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Research Article

PHONOLOGICAL PROCESSING OF STRESS BY NATIVE ENGLISH SPEAKERS LEARNING SPANISH AS A SECOND LANGUAGE

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Abstract
One feature of Spanish that presents some difficulties to second language (L2) learners whose first language (L1) is English concerns lexical stress. This study explores one aspect of the obstacle these learners face, weak phonological processing routines concerning stress inherited from their native language. Participants were L1 English L2 learners of Spanish. The experiment was a sequence-recall task with auditory stimuli minimally contrasting in stress (target) or segmental composition (baseline). The results suggest that learners are more likely to accurately recall sequences with stimuli contrasting in segmental composition than stress, suggesting reduced phonological processing of stress relative to a processing baseline. Furthermore, an increase in proficiency—assessed by means of grammatical and lexical tests—was found to be modestly associated with an increase in the accuracy of processing stress. We conclude that the processing routines of native English speakers lead to an acquisitional obstacle when learning Spanish as a L2.

INTRODUCTION

One aspect of Spanish that seems to present some degree of difficulty to second language (L2) learners whose first language (L1) is English concerns lexical stress (Beaudrie, 2007; Face, 2005; Kim, 2020; Ortega-Llebaria et al., 2013; Romanelli & Menegotto, 2015;

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Romanelli et al., 2015; Saalfeld, 2012). In Spanish, lexical stress is contrastive: it minimally distinguishes words such as *caso* [ˈkaso] "case" and *casó* [kaˈso] "s/he married." Stress is also contrastive in English: it distinguishes words such as *trusty* and *trustee.* Spanish and English differ from each other in the lexical distribution patterns of stress, which, though contrastive in both languages, displays some positional regularities in both. The phonetic correlates of this phonological feature also differ for the two languages, but only slightly (Fry, 1955; Ortega-Llebaria et al., 2013; Ortega-Llebaria & Prieto, 2011; Sluijter & van Heuven, 1996). Transfer from the L1 (or cross-linguistic influence) is known to be a major determinant of many phonological obstacles encountered in the acquisition of a L2 (Best & Tyler, 2007; Chang, 2018; Colantoni et al., 2015; Escudero, 2005; Flege, 1995; Simonet, 2016; van Leussen & Escudero, 2015), which would suggest, as an initial hypothesis, that English speakers' difficulties with Spanish lexical stress could result from some type of cross-linguistic influence. But, if stress is contrastive in both languages, what exactly causes the difficulty? And is there such a difficulty in the first place?

The present study explores one aspect of the obstacle native English speakers seem to face when learning Spanish lexical stress, weak phonological processing routines pertaining to stress. The strategies listeners deploy to deal with speech sounds in real time—translating them into prelexical, abstract representations and, ultimately, into words—is hereby referred to as *phonological processing*. Spanish speakers have been shown to manifest high levels of sensitivity to stress distinctions in tasks that tap into phonological processing (Dupoux et al., 1997, 2001; Sagarra & Casillas, 2018; Soto-Faraco et al., 2001). The availability of stress-induced routines in phonological processing suggests that stress is represented at some level of the implicit knowledge of native Spanish speakers, perhaps included in the phonological representation of words, or as a phonological schema extracted from lexical patterns, or as a prelexical unit in perception. We postulate that one of the reasons native English speakers may find acquiring Spanish lexical stress challenging is that stress is not (or is less) available during phonological processing for this population, in part because native English speakers may not include stress in the phonological representation of words in their native language (Cooper et al., 2002; Soto-Faraco et al., 2001; van Donselaar et al., 2005).

The present study reports on a perceptual sequence-recall experiment with nonwords (Dupoux et al., 2001, 2008, 2010; Lin et al., 2014; Peperkamp & Dupoux, 2002; Peperkamp et al., 2010; Qin et al., 2017). Participants were L2 learners of Spanish with English as their L1. Sequence-recall tasks of the kind employed in the present study tap into one aspect of phonological processing by asking participants to compare auditorily presented nonwords in working memory. The task taps into prelexical processing in that it does not directly involve lexical activation because nonwords are used. Such studies have found a robust difference in the phonological processing of stress between speakers of languages that possess contrastive stress, such as Spanish, and those of languages that do not, such as French (Dupoux et al., 2001; Peperkamp et al., 2010). Whereas some studies have included samples of English-speaking participants (Lin et al., 2014; Qin et al., 2017), no studies have compared native English and native Spanish participants directly, neither have they investigated the behavior of L2 Spanish learners whose L1 is English. The present study investigates whether native English and native Spanish speakers differ in their stress processing routines and, if so, whether learning Spanish as a L2 helps native English speakers develop more effective stress processing routines.

STRESS AND SECOND LANGUAGE LEARNERS OF SPANISH

The apparent developmental obstacles pertaining to Spanish stress that native English speakers face when learning Spanish as a L2 have been investigated in a small number of experimental studies (Beaudrie, 2007; Face, 2005; Kim, 2020; Lord, 2007; Ortega-Llebaria et al., 2013; Romanelli et al., 2015; Romanelli & Menegotto, 2015; Saalfeld, 2012). In the L2 Spanish classroom, the aspect of Spanish stress that receives the most attention is the fact that it is marked in the spelling of some words (Beaudrie, 2007, 2017). This makes lexical stress highly visible for both learners and teachers of Spanish. Whether a Spanish word receives a written accent mark or not is determined by a set of spelling rules, but success in applying such rules depends on knowing *a priori* where phonological stress falls in the word. Beaudrie (2007) postulated that it is not the spelling rules per se that trigger the difficulties L2 learners have when learning the spelling conventions involving Spanish stress. What learners seem to struggle with is identifying the stressed syllable, teasing it apart from the unstressed ones. Beaudrie (2007) concluded that the nature of the learners' obstacles with Spanish stress is perceptual, not orthographic.

A series of studies have investigated the perceptual identification of lexical stress in multisyllabic sequences by L2 learners of Spanish whose L1 is English (Beaudrie, 2007; Kim, 2020; Ortega-Llebaria et al., 2013; Romanelli et al., 2015; Romanelli & Menegotto, 2015). One of these studies examined the possibility that stress-identification is particularly hard for learners due to low-level perceptual phonetic factors (Ortega-Llebaria et al., 2013). One major difference between the two languages is that stress induces phonological vowel reduction in English, but not in Spanish. English speakers' stress perception routines rely heavily on phonological vowel reduction (Warner & Cutler, 2017). The phonetic, suprasegmental correlates of stress in Spanish are slightly different from those of English, as consequence of vowel reduction, but both languages exploit duration, pitch, and intensity (Fry, 1955; Ortega-Llebaria & Prieto, 2011; Sluijter & van Heuven, 1996). Ortega-Llebaria et al. (2013) found that orthogonally varying duration, pitch, and intensity in resynthesized auditory stimuli affected the identification of stress in disyllabic sequences differently in listeners as a function of whether Spanish was their native language or not. The relative weight of suprasegmental correlates of stress varied as a function of phonetic context, and the effects of context were found to affect listeners' reliance on such cues slightly differently for native versus nonnative Spanish speakers (Ortega-Llebaria et al., 2013). Ortega-Llebaria and colleagues were able to show that L1 English learners of L2 Spanish exploit slightly different acoustic cues than native Spanish speakers when processing Spanish stress minimal pairs (particularly when such cues are manipulated artificially and listeners must compensate for the absence of some cues), but there are also large similarities between both populations—for instance, both Spanish and English listeners rely on durational patterns, but English listeners rely more on this acoustic feature than Spanish listeners do, at least in some contexts. The present study is concerned with higher (or deeper) stages of perceptual processing (phonological processing of stress), not with perceptual phonetic challenges per se. Difficulties with phonological processing, perhaps due to fuzzy or inexistent representational units, could operate in addition to (or on top of) perceptual phonetic differences. Our study, therefore, does not revisit that of Ortega-Llebaria et al. (2013), but complements it by investigating a different processing stage.

