is the case, and significant priming is

still seen on mixed pairs (pseudo+real), then priming on real+real pairs might be attributed merely to effects of the experiment.

A later study (Navarra, Sebastián-Gallés & Soto-Faraco, 2005) looked again at early bilinguals of Spanish and Catalan. In it, the authors argue that previous research involving conscious discrimination may not capture the reality of the unconscious perception/recognition process. The task involved listening to disyllabic nonwords and determining which category the first syllable belonged to (between two categories, /ti/ and /pu/). The subjects were instructed to attend to the first syllable, since the second did not matter to the task. Minimal pairs contrasted in terms of the second-syllable vowel (/tike/-/tikɛ/, /puke/-/pukɛ/), and Catalan-dominant bilinguals took longer to respond to the second item while Spanish-dominant subjects did not, indicating that processing took longer for the Catalan-dominant group because they perceived the contrast.

Heritage Bilinguals

The Catalan-Spanish early bilinguals who participated in studies described above fit the definition of heritage bilinguals, although development of their L1 (Catalan) is supported through bilingual education. For Spanish heritage speakers in the United States, this kind of support typically does not exist. Heritage bilinguals differ from late bilinguals in that their input from the L2 begins early and may overtake that of the L1. Late bilinguals often learn about their L2 in a classroom setting, and this way gain metalinguistic knowledge that heritage bilinguals

may lack, since heritage bilinguals' knowledge of their first language is acquired in a naturalistic setting.

It is well established that heritage Spanish speakers enter Spanish classrooms with unique advantages over their English-L1 peers. Of these perhaps the most notable is their often native or near-native pronunciation, hinting at their early acquisition of the L1 phonology despite frequent deficits in syntax, lexicon and other areas when compared to native speakers.

The use of the term *heritage speaker* is preferred here for a few reasons. While heritage speakers in most cases fit the academic definition of bilingual, it is useful to make a distinction both within and outside academia to refer to the unique linguistic and social characteristics found in heritage speakers. The population studied in Pallier et al. (2001) are called early bilinguals. While this term certainly describes heritage speakers, it is clear from the description of Pallier et al.'s population that there are important differences. The bilinguals studied by Pallier et al. came from Spanish or Catalan speaking homes, and had started learning the other language when they began school, at or about the age of five years. The important difference is that these bilinguals had gone through school learning in both Spanish and Catalan. Their proficiency in their L2 is qualified as "highly fluent". On the other hand, the population of the present study have likely received little to no schooling in their native language, relegating the L1 to extremely limited domains including home and family life and certain community gatherings. While they are bilingual, it would be inaccurate to say that their L1 proficiency matches or dominates that of their L2. On the contrary, it is clear that in many respects their L1 grammars lack many features found in highly proficient bilinguals. As a group, heritage speakers represent a linguistically

heterogeneous population made up of individuals with widely varying abilities in their L1, which may vary from only passive receptive skills to full productive skills.

While their linguistic characteristics make this categorization problematic, they all share important social characteristics that differentiate them from the highly fluent bilingual. They all come from a minority L1 background, and were raised for most or all of their life in an L2-dominant society. Many receive little or no linguistic support from school or other public domains.

While researchers have indicated an awareness of heritage speakers (HSs) for decades (Fallis, 1975), research focusing on them specifically from the acquisition and educational fields has only truly begun relatively recently. Two definitions, put forward by Valdés (2001), have generally been adopted to describe heritage learners. One, the broader definition, is anyone with a personal connection to a *heritage language*, which is defined as a minority language, at least in the United States. The more narrow, linguistic, definition is someone "who is raised in a home where a non-English language is spoken, who speaks or at least understands the language, and who is to some degree bilingual in that language and in English." (Valdés 2001) By the broad definition, seemingly any rationalization for an increased motivation to learn the language would, by definition, qualify the learner as a heritage learner. The author's Danish ancestry, for example, if he cited it as a reason for wanting to learn Danish, would qualify him as a heritage learner of Danish. It is the narrow, linguistic definition, however that is used here.

Phonological perception research on heritage bilinguals is relatively recent. A 2013 study (Boomershine, 2013) used a similarity rating task to examine HSSs' perceptions of English front vowels, compared to the results from other groups. Boomershine found that the heritage subjects' perceptions patterned identically to the native Spanish late bilinguals, which implies the

strong phonological effects of early acquisition. She suggests, however, that much more research is needed looking into the perception of HSSs.

In this study, English minimal pairs were tested for priming effects in HSSs. First-language (L1) English speakers do not show priming on English minimal pairs, since the second item is not perceived as a repetition of the first. However, depending on the pair in question, L1 Spanish speakers often do show repetition priming on pairs whose contrast does not exist in Spanish.

METHODOLOGY

Study Design

A Lexical Decision Task is a type of psycholinguistic experiment design in which the subject responds to stimuli one by one, answering the question of whether each stimulus is a word or not. As can be guessed, some of the stimuli are real words, while others are not (i.e., pseudowords). The stimuli may be presented visually, in audio or both, depending on what is being tested. While it may be important how well each subject performed at the lexical decisions (i.e. getting the answers "right"), the crux of the study is the time taken to respond to each item. When an item's response times are significantly lower (faster) relative to others due to its following a priming item, it can be said that this item has been "primed". That is, the subject was, due to the preceding stimulus, more prepared for it than for the others. While many different types of priming exist, this study concerns itself with repetition priming.

Repetition priming refers to the effect seen when an item is repeated after having already been presented once. The second presentation of a stimulus reliably shows repetition priming, indicating that the first presentation of the item "primed" the second. Repetition priming only occurs when the repeated stimulus is a real word (Pallier et al., 2001). That is, the priming implies that the subject's lexicon has been tapped. This effect can be used to test a subject's perception of minimal pairs. For any given native-language minimal pair (***b**ask*-***t**ask*), a native speaker subject will show response times to the second item (*task*) that are just as high (slow) as the first (*bask*). This is expected, since the second member of the pair is perceived as unique from the first. However, let's suppose that a non-native speaker takes the same test. If the minimal pair's contrast is not found in the subject's native language, and the contrasting

phonemes are known to assimilate to one phoneme in the subject's native language, we can expect that this subject's response time to the second member of the minimal pair will show a priming effect similar to true repetition priming. This effect would imply that the subject perceived the minimal pair as (functional) homophones, phonetically distinguishable (Lively et al., 1994) but phonemically assimilated to the same category (Pallier et al., 2001).

For this study, two English-specific phonemic contrasts were the object of study: the /i/-/ɪ/ contrast and the /æ/-/ɑ/ contrast. It is well known that these English contrasts produce difficulty for native Spanish speakers (Iverson, 2009). The Spanish vowel system consists of five monophthongs: /i/, /e/, /a/, /o/, /u/. If these vowels are thought of as filling the acoustic space, then, relative to a "more crowded" system like English, each Spanish vowel occupies a much larger space (Flege, 1994). The English phoneme /i/ is very similar to Spanish /i/, and the English /ɪ/ is less similar to the Spanish /i/. The English /ɪ/ (or at least many instances of it, speaking phonetically) is, nonetheless, found within the space occupied by acceptable variants of the Spanish /i/, leading to English /i/ and /ɪ/ both being perceptually neutralized to the Spanish /i/. Similarly, while the English /æ/ is similar to the Spanish /a/, both /æ/ and /ɑ/are found within the Spanish /a/ acoustic space, albeit on different ends of it. This perceptual assimilation is the cause of the apparent filtering effect seen in perception studies, by which L2 phonemes seem to filter through the L1 phonology.

Putting the previous explanations together, consider a native Spanish speaker who takes an English Lexical Decision Task. Dispersed throughout this LDT are minimal pairs in which the two members of the pair are spaced from eight to 20 items apart (medium-term, as in Pallier et al., 2001). These minimal pairs show the contrasts mentioned above. That is, some of them are of the /i/-/ɪ/ type (e.g. *seat*, *sit*; /sit/, /sɪt/), while others are of the /æ/-/ɑ/ type (e.g. *cat*, *cot*; /cæt/,

/cɑt/). We should expect that the native Spanish speaker will show significant priming effects on the second item of each minimal pair if their L1 phonology influences their responses. To compare, some items of the LDT will be real repetitions (e.g., *leak...leak*), and the minimal pair priming effect will be the same as (not significantly different from) true repetition priming. Additionally, other minimal pairs will be included whose contrasts are common to both languages (e.g. *ghost* /gost/, *boast* /bost/). The native Spanish speaker will show no repetition priming for these minimal pairs. The same LDT will be given to native English-speaking control subjects. These controls will arguably show the same repetition priming on repeated items, the same lack of repetition priming on commonly contrasting minimal pairs, but will importantly also show no repetition priming on the English-specific minimal pairs. The conditions and their hypothesized results are summarized in Table 3.1.

