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What Predicts the Effectiveness of Foreign Language Pronunciation Instruction?: Investigating the Role of Perception and Other Individual Differences

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Abstract

This study investigated second language (L2) learners' perception of L2 sounds as an individual difference that predicted their improvement in pronunciation after receiving instruction. Learners were given explicit pronunciation instruction in a series of modules added to their Spanish as a foreign language curriculum and were then tested on their pronunciation accuracy. Their perception of the target sounds was measured with an AX discrimination task. Though the best predictor of pronunciation posttest score was pretest score, perception made a unique and significant contribution. The other factors associated with better pronunciation of some L2 sounds were time spent using Spanish outside the classroom, age, and attitude. The results suggest that instructors should give adequate time for learners to hone their perception of target sounds at the outset of pronunciation instruction, because their initial ability to perceive the target sounds will in part determine how much they learn from such instruction. The results support models of L2 speech acquisition that claim that target-like perception is a precursor to target-like production, in this case in a formal learning context.

Keywords

pronunciation instruction, phonetics instruction, accent, discrimination, perception, Spanish

Résumé

Cette étude a investigué la perception des apprenants de langue seconde en ce qui concerne les sons de celle-ci comme différence individuelle qui prévoyait une amélioration de leur prononciation après enseignement. On a donné aux apprenants un enseignement explicit sur la prononciation dans une série de modules ajoutée à leur curriculum d'enseignement d'espagnol comme langue étrangère, et on les a testés sur la précision de leur prononciation. Leur perception des sons en espagnol était mesurée avec une tâche de discrimination AX. Quoique le meilleur indice des résultats post-test soit les résultat pré-test, la perception a fait une contribution unique et significative. Les autres éléments associés à une meilleure prononciation de certains sons dans la langue-cible étaient le temps dévoué à l'utilisation de l'espagnol en dehors du cours, l'âge, et l'attitude. Les résultats suggèrent que les enseignants devraient donner suffisamment de temps pour les apprenants de perfectionner leur perception de la langue-cible dès le début de l'enseignement de la prononciation, parce que leur capacité initiale de percevoir les sons-cible déterminera, en grand mesure, combien ils apprendront d'un tel enseignement. Les résultats soutiennent les modèles de l'apprentissage de langue seconde qui prétendent que la perception quasi-maternelle est un précurseur de la production quasi-maternelle, dans ce cas dans un contexte d'apprentissage formel.

Mots clés

enseignement de la prononciation**,** enseignement de la phonétique, accent, discrimination, perception, espagnol

What predicts the effectiveness of foreign language pronunciation instruction?

Investigating the role of perception and other individual differences

This article describes a study investigating second language (L2) learners' perception of L2 sounds as an individual difference which predicted their improvement in pronunciation after receiving instruction. Several theoretical accounts of L2 speech learning (Colantoni & Steele, 2008) and a wealth of empirical studies have linked perception to production (e.g., Akerberg, 2005; Flege, 1988, 1995; Munro, 2008; Newman, 1996; Rochet, 1995). Flege's (1995) Speech Learning Model (SLM) claims that accurate speech perception precedes or is central to the development of accurate production abilities, an assumption supported by studies that found significant correlations between L2 learners' perception and production of English segments (vowels and consonants) as well as studies reporting that gains made in perception of segments and suprasegmentals (aspects of speech prosody) after training transfer to the production domain (Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997; Wang, Jongman, & Sereno, 2003). Though there is some evidence inconsistent with the SLM's predictions, namely that some learners have produced contrasts they could not perceive (Goto, 1971; Sheldon & Strange, 1982) and demonstrated different acquisitional patterns in the perceptual and productive modes (de Jong, Hao, & Park, 2009), the perception-production link has been well attested (for review, see Colantoni & Steele, 2008).

In particular, the SLM claims that the first step in acquiring L2 speech involves detecting subtle phonetic differences between L2 sounds and phonetically similar native language (L1) sounds, at which point new categories (perceptual representations) can be formed for the L2 sounds. In other words, acquiring L2 speech begins first with detecting differences between native and non-native sounds and then developing the appropriate selective perceptual routines to "hear" them reliably (Strange & Shafer, 2008). If it is true that learners' perception determines their production, then it makes sense to investigate perception as a possible initial learning aptitude that could predict how much learners stand to gain from pronunciation instruction. Pronunciation instruction comes in different forms, however, and there might be a complex interaction between aptitude and type of instructional treatment. This article describes a study in which learners were given either explicit phonetics instruction or a treatment without such instruction and were then tested on their pronunciation accuracy. Their perception of the target sounds was measured with an AX discrimination task. Discrimination was found to be more predictive of improvement in production than other individual difference factors, but only for the group receiving phonetics instruction.

Individual differences and L2 accent

Researchers seeking to explain variability in outcomes of L2 acquisition have investigated many individual difference factors that fall into three main categories: social, cognitive, and affective (Ellis, 2004). Studies of individual differences in L2 speech have focused mainly on the phenomenon of foreign accent in English and have found that L1, age of acquisition, length of residence, and exposure to L2 are some of the best predictors of foreign accent, though these last variables often correlate (Birdsong, 2006; Davidson, 2011; Leather & James, 1996; Piske, MacKay, & Flege, 2001). The more similar the L1 is to the L2, the younger the learner starts to learn, the longer the learner resides in the L2 environment, and the more exposure the learner has to the L2, the less likely it is that her speech will be foreign accented.