Some of the extant studies on L2 Spanish stress focus on stressed-syllable identification in nonwords (Beaudrie, 2007; Romanelli et al., 2015; Romanelli & Menegotto, 2015). In these studies, participants are presented with nonwords in auditory form, and they are asked to circle the stressed syllable in spelled-out renderings of the nonword items (Beaudrie, 2007) or to pick from amongst a list of spelled-out options, such as <semapa> and <semapá> (Romanelli et al., 2015; Romanelli & Menegotto, 2015). These studies find that, whereas native Spanish-speaking controls are consistently able to identify the stressed syllable in nonwords, learners (as a group) tend to perform rather poorly. From their data, the authors infer that successfully perceiving stress is difficult at the initial stages of learning. The studies in this body of literature, however, hardly demonstrate that L2 learners have "problems" with their *implicit* phonological processing of stress or even "perceptual difficulties" involving stress. What these studies test is the learners' phonological awareness of stress (i.e., their *explicit* phonological knowledge), not their perception, let alone their implicit phonological competence. For instance, when participants are asked to circle the stressed syllable, as in Beaudrie (2007), they must be able to break up nonwords in syllable-sized chunks and, from amongst the chunks, select the emphatic one. One could conceive of participants who are able to perceive rather clearly and consistently the difference between *caso* [ˈkaso] "case" and *casó* [kaˈso] "s/he married" and yet not to pin down the phonological feature that makes these word forms differ from each other. One could hypothesize that illiterate native Spanish speakers could be such participants. A participant who is unable to distinguish [ˈkaso] from [kaˈso] (i.e., one who processes them as homophones) would indeed demonstrate a poor (or fuzzy) implicit knowledge of stress, a perceptual or phonological challenge of some sort, with lexical repercussions. However, participants who fail to identify the stressed syllable in a nonce word or to pick from two orthographic renderings show only that they may not have explicit stress awareness or that they have overall low phonological awareness.

Three experimental studies represent significant methodological improvements (Kim, 2020; Saalfeld, 2012; Sagarra & Casillas, 2018). Kim (2020) played her participants lexical contrasts such as *paso* [ˈpaso] "I pass" and *pasó* [paˈso] "s/he passed" in sentence context and asked them to indicate the agent (or subject) of the verb: *yo* "I" (corresponding to the paroxytones in the data set) or *él* "he" (corresponding to the oxytones). Notice that this is an implicit linguistic task that does not necessarily require overt phonological awareness; it does require, however, lexical and morphosyntactic knowledge. Whereas the group of native controls were at ceiling, the L2 learners' average accuracy rate was 63%. The results of this experiment do suggest that L2 learners encounter some sort of phonological obstacle pertaining to stress; however, because this task requires grammatical knowledge as well as the ability to process whole sentences—which is arguably cognitively demanding—one could argue that the study does not *unequivocally* demonstrate that learners encounter acquisitional obstacles of a (specifically) phonological nature. With an eye-tracking study, Sagarra and Casillas (2018) showed that L2 learners of Spanish with English as their L1 can exploit stress information during auditory lexical access, but only proficient, advanced learners do—novice learners do not. Nevertheless, it is not known whether this finding demonstrates that novice learners have a reduced ability to deploy stress—a "problem" with stress processing—or a narrower difficulty with L2 spoken word recognition when it involves stress.

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Unlike other studies on the L2 acquisition of Spanish stress, Saalfeld (2012) utilized an implicit task that does not require metalinguistic abilities and is potentially able to isolate the process of phonological processing from other processes involved in comprehension. In Saalfeld's study, participants heard sequences of three sentences. In each trial, the first and second sentences differed in the location of stress on the main verb (e.g., *participo* [paɾtiˈsipo] "I participate" ~ *participó* [paɾtisiˈpo] "s/he participated" in *Para sacar una buena nota, __ en clase* "To get a good grade, __ in class"), and the third sentence matched either the first or the second. Participants were asked to match the third sentence with one of the preceding ones. It was found that, whereas controls were near ceiling, learners were at chance. The phonological processing of stress seems to pose some significant challenges to English-speaking Spanish learners. Due to the length of the sentences, however, this task may have been too cognitively demanding for the learners (to the extent that learners know the words in the sentences, lots of lexical items are being activated simultaneously, and sentences are being processed syntactically), thus potentially obscuring the effects of phonological processing or lack thereof.

In sum, to date, we do not know whether English-speaking L2 learners of Spanish have difficulties with their phonological processing of stress or not. The extant literature suggests that they do, but the existence of confounds in the experiments may hide some of the facts. The present study revisits the hypothesis that English-speaking L2 learners of Spanish face difficulties of a (specifically) phonological nature when acquiring Spanish stress—the study concentrates on phonological processing. To focus on phonological processing (and not speech perception or phonetic categorization), we employ an experimental working-memory task utilized in a collection of psycholinguistic investigations on the processing of stress by various populations, the *sequence-recall* task (Dupoux et al., 2001, 2008, 2010; Lin et al., 2014; Peperkamp et al., 2010; Qin et al., 2017).

PHONOLOGICAL PROCESSING OF STRESS ACROSS LANGUAGES

The functional role of stress differs across languages. Some languages, such as Spanish, use stress contrastively whereas others, such as French, do not. Native speakers of languages with contrastive stress have been found to display high sensitivity to stress distinctions, even in nonwords, whereas native speakers of languages with predictable stress have not (Altman, 2006; Dupoux et al., 1997, 2001; Lin et al., 2014; Peperkamp et al., 2010; Peperkamp & Dupoux, 2002; Qin et al., 2017). In a seminal study, Dupoux et al. (1997) compared the processing of stress contrasts by native French and native Spanish speakers in a battery of discrimination experiments, including AX (same-different) and ABX (matching) tasks. Most subsequent studies have employed the sequence-recall experimental paradigm of Dupoux et al. (2001). In a sequence-recall task, participants learn to associate keys with nonwords (auditory stimuli), and then such items are presented to them in pseudorandom order within trials that comprise short sequences of such items. Participants are asked to recall the order of the items within each trial—they are asked to recall the sequence. This task can be said to tap into phonological processing because, to recall a sequence, participants must be able to discriminate the tokens from each other in addition to retaining them (and the order in which they were played) in working memory. The task tests for sensitivity to stress manipulations as well as working-memory retention.

Relative to native Spanish speakers, native speakers of French have been found to display rather poor discrimination and recall of nonwords differing exclusively in stress configuration (Dupoux et al., 1997, 2001). These findings suggest that French speakers do not encode stress phonologically, likely because lexical stress is not a property of their native language—stress is irrelevant for finding words in the French lexicon. French speakers, therefore, may have "learned to ignore" any extant acoustic correlates of word-level prosody over the course of their experience with their native language. Native speakers of languages that, like French, lack contrastive stress, such as Korean, Finnish, and Hungarian, have also been found to not encode stress phonologically (Lin et al., 2014; Peperkamp et al., 2010; Peperkamp & Dupoux, 2002). In the sequence-recall task, speakers of languages that lack contrastive stress perform much better in trials whose items differ exclusively on their segmental composition than in trials whose items differ exclusively on their stress configuration. Spanish speakers, however, perform similarly well in both types of trials (if not better in stress contrasts), which suggests that, in Spanish, stress enjoys a phonological status similar to that of segments (a baseline).