Table 3.1

	True Repetition *time-time*	English-only Minimal Pairs *seat-sit*	Both-language Minimal Pairs *ghost-boast*
English Native Speakers	YES	NO	NO
Spanish Heritage Speakers	YES	YES	NO

YES and NO here refer to whether we expect (hypothesize) to observe significant priming.

Instrument

The design of the instrument was taken largely from Pallier, et al. (2001). The instrument used was a Lexical Decision Task . The LDT was run using the experiment presentation software DMDX (Forster, 2016). Each participant was administered one of four versions of the LDT,

based on four unique counterbalanced wordlists. These four wordlists were converted into scripts to be readable by DMDX, and were distributed evenly to the participants (i.e., each wordlist was used for ten of the 40 participants).

Wordlist Design

Each of the four wordlists was made up of 136 filler items and 144 test items. The 136 filler items were in the same locations (item numbers) across all four lists. Half (68) of these filler items were real, one-syllable English words, and half were phonotactically plausible one-syllable English pseudowords.

Table 3.2

Totals	Experimental Items: 144	Filler Items: 136
One-syllable real English words: 140	72	68
One-syllable English pseudowords: 140	72	68

Breakdown of all items by experimental/filler and real/pseudoword.

The remaining 144 (experimental) items made 72 minimal pairs. There were three divisions in the type of pairs making up this group. Twenty-four were pairs in which both members were real English words. Another 24 were pairs in which both members were phonotactically plausible English pseudowords. The remaining 24 were pairs in which one item was a real English word and the other was a phonotactically plausible pseudoword. Each of these groups was further divided three ways into eight pairs representing 1) the /i/-/ɪ/ English phonemic distinction (e.g., *seek* and *sick*), 2) the /æ/-/a/ English phonemic distinction (e.g., *cap*

and *cop*), and 3) phonemic contrasts common to both English and Spanish (e.g., *ghost* and *boast*) randomly selected by the author.

Table 3.3

: 72 pairs	/i/-/ɪ/: 24 pairs	/æ/-/ɑ/: 24 pairs	Common contrasts: 24 pairs
Real English word + real English word: 24 pairs	8 pairs *seek* + *sick*	8 pairs *cap* + *cop*	8 pairs *ghost* + *boast*
English pseudoword + English pseudoword: 24 pairs	8 pairs /ʤik/ + /ʤɪk/	8 pairs /næθ/ + /nɑθ/	8 pairs /feɪŋk/ + /peɪŋk/
Real English word + English pseudoword: 24 pairs	8 pairs *weed* + /wɪd/ and /kwit/ + *quit*	8 pairs *past* + /pɑst/ and /dæk/ + *dock*	8 pairs *laugh* + /pæf/

Breakdown of experimental items by minimal pair type and contrasting phonemes. The bottom row examples show the bidirectionality of the pairs. NOTE: *italics* indicates real words, while pseudowords are between //.

The group of 24 minimal pairs with real + pseudoword were split evenly (four each) within each of the three groups of contrasts they represented. That is, for example, four of the /i/-/ɪ/-type pairs had the /i/ represented in a real English word, while the other four had the /ɪ/ represented by the real word (e.g., four were of the type ***weed***/*wid* while four were of the type *feeg*/***fig***, bold indicating the real word).

The locations of all minimal pairs were determined using a random number generator. A random number generator was also used to determine how many items away from the first member of each pair the second member of each pair would be.

Following the random placement of the minimal pairs, the list of filler items was placed in a randomizer, creating a randomized version of the list. This list of filler items was then placed

in its randomized order into all of the leftover slots in the 280-item list, creating a master list from which each of the four counterbalanced lists would be created.

To create these four lists, each minimal pair was distributed across the four lists such that one list contained a repetition of, for example, *peak*, another list contained a repetition of *pick*, the third list contained *peak* followed by *pick*, and the fourth contained *pick* followed by *peak*. This staggering evenly distributed the assignments, resulting in each list containing the same number of pairs within each group ordered in any specific way, and also resulting in each minimal pair appearing each of the four different possible ways only once.

Test item rating

During the process of creating the wordlists, it was realized that, as to the validity of the lexical status of each word (especially pseudowords), only one person had been consulted. The decision was made to separately consult four L1-English speakers as to the status of each of the 280 items in the master list as either real or pseudoword. For all four consultants, the items were read aloud, and the spellings of these items was not known. Two of the consultants could not only hear the words being read, but could see the face of the reader. The other two consultants could not see the reader's face, approximating the audio-only conditions of the experiment. The consultants were permitted to ask for an item to be repeated as many times as they wanted, which some of them did on some items. As can be guessed, the only items on which the consultants disagreed were supposed pseudowords. When at least two of the raters disagreed with the item's status as pseudoword, the item was replaced with a new item. One rater pointed out that two intended pseudowords, unnoticed by the other three raters, sounded like real words made up of two morphemes each (*fownce* /fauns/ and *mose* /mouz/, which this rater heard as *founts* and *mows*, respectively). These two were substituted for two new pseudowords. In any instance that

substituting a new item interrupted an experimental minimal pair, the other member of the pair was changed accordingly. The eleven items that were changed were subsequently presented to each of the four consultants for a final confirmation of their statuses.

In addition to the consulting explained above, it was found during the compilation of these lists that in some instances items had been placed between members of minimal pairs whose results they had the potential to interrupt due to their phonetic similarity to them. These items were switched with others at the researcher's discretion. Although it is possible that some of these overlaps weren't corrected, any remaining instances shouldn't significantly affect the overall results.

The four completed and revised lists were used to build the scripts to use in the DMDX program for the LDT. To facilitate analysis of the results, each item of each of the four 280-item

lists was given an eight-digit number. The independent variables represented by each digit were as follows:

Table 3.4

Digit	Explanation	Variable Descriptions
1	No variable, it was used to ensure that the computer program used to perform analyses did not simplify any number beginning with a *0*.	Universally *1*.
2,3,4	The number of the item within the list itself.	From *001* to *280*.
5	The type of contrast represented in the minimal pair.	*0* for a filler word; *1* for an English-only contrast; *2* for a common contrast.
6	The statuses of both members of the minimal pair.	*0* for a filler word; *1* for a real/real pair; *2* for a pseudo/pseudo pair; *3* for a pseudo/real pair.
7	The ordering of the pair.	*0* for a filler word; *1* for the first pair member; *2* for the second pair member; *3* for a repetition.
8	The status of the word.	*0* for a pseudoword; *1* for a real word.

Within the DMDX scripts, response timeout was set at 2,500 milliseconds, and time between a response and the following item was set at 1,250 milliseconds.

The audio clips themselves were recordings of the author speaking the words. The recordings were made in a recording booth using Shure KSM32 microphones to record and AVID M-Box Pro as the analog to digital converter.

Participants

The participants were all recruited on a volunteer basis. Aside from the criteria for control and experimental subjects, all participants were at least eighteen years of age. The Spanish heritage speakers were recruited from heritage Spanish courses offered at Purdue University and using flyers at the Latino Cultural Center at Purdue University.