In addition to these learner-external variables, learner-internal variables such as motivation and willingness to integrate in the target culture have been recognized as predictors of pronunciation (e.g., Ellis, 2004; Gardner & Lambert, 1972). Studies investigating a range of factors with learners of Spanish as a foreign language (FL) found that age of acquisition, formal instruction, and time spent in Spanish-speaking countries were correlated with pronunciation accuracy, and that enjoyment of Spanish culture, integrative motivation (as opposed to instrumental motivation), and concern with pronunciation were also correlated with more native-like pronunciation (Shively, 2008; Yager, 1988). A variety of learner-internal cognitive variables have been explored as well. Early studies such as Purcell and Suter (1980) found that "aptitude for oral mimicry" (the capacity to repeat novel speech accurately) predicted English L2 pronunciation accuracy.

More recent studies have teased apart the perceptual and productive abilities that support accuracy in oral mimicry tasks. For instance, after conducting a series of five experiments with Mandarin/L2 English bilinguals, Munro (2008) concluded that sensory memory supported the acquisition of novel L2 phonetic categories, auditory sequence memory supported the acquisition of higher-order phonotactics, better perception led to better production, and target-like perception was necessary but not sufficient for target-like production, "because low-capacity individuals displayed a fairly invariant degree of high accent while individuals with greater memory were relatively variable in their accent outcomes" (p. 195). Other studies also found an association between L2 pronunciation and perception, operationalized as the ability to detect accents (Flege, 1984; Magen, 1998). While people do not vary greatly in their auditory perception abilities, some individuals seem better able to process linguistic input in a bottom-up manner and notice more phonetic detail than others, and these processing differences can help explain why some people detect subtle differences between L1 and L2 sounds more easily than others (for review, see Munro, 2008).

Though the participants in most of the abovementioned studies had some formal language instruction, the studies themselves were designed to discover relationships between aptitudes and achieved accent, not outcomes of pronunciation instruction per se. Yet Baran-Łucarz (2012) found an interaction between aptitudes and instruction for Polish learners of L2 English (see also Trofimovich, Lightbown, & Halter, 2013). Field independence, auditory preference, and musical talent predicted high pronunciation accuracy for learners in naturalistic contexts, but learners lacking those innate predispositions could attain high pronunciation accuracy through formal instruction if they were highly motivated (preferably "aesthetically motivated"), believed they controlled their own progress, and considered their goal realistic. Baran-Łucarz hypothesized that the learners who needed formal instruction were field dependent visual learners lacking musical ability and internal motivation, but her hypothesis should be tested systematically.

Individual differences and L2 pronunciation instruction

Much L2 acquisition research has investigated the interactions between individual difference factors and instructional treatment types (for reviews see DeKeyser, 2012; Ellis, 2004), though phonology has received less attention than morphosyntax. Many laboratory studies have provided participants with intensive perceptual training on novel L2 phonemic contrasts, and while they reported generally positive results (e.g., Logan & Pruitt, 1995), there was variability across learners explained by individual differences. For instance, in Bradlow, Pisoni, Akahane-Yamada, and Tohkura's (1997) study training Japanese participants to perceive the English /□/-/l/ contrast, "the two high performers used the training sessions to 'fine-tune' an already well-defined preexisting two-way perceptual contrast […whereas] even after 45 sessions of minimal-pair identification training, the poorest performer showed almost no evidence of learning" (p. 2306). Several cognitive differences have been put forth as contributing to the variability across individuals in these perceptual training laboratory studies, such as differences in brain white matter morphology (Golestani & Zatorre, 2009) and phonological short-term memory (Aliaga-García, Mora, & Cerviño-Povedano, 2011). Perrachione, Lee, Ha, and Wong (2011) reported that the participants in their study who had good perceptual abilities did well in a training paradigm that used stimuli with high acoustic-phonetic variability (i.e., stimuli spoken by multiple talkers), whereas those with poorer perceptual abilities did better in a low-variability condition (i.e., stimuli produced by just one talker).

The research on interactions between L2 speech aptitudes and treatments should be extended beyond the perceptual training paradigms to more traditional instruction delivered in classrooms. Traditionally, foreign language (FL) classroom-based research has been concerned with the ability of pronunciation instruction to reduce learners' foreign accent and has reported generally positive results (Barrera Pardo, 2004). Few such studies have considered individual difference factors, though there are some exceptions (Elliott, 1995; Helmke & Wu, 1980; Kennedy & Trofimovich, 2010). Kennedy and Trofimovich (2010) found that for students enrolled in a semester-long English pronunciation course, there was an association between higher pronunciation ratings and more qualitative awareness comments in students' journals (i.e., comments about how pronunciation relates to language use), compared to comments about discrete aspects of pronunciation (quantitative language awareness). However, those students who made more qualitative language awareness comments also spent more time listening to English outside of class. Elliott (1995) found that neither field independence nor pronunciation attitude predicted the improvement intermediate FL students made in pronunciation of Spanish segments after a semester of brief lessons in Spanish phonetics but argued that instruction should be "multimodal" to accommodate varying learning styles. Helmke and Wu (1980) suggested that there was an aptitude-treatment interaction for their German speakers learning novel English contrasts: the high auditory discriminators benefited from "pronunciation drills" in which they repeated the target sounds many times, but low auditory discriminators benefited from "pronunciation exercises" in which they produced each target sound only once.

Helmke and Wu's pronunciation drills were akin to the repeated practice and feedback usually delivered in pronunciation courses, along with the core instructional component of explicit phonetics lessons. Such courses have been moderately successful in improving Spanish FL learners' accent (e.g., Elliott, 1995; González-Bueno, 1997; Lord, 2005), though most such studies lacked a control group. What is clear from all the abovementioned studies is that formal instruction helps some learners more than others, but precisely for whom the instruction is likely to be most beneficial is still an empirical question. Learners' perception abilities and a variety of other individual differences likely interact with different instructional methods in complex ways. The goal of the present study was therefore to clarify some of those relationships. The research question was: Which individual difference factors predict learners' improvement in pronunciation of Spanish consonants after receiving phonetics instruction?