This phenomenon has also been investigated in L2 learner populations. L2 learners of languages with contrastive stress whose L1 lacks this phonological feature tend to find stress acquisition very challenging, and sequence-recall tasks with such learners consistently find that the effects of L1 phonology are persistent (Dupoux et al., 2008; Lin et al., 2014; Qin et al., 2017). Proficiency does not seem to modulate the challenges of stress processing: an investigation comparing the processing of stress contrasts in novice and advanced L2 learners of Spanish whose L1 was French failed to find any effects of experience (Dupoux et al., 2008). In fact, even simultaneous bilinguals may see their stress processing habits impacted by the fact that one of their native languages lacks contrastive stress (Dupoux et al., 2010).

Subsequent studies with native-speaking populations suggest that the cross-linguistic facts may be more nuanced than they initially seemed. There are languages, such as Polish, in which lexical stress is neither entirely surface-predictable nor phonemically contrastive. Native Polish speakers have been found to perform better than French speakers but worse than Spanish speakers in a sequence-recall task investigating the role of stress (Peperkamp et al., 2010). This finding suggests that, concerning stress, it is the lexico-statistical patterns of a language, and not merely the presence versus absence of phonemic contrast, what determines the strength of the stress processing routines of its speakers. To be clear, the sequence-recall literature has not necessarily put into question the phonological processing of speakers of languages with contrastive stress. Only that of speakers of languages that lack contrastive stress has—amongst these, languages vary as to how surface-predictable stress is, and this variation appears to lead to gradience in the phonological processing of stress. But, we ask, could there be gradience also within the group of languages that possess contrastive stress?

PHONOLOGICAL PROCESSING OF STRESS IN ENGLISH

Prima facie, one would not expect any differences in stress processing between English and Spanish native speakers because stress is contrastive in both. Native English speakers have indeed been tested in sequence-recall experiments, but typically as a control group expected to be at ceiling (Lin et al., 2014; Qin et al., 2017). They have not been compared directly with Spanish speakers, but they have been compared with (Beijing) Mandarin speakers, a language variety that possesses lexical stress (and lexical tone). The initial, implicit assumption in these studies was that native English speakers encode stress robustly. Interestingly, however, English-speaking participants are rarely found to be at ceiling in such tasks. In fact, Lin et al. (2014) found that (Beijing) Mandarin speakers were better than native English speakers at recalling nonword sequences of four stimuli or more. Perhaps stress processing is only available to native English speakers when stress is instantiated by means of vowel timbre modifications, the authors speculate (Lin et al., 2014).

Several studies have investigated whether native English speakers exploit stress differences during lexical processing in the absence of vowel reduction patterns (Cooper et al., 2002; Cutler, 1986). Spanish speakers are known to utilize stress during lexical access (Sagarra & Casillas, 2018; Soto-Faraco et al., 2001); for instance, Soto-Faraco et al. (2001) found that disyllabic auditory primes (fragments), such as [ˈpɾinsi] and [pɾinˈsi], facilitate the recognition of visual targets, such as *príncipe* [ˈpɾinsipe] “prince” and *principio* [pɾinˈsipjo] “beginning,” but only when prime and target are matched by the stress pattern in the first two syllables. When the stress configuration of the prime mismatches that of the target, response times to targets are slowed down—lexical recognition is inhibited. For English, the facts are not as straightforward as they are for Spanish (Cooper et al., 2002). On the one hand, disyllabic auditory primes, such as [ˈædmɪ] and [ˌædmɪ], facilitate the recognition of visual targets, such as *admiral* and *admiration*, when prime and target match their stress configuration. On the other, mismatch does not produce inhibition in English. Also, minimal pairs such as *forebear* (noun) and *forbear* (verb) prime each other’s semantic associates (Cutler, 1986). Taken together, these studies suggest that English phonological entries do not include detailed stress representations (i.e., independent from vowel reduction) and that lexical access is not constrained by prosodic information in this language. We postulate that the differences between Spanish and English in regard to the role of stress distinctions in the lexicon are indicative of a lesser role of stress during phonological processing in English—the presence (versus absence) of lexical patterns affects the likelihood of developing stable stress processing strategies.

Phonological processing is involved in spoken word recognition, but some phonological processing strategies can be deployed even in tasks that do not involve lexical access, suggesting that some aspects of processing are prelexical (or nonlexical). The present study—informed by investigations on spoken word recognition, phonological processing in nonwords, speech perception, and L2 acquisition—asks whether adult L2 learners of Spanish with English as their L1 encounter an obstacle in their acquisition of Spanish stress of a (specifically) phonological nature, one instantiated in prelexical phonological processing patterns.

THE PRESENT STUDY

We hypothesize that native English speakers who are learning Spanish as their L2 find Spanish lexical stress patterns relatively difficult to acquire because, at the initial stages of their learning, they possess a phonological system with minimal phonological processing routines for stress. Most studies on the L2 acquisition of Spanish stress have demonstrated

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that native English speakers learning Spanish have low metalinguistic awareness of stress (Beaudrie, 2007; Kim, 2020; Ortega-Llebaria et al., 2013; Romanelli et al., 2015; Romanelli & Menegotto, 2015). To demonstrate that a particular population (also) lacks *implicit* knowledge of stress one must employ an experimental task that does not rely on metalinguistic awareness. In the present study, we employed the sequence-recall task of Dupoux et al. (2001). Participants who recall sequences accurately can be said to be able to discriminate between experimental items, retain such items in short-term memory, and perform comparisons of such items in working memory. Although cognitively demanding in itself, this task does not rely on metalinguistic awareness pertaining to the phonological feature that minimally distinguishes the experimental items (stress) and neither does it require the deployment of linguistic knowledge.

In addition to testing whether L2 learners of Spanish have reduced phonological processing routines pertaining to lexical stress (relative to native Spanish speakers), we address the following question: Does the experience of learning Spanish as a L2 modulate stress processing in any way? In particular, do learners' processing routines become more effective with increased proficiency in Spanish? Dupoux et al. (2008) found that an increase in L2 proficiency did not lead to an improvement in stress processing, but this study tested only French-speaking learners of Spanish. Because English speakers must process lexical stress in their native language—at least to some extent—we hypothesize that they are more likely to learn the stress patterns of Spanish than French-speaking learners.

METHOD

PARTICIPANTS

A sample of 107 young adults participated in a sequence-recall experiment with auditory stimuli. Participants were recruited from among the members of the student body of a large university located in the United States of America. The participants were either native speakers of Spanish (controls, $N = 10$) or native English speakers learning Spanish as a L2 (target sample, $N = 97$).

The control group consisted of students raised as monolinguals in a Spanish-speaking country who studied English as a foreign language starting in puberty and emigrated to the United States after their bachelor's degree, at age 22 or later, for their graduate studies. These participants, while bilingual, continue to use their native language, Spanish, daily. The target group was comprised of undergraduate students raised as English-speaking monolinguals in the U.S. southwest. These participants were recruited from a Spanish as a L2 program. Participants in this group represented a variety of experience levels, including students enrolled in first-, second-, and third-year college Spanish classes.

All participants, including the controls, completed a language profile questionnaire and three Spanish proficiency tests. For the background questionnaire, we used the Bilingual Language Dominance Profile (Gertken et al., 2014). The questionnaire was used mainly to confirm that all our participants fell clearly within two main groups, native and adult L2 speakers of Spanish. We were careful not to recruit any early Spanish/English bilinguals or heritage Spanish speakers. In our implementation of the survey, a preferred orientation toward Spanish is indicated by a negative overall score in the survey, while a positive score indicates a preferred orientation toward (or dominance in) English. The questionnaire assesses bilinguals' linguistic histories, usage rates, attitudes, and self-rated proficiencies. We take this questionnaire to be an index of linguistic experience and dominance.

