Concordia Working Papers in Applied Linguistics

Proceedings of the International Symposium on the Acquisition of Second Language Speech
Concordia Working Papers in Applied Linguistics, 5, 2014 © 20134 COPAL

Effects of Perceptual Training on the Identification of English Vowels by Native Speakers of European Portuguese

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Abstract

The present study investigated whether high variability perceptual training can be effective in the modification of Portuguese EFL learners' mature perceptual patterns of three English vowel contrasts (/i/-/ɪ/, /ɛ/-/æ/, and /u/-/ʊ/). Learners' perception was assessed three times (pretest, posttest and delayed posttest) with an identification test. The five-session perceptual training included discrimination and identification tasks with immediate feedback. The results revealed that the Portuguese learners' performance in the identification of the target vowels improved significantly after training, and the knowledge gained during perceptual learning was retained two months after completion of the training program. Moreover, the scores of the generalization test indicate that there was robust learning of two of the target vowel contrasts. The results of this experiment support the claim that perceptual learning can occur in non-naturalistic environments within a short period of time and corroborate previous findings on the malleability of L2 adult learners' perceptual systems.

Second language (L2) speech learning often poses a challenge to adult learners in terms of articulation and perception of non-native phonetic contrasts, that is, L2 speech sounds that do not exist or are not phonologically distinctive in the native language (L1). As a result, adult L2 learners are frequently characterized as having not only foreign pronunciation but also "accented" perception (Strange, 1995, p. 2). Difficulties with L2 sounds may result from the interaction of diverse factors related to learners' L2 background (viz. age of L2 learning, quantity and quality of L2 exposure, amount of L1 and L2 use) and with individual differences such as motivation and language learning aptitude (Munro & Bohn, 2007; Piske, 2007). Another main factor that accounts for these difficulties is the relation (i.e., the (di)similarities) between the L1 and L2 phonological and phonetic systems.

A few theoretical models explain how non-native sounds are perceived by L2 learners, including the Perceptual Assimilation Model (PAM and PAM-L2) (Best, 1995; Best & Tyler, 2007) and the Speech Learning Model (SLM) (Flege, 1995). Both models depart from cross-language (L1 and L2) phonetic similarity to predict learners' success or failure in the acquisition of non-native segmental contrasts.

PAM predicts the occurrence of three main patterns in the perceptual assimilation of L2 contrasts. If L2 sounds are similar to native segments, they can be perceived as either good or bad exemplars of an L1 phonemic category. If an L2 segment is very dissimilar from any L1 sound, that is, if it is a sound category non-existing in the L1, it can be uncategorizable in the L1 system or perceived as a non-speech sound. SLM also hypothesizes that the acquisition of L2 phonetic categories depends on the perceived similarity of L1 and L2 sounds. Flege (1987, 1995) claims that if an L2 sound is perceived as new, that is, if it is sufficiently dissimilar from any L1 phonetic category, the learner's tendency is to create a new category for that sound. However, if it is perceived as similar, that is, as perceptually equivalent to an L1 sound, the learner fails to create a new category for that segment. In conclusion, the higher the degree of perceived cross-linguistic similarity between L1 and L2 sounds, the poorer the perception of non-native sounds; conversely, the greater the perceived phonetic dissimilarity between L1 and L2 sounds, the higher the changes of establishing new L2 categories.

Regardless of the difficulties L2 learners' may face, Flege (1995) claims that the perceptual ability to learn non-native sounds is available throughout the lifespan. Several studies have provided evidence of the plasticity of L2 learners' perceptual systems by showing that auditory training can improve both perception and production of L2 phonetic contrasts both at a segmental and suprasegmental level.