Method

Participants

Learners ($n = 74$) were enrolled in introductory level 1 Spanish, intermediate Spanish conversation, or advanced Spanish conversation courses at a large public university in the southeastern United States. Though course sequencing was flexible at this institution, most students enrolled in these courses were in their first year, second year, or third year of college Spanish study, respectively. To avoid conflating course level with proficiency, learners in this study will henceforth be referred to as first year, second year, and third year learners. Their instructors were Spanish-dominant until adolescence, were college educated, and had lived in the United States and taught Spanish for eight or more years. Initially 124 participants were recruited, but the data of 50 participants were not included in the analysis because participants either missed sessions or partial sessions, did not fully complete the background questionnaire, or did not meet the background criteria (minimum age 18 years, no Spanish exposure before age 10, and no previous instruction in Spanish phonetics). Of the remaining participants, 48 were female and 26 were male. Their mean age was 21.53 years (range: 18–44) and their mean age at the onset of learning Spanish was 15.19 years (range: 11–40).

Participants were randomly assigned to one of two phonetics instruction (PI) conditions (+PI or –PI). Four first year classes, two second year classes, and two third year classes were recruited because there were fewer upper- than lower-level courses offered at the institution. Half of the learners in each class were randomly assigned to the +PI group and half to the –PI group. However, more learners in the –PI group were eliminated from the analysis due to a variety of the factors mentioned above, so the final participant pool included more learners in the +PI group. Learners participated during class time and were not compensated. Between the study sessions, classes within each course level followed similar syllabi, which did not contain any pronunciation instruction. Instructors and learners, who were unaware of the research questions and target sounds, were told that the study was designed to develop instructional materials for listening and speaking skills.

Target sounds

Eight Spanish consonants [p, t, k, β□, ð□, □□, □, r] were chosen as the linguistic targets in this study because they are the segments most commonly investigated in Spanish FL phonetics instruction research in the United States and have been widely cited as being late acquired by native English speakers (e.g., Elliott, 1995, 1997; Lord, 2005). Native speakers of English tend to aspirate /p, t, k/ in initial and stressed syllables when speaking Spanish (Lord, 2005). They tend to produce stops for Spanish /b, d, g/ in many phonological environments that require their approximant allophones [β□, ð□, □□] (Zampini, 1993), hereafter written without the diacritic for openness [β, ð, □] as in most other studies. Learners also tend to produce /□/ or other non-target sounds for the Spanish rhotics /□/ and /r/ (Elliott, 1997; Rose, 2010). Learners typically are not aware that their pronunciation of these segments is non-targetlike, with the exception of the rhotics (the substitution of /□/, which is quite salient). Researchers have reported positive effects of instruction on learners' production of these consonants, though results have been mixed as regards to which ones are actually amenable to instruction and for whom the instruction might be most beneficial (see Kissling, 2013, for review), and the role of perception has not been considered (Kissling, in press).

Instructional materials

Learners in the phonetics instruction group (+PI) completed four computer-delivered modules over two weeks. The modules presented: (a) an introduction to articulatory phonetics; (b) the voiceless stops /p, t, k/; (c) the voiced stops /b, d, g/ and their approximant allophones [β, ð, □]; and (d) the rhotics /□, r/ (courtesy of Dr. Gillian Lord at the University of Florida and accessible at http://talcomosuena.spanish.ufl.edu/). Learners first completed the introduction to articulatory phonetics and then the three other modules, counterbalanced in order of presentation. Each module included: an explanation of grapheme-phoneme correspondences, an animated vocal tract illustration of the place and manner of articulation, a comparison with English, and an identification activity which allowed learners to identify the Spanish and English sounds in isolation. Each section concluded with a brief multiple-choice comprehension test that had to be answered correctly. Each module concluded with a pronunciation practice activity in which learners repeated six short Spanish phrases after a native speaker until they believed that their pronunciation approximated the native speaker. There was no other feedback. The modules were self-paced, and learners spent between 15 and 40 minutes on each module. The instructional time per consonant was brief but similar to that of other FL class studies (Elliott, 1995; González-Bueno, 1997). The instruction exposed learners minimally to 10 unique tokens of each target phone, three of which were contained in the pronunciation practice section.

Learners in the –PI group also completed computer-delivered modules. These modules provided exposure, practice, and feedback similar to the +PI, but without the explicit instruction in phonetics. Learners watched level-appropriate video vignettes (courtesy of the University of Texas, Austin, series accessible at http://laits.utexas.edu/spe) featuring a Spanish speaker discussing a topic relevant to their curriculum. The speakers were from different regions but none produced the target consonants in non-standard ways. Learners completed a dictation (pausing the video when necessary), compared their dictation with a transcript, read an English translation for meaning, and commented on the speaker's accent. They also repeated aloud 1-2 sentences from the video until their pronunciation was like the speaker's, thus practicing utterances that were similar in length (5-6 clauses) to the +PI group. On average, learners in the –PI were exposed to the same number of unique tokens of the target consonants as the +PI. However, learners in both groups could rewind and repeat if desired, and so most heard and pronounced more than the minimal number of tokens. It appeared that most learners chose to rewind and replay sections of the modules, especially learners in the –PI group, but unfortunately the precise amount of input each student received could not be captured with the technology available. In sum, the learners in the two groups were exposed to comparable amounts of input, but only the learners in the +PI group received explicit phonetics instruction.