The Spanish proficiency tests comprised two cloze tests adapted from Martínez García (2016), of which one was a passage cloze test and the other a cloze test with individual sentences. We also administered the LexTale-Esp task (Izura et al., 2014). The LexTale-Esp is an instrument used to assess Spanish vocabulary size. The test includes 60 Spanish words and 30 nonwords, and the participants' task is to make lexical decisions on the word forms. To obtain each participant's score, one point was added for every correct response, and two points were subtracted for every incorrect response. The maximum score is 60, and negative values are possible. A higher score is indicative of a larger vocabulary size.

The two cloze tests were administered through an online form. The first test consisted of a passage in which 20 words had been omitted, and the second test contained 30 sentences in which one word per sentence had been omitted. Participants were asked to fill the space of the omitted words with a context-appropriate word, and options were provided to them in a dropdown menu. To obtain the participant's score, one point was added for every correct response; thus, the maximum score is 20 for the passage cloze test and 30 for the sentence word test. Table 1 reports the descriptive statistics pertaining to the experience and proficiency scores.

Because the controls and the learners did not overlap in any of the score distributions, we can affirm that these two groups are statistically different in grammatical proficiency, vocabulary size, and linguistic experience. The two samples clearly belong to separate populations. For the L2 learners only, the proficiency and experience scores were normalized (z-scored) so that they could be compared with each other. Most scores were modestly associated with each other: passage-sentence, $r = .23$ (95% CI [.03, .41], $p = .025$), passage-vocabulary, $r = .07$ (95% CI [−.13, .27], $p = .492$), sentence-vocabulary, $r = .30$ (95% CI [.10, .47], $p = .0003$), vocabulary-experience, $r = -.25$ (95% CI [−.42, −.05], $p = .015$), passage-experience, $r = -.19$ (95% CI [−.37, .01], $p = .068$), and sentence-experience, $r = -.42$ (95% CI [−.57, −.25], $p < .0001$). A multivariate analysis

TABLE 1. Descriptive statistics of the dominance (score obtained with linguistic profile questionnaire) and proficiency scores (a vocabulary-size test, a sentence cloze test, and a passage cloze test) as a function of participant group: native Spanish speakers, acting as controls, and L2 learners of Spanish with English as their native language, further divided as a function of their year of enrollment in college Spanish

		Dominance		Sentence Cloze		Passage Cloze		Vocabulary Size	
Group	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Natives	10	−129.7	18.3	29.0	0.8	17.9	0.7	57.4	1.7
Learners	97	142.2	29.0	10.3	3.9	6.1	2.1	−0.7	6.7
First	29	162.5	17.6	8.1	2.3	5.9	1.7	−2.9	7.1
Second	46	138.9	28.1	10.0	3.4	5.8	2.3	−0.3	5.8
Third	22	122.3	26.7	13.9	4.1	6.8	1.9	1.5	7.4

of variance (MANOVA) explored the normalized scores as a function of year of enrollment in college Spanish (first, second, third). The model predicted about 40% of the variance in the variables, Wilk's $\lambda = .59$, $F(8,182) = 6.98$, $p < .0001$. Only two variables were identified as being modulated by year of enrollment: experience (or dominance), $F(2,94) = 16.77$, $p < .0001$, sentence cloze test, $F(2,94) = 20.19$, $p < .0001$, passage cloze test, $F(2,94) = 1.80$, $p > .05$ [.176], and vocabulary size, $F(2,94) = 2.91$, $p < .05$ [.059]. The proficiency and experience (dominance) scores are retained for further exploration as predictors of perceptual behavior—year of enrollment is discarded.

INSTRUMENT

The experimental task of choice for the present study was the sequence-recall task, first used by Dupoux et al. (2001) in a study of the phonological processing of lexical stress in working memory by native French and Spanish speakers, and later also employed in a series of studies with both monolingual and bilingual participants (Dupoux et al., 2010; Lin et al., 2014; Peperkamp et al., 2010; Peperkamp & Dupoux, 2002; Qin et al., 2017). Our sequence recall task involved a minimal pair differing in a *consonant* contrast ([ˈtuki], [ˈtupi]; our control condition) and a minimal pair differing in *stress* configuration ([ˈnumi], [nuˈmi]; our target condition). None of the resulting stimuli are real words in neither English nor Spanish. Six iterations of each of the four items produced in isolation were recorded from a female native speaker of Spanish. In addition, the word "okay" was recorded from a male native speaker of Spanish. This auditory word was used to interfere with the potential effects of acoustic memory in listeners and was played at the end of all trials, prior to the participant's response. Recordings took place in a sound-attenuated booth. All the stimuli were recorded with a Marantz PMD660 digital recorder, a Sound Devices MM-1 pre-amplifier, and a Shure SM10A head-mounted, dynamic microphone. The recordings were digitized at a sampling rate of 44.1 kHz and 16-bit quantization.

Two blocks of 8 experimental trials were constructed for each contrast, resulting in 16 trials per contrast and a total of 32 experimental trials in the experiment (2 contrasts × 2 blocks × 8 trials). The first block was comprised of trials playing four items in sequence, and the second block had six-item sequences per trial. The items in each sequence were separated by a stimulus onset asynchrony of 1 s. We selected the same sequence combinations used in Dupoux et al. (2001). The sequences were comprised of a combination of the two members of the minimal pair in which one member could only be repeated three times in a row. Sequences always included different productions of each item. This means that even if, for instance, the nonword *túki* appeared four times in a six-item sequence, all these instances were different iterations of the same nonword recorded from the same talker. Therefore, all the instances of the same item that appeared in a given sequence were phonetically different from each other, requiring some level of abstraction to be considered members of the same item.

Participants completed the task in a sound-attenuated booth using MDR-7502 Sony headphones with a computer running the experiment from a Python script (Peirce, 2007; Peirce et al., 2019). They were tested first on the consonantal contrast and then on the stress contrast, in separate blocks. In both blocks, the procedure was identical: there was a training phase, a practice phase, and an experimental phase. First, participants were taught to associate each of the members of the minimal pair to a number key. For the consonantal contrast, *túki* was linked to [1] and *túpi* was linked to [2]. For the stress contrast, *númi* was linked to [1] and *numí* was linked to [2]. During the training phase, participants were instructed to press keys [1] and [2] as many times as they wished to hear different iterations of the two items with the purpose of familiarizing themselves with the items and their linked keys. Next, participants proceeded to a practice session in which they were asked to identify the item they had heard by pressing keys [1] or [2]. If they heard *túki* or *númi* they were to press to key [1] and if they heard *túpi* or *numí* they were to press key [2]. They received feedback as to whether they were correct immediately after pressing each key, and they needed to provide eight correct responses in a row to proceed to the experimental block.

After the practice session, participants were tested first in a block playing only trials comprised of four-item sequences, and then in a block playing only trials comprised of six-item sequences. Before each block, they were presented with instructions and examples. They were told that they would hear a sequence of words involving the nonword pair they just associated to keys [1] and [2], followed by the word "okay." Participants were instructed to indicate the sequence they heard by using the keys on the keyboard and then press the ENTER key. For example, if they heard the sequence *túki-túki-túpi-túki*, they would have to enter the combination 1121 and press ENTER. Within each block, the trials were presented in random order.

In each trial, the sequence was presented auditorily after 500 ms of silence. After the nonwords in the trial were played, the screen displayed a visual reminder of the number of words in the sequence (i.e., "4 words" or "6 words"). Then, participants could enter their response, and they were able to see their responses as they typed the answer. Participants did not receive feedback on the experimental trials.

All instructions were in English to ensure all participants could understand them well. Participants were explicitly told they would listen to nonwords produced by Spanish talkers, and that they had been recruited because they were Spanish speakers or learners of the language.