It was decided that L1 English speakers, without regard to other linguistic background, would be recruited as control subjects. All participants in the control group were native English speakers. As the idea behind this study was a replication of Pallier et al. (2001), an early logistical roadblock arose with the proposed linguistic background of the control subjects. Since in Pallier et al. the control group were early Catalan-to-Spanish bilinguals, the analog in this study would be English-to-Spanish early bilinguals. While such bilinguals exist, it seemed impractical to seek them out in significant numbers, especially in the U.S. For pragmatic reasons, it was decided that an alternative route might serve the same purpose. Many recent studies of heritage bilinguals in the U.S. examining proficiency in the heritage language make use of monolingual speakers of the heritage language as controls (Baker, 2006). Following this trend, since this research examines their perception of English, it was decided that monolingual English speakers would be sought. As time went on, however, the author realized that including L1-English bilinguals shouldn't affect the results in any significant way. The theoretical reasoning underlying this study is that one's L1 dominates auditory perception, regardless of L2. The Pallier et al. study lends strong support for this argument, since their control subjects, as early and highly proficient speakers of L2 Spanish, ought to have been expected to show strong L2 Spanish influence if indeed the L2 could be expected to influence perception in any significant way. Indeed, a great diversity of L2s and L2 proficiencies were shown by control participants.

No early bilinguals were among this group, and several had little to no experience with a second language (i.e., functionally monolingual).

Every participant in the experimental group met the following qualifications: 1) dominant childhood home language was Spanish, 2) started living in the United States and learning English at or before the age of six years, 3) has spent the majority of the intervening time living in the United States.

Four of the nineteen experimental participants were not born in the United States, but came from a Spanish-speaking country at a young age (Colombia, Costa Rica via Mexico, Honduras, Panama). The age at which control participants began speaking English ranged from three years to six years.

Although it was not planned, there were some significant differences between the experimental and control groups. The control participants were noticeably older than the experimental participants. We can attribute this age difference to the fact that the heritage Spanish participants were recruited from undergraduate Spanish courses for heritage speakers, while the English L1 subjects were recruited more broadly. Ideally, the participants would have been matched for age. Since significant differences in age could influence results, age was controlled for in the analysis.

Procedure

A recording booth was used for conducting the LDT. Since the experiment measures auditory perceptions, it was decided that ideal conditions would reduce noise as much as possible. Sound attenuated booths were unavailable, but a recording booth was available, and

provided sufficiently ideal levels of noise reduction. For all participants the experiment was administered using the same HP laptop and Sony MDRZX110 series headphones.

Upon guiding the participant into the recording booth, the LDT was explained to the participant. This explanation appears here in the appendix, and was followed more or less verbatim. Following this explanation and after answering any questions, the experiment was run with the door closed and the researcher outside.

RESULTS

Extraneous Variables

Error rate

This Lexical Decision Task provides two pieces of data for every item: the time in milliseconds taken to respond and the response itself about the lexical status of the item (more precisely, whether the participant's "yes" or "no" response was expected or not). While the object of this study focuses on the response time data, the responses themselves are important for determining similarity between the two groups in terms of their lexical extent in English. Both test and filler items are considered here. A certain amount of error is common, and indeed expected given the rapid-fire nature of the task and the possibility of mistaken categorization of items (i.e. pseudowords labelled as real and vice versa). But if it is found that the English-native control and the Heritage Spanish experimental groups differ statistically significantly in their error rates, then this difference must be controlled for.

Thus, to determine whether a significant difference was found between the two groups, an independent samples t-test was used. Group means were 6.24% for controls, 11.00% for experimentals. The Levene's test was significant ($p = .047$), and the Welch's t-test resulted significant: $t\ (24.495) = -2.951$, $p = .007$. One experimental subject was not included in this or other analyses for reasons described below (§**Outliers**). A significantly different error rate between groups is troubling, and confounds the reaction time results, since it is assumed that control and experimental subjects know all of the real words. Subjects consistently take longer to respond to known words than to unknown or pseudowords. Thus, because the principal research

questions have to do with response delay, error rate disparity between groups could have influenced response times. For this reason, all erroneous responses were excluded from the statistical analysis.

Timeout rate

The term "timeout" here refers when the participant makes no response before the experiment moves on to the next item. The experiment was set up to give the participant 2.5 seconds (2500 milliseconds) to respond to each item before moving on. Timeouts were relatively rare, and although it is unclear what they could tell us about group differences, they were tested, nonetheless. The Levene's test was not significant, and neither was the t-test: t (37) = .274, p = .786. The generally low numbers of timeouts (only nine participants had any) may be why timeout rates weren't significantly different between groups.

Outliers

Preliminary scanning of the results revealed that one (experimental) participant's response data was plagued by timed out responses. It was expected that there would be a small average rate of timed out responses. Obviously, repetition effects based on these must be excluded. However, since this individual's rate was much higher than average (51.4% of all responses), their data was removed from analyses. It is possible that this individual simply misunderstood the experiment's instructions, or that some other individual factor caused the higher timed out response rate (subjects were not tested for hearing, for example). Since the cause of the higher timeout rate is unknown, all data from this participant was removed from further analyses.

Participant error rate

Error rate outliers were all tested for. For each test item, each participant was asked whether the item was a real word or not. Error rate for each participant refers to the percentage of these responses that coincided with the expected response (real vs. pseudoword). Participants with outlying error rates introduce potential problems to the analysis of response times. The formulae used were as follows: for lower outliers, Q1 - 1.5 * IQR (Where "Q1" refers to the first quartile and "IQR" is the interquartile range.). For upper outliers, Q3 + 1.5 * IQR was used. As expected, no lower outliers were found for participants or items (i.e, no one did extremely well). Three participant upper outliers were found. All response time analyses were conducted first with these outliers included and then without. It was found that removal of participant error rate outliers had no effect on the analyses of response times.

Test item error rate

Additionally, test items were examined for error rate. Although all test items were rated for lexical status before the study began, test items' error rates were also examined following the study. Test item error rate here means the percentage of responses for every item that were not the expected response. Removing item outliers based on error rate serves as an additional guard against errors in the methodology, since an item that consistently received the "incorrect" response indicates that the expected response was incorrectly assigned. 22 item outliers were found, twelve of which were test items. As stated above, subsequent to removing the data for these outliers, the same analyses were run. Similar to participant outliers, removal of item outliers had no significant effect on the results.

"Repetition Effect"

The main research question of this study is related to the results of the participants' response times. As in Pallier et al., a *repetition effect* (RE) is defined here as a decrease in reaction time between the first and second occurrences of a repeated item, or between the first and second members of a minimal pair. Subtracting the reaction times of the second item from those of the first, a positive value indicates a repetition effect.

"Significant Repetition Priming"

In the previous chapter, table 4.1 (seen below) was used to summarize the hypotheses about how each of the groups examined were expected to behave. The table used *YES* and *NO* to define simply whether or not "significant repetition priming" was expected. How do we define this term? Is there a cutoff? What is significant and what is not? Although we can make predictions about repetition priming, the reality is that item response times vary both within group and within subject, and although we may say we expect no repetition priming on a category of pairs, what we really mean is that the repetition effects will tend toward zero. Given this state of affairs, hypotheses about "significant repetition priming" can only be tested by comparing pairs to other pairs. It is crucial to the analysis that we are comparing heritage Spanish speakers' RE on the test pairs (third column) to English native speakers' RE on the same pairs AND that we are comparing HSS repetition effects on these pairs to their RE on common contrasts (fourth column). In both comparisons (bold in the table), significant differences confirm the hypothesis.

Table 4.1

	True Repetition *time-time*	English-only Minimal Pairs *seat-sit*	Both-language Minimal Pairs *ghost-boast*
English Native Speakers	YES	**NO**	NO
Spanish Heritage Speakers	YES	**YES**	**NO**

YES and NO here refer to whether we expect (hypothesize) to observe significant priming.