Production test

Learners read aloud a list of 27 words and phrases (shown in Appendix A, with graphemes representing the target consonants in bold, though they were not bolded for students). A word list was used rather than a sentence task or spontaneous speech so that first year learners would not be cognitively overburdened by the task and could focus mainly on pronunciation. In an effort to equalize the difficulty of the test for learners at different levels, the test included 19 vocabulary items that were likely to be very familiar to them and 8 items that were likely unfamiliar (e.g., *calaba* [was soaking]). To confirm this assumption of familiarity, learners were asked to translate the words. Indeed, most learners could translate the "familiar" items (e.g., 82% of first-year, 95% of third-year at pretest) but none could translate the "unfamiliar" items (0% all levels at delayed posttest). In total, the test included four tokens of each target consonant, with a variety of vowels. The items were presented in different orders in the pretest, immediate posttests (after each instructional module), and delayed posttest (three weeks later).

Learners recorded their production tests as WAV files with a sampling rate of 22 kHz and a resolution of 16 bits. An independent rater who was a phonetician and native speaker of Spanish transcribed the blinded production data and rated the approximant and rhotic consonants using auditory cues as well as waveforms and wide-band spectrograms in Praat (Boersma & Weenink, 2012). These consonants were assigned 3 points if the learners demonstrated all the auditory and acoustic properties associated with their ideal Spanish pronunciation, and 1–2 points if they were non-targetlike. For example, the target consonant [β] was assigned 3 points if it was heard as an approximant, the waveform showed little decrease in amplitude from the surrounding vowels, and the spectrogram showed formants and voice bar with no evidence of occlusion or release burst. It was assigned 1 point if it had properties characteristic of a voiced bilabial stop in English such as occlusion and release burst. It was assigned 2 points if it fit somewhere between these two extremes. The rating was reliable; the researcher independently rated a randomly selected 10% of the data and found complete inter-rater agreement for 95% of those data (Cronbach's □ = .96). The researcher also measured voice onset time values (VOT, a measure of aspiration) for all tokens of /p/, /t/, and /k/, which was defined as the distance between the release of the stop closure and the first glottal pulse. VOT data were analyzed separately from the data for the approximant and rhotic consonants but were then transformed into the 1–3 rating scale so that an aggregate score could be calculated.[1]

Perception test

Learners' perception of the target consonants was assessed at the outset of the study with a discrimination test that paired targetlike Spanish consonants with their English-accented counterparts, that is, the non-targetlike consonants that learners tend to produce in specific phonological environments. According to the SLM, the first stage of L2 speech learning involves learning to discern subtle phonetic differences between L2 sounds and similar sounds in the L1. Therefore, for learning to take place, learners need to be able to reliably distinguish target L2 sounds from their L1-colored non-target variants. The test items, detailed in Table 1, presented the voiceless stops in initial position, the approximants in intervocalic position, and the rhotics in initial, medial, and final positions, all with a variety of vowels. So, for instance, an item might pair English-accented [t^{h}a] with Spanish targetlike [ta]. There were five items for most pairs but only three items for [□]/[□] and [r]/[□] because pilot testing suggested that participants would discriminate these pairs well. The phonological environments of the target consonants were identical to those used in the production test. There were a total of 36 items that contrasted the target consonants with English consonants, with 49 other items included as distracters.

<Table 1 here>

The voice of a male native Argentinian Spanish speaker trained in Spanish phonetics with near-native proficiency in English was used for all the perception test stimuli. His realizations of the target consonants in Spanish were similar to the standard pronunciations presented in the instructional modules. The researcher and another native speaker of English with extensive training in phonetics both found his realizations of the non-targetlike consonants to be representative of English-accented Spanish consonants. The recordings were made with SoundTrackPro at a 16-bit resolution and a sampling rate of 48 kHz in a soundproof booth. A single recording was used for each of the token types, so, for instance, all tokens of [ta] were acoustically identical. Volume, pitch, duration, and quality of the surrounding vowels were consistent between the two stimuli in the AX pairings. The one-second stimulus exemplars were presented with a 1500 ms inter-stimulus interval (ISI). This relatively long ISI should have precluded participants from using only their acoustic store to compare the stimuli, and therefore acoustically identical tokens could be used without compromising the objective of the task (Werker & Logan, 1985). Learners received these instructions: *If you hear any difference at all between the two recordings*, *choose "different."*

Measures of other individual differences

Learners filled out a background questionnaire in which they reported their sex, current age, age at the onset of Spanish learning, number of Spanish courses taken in high school, number of Spanish courses taken in college, time spent using Spanish outside of class, and time spent abroad in Spanish-speaking areas. Learners also filled out a Pronunciation Attitude

Inventory (Elliott, 1995) because attitude has been correlated with achieved accent after instruction (Baran-Łucarz, 2012). The 12 items of the questionnaire targeted learners' desire to acquire a native-like accent (e.g., One of my personal goals is to acquire proper pronunciation skills and preferably be able to pass as a near-native speaker of the language) relative to other areas of language (e.g., Good pronunciation skills in Spanish are not as important as learning vocabulary and grammar) and learners' belief about their ability to change their accent (e.g., I believe I can improve my pronunciation skills in Spanish). Responses were chosen from a 5-option Likert scale ranging from "Strongly Disagree" to "Strongly Agree." To avoid a positive response bias, both items that were oriented positively and negatively towards pronunciation were included. The Likert scale responses were interpreted accordingly, with more points being assigned to the responses that indicated more positive attitude towards pronunciation. Thus, the maximum score was 60.

Learners took a non-word repetition task (Lado, 2008) as a measure of phonological short-term memory (PSTM). PSTM was included because auditory sequence memory supports the acquisition of phonotactics (Munro, 2008), and the difficulties English speakers face when producing the Spanish consonants targeted in this study likely involve phonotactics. For example, this includes learning not to aspirate /p, t, k/ when in syllable-initial stressed position and learning to trill the rhotic when it is word-initial. In the PSTM test, leaners heard 16 pairs of English-like non-words of increasing length and repeated what they could remember after a short pause. The shortest words contained three syllables (e.g., *melistok, nutolon*) and the longest contained eight syllables (e.g., *Towarymanitacorous*, *finterprofensibolities*). One point was assigned for each pair that a learner repeated faithfully with no more than one erroneous syllable, for a total maximum score of 32. Learners also took the phonetic script subtest of the Modern

Language Aptitude Test (MLAT) (Carroll, 1962), which was included because the ability to learn correlations between a speech sound and written symbols might determine in part how much a learner could benefit from traditional phonetics instruction. In this test, learners listened to a list of novel words as they studied symbols that represented the phonemes in these words. They then heard the words in isolation and had to choose the symbols that corresponded to the words.