DATA ANALYSIS

The data from the control and experimental groups were analyzed separately because the groups differ in size. A native control group was included merely to verify the usefulness of the instrument because this population has already been investigated with this paradigm, although not with these exact auditory stimuli (Dupoux et al., 2001). Data were explored in three main steps. First, we analyzed the behavior of the native controls. Second, we explored the entire sample of L2 learners, as a group. This resulted in a conceptual comparison of the native and learner data—that is, the overall patterns found in the two groups. Third, we investigated whether L2 proficiency and/or experience were able to predict any of the variance in the L2 group. In other words, our third step examined whether proficiency and/or experience modulate the phonological processing of stress in L2 learners of Spanish whose L1 is English.

The data consisted of by-participant accuracy rates as a function of two experimental conditions: type of *contrast* manifested in the trial (stress, consonant), and number of nonword stimuli in the trial or *length* (4 nonwords per trial or "short," 6 nonwords per trial or "long"). This resulted in two data sets, one with 40 observations (2 *length* conditions ×

2 *contrast* conditions × 10 participants) and one with 388 observations (2 *length* conditions × 2 *contrast* conditions × 97 participants), for the native and learner groups, respectively. Accuracy rates—that is, proportion of correct responses (*P*) per participant, per condition—were subjected to a *logit* transformation, log(*P*/(1-*P*)), prior to their submission to inferential statistics.

Data preparation was conducted with a collection of *R* (version 4.0.1) scripts (r-project.org), with package *tidyverse* (version 1.3.1) (tidyverse.org). Statistical data analyses were conducted in *Jamovi* (version 1.2.22), a reproducible open-source GUI for *R* (jamovi.org). Three *R* packages were used in the analyses: *afex* (version 0.27-2), *emmeans* (version 1.4.7), and *esci* (version 0.9.1). Synthetic data, data tidying *R* scripts, and *Jamovi* files may be made available to readers interested in reproducing our analyses. Interested readers should contact the corresponding author.

RESULTS

Table 2 reports on the descriptive statistics concerning accuracy rates (proportion of correct responses) as a function of participant group (native Spanish controls, L2 learners of Spanish) and the two experimental conditions: number of items in the trial (four, six), and type of contrast instantiated in the trial (consonant, stress). Table 2 reports on proportion of correct responses, but subsequent analyses were conducted on logit-transformed accuracy rates.

NATIVE SPANISH CONTROLS

Figure 1 plots the descriptive central tendencies of the logit-transformed accuracy rates corresponding to the 10 native Spanish controls. The logit-transformed accuracy rates were submitted to a (2) × (2) repeated measures ANOVA with Contrast (consonant, stress) and Length (short [4 items], long [six items]) as factors. The ANOVA yielded statistically significant effects of Contrast, $F(1,9) = 8.93$, $p < .05$ [.0153], $\eta^2_p = .50$, and Length, $F(1,9) = 30.15$, $p < .05$ [.0004], $\eta^2_p = .77$, but no statistically significant interaction between the two factors, $F(1,9) = 0.02$, $p > .05$ [.8832], $\eta^2_p = 0.00$. The estimated marginal means and 95% confidence intervals are reported in Table 3.

TABLE 2. Descriptive statistics pertaining to response *accuracy* (proportion of correct responses) in an auditory sequence-recall experiment as a function of participant group (native Spanish controls, L2 learners of Spanish) and two experimental conditions: type of *contrast* (consonant, stress) and *length* of trial in number of items (short [4 items], long [6 items])

		Consonant				Stress			
		Short		Long		Short		Long	
Group	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Natives	10	.81	.20	.45	.21	.92	.09	.65	.20
Learners	97	.79	.17	.46	.19	.76	.19	.37	.21

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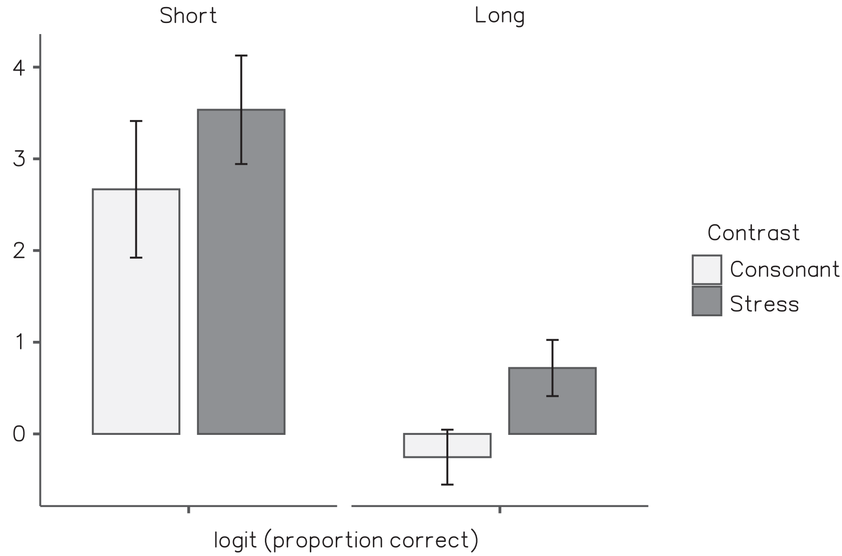

FIGURE 1. Logit-transformed mean (and standard errors) accuracy (proportion of correct responses) in a sample of 10 native Spanish speakers plotted as a function of *contrast* type and *length* of sequence in number of auditory tokens.

TABLE 3. Estimated marginal means and 95% confidence intervals with equal cell weights of logit-transformed accuracy rates of native Spanish controls as a function of *contrast* (consonant, stress) and *length* (Short [4 items], Long [6 items])

			95% CI	
Contrast	Length	*M*	*LL*	*UL*
Consonant	Short	2.67	1.59	3.75
	Long	−0.25	−1.33	0.83
Stress	Short	3.53	2.46	4.61
	Long	0.72	−0.36	1.80

Interestingly, native controls were more likely to be accurate when responding to stress contrasts than when responding to consonant contrasts, $M_{diff} = 0.92$, 95% CI [0.22, 1.62], $r = .742$. Unsurprisingly, they were much more likely to be accurate in short trials than in long ones, $M_{diff} = 2.87$, 95% CI [1.69, 4.05], $r = .489$. Both main effects were rather large in magnitude, with the effect of Length being particularly large. The standardized paired differences—Cohen's *d*, with the averaged standard deviation of the two conditions as standardizer—were as follows: Contrast, $d_{avg} = 0.67$, 95% CI [0.22, 1.29],[1] and Length, $d_{avg} = 1.86$, 95% CI [1.14, 3.04].

This sample consisted of only ten observations. A sample of this size is very unlikely to yield a precise estimate of the behavior of the population—note the wide 95% CI bars for the standardized contrast effect, for instance. The findings pertaining to Length are hardly surprising, and the effect is very large. The relevant finding pertains to the effects of contrast. Note that the native controls were more likely to be accurate when processing stress contrasts than when processing consonant contrasts. This finding was not entirely expected, as we had hypothesized that there would be no effects of contrast in this group, but a trend in this direction has also been found elsewhere (Dupoux et al., 2001). Nevertheless, it is important to highlight that the detected effects of contrast go in the direction contrary to what was predicted for the learners; in other words, it is important to highlight that stress sequences have not been found to lead to lower accuracy than the baseline condition.