Considering that "difficulties in perception of non-native vowel contrasts are a significant part of the problems many L2 learners have in mastering the L2 phonology" (Strange, 2007, p. 36), the perceptual training of English vowels with native speakers of various L1s has been investigated, and various studies have reported overall significant improvement in perceptual performance immediately after training. Generalization of perceptual learning to new talkers (e.g., Aliaga-Garcia, 2010; Nobre-Oliveira, 2007; Wang, 2008), to new tokens (e.g., Aliaga-Garcia, 2010; Lacabex et al., 2009; Nobre-Oliveira, 2007) and to new contexts (e.g., Lacabex et al., 2008a, 2008b) was reported, and long-term retention was also observed one month (e.g., Nobre-Oliveira, 2007) and three months (e.g., Nishi-Kewley, 2007; Wang, 2008) after completion of training. Several experiments were conducted to investigate which training procedures are more effective in promoting L2 categorical learning. For example, Nobre-Oliveira (2007) compared the use of natural stimuli to synthesized stimuli and found that there was no significant difference between them. Wang (2008) also included synthesized and natural tokens in the training but did not compare the learning effects of the two stimulus types.

A comparison between auditory (perceptual) and articulatory (production) training was also done, for example by Lacabex et al. (2009) and Aliaga-Garcia (2010), who concluded that both methods are effective. Preliminary results of Pereira and Hazan's (May, 2013) comparative study between visual (V), audio (A) and audiovisual (AV) training modalities seem to indicate that adding visual cues to training stimuli (i.e., audiovisual stimuli) does not facilitate learning of English vowels. The influence of other variables have also been examined, namely L2 experience or language proficiency (Iverson et al., 2012; Wong, May, 2013, respectively), L1 and L2 vowel inventory size (e.g., Iverson & Evans, 2009; Lengeris, 2009), degree of stimuli variability (low vs. high, as in Wong, 2012), and number of vowels included in the training (fullset vs. subset, as in Nishi & Kewley-Port, 2007, 2008). Regarding L2 experience and proficiency, no significant differences were found, which seems to indicate that laboratory training equally promotes learning in groups with diverse L2 backgrounds. Another important finding with L2 vowel learning experiments was that, although large L1 vowel inventories, such as German, seem to facilitate learning (e.g. Iverson & Evans, 2009), learners, whose L1s have a small vowel space, such as Greek, can successfully learn L2 vowels within larger inventories (e.g., Lengeris, 2009). Finally, a high-variability training method (with multiple talkers and stimuli) has proved to be very effective (e.g. Aliaga-Garcia, 2010; Iverson et al., 2012; Pereira & Hazan, May, 2013; Wong, 2012).

Adult Portuguese learners of English as a foreign language (EFL) seem to have difficulty perceiving and producing English vowel contrasts that differ both in terms of spectral quality and duration (e.g., Rato, Rauber, Soares & Lucas, June, 2012). While the American English vowel system includes four monothongs (/i/, /ɪ/, /æ/, /ɛ/) and one homogenous or semi-diphthong (/e/) in the front vowel space, the European Portuguese phoneme inventory comprises three front vowels (/i/, /e/, /ɛ/), which differ in spectral quality and only have intrinsic vowel duration differences (Escudero, Boersma, Rauber & Bion, 2009). The same happens in the high back space, where EP has one high back vowel (/u/), whereas AE has two vowels (/u/, /ʊ/) that differ both in quality and length.

Therefore, though some studies have investigated the effects of perceptual training on L2 vowels, to my knowledge, computer-assisted learning of English vowel contrasts by European Portuguese EFL learners has not yet been examined. The present experiment, which is part of a larger study that includes production data, aims at investigating (1) whether high variability perceptual training (HVPT) promotes the learning of English vowel contrasts by Portuguese EFL learners; (2) if perceptual improvement is generalized to new words and new speakers; (3) whether learning remains two months after the training is over; and (4) which AE vowel contrasts /i-ɪ/, /ɛ-æ/ or /u-ʊ/ will be more easily perceived by EP speakers, before and after training.

METHOD

Participants

The participants of this study were a group of 34 Portuguese undergraduate students, 18 women (52.9%) and 16 men (47.1%), whose ages ranged from 18 to 42 years old (mean = 23.03 years, SD = 6.76). The cohort was divided into an experimental group and a control group, according to their results in the perception pretest, so that the mean scores of correct vowel identification would be matched between both groups. The two groups suffered attrition (four dropouts) from the posttest to the delayed posttest, as shown in Table 1. In order to control for the degree of improvement due to the effect of task repetition, both groups undertook training. The experimental group underwent a high variability phonetic training (HVPT) on vowel contrasts, whereas the