Procedure

During the first session, learners were randomly assigned to an instructional condition by being instructed upon entry to the classroom to sit at the next available computer station. Every other computer station was set up for the +PI condition. Learners completed all parts of the study via computer while wearing noise-cancelling headphones. The first session included the background questionnaire, consent form, Pronunciation Attitude Inventory, PSTM non-word repetition task, pronunciation pretest with all target consonants, and discrimination pretest with all target consonants. One week later, learners participated in the second session, during which they completed their first two instructional modules followed by a pronunciation posttest with items specific to the target consonants included in the modules they had just completed. The third session, one week later, was identical in procedure to the second session except that it presented learners with the last two instructional modules. Three weeks later (week 6 of the study) learners participated in their final session, which included the pronunciation delayed posttest with all target consonants, MLAT phonetic script test, post-study questionnaire and debriefing memo. The first module for all learners in the +PI group was the introduction to articulatory phonetics. After that, the order of the other instructional modules and all the testing measures was counterbalanced across participants for both groups (+PI, –PI) and within each study session.

Results

Descriptive statistics of learners' scores on the production test are presented in Table 2, separated into instructional groups (+PI or –PI) and course level. The scores in Table 2 indicate that all groups of learners improved in production of the target consonants after instruction and most groups retained some gains in the delayed posttest. Gain scores in the +PI group ranged from -3.0 to 2.75, indicating that some learners made gains but others showed poorer performance after instruction. In order to test effects of instruction, learners' production test scores were analyzed with a repeated measures analysis of variance (ANOVA). The between-groups factors were instructional condition (+PI, –PI) and course level (first, second, third), and the within-groups factor was time (pretest, posttest, delayed posttest). In the full production test (aggregate of eight consonants), there was a significant main effect for time, $F(2, 136) = 5.28$, $p = .006$, $\eta_p^2 = .07$, and level, $F(2, 68) = 6.04$, $p < .004$, $\eta_p^2 = .15$, but no other main effect or interaction reached significance (all $F \leq 1.82$, all $p \geq .07$). Learners' scores improved significantly from pretest to posttest and did not change significantly from posttest to delayed posttest. First year students' scores were significantly lower than those of second and third year students, but second and third year students' scores were not significantly different from each other. Thus, for the production test learners overall improved slightly after instruction, with the time factor accounting for 7% of the variance in scores ($\eta_p^2 = .07$), but instructional condition and course level did not interact significantly with time.[2] However, the statistical power to find any such potential interaction effects was too low for the results to be conclusive, and when graphed the scores appeared to indicate that the +PI group improved slightly more after instruction than the –PI group.

<Table 2 here>

A similar ANOVA was carried out for each target consonant as well as for the three natural classes of sounds (stops, approximants, and rhotics) because the instructional modules presented the phonetics instruction organized by natural classes. Consistent with the findings of the overall analysis, there was a significant main effect of time for five consonants ([p, ð, □, □, r]) as well as all three natural classes. The only significant interaction occurred in the approximant class, and this Time × Instructional Condition × Course Level interaction was related to the velar approximant [□], for which first and third year learners faired better in the +PI condition than in the –PI, but second year learners did not.

Clearly, course level and instructional condition did not explain much of the variation in learners' production after instruction, which is what prompted an analysis of individual difference factors as possible predictors. Descriptive statistics of the individual difference measures collected are summarized in Table 3. Number of high school courses was not used in the subsequent analysis because the length of the courses, and thus contact hours in Spanish, was not consistent across the learners' different high school programs. Time spent abroad was not used in the subsequent analysis because it was heavily skewed towards zero (with just a few students having spent short periods abroad), which could have affected the regression results. Some of the variables used in the analysis were significantly correlated, but none correlated so strongly that they should not be entered into a regression analysis together (age of acquisition and current age, $r = .47$; MLAT and discrimination, $r = .36$; MLAT and PSTM, $r = .35$; number of university classes and time outside class, $r = .40$; number of university classes and pronunciation attitude, $r = .24$; time outside class and pronunciation attitude, $r = .33$; all $p < .05$).

<Table 3 here>

In order to find out which individual differences predicted learners' production accuracy after receiving instruction, the remaining individual difference measures were entered as independent variables in the first step of a hierarchical multiple regression analysis. Rather than course level, two finer-grained measures were included: number of university courses taken (an estimate of global Spanish language proficiency and exposure) and production pretest scores (an estimate of pronunciation proficiency).[3] The dependent variable was production posttest score. In order to ascertain the unique contribution of perception, discrimination score was entered as the second step in the regression.[4] The analysis was run separately for each instructional group (+PI, –PI) and summary statistics for each regression model are shown in Table 4. For both groups, pretest score was by far the best predictor of posttest score, accounting for 65% and 67% of shared variance, respectively. No other explanatory variable was a statistically significant predictor for the –PI group. However, for the +PI group, both time outside class and discrimination were statistically significant predictors, each accounting for 11% of shared variance. Put differently, the less time a learner spent using Spanish outside the classroom and the better a learner's discrimination of target sounds, the better her production of the target sounds after phonetics instruction.