SECOND LANGUAGE LEARNERS

We first explore the entire group of learners making no distinction as to their overall proficiency. Figure 2 plots the logit-transformed accuracy rates of the 97 L2 learners as a function of the two experimental factors in the experiment. The transformed accuracy rates were analyzed with a repeated measures ANOVA with Contrast (consonant, stress) and Length (short [4 items], long [six items]) as factors. The ANOVA yielded statistically significant effects of Contrast, $F(1,96) = 12.50$, $p < .05$ [.0006], $\eta^2_p = .12$, and Length, $F(1,96) = 254.93$, $p < .0001$, $\eta^2_p = .73$, but no statistically significant interaction between the two factors, $F(1,96) = 1.22$, $p > .05$ [.2713], $\eta^2_p = 0.01$. The estimated marginal means and 95% CIs are reported in Table 4. The L2 learners were much more likely to be accurate in short trials than in long ones, $M_{diff} = 2.32$, 95% CI [2.03, 2.61], $r = .393$, which is not surprising. This particular statistical effect is very large, $d_{avg} = 1.79$, 95% CI [1.53, 2.10]. Most importantly, unlike the native controls, the learners were *less* likely to be accurate when responding to stress contrasts than to consonant contrasts, $M_{diff} = 0.40$, 95% CI

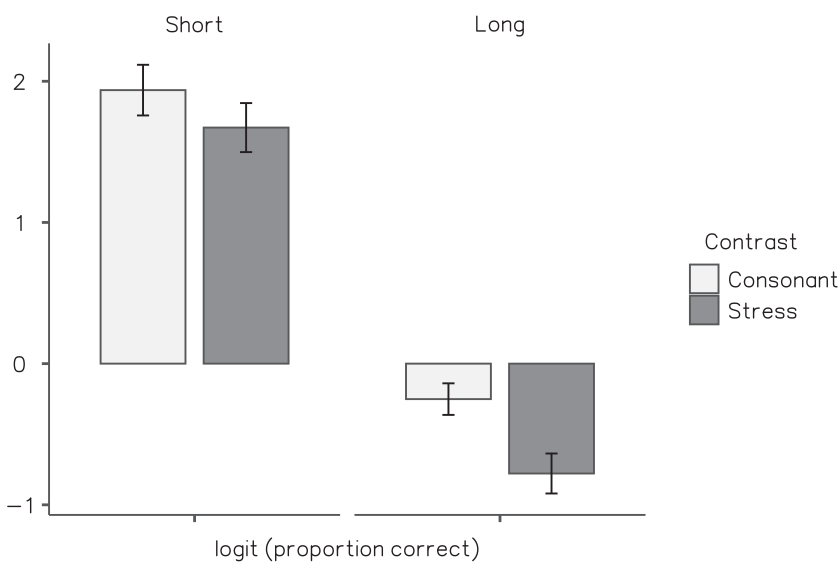

FIGURE 2. Logit-transformed mean (and standard error) accuracy (proportion of correct responses) in a sample of 97 native English speakers who are learning Spanish as a second language plotted as a function of *contrast* type and *length* of sequence in number of auditory tokens.

TABLE 4. Estimated marginal means and 95% confidence intervals with equal cell weights of logit-transformed accuracy rates of L2 learners of Spanish as a function of *contrast* (consonant, stress) and *length* (Short [4 items], Long [6 items])

			95% CI	
Contrast	Length	*M*	*LL*	*UL*
Consonant	Short	1.94	1.63	2.24
	Long	−0.25	−0.55	0.05
Stress	Short	1.67	1.37	1.98
	Long	−0.78	−1.08	−0.47

[0.17, 0.62], $r = .58$. When standardized, the size of the effect is revealed to be relatively modest, $d_{avg} = 0.33$, 95% CI [0.14, 0.52].[2]

To summarize, L2 learners were found to be, on average, less accurate when recalling trials differing in stress contrasts than in the baseline condition, and they were much less accurate when recalling long sequences than shorter sequences, as one would naturally expect. The effects of sequence length are unimportant, but the effects of contrast are very relevant, particularly because this is a large sample of participants and the findings are quite precise—note that the 95% CI bars of the standardized contrast effect are much shorter for this group than for the native controls.

THE ROLE OF PROFICIENCY AND EXPERIENCE

To assess whether proficiency and experience modulate stress processing in our population of interest, we subtracted the logit-transformed accuracy rates of all participants in the stress condition from those in the consonant condition. This produced a *contrast effect* measure, a within-participant difference metric. This metric was then regressed against normalized BLDP scores (experience), normalized cloze test scores (both sentence and passage), and normalized LexTale-Esp scores (vocabulary size). The linear regression model yielded a statistically significant, albeit very modest, result: $R^2 = .11$, $F(4, 92) = 2.83$, $p < .05$ [.0291]. The model predicted 11% of the overall variance. The effects of the individual predictors are not interpretable because there is collinearity in the regression model—the model coefficients are nevertheless reported in Table 5.

A series of Pearson correlations between the contrast effect metric and the proficiency and experience metrics revealed an association only in one case: passage cloze test, $r = -.29$, 95% CI [−.10, −.46], $p = .004$, sentence cloze test, $r = -.14$ [.06, −.33], $p = .161$, vocabulary-size test, $r = -.05$ [.15, −.25], $p = .638$, and experience score, $r = .12$ [.32, −.08], $p = .226$. To summarize, we found evidence of a modest association between participants' proficiency in Spanish and their phonological processing of stress contrasts —an increase in Spanish proficiency was associated with a decrease in the difference between accuracy in the baseline condition and the stress condition. As L2 learners improve in their proficiency, the stress processing routines come to resemble more their segment processing routines, a processing baseline.

TABLE 5. Full results of a linear regression model with *contrast effect* (by-participant logit-transformed accuracy in consonant trials minus logit-transformed accuracy in stress trials) as response and four Spanish proficiency and experience metrics as predictors: experience (BLDP survey scores), cloze test scores (sentences, passage), and vocabulary-size (LexTale-Esp). The participant sample is comprised of 97 L2 learners of Spanish with English as L1

			95% CI			
Predictor	Estimate	*SE*	*LL*	*UL*	*t*	*p*
Intercept	0.45	0.12	0.22	0.69	3.84	.0002
Experience (BLDP)	−0.01	0.13	−0.28	0.25	−0.09	.9257
Passage Cloze Test	0.28	0.13	0.03	0.53	2.22	.0288
Sentence Cloze Test	0.08	0.14	−0.20	0.36	0.54	.5888
Vocabulary-Size Test	0.23	0.13	−0.03	0.48	1.76	.0811

DISCUSSION

SUMMARY OF FINDINGS

A group of 107 people participated in a sequence-recall task in which trials differed according to the number of auditory tokens in the trials (four items or six items) and, crucially, the nature of the phonological contrast instantiated in the auditory tokens (items could differ in stress configuration or consonant composition, our baseline condition). We had a small group of 10 native Spanish controls and a large group of 97 L2 learners of Spanish whose native language is English.

The most relevant findings in the study have to do with the effects of phonological contrast. Interestingly, it was found that natives were more likely to be accurate when processing stress contrasts than a particular consonant contrast, taken to be a baseline condition. We had initially predicted the absence of an effect, but an effect in this direction is not entirely surprising given the fact that such a trend had already been found for this population (Dupoux et al., 2001). Learners, however, were more likely to be accurate when processing the baseline condition than the stress condition. Figures 3 and 4 plot the paired effects of contrast type for the two groups of participants. These figures allow us to compare not only the direction of the effects but also their size. The 95% confidence intervals allow us to assess the overall precision of the study. Whereas we are reticent to make any conclusive claims concerning the native speakers (as to whether there is a real effect in the population in the direction captured here), we believe that our study does confirm that native English speakers who are learning Spanish as a L2 are less likely to be accurate, in a sequence-recall task, in trials involving stress contrasts than in baseline phonological processing conditions, exemplified here as a particular consonant contrast condition. The size of our L2 learner sample allows us to put forth this claim, and the short length of the confidence intervals suggest the study is quite precise.