Analysis

The study on which this study was based (Pallier et al., 2001) used subject-based and item-based analyses of variance to compare differences between groups. For the analysis of the data here, it was decided that a Mixed Effects Analysis would be best suited to the data. The same variables were used here as in Pallier et al. The dependent variable was Repetition Effect. The independent variables were **L1** (English vs. heritage Spanish), **Condition** (repetition vs. minimal pair), **Contrast** (English-specific vs. common contrast), **Pair Type** (real-real vs. pseudoword-pseudoword vs. real-pseudoword), **Age** (in years), and **Gender** (male vs. female). The following variable interactions were also tested:

Table 4.2

Two-way	Three-way	Four-way	Five-way
Contrast * Pair Type **Contrast * Pair Order** **Contrast * L1** **Contrast * Gender** **Pair Type * Condition** **Pair Type * L1** **Pair Type * Gender** **Condition * L1** **Condition * Gender** **L1 * Gender**	**Contrast * Pair Type * Condition** **Contrast * Pair Type * L1** **Contrast * Condition * L1** **Pair Type * Condition * L1** **Pair Type * Contrast * Gender** **Pair Type * L1 * Gender** **Pair Type * Gender * Condition** **Contrast * L1 * Gender** **Contrast * Gender * Condition** **L1 * Gender * Condition**	**Contrast * Pair Type * Condition * L1** **Pair Type * Contrast * L1 * Gender** **Pair Type * Contrast * Gender * Condition** **Pair Type * L1 * Gender * Condition** **Contrast * L1 * Gender * Condition**	**Pair Type * Contrast * L1 * Gender * Condition**

Variable interactions tested in the Mixed Effects Analysis

Participant and item random factors were included in the analysis to account for the repeated measures in the study.

The results of the mixed effects analysis did not support Hypothesis 1. Only the **Condition** (p = .002) and **Contrast * L1** (p = .029) variables were found to be significant . No other main effects or interactions reached significance. All p-values are listed below, with significant ones in bold:

Table 4.3

Variable	p-value
MAIN EFFECTS:	
L1	= .987
Condition	**= .002** Repetitions showed significantly higher RE than minimal pairs across all variables.
Contrast	= .265
Pair Type	= .996
Gender	= .316
Age	= .274
TWO-WAY:	
Contrast * Pair Type	= .980
Contrast * Pair Order	= .837
Contrast * L1	**= .029** On common contrasts, HSSs had significantly higher RE than English L1; English L1 had significantly higher RE on English-only contrasts than on common contrasts.
Contrast * Gender	= .799
Contrast * Condition	= .837
Pair Type * Condition	= .321
Pair Type * L1	= .683
Condition * L1	= .268
Pair Type * Gender	= .384
L1 * Gender	= .954
Gender * Condition	= .765
THREE-WAY:	
Contrast * Pair Type * Condition	= .128 Condition is doing the work here; the

	only significant differences happen between repetition and minimal pairs, and this happens on English-only real+real and pseudo+pseudo pairs and common contrast real+real and real+pseudo pairs.
Contrast * Pair Type * L1	= .507
Contrast * Condition * L1	= .941
Pair Type * Condition * L1	= .518
Pair Type * Contrast * Gender	= .378
Pair Type * L1 * Gender	= .833
Contrast * L1 * Gender	= .450
Contrast * Gender * Condition	= .812
Pair Type * Gender * Condition	= .571
L1 * Gender * Condition	= .389
FOUR-WAY:	
Pair Type * Contrast * L1 * Gender	= .162
Pair Type * Contrast * Gender * Condition	= .563
Pair Type * L1 * Gender * Condition	= .670
Contrast * L1 * Gender * Condition	= .342
Contrast * Pair Type * Condition * L1	= .604
FIVE-WAY	
Pair Type * Contrast * L1 * Gender * Condition	= .197

Additionally, individual comparisons between groups of data were made, which are described below.

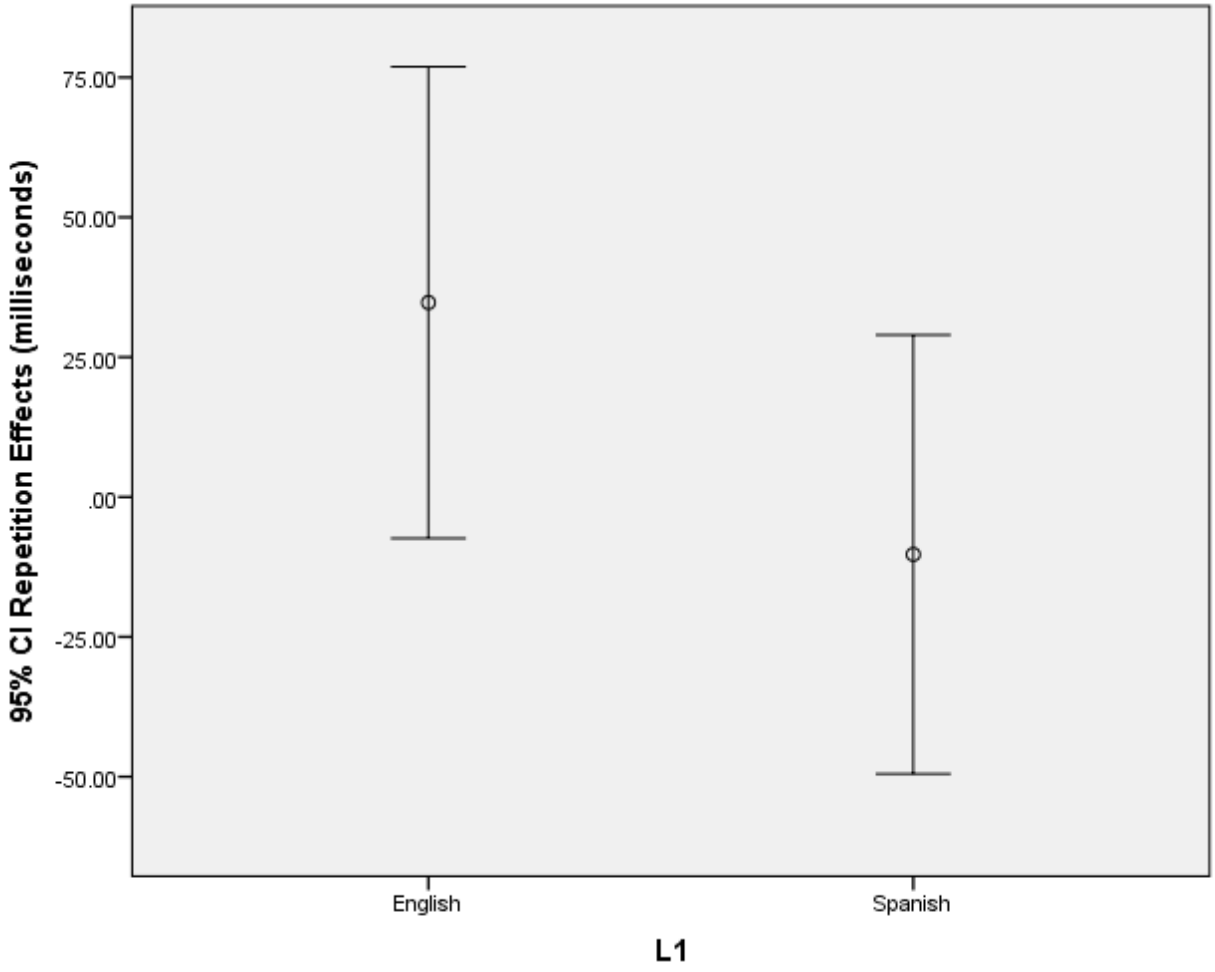
Research Question One

The first and principal research question of this study as stated in the introduction and repeated here is as follows:

> Do L1-Spanish L2-English heritage speakers demonstrate facilitation effects (repetition priming) on English minimal pairs differing in contrasts that don't exist in Spanish?

It was hypothesized that HSSs would show significantly higher priming than English native speakers on these pairs (see Figure 4.1 below). Post hoc tests (Bonferroni) were used to compare subsets of the data for significant differences. To test this hypothesis, repetition effects were compared between HSSs and English native speakers on real+real minimal pairs with English-only contrasts. Although an effect was observed and the results approached significance ($p = .065$), the directionality was the inverse of the hypothesis. That is, English native speakers showed higher priming to these minimal pairs than Spanish speakers. The hypothesis of research question one was not confirmed.