<Table 4 here>

A similar hierarchical multiple regression analysis with the same predictor variables was performed with production posttest scores for each of the 8 target consonants. In each case only the relevant items on the AX discrimination test were used, so for instance only items testing discrimination of [p]/[p^h] were entered into the analysis of /p/. For the +PI group, the models were significant in all cases (p < .05), with an R^2 range of .37 (for [□]) to .87 (for /r/) and a mean R^2 of .61. The only variable that was a significant predictor in all models was pretest score, with an unstandardized beta weight range of .28 (for [ð]) to .87 (for /r/). For two target consonants, however, there were other significant predictors in addition to pretest score, and these results are summarized in Table 5. A more positive attitude towards pronunciation was associated with greater [ð] production posttest scores (28% of variance explained). Learners' ability to discriminate [ð] from [d] further explained 6% more of the variance in their production scores. Age was more important for /r/; older age of learning and younger current age were associated with greater /r/ production posttest scores. Discrimination did not contribute to the model, but since discrimination scores were near ceiling level (because it was quite easy to distinguish the English /□/ from Spanish /r/), this lack of variance in scores likely prevented discrimination from becoming a statistically significant predictor.

<Table 5 here>

Though effects of phonetics instruction were the focus of this study, the results of the –PI group will be summarized here for sake of comparison. In all regression models, R^2 ranged from .37 (for [□]) to.79 (for /p/), with a mean value of .67, which was similar to the +PI group. Almost all models were statistically significant (p < .05), with the exception of the one targeting [β] (p = .37). Pretest score was a significant predictor in all models except for /r/, with an unstandardized beta range of .45 (for [□]) to .82 (for /t/). However, discrimination was not a significant predictor in any of the –PI regression models. Other factors emerged as significant predictors for some target consonants, namely, number of university courses (*B* = –.01 for /p/ and *B* = .35 for [ð]), age of learning (*B* = –.10 for /□/) and MLAT (*B* = .43 for [□]).

Discussion

In this study, Spanish FL learners at three different curricular levels were given either explicit instruction in Spanish phonetics (+PI) or treatment that consisted of listening to native speakers and taking dictation (–PI). After both types of instruction, learners produced eight difficult-to-acquire Spanish consonants ([p, t, k, β, ð, □, □, r]) in more target-like ways in a word-reading task, and they retained some of those gains three weeks later. Neither course level nor instructional type explained much of the variation in learners' scores over time, according to an ANOVA. To help explain why some learners improved after instruction whereas others did not, several individual difference variables were entered into hierarchical multiple regression analyses. These included cognitive variables: perception of the target phones as measured by an AX discrimination task, phonological short-term memory (PSTM) as measured by a non-word repetition task, phonetic encoding ability as measured by a subtest of the MLAT, and current age; variables relating to proficiency and exposure: production pretest score, number of university courses taken, age of onset of learning, and time spent using Spanish outside of class; and a variable measuring learners' attitude towards Spanish pronunciation. The prediction of the current study was that discrimination ability would impact learners' ability to learn from phonetics instruction, so their discrimination test scores were entered as the second step in each regression analysis.

Not surprisingly, by far the best predictor of production posttest score was pretest score. Learners with better pronunciation of the target consonants at pretest also had higher posttest scores. In addition, more time spent using Spanish outside class was associated with slightly lower posttest scores (.06 – .08 points lower for each additional hour outside class). The learners who used Spanish outside class reported that they interacted frequently with coworkers or friends. Some of their interlocutors may have had non-targetlike pronunciations of the target sounds, or the learners may have been practicing their own non-targetlike pronunciation of the sounds in these interactions, thereby becoming more entrenched in their pronunciation routines for some consonants during the study period. Unfortunately, learners were not asked detailed information about their interlocutors, so this explanation is speculative.

In the model focusing on the total production scores for all eight target consonants, the pretest production score and amount of time spent outside class together explained 91.4% of variance in posttest scores. Learners' discrimination (perception) scores were added as a predictor in the second step of the regression. Perception was operationalized here as ability to discriminate target Spanish consonants from similar English consonants, following an assumption of the SLM that the first step in acquisition of L2 speech is being able to perceive subtle phonetic differences between L1 and L2 sounds (Flege, 1995). As hypothesized, discrimination was a significant predictor of posttest scores and made a significant and unique but small contribution, explaining an additional 1.2% of the variance in posttest scores. The relationship was positive, meaning that better discrimination related to higher posttest scores, which is consistent with the SLM's claim that perception can determine production. The significant but small effect was also consistent with the claim that perception is necessary but not sufficient for targetlike pronunciation because there are other processes involved in production, including gaining control over articulatory gestures (Munro, 2008). However, no other individual difference measures emerged as significant predictors, meaning that discrimination was one of few good predictors of post-instruction pronunciation accuracy of these target consonants.

The same analysis was conducted for each target consonant individually, and the results were similar to those of the aggregate test scores. That is, the ANOVAs found few interactions, the regressions showed pretest scores to be the best predictor of posttest scores, and there were very few other significant predictors. The amount of variance explained by each model differed across consonants, explaining relatively less variance in production of approximants than other classes of consonants. This seemed to suggest that leaners' production of approximants was less stable, which is consistent with previous findings that approximants are resistant to instruction and late acquired (Díaz-Campos, 2004; González-Bueno & Quintana-Lara, 2011; Zampini, 1993). Learners' discrimination of the approximants was much poorer than their discrimination of other target sounds, around chance in fact, which likely limited their ability to produce the approximants accurately and reliably. Discrimination was found to be particularly important for production of one approximant: discrimination ability explained 6% of the variance in posttest scores of the interdental [ð□]. Pronunciation attitude was also positively associated with pronunciation of this consonant. Perhaps individual differences were more predictive of changes in learners' production of the interdental approximant because its analogous L1 sound, an interdental fricative, is acoustically more similar to an approximant than is the case for the other approximants' ([β, □]) analogous L1 sounds, both of which are stops (/b, g/). It is possible that perception played a greater role for other consonants than these statistical analyses could find, because with the relatively easy discrimination test employed in this study, discrimination scores were near ceiling levels for several sounds ([p, □, r]). A more difficult perception test, such as one that embedded the target consonants in utterances longer than one or two syllables, might have better differentiated leaners according to their perception abilities.