INTERPRETATION AND IMPLICATIONS

Native controls were found to be more accurate in stress trials than in the baseline condition; crucially, they were not less likely to be accurate when processing stress

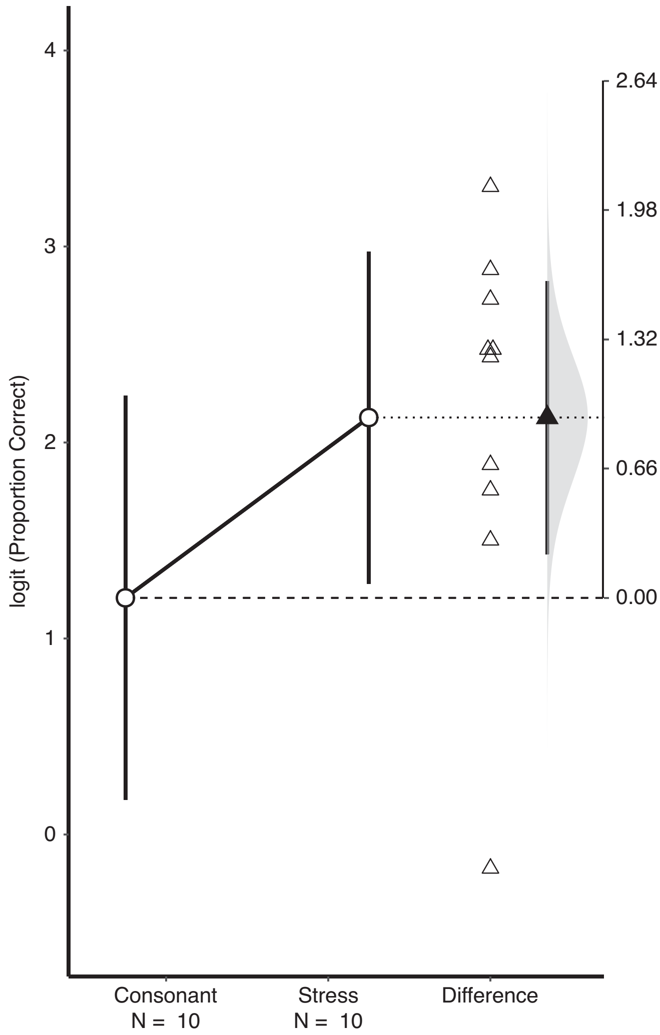

FIGURE 3. Pairwise comparison in logit-transformed accuracy (proportion of correct responses) as a function of *contrast* type in a sample of 10 native Spanish speakers. White dots are condition means, and the black triangle is the mean difference between the two conditions. White triangles are individual difference values. Error bars are 95% confidence intervals.

contrasts than consonant contrasts. These findings suggest that native Spanish speakers have detailed phonological representations of stress, and online phonological processing entails activation of such representations, as expected (Dupoux et al., 2001; Peperkamp et al., 2010). Native Spanish speakers encode stress contrasts as robustly as they seem to encode other contrasts in their phonological grammar, if not more so. Further research with a much larger sample should revisit this particular population to verify whether the trend we found results in an actual statistical effect.

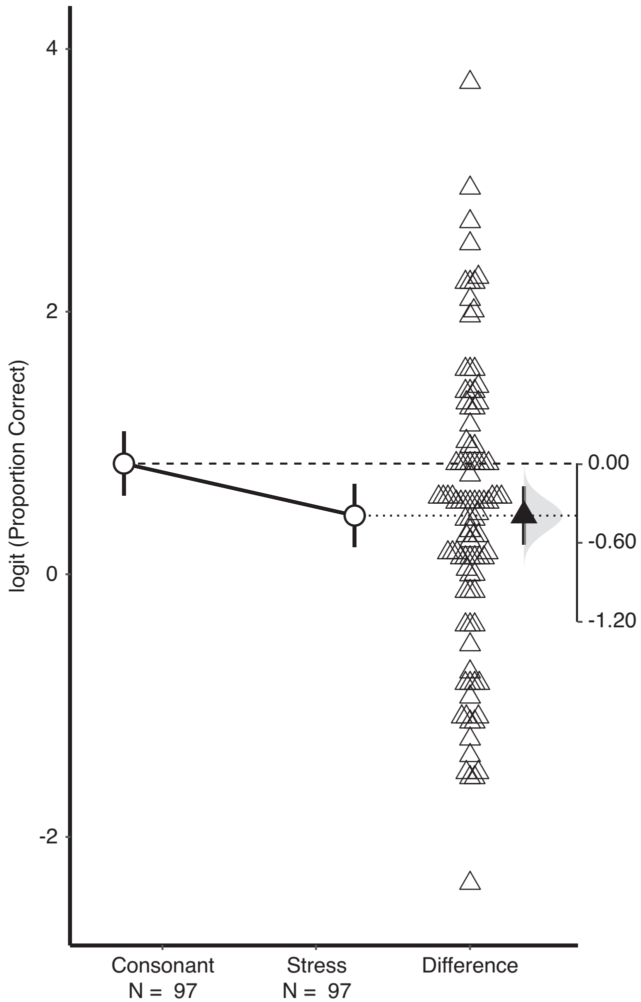

FIGURE 4. Pairwise comparison in logit-transformed accuracy (proportion of correct responses) as a function of Contrast type in a sample of 97 native English speakers who are learning Spanish as a second language. White dots are condition means, and the black triangle is the mean difference between the two conditions. White triangles are individual difference values. Error bars are 95% confidence intervals.

The present study set out to investigate the behavior of L2 learners of Spanish whose L1 is English. As a group, the L2 learners in our sample were found to be more likely to be less accurate in their processing of stress contrasts than in the baseline condition, which entailed a particular consonantal contrast (cf. Lin et al., 2014; Qin et al., 2017). These findings suggest that L2 learners' representation of lexical stress is not as robust as their representation of other contrasts in their phonological grammar. Activation of only fuzzy or ephemeral phonological representations of stress in working memory (during phonological processing not involving lexical access) may trigger relatively low accuracy in their responses in stress trials. The present study thus comes to confirm with a new method the findings of previous studies on the acquisition of Spanish stress by learners whose native language is English (Beaudrie, 2007; Kim, 2020; Ortega-Llebaria et al., 2013; Romanelli et al., 2015; Romanelli & Menegotto, 2015; Saalfeld, 2012). To some extent, native English-speaking learners of Spanish as a L2 find lexical stress contrasts relatively challenging to process. Whereas prior studies focused on overt phonological awareness or required that participants utilized higher-order processing routines to complete experimental tasks (such as those requiring lexical and grammatical knowledge), the present study suggests that learners encounter an acquisitional obstacle based on implicit phonological knowledge—that is, one based on phonological representations and phonological processing. This is the main conclusion of our study. Now, because lexical stress is contrastive in their native language, why do native English speakers seem to have inefficient stress processing routines relative to native Spanish speakers?

As reviewed, studies on stress processing using the sequence-recall task have typically found differences between, on the one hand, speakers of French, Hungarian, Finnish, and Korean, and, on the other hand, speakers of Spanish, (Beijing) Mandarin, and English (Dupoux et al., 2001; Lin et al., 2014; Peperkamp et al., 2010; Qin et al., 2017). In the languages in the former group, stress is predictable (not contrastive), whereas the languages in the latter group have contrastive stress (not predictable). This suggests that speakers of languages with contrastive stress develop robust phonological representations of stress contrasts (and patterns), and such representations facilitate online phonological processing (including processing of nonwords). Speakers of languages with fully predictable stress do not develop such representations and, consequently, do not have them available in phonological processing (including nonwords). But the absence (versus presence) of contrast does not tell the whole story, as native Polish speakers have been found to be more accurate than French speakers but less so than Spanish speakers (Peperkamp et al., 2010). Polish lacks contrastive stress, but the location of stress is not fully surface-predictable. This fact of the phonology of Polish may encourage its speakers to not entirely dismiss suprasegmental information during speech processing in their native language. And accumulated experience with the sound patterns of their language may implicitly encourage them to develop stress representations, albeit such representations may be less detailed or stable than those of speakers of languages with contrastive stress, such as Spanish.