Figure 4.1

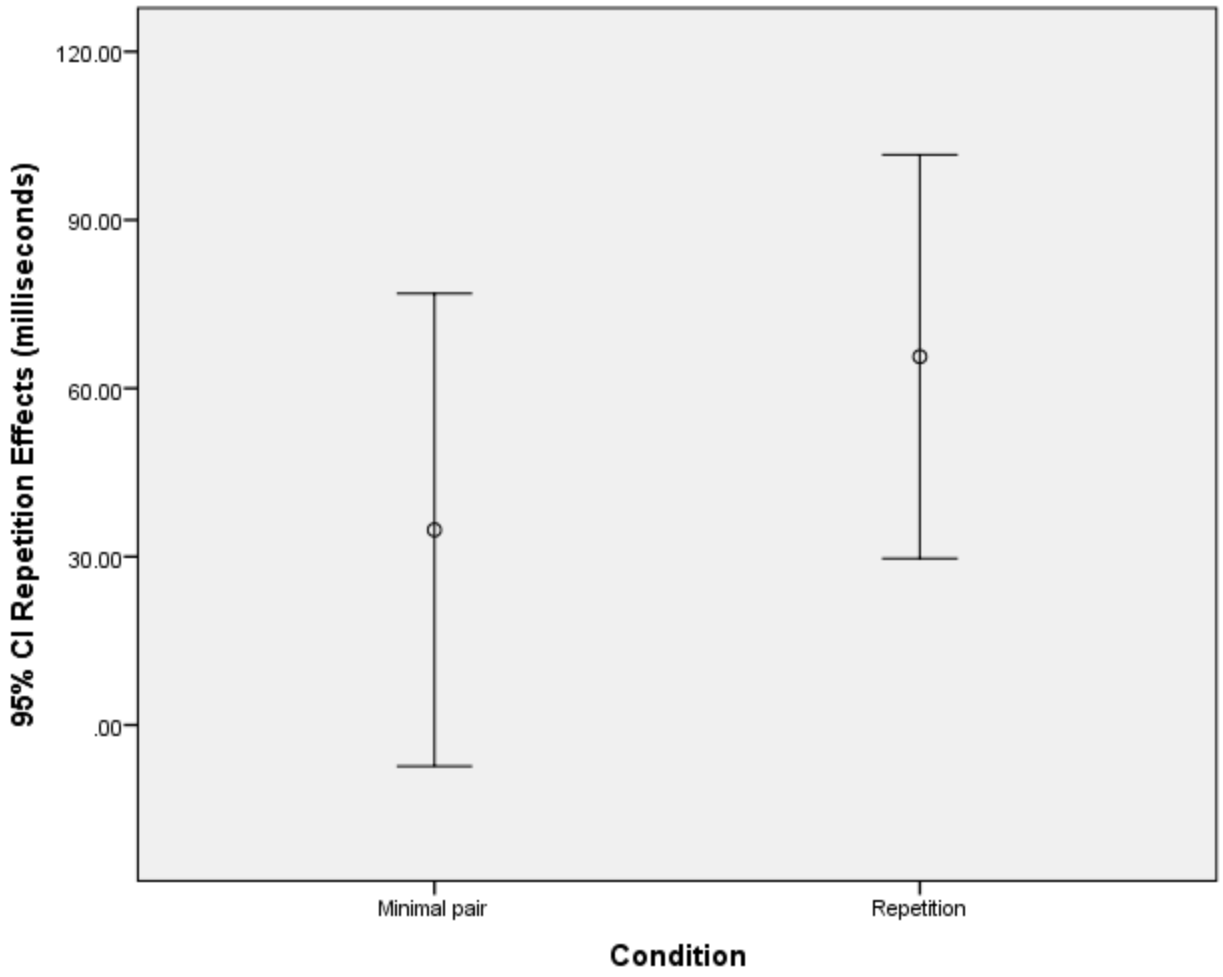


Priming effects seen on real+real minimal pairs with English-only contrasts.

Importantly, a number of methodological assumptions underlie this research question, and none of them were met. These assumptions were tested through further post hoc comparisons, and relate to expected behavior of the control and experimental groups. These assumptions are discussed below. Note: while these assumptions bear important influence on the interpretation of the results of Research Question One, it has already been demonstrated that the study's central hypothesis was not confirmed.

> **Assumption 1**: on English-only contrasts, native English speakers would show significantly higher RE on true repetitions than on minimal pairs (Figure 4.2 below). This assumption reflects the fact that English natives do not treat English minimal pairs as repetitions. This assumption was tested on all contrasts (English-only and common), and then on English-only contrasts alone. When all contrasts were considered, the results were not significant ($p = .119$). Looking specifically at English-only contrasts, still no significance was found ($p = .306$). On English-only contrasts, native English speakers did not treat minimal pairs significantly differently than true repetitions. This assumption was not met.

Figure 4.2

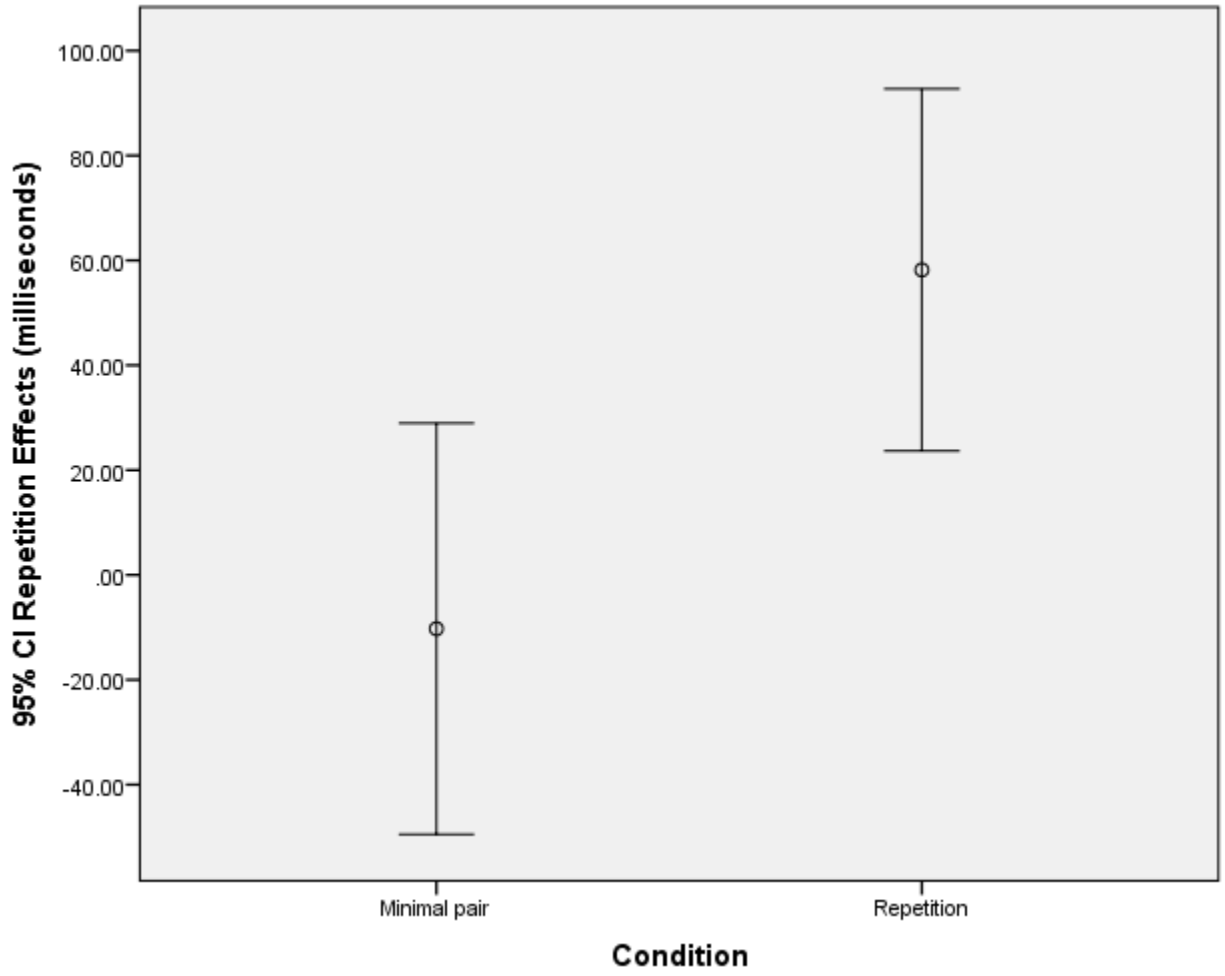


Native English speaker priming effects seen on real+real, English-contrast minimal pairs and repetitions.

Assumption 2: on English-only contrasts, heritage Spanish speakers would show RE that are not significantly different between minimal pairs and true repetitions on English-only real+real pairs (Figure 4.3, below). This assumption means that HSSs treat English minimal pairs as not significantly different from repetitions. This comparison was significant ($p = .029$), meaning that this assumption was not met. Heritage Spanish speakers did treat minimal pairs significantly differently from true repetitions. The fact

that the HSS results reached significance here while the native English speakers did not (see **Assumption 1**) is notably the inverse of hypothesized results.

Figure 4.3



Priming effects seen on real+real, English-contrast minimal pairs and repetitions from HSSs.

Comparisons testing Assumptions 1 and 2 are summarized in Table 4.4.

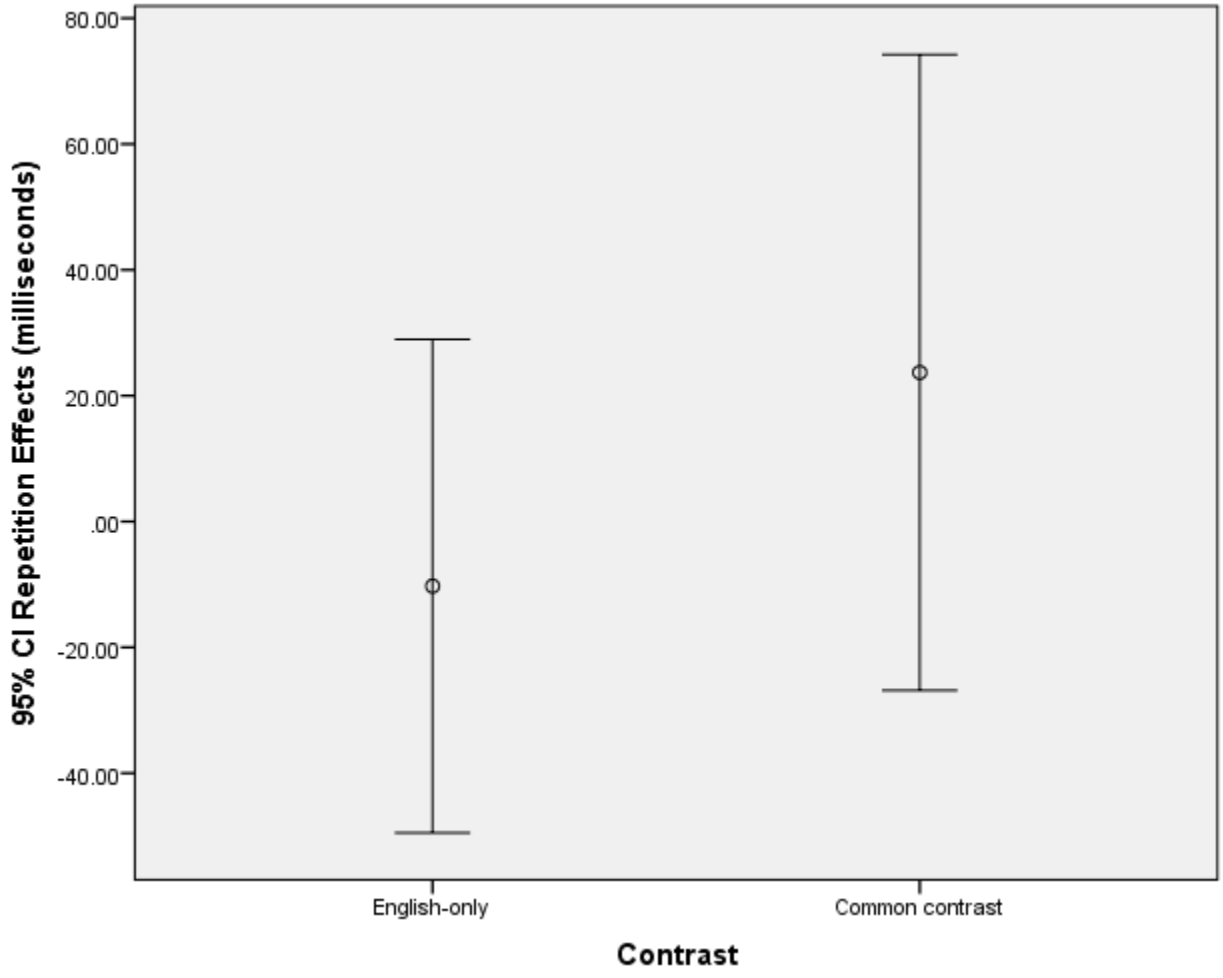
Table 4.4

	English-specific	English-specific and common
English L1	.306	.119
Spanish L1	.029	.018

Comparison of priming effects of true repetitions vs. minimal pairs.

Assumption 3: on minimal pairs, heritage Spanish speaker's RE would be significantly higher for English-only contrasts than for common contrasts (Figure 4.4, below). This means that HSSs treat English-only contrasts like homophones, while treating common contrasts as separate words. If this assumption is confirmed, it would be strong evidence that perceptual neutralization of English-specific contrasts causes these minimal pairs to be treated like homophones. This comparison found no significant difference between contrast types ($p = .499$). This assumption was not met. HSSs do not treat English-only contrasts differently than common contrasts.

Figure 4.4



Priming effects of HSSs on real+real minimal pairs, comparing English-only to Common contrasts.

The three assumptions underlying Research Question One are summarized in Table 4.5. As can be seen, none were met.

Table 4.5

Assumption 1	**Assumption 2**	**Assumption 3**
Not met	Not Met	Not met

According to post hoc tests, were the assumptions underlying Research Question One met?

Research Question Two

The second research question was as follows:

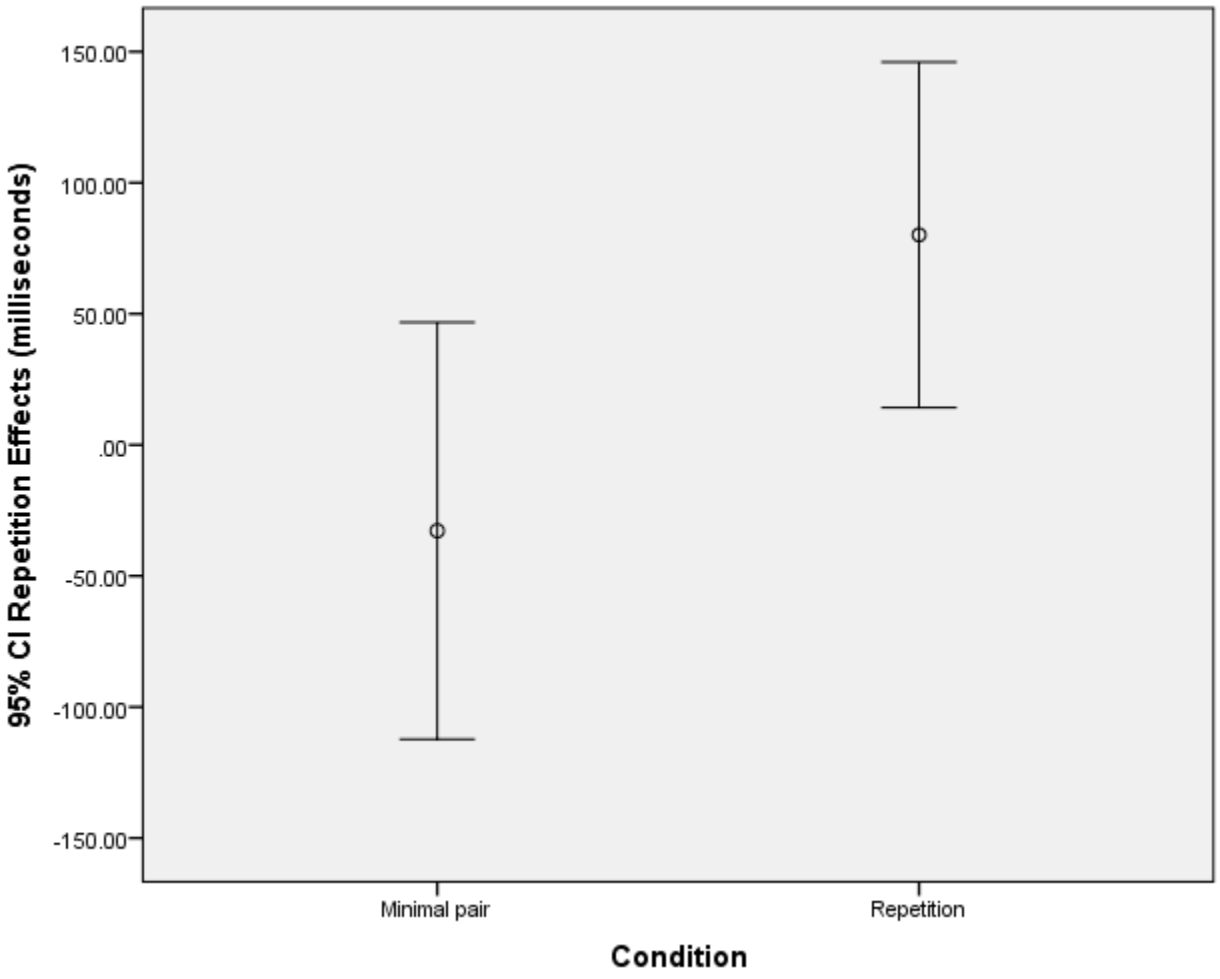
Do real word + pseudoword mixed pairs behave similarly to real+real pairs in terms of priming effects?

This area of inquiry centers on the introduction of a novel pair type containing one real word and one pseudoword each. The new pair type was introduced to offer answers to questions raised by Pallier et al.'s study. Namely, if the experimental participants perceive minimally contrasting real words as homophones, perhaps a pseudoword (*wid*) contrasting minimally from a real word (*weed*) would prime that real word and would produce the same repetition priming as pairs made of two real words.

The only significant comparison found for the new pair type was the difference between minimal pairs and repetitions for Spanish heritage speakers on common contrast pairs ($p = .026$) (Figure 4.5, below). As mentioned at the outset, it was hypothesized that mixed pairs may cause experimental participants to take longer on the second item than the first. Interestingly, this hypothesis is borne out in the common contrast pairs, the only subset of the data showing average RE noticeably below zero. It isn't clear whether directionality was significant, since this

was not coded into the variables and could not be tested at this time. It was a late thought of the author that minimal pairs in which the /ɪ/ word appeared first may have had significantly higher RE than words in which the /i/ word appeared first. Since these results show the average of all item orders, it is suspected that separating the results will reveal an even stronger negative RE. If this could be confirmed, it may implicate task effects (working memory) in lexical decision tasks.

Figure 4.5



Heritage Spanish speaker priming effects on real+pseudoword, common contrast pairs.

DISCUSSION AND CONCLUSIONS

Discussion

Research Question One

The first research question concerned whether Heritage Spanish speakers' L1 (Spanish) phonology influences their perception of English-specific phonemic vowel contrasts. That is, do the perceptual difficulties that plague monolingual Spanish speakers when discerning English have any demonstrable corollary in heritage Spanish speakers? The study's primary hypothesis, that HSSs would show significantly higher facilitation effects than native English speakers on minimal pairs with English-specific contrasts, was not confirmed. Not only this, but the results nearly reached significance in the opposite direction: HSSs showed nearly significantly lower RE than native English speakers.

As stated in the results chapter, this research question makes numerous assumptions about the behavior of control subjects and experimental subjects and the differences between them. None of these three assumptions were met. They are discussed below.

1. The English native speakers did not show significant differences between true repetitions and minimal pairs with English-specific contrasts. In this study at least, English native speakers didn't behave as expected, and as shown in previous studies. How can we say that heritage Spanish speakers don't perceive the difference between English minimally contrasting pairs when native English speakers themselves seem not to?

2. Heritage Spanish speakers show significantly different repetition priming effects on these minimal pairs compared to repetitions. At $p = .029$, the heritage Spanish speakers demonstrated a significant difference, while their native English peers were far from it.
3. Heritage Spanish speakers do not show a significant difference in perception of English-specific minimal pairs compared to common contrast minimal pairs. It was hypothesized that perception may lead to English-specific contrasts demonstrating repetition priming while common contrasts do not. The results did not support this assumption.

To say that the hypothesis of Research Question One was not confirmed, while technically true, would be a bit misleading here, since its underlying assumptions were not met. The hypothesis that "heritage Spanish speakers demonstrate significantly higher repetition effects on English-specific minimal pairs" carries the assumption that English native speakers do not. Since the control participants demonstrated the very behavior expected of the experimental participants, it is more accurate to say that the methodology failed in some way to measure perception of English-specific contrasts.

A number of differences between this study and previous studies, like Pallier et al. (2001), mean that the relationship between results found here and those of previous studies are tenuous at best. For example, the current study used as experimental participants anyone raised in a Spanish-speaking home who began learning English at or before the age of six (6) years. No level of proficiency or fluency was used as a criteria here. This could potentially influence the results, since these individuals, who can be appropriately described as heritage speakers of Spanish, may be different enough from each other linguistically (i.e. simultaneous vs. sequential bilinguals) that placing them all in the same group without accounting for these differences weakens the theoretical validity of the results.

Also of importance is the fact that Paller et al.'s bilinguals were considered dominant in their L1. The principal distinction made between the experimental and control participants is their (dominant) L1. Here it is perhaps a bit inadequate to call these Spanish L1 bilinguals dominant in Spanish, since many of them have much higher proficiency in English. This factor could have huge implications in comparing results, since the original study took as given the fact that the L1 is the participant's dominant language. This study's participants may very well be dominant in their L2, and this difference in dominance may affect their perception of contrasts in English.

For reasons of practicality, the only linguistic criterion for control subjects was that they be native speakers of English and either late bilinguals or monolinguals. The Pallier et al. study, upon which this was originally based, used early bilinguals as both control and experimental subjects. While early bilingual control subjects seem to have worked well, for this study they were not judged to be necessary or practical from a logistical point of view. It is assumed that recruiting an entire group of 20 early English-to-Spanish bilinguals would be near impossible, especially in the location of the study. It is also assumed that L1 English speakers ought to demonstrate the expected control results without significant difference.

The test language itself is another difference that mustn't be ignored. While it couldn't be avoided due to the languages of the bilinguals under study here, the fact that the original study used Catalan minimal pairs as test items while this study used English could affect the results. Attention is due here to the relationships, linguistic, geographic, social and political, between these languages and Spanish. Catalan and Spanish are geographically adjacent Romance languages who both enjoy official political status in Spain. While Spanish is the nationally spoken language in Spain, Catalan enjoys status as a socially prestigious language in the area that

Pallier et al.'s study took place, Barcelona. The relationship between English and Spanish is different in almost every way. Though they share a great number of cognates, English is not a Romance language and thus is not as similar to Spanish as is Catalan. While the United States has no official language, English is recognized as the *de facto* official language, while Spanish is far from socially prestigious. The factors discussed here as aspects of the relationship between the bilinguals' languages alone are enough to potentially greatly influence the acquisition process undergone by the participants. Aside from these, the purely linguistic differences between Catalan and English introduce danger of extraneous variables, though they are unknown here.

Research Question Two

The second research question concerned the new pair type used in this study consisting of one real word and one pseudoword each. To take the extreme track of the implications of repetition priming on LDT is to say that individuals perceive (even incorrectly) that a word (or pseudoword) is some other real word. A less extreme take is to posit that while perhaps conscious mixups do not occur, the memory of a phonetic form can influence the perception of its repetition or a minimally contrasting form. These novel pairs were meant to test this assumption by examining what effect (if any) a minimally contrasting pseudoword can have on the perception of a later real word. As explained in the results, only one group of responses differed significantly: those of heritage Spanish speakers on common contrast pairs. Limitations discussed below precluded finer examination.

The results of this study parallel those of another. The study described here in the literature review (Solé, 2012) looked at advanced native Spanish and Catalan learners of English and their perceptions of English-specific vowel contrast minimal pairs. Although details about the study are scant, Solé indicates that the test subjects did not show repetition priming on

English-specific minimal pairs, while showing repetition priming on pseudoword pairs with English contrasts. Solé interpreted her results as indicative of the subjects' having differentiated contrasts on lexical items at a later stage, explaining why completely novel pseudowords may present greater perceptual difficulty on the same contrasts. Her results were not identical to those found here, but are similar in that they cast doubt on the underlying assumptions of this use of the lexical decision task. If it can be shown that control and test subjects do not reliably confirm assumptions about perceptual behavior, it may be found that the lexical decision task is not testing what it is thought to test here, or that it is not doing so reliably.

Limitations

The conditions of this study and a number of involved variables were not ideal. Significant differences in age and error rate were found between the two groups. Additionally, the results of the novel real word + pseudoword pair type were not able to be thoroughly studied due to methodological limitations.

It was found in the analysis that the experimental group had an error rate significantly higher than that of the control group. This significant difference calls into question whether the two groups have similar command of the English words they were exposed to. If it were not controlled for, this would deal a heavy blow to any attempt to answer the research questions, since it is assumed that error rates will not significantly differ between the two groups. Response time data for all erroneous responses was not considered in the statistical analysis, controlling for the effects of incorrect responses. Also, since the two groups were also different in age, differences in error rate cannot with confidence be attributed to differences in age, linguistic background, or some combination of the two. Something not yet examined here is whether the two groups got the same test items wrong or if there was a significant difference in terms of

lexical status. For example, did the heritage speakers tend to think real words were not real while native English speakers tended to think that pseudowords were real words, or vice versa? Such insights may help to understand other results. As it stands, the implications of a lexical decision task are to some degree limited when it is clear that the control group and the experimental group have a significantly different idea of what is and what is not a real word. This study especially depends upon the assumption that only real words can produce priming on true repetitions (an assumption not borne out in the data).

To this author's mind, the question remains as to whether pseudowords can prime real words and not the other way around. Another question is whether certain sounds are better at priming their partners than vice versa. Answers to these questions would have implications for studies of perception, including what is truly being studied and what really is priming.

While this study specifically measured minimal pair priming, it is clear that HSSs are able to consciously discriminate English vowel contrasts. As part of their debriefing following the LDT, several experimental participants were asked what the difference is between *seat* and *sit* in order to explain what was being studied. All of those asked were able to differentiate the two.

Although the phenomenon of repetition priming was used for this study, other causes of priming were not controlled for. Effects of frequency and semantics, for example, were not considered or controlled for during the design of the LDT.

There was a methodological limitation in the fact that while test contrasts were vowel contrasts, common contrasts were all consonant contrasts. This difference may explain the unexpected differences between responses along the English-only vs. common contrast variable.

Implications

Not much can be said about implications of this study. The few significant results must be taken with caution. While the principal hypothesis was not confirmed, every assumption that this hypothesis depends on also failed. If any implication can be made, it must be against the methodology. This study was simply not controlled enough to be able to say anything significant.

Future Research

In terms of this study, there are a number of questions yet to be answered. Did the two groups differ in the types of errors made, and can such differences be explained as a function of their first language? Do the real word + pseudoword pairs show anything significant when examined more closely, for example it terms of which member of the pair appeared first?

More broadly, since this study cannot make any firm declarations about the perceptual behavior of heritage Spanish speakers, future studies ought to replicate it to discover whether similar results are found and whether there are any flaws in the validity or reliability of such an experimental design. Future studies of this type ought to examine the actual values of HSSs' Spanish vowels, so that more careful observations can be made about how their phonetic perception of English vowels matches to phonetic values of their Spanish vowels.

Conclusions

This study used a medium-term auditory lexical decision task to examine whether heritage speakers of Spanish perceive English-specific contrasts as homophonic. It had been found in previous studies (Pallier et al., 2001) that even early bilinguals show repetition priming on non-native minimal pairs, indicating tentatively that at some level these minimal pairs are perceptually homophonic. While heritage speakers demonstrated consistently that they

consciously know the difference between English minimal pairs like *seat*/*sit*, this study sought to answer the question of whether one primes the other at some unconscious level. The hypotheses including that they do, many of the assumptive hypotheses were not confirmed, such that it cannot be said that heritage Spanish speakers behave in any significantly different way from native English speakers.

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APPENDIX

Test Items

The following are all test items by category.

Real + real pairs

The following are all minimal pairs consisting of two real words. They are divided into three sections based on how they contrast.

Appendix Table 1

/i/-/ɪ/	/æ/-/a/	Common contrasts
1. heat-hit	1. cat-cot	1. ghost-boast
2. eat-it	2. math-moth	2. pot-pod
3. deep-dip	3. bat-bot	3. fun-fin
4. leave-live	4. map-mop	4. grease-crease
5. peak-pick	5. rack-rock	5. write-ride
6. seek-sick	6. cap-cop	6. beet-boot
7. bean-bin	7. calf-cough	7. mice-nice
8. greet-grit	8. lag-log	8. slack-slap

Pseudoword + pseudoword minimal pairs

All minimal pairs featuring two pseudowords appear below. They are divided based on their contrast.

Appendix Table 2

/i/-/ɪ/	/æ/-/a/	Common contrasts

1. jeek-jik	1. nath-noth	1. fank-pank
2. reen-rin	2. bant-bont	2. mip-mig
3. veet-vit	3. grap-grop	3. hab-hoob
4. freep-frip	4. vap-vop	4. nike-vike
5. feek-fik	5. plag-plog	5. pleeb-pleek
6. breeb-brib	6. thap-thop	6. pabe-pob
7. zeed-zid	7. braff-broff	7. tuke-muke
8. cleest-clist	8. cass-coss	8. trab-trass

Real + pseudoword pairs

The following are all minimal pairs containing one real word and one pseudoword. They are divided by contrast. Real words are in bold.

Appendix Table 3

/i/-/ɪ/	/æ/-/a/	Common contrasts
1. **bleak**-blick	1. **path**-poth	1. paff-**laugh**
2. **weed**-wid	2. **brag**-brog	2. **club**-clup
3. **plead**-plid	3. **gap**-gop	3. **week**-wuke
4. **beam**-bim	4. **nap**-nop	4. vond-**pond**
5. queet-**quit**	5. dack-**dock**	5. **joke**-jote
6. leem-**limb**	6. dag-**dog**	6. lom-**lame**
7. feeg-**fig**	7. frath-**froth**	7. **name**-pame
8. cleep-**clip**	8. prad-**prod**	8. **tweak**-tweep

Filler words

Filler words are listed below. Real words are separate from pseudowords.

Appendix Table 4

Real words	Pseudowords
tired, serve, beef, face, love, lose, meet, grow, school, door, stop, pale, pay, fall, team, might, reach, speak, run, brush, join, child, lead, main, full, close, free, stamp, win, walk, brick, huge, man, car, green, time, blue, wait, poor, fine, cut, hot, day, dry, small, neck, case, thin, spend, world, proud, dumb, build, dice, change, lush, year, buy, hard, state, thing, cold, tense, lean, read, dark, life, way	croice, wike, polt, boff, trum, plocked, lote, turl, byoo, nopped, rudge, veck, narp, plish, desh, sprud, yorf, klat, doof, twose, dret, mant, hudd, burse, bine, stike, murt, relt, tront, rast, lort, skeep, proot, hake, prowt, swib, tane, kwum, frooked, quate, grite, olt, blate, welk, coath, noke, gope, coaft, skome, clanned, swack, sarf, zung, reet, froop, borth, nipe, frem, geep, seef, thraw, vore, bance, thill, plike, drunt, snouf, brind

LDT Explanation Script

The following represents how the Lexical Decision Task was explained to the participant just prior to their taking the test:

> "In this experiment, you will hear what sound like English words one at a time. Some of them are real English words, and some are made up. You'll hear the word, and then push the RIGHT SHIFT button if you think it's a real word, or push the LEFT SHIFT button if you think it's not a real English word. You may also notice that sometimes the words repeat.
>
> With this experiment, we're trying to get you to respond quickly, while still being accurate. The experiment gives you two seconds to respond before it moves on to the next word, but two seconds is usually plenty of time to figure out if it's a word or not.
>
> Don't worry about getting an answer wrong or hitting the wrong button every once in a while. That happens for everybody.
>
> It only takes nine minutes, but it's 280 items and it can get pretty monotonous."