In sum, after learners received phonetics instruction, some of the variance in their production accuracy scores (for all target consonants combined and for at least one consonant individually) was uniquely attributable to discrimination ability, but not to other cognitive variables. For the group that received no phonetics instruction, on the other hand, discrimination was not a significant factor. Saito (2013) found that providing explicit phonetics instruction at the outset of form-focused instruction about pronunciation of the English rhotic /□/ served to enhance the generalizability and effectiveness of the form-focused instruction for Japanese learners of English. Taken together with Saito's (2013) study, the present findings suggest that providing explicit phonetics and form-focused instruction targeting difficult-to-acquire L2 consonants might be particularly beneficial to those learners with good initial discrimination abilities. In contrast, discrimination ability might matter less in other instructional conditions or such conditions might require a different threshold of initial discrimination ability for learners to succeed.

The effect size of perception in the present study might have been reduced due to limitations of the study design (i.e., brief instruction, little feedback, multiple target phones, easy discrimination test), and one might expect an even larger effect size under different conditions, such as more frequent and detailed lessons delivered over the course of a semester. Obviously, one would not expect for such a brief instructional intervention to remedy all pronunciation problems, and indeed learners experienced small changes in production scores over time, yet some learners benefited more than others. The fact that discrimination surfaced as a significant predictor of learning should be heartening to language teachers because perception is a skill that can be trained in a classroom context, whereas other individual differences, such as age, PSTM and attitude would be either difficult or impossible to address in a language classroom. In fact, phonetics courses usually include perception practice in the form of discrimination and identification tasks. The results of this study suggest that instructors should give adequate time for learners to hone their perception of target phones at the outset of phonetics instruction, because their ability to discriminate the target phones might in part predict how much they learn from such instruction. That is, instructors should provide practice to help learners reliably perceive the subtle phonetic differences between Spanish sounds and similar English sounds. This stands in contrast to early findings that training in articulation rather than perception from the start is a more effective approach (Catford & Pisoni, 1970), but is consistent with more recent research suggesting that perception training can improve production (Thomson, 2011).

In addition to discrimination, several other individual difference factors were included in the analysis because it was thought that they could play a role in pronunciation accuracy. The paucity of significant results could be due to the limited range of values in some of these measures, such as age of learning (no learner began studying Spanish before age 10) and current age (all were at least 18), or the coarseness of the scales (attitude was measured with a 12-item Likert scale test). It is possible that the instructional treatments were too brief for some of these learner differences to have an effect, or it might be that these learner differences do not have much effect when the instruction is highly explicit and delivered in a controlled, formal learning context. One might expect to see them play a greater role in more naturalistic settings (as in Baran-Łucarz, 2012) or in more implicit training conditions. Perhaps other individual differences were better predictors of learning than any of those collected in this study. Other individual difference factors not considered but potentially predictive of learning are phonological awareness (Venkatagiri & Levis, 2007), cross-cultural sensitivity (Martinsen & Alvord, 2012), and musical ability (Morgan, 2005), among others.

Another limitation of the current study was its reduced inventory of L2 sounds (only eight consonants) and the reduced units of language employed in the tasks—monosyllabic and disyllabic utterances in the discrimination test and short phrases in the production test. Future studies should employ longer discourse units that better approximate real-world communicative tasks (Bradlow, 2008). Word and sentence reading tasks are commonly used in L2 pronunciation training studies (e.g., Lord, 2005), and a simple reading task was chosen here to relieve the more novice learners of cognitive burden so that they could focus on their pronunciation. However, gains made after instruction in the reading task could be due to improved surface monitoring ability rather than changes in learners' interlanguage. Indeed, Elliot (1995, 1997) found that after phonetics instruction intermediate learners improved their pronunciation in word repetition, sentence repetition and word reading tasks, but not in spontaneous speech. Thus, one should not assume that post-instruction improvement as measured in a reading task would necessarily extend to leaners' extemporaneous speech.

Conclusion

Unfortunately, there is still scant research on interactions between individual differences and teaching methodologies in L2 acquisition (DeKeyser, 2012). The current study contributes to the field by analyzing the interactions between various individual difference factors and pronunciation instruction. The main finding is that discrimination ability predicts the improvement that learners make after explicit phonetics instruction, but not after comparable instruction lacking an explicit teaching component. The study suggests that teachers should help learners hone their perception skills at the outset of phonetics instruction. Moreover, the study contributes to the growing body of research on the link between L2 speech perception and production. The finding concerning L2 perception lends credence to models of L2 speech acquisition such as the SLM that claim targetlike perception is a precursor to targetlike production, particularly in a formal learning context in which learners are given explicit instruction about production targets.

Notes

1 This transformation was performed on each test item, utilizing the VOTs produced by 10 native speakers (NS) of Spanish recruited to provide baseline pronunciation data for these experimental tasks. Learner VOTs that fell within the NS range were assigned 3 points. Learner VOTs that were no longer than the NS maximum plus the value of the NS range were assigned 2 points. Longer VOTs were assigned 1 point. For example, for the test item *para*, NSs produced a VOT range of 16 ms (5-21ms). For *para*, then, learner VOTs of 0–21ms were assigned 3 points, VOTs of 22–37 ms were assigned 2 points, and VOTs longer than 37 ms were assigned 1 point.

2 These results are similar but not identical to what was reported in Kissling (2013). Not all learners from that study (n = 95) could be included in the present analysis because some failed to complete all the individual difference tests. The small differences in results are due to this difference in sample populations.

3 The ANOVA suggested that second and third year students were not significantly different from one another in production, meaning that course level was not a good measure of proficiency. According to their reports on the background questionnaire, the first year students had completed no college courses in Spanish, second year students had completed on average 2.75 (range: 1-6), and third year students had completed 3.68 (range: 2-7).

4 Assumptions were met for this and all subsequent regression models. Outliers were investigated. The effect of removing outliers on the model was tested, and in each case the resulting effect on the model was minimal, so all individuals were retained.

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TABLE 1

Target Consonants in Discrimination Test

Phone Pairs	Phonological Environments
[p]/[p^h], [t]/[t^h], [k]/[k^h]	[_a], [_e], [_i], [_o], [_u]
[β□]/[b], [ð□]/[d], [□□]/[g]	[a_a], [e_e], [u_o], [i_e], [o_i]
[□]/[□]	[o_o], [i_], [_a]
[r]/[□]	[a_a], [e_], [_u]

TABLE 2

Production Test Scores (out of 32)

	First year			
	+PI (*n* = 17)		–PI (*n* = 18)	
	M	*SD*	*M*	*SD*
Pretest	12.63	2.75	13.43	2.51
Posttest	13.79	2.85	13.58	2.84
Delayed Posttest	13.63	2.74	13.29	2.73
	Second year			
	+PI (*n* = 15)		–PI (*n* = 6)	
	M	*SD*	*M*	*SD*
Pretest	15.63	3.08	14.67	2.69
Posttest	15.84	2.73	14.88	2.60
Delayed Posttest	16.07	2.97	14.17	3.95
	Third year			
	+PI (*n* = 10)		–PI (*n* = 5)	
	M	*SD*	*M*	*SD*
Pretest	15.45	3.63	16.7	0.65
Posttest	15.93	2.73	18.1	1.93
Delayed Posttest	15.68	3.42	17.7	2.22

TABLE 3
Individual Difference Measures (*n* = 74)

	M	*SD*
Discrimination (out of 36)	27.93	5.37
Age of acquisition	15.19	4.46
Current age	21.53	4.51
MLAT phonetic script learning (out of 30)	24.51	3.32
Phonological short-term memory (out of 32)	17.11	3.37
Pronunciation attitude (out of 60)	45.52	6.07
Number of high school courses	2.77	1.72
Number of university courses	1.58	1.67
Time using Spanish outside class (hours per week)	4.60	5.40
Time spent abroad (total hours)	18.87	49.72

TABLE 4

Hierarchical Regression of Production Test: Aggregate of Eight Target Consonants

	Model	Total R2	ΔR2	Age of Learning B	Current Age B	Number University Courses B	Time Outside Class B	MLAT B	PSTM B	Attitude B	Pretest Score B	Discrimination B
Posttest (+PI)	1	0.91*	0.91*	0.02	-0.03	-0.01	-0.08*	0.02	0.01	0.03	0.85*	
	2	0.93*	0.01*	0.01	-0.03	0.02	-0.06*	-0.01	0.04	0.03	0.84*	0.08*
Posttest (-PI)	1	0.83*	0.83*	0.09	-0.02	0.27	0.00	-0.02	-0.05	0.03	0.92*	
	2	0.83*	0.00	0.08	-0.01	0.25	0.00	-0.04	-0.05	0.04	0.92*	0.02

* *p* < .05

TABLE 5

Hierarchical Regression of Production Test: Individual Consonants

	Model	Total R2	ΔR2	Age of Learning B	Current Age B	Number University Courses B	Time Outside Class B	MLAT B	PSTM B	Attitude B	Pretest Score B	Discrimination B
[ð] Posttest (+PI)	1	0.57*	0.57*	-0.00	0.00	-0.02	0.00	0.00	-0.01	0.02*	0.28*	
	2	0.63*	0.06*	-0.01	0.00	-0.03	0.01	0.00	-0.01	0.02*	0.32*	0.06*
/r/ Posttest (+PI)	1	0.83*	0.83*	0.03*	-0.02*	0.02	0.00	0.00	-0.01	0.01	0.87*	
	2	0.83	0.01	0.03*	-0.02*	0.03	0.00	0.03	-0.01	0.01	0.87*	-0.09

* *p* < .05.

Note. Discrimination scores for /r/ - /□/ were at ceiling.

Appendix A
Production Test Items

1. ¿**C**ómo?	'What?'
2. ¿**Q**ué **t**al?	'How are you?'
3. señori**r**ita	'Miss'
4. aveni**d**a	'avenue'
5. Hasta lue**g**o.	'See you later.'
6. **p**e**rr**o	'dog'
7. a**g**osto	'August'
8. **c**u**b**ano	'Cuban'
9. ru**b**io	'blonde'
10. **p**a**r**a ella	'for her'
11. **t**ú y yo	'you and I'
12. **p**intar	'to paint'
13. a**b**u**rr**ido	'bored'
14. lle**g**ar	'to arrive'
15. computa**d**ora	'computer'
16. ba**rr**io	'neighborhood'
17. A**d**iós.	'Good bye.'
18. núme**r**o	'number'
19. **t**ocar	'to touch'
20. **t**alle	'figure, shape, form'
21. **c**ace	'hunt' [3 sing., pres. subjunctive]
22. **p**ace	'graze' [3 sing., pres. indicative]
23. ama**g**a	'threaten' [3 sing., pres. indicative]
24. cala**d**a	'soaked' [adj., fem. sing.]
25. a**r**a	'altar'
26. a**rr**as	'wedding coins'
27. cala**b**a	'was soaking' [3 sing., past imperfect]