The findings of the present study suggest that the behavior of native English speakers is also somewhere between that of Spanish and French speakers. It would appear that, if there is gradience in stress processing routines within the subgroup of languages that lack contrastive stress (e.g., French vs. Polish), there is also gradience within the subgroup of languages that possess it (e.g., Spanish vs. English). Lin et al. (2014), who also noted that English speakers do not seem to be at ceiling when discriminating stress minimal pairs in nonwords, pointed to a series of findings pertaining to how native English speakers process suprasegmental features during spoken word recognition (Cooper et al., 2002; Cutler, 1986; Cutler et al., 2004; Cutler & Pasveer, 2006; van Donselaar et al., 2005). The findings in this body of literature suggest that, in English, stress minimal pairs not accompanied by vowel-timbre distinctions, such as *trusty* and *trustee*, are stored as homophones in the mental lexicon (Cutler, 1986). And native English speakers do not actively exploit stress patterns when resolving lexical competition during lexical access

(Cooper et al., 2002). These findings suggest that stress configuration is not necessarily included in the phonological representation of English words by native English speakers.

The functional load of stress contrasts is relatively light in both Spanish and English—there are few minimal pairs distinguished by stress. In English, the number of such pairs is truly minimal. In Spanish, words belonging to different parts of speech might contrast in stress configuration (such as *caso* "case" and *casó* "s/he married"), but such pairs are also few and far between. Within verbal paradigms, however, stress minimal pairs are frequent: *corto* [ˈkoɾto] "I cut (pres.)" ~ *cortó* [koɾˈto] "s/he cut (pret.)," *toco* [ˈtoko] "I touch (pres.)" ~ *tocó* [toˈko] "I touched (pret)," *pasara* [paˈsaɾa] "s/he would pass (pres., subj.)" ~ *pasará* [pasaˈɾa] "s/he will pass (fut., ind.)." Whereas the functional load of stress might be relatively limited in both Spanish and English, it seems to be heavier in Spanish. This might implicitly encourage Spanish speakers to develop strong phonological representations of stress.

Consider now an additional fact noted by Cutler and colleagues (Cutler et al., 2004; Cutler & Pasveer, 2006). Words are likely to include other words embedded in them (e.g., *sea* is embedded in *secret* and *senior*), and such embedded words are spuriously activated during lexical access (e.g., [ˈsikɹət] activates both *sea* and *secret*). The average number of words embedded in other words is much lower in English than it is in Spanish—the latter has a smaller segmental inventory and words are, on average, longer. Interestingly, when one considers mismatches in stress configuration, the average number of embedded words in Spanish is drastically reduced (relative to when one does not), but only modestly so in English. For example, when considering only segments, *casa* [ˈkasa] "house" is embedded in *casado* [kaˈsaðo] "married," but it is not when one requires stress configuration to match. The average number of embedded lexical competitors is reduced when considering stress configuration, but only significantly so in Spanish (Cutler et al., 2004). This suggests that the benefit of including stress in underlying phonological representations might be fundamental in Spanish, but negligible in English. As a consequence, one may postulate, English speakers are not implicitly encouraged by the structure of their native language to develop robust stress representations that they can exploit during lexical processing in their native language. We hypothesize that this fact causes the apparent acquisitional obstacle native English speakers encounter when they begin to learn Spanish. In particular, lifelong experience with their native language has encouraged them to ignore suprasegmental features (or has failed to encourage them to include them in their phonolexical representations) because such features are not particularly helpful to them to resolve lexical competition in their native language.

The present study also found some evidence that, with increased exposure to Spanish (or increased proficiency), comes improved stress processing routines. Arguably, mental representations of stress patterns become more detailed and stable over time for L2 learners of Spanish. The association between proficiency and stress processing routines we found is, however, only very modest, and further research is needed for this association to be understood. Sagarra and Casillas (2018) found that very advanced, but not novice, L2 learners of Spanish exploit suprasegmental information (stress configuration) during lexical access. The present study collected processing data from a relatively large sample of learners, but the most advanced learners in our sample were enrolled in third-year college Spanish courses. While our study documented improved stress processing performance associated with increased linguistic proficiency, it has done so only for the relatively initial stages of L2 learning. We postulate that, as their vocabularies become larger (and they become more adept at using their L2 vocabulary), L2 learners come to implicitly discover the need to attend to suprasegmental information to resolve lexical competition in Spanish. This, in turn, may lead to more robust representations of stress patterns not directly dependent on the lexicon (an epiphenomenon of phonolexical development)—such representations may then be deployed during the processing of nonwords. It is likely that gains are larger in more advanced stages of learning, as we found them to be only very modest in our sample.

To a certain extent, our finding concerning proficiency contrasts with that of Dupoux et al. (2008), who documented that native French-speaking L2 learners of Spanish did not seem to improve their stress-processing performance with increased proficiency in their L2. Whereas French-speaking learners of Spanish may find Spanish stress extremely difficult to acquire, English-speaking learners find it to be only somewhat difficult—that is, perhaps more difficult than one would expect considering that their native language also uses stress contrastively, but less difficult than French listeners find it to be. Arguably, the size of the acquisitional obstacle is determined by the starting point (the initial advantage or disadvantage afforded by the native language), that is, the nature and size of the acquisitional obstacle is determined by the phonological system of the native language and the processing strategies it encourages. It is reasonable to conclude that acquisitional obstacles vary in size, not only on whether they are present or absent from the path of L2 learners. Spanish stress poses an obstacle to both English and French learners, but not of the same size.

CONCLUSION

The present study hypothesized that English speakers may find the acquisition of Spanish stress patterns challenging because experience with their native language may not have led them to develop robust phonological processing routines pertaining to lexical stress even in their native language. This does not detract from the role of perceptual difficulties having to do with differential acoustic cue weighting which have been found in the literature (Ortega-Llebaria et al., 2013). The present study hypothesized that, in addition to perceptual phonetic difficulties (found elsewhere), English speakers learning Spanish as a L2 find the phonological processing of stress implicitly challenging (not overtly). Prior studies had demonstrated that linguistic experience is a major determinant of stress processing patterns, and this has been typically assessed by means of working-memory tasks with nonwords (Dupoux et al., 1997, 2001; Peperkamp et al., 2010). A direct comparison of Spanish and English speakers, however, had not been conducted. Our hypothesis was that one of the aspects the acquisitional obstacle English speakers face with regard to lexical stress is phonological, one that could be captured by phonological-processing tasks involving nonwords.

The results of our study suggest that native English speakers' stress-processing routines are less effective than a baseline processing routine involving another type of phonological contrast, plosives differing in place of articulation. We found a difference between learners and native speakers, but the informative difference is that between experimental and baseline conditions within the learner group. Contrary to the case of French-speaking learners of Spanish (Dupoux et al., 2008), English-speaking ones seem to be able to utilize

Spanish input to develop their stress-processing routines, at least to some extent (Sagarra & Casillas, 2018). Learners seem to improve their processing of stress with increased proficiency in Spanish. Because English is a language with contrastive stress, the task of acquiring Spanish stress might be easier for English-speaking learners than for French-speaking ones. At any rate, the phonological characteristics of English stress (and lifelong experience with their language) may fail to encourage native English speakers to initially develop robust phonological processing routines for stress (comparable to the processing routines they perhaps have for other phonological contrasts, such as consonants), which ultimately creates an obstacle when learning Spanish as a L2.

NOTES

[1]For an effect size of $d = 0.67$ and $N = 10$, observed power is 0.47 assuming a two-tailed paired samples *t*-test.

[2]For an effect size of $d = 0.33$ and $N = 97$, observed power is 0.9 assuming a two-tailed paired samples *t*-test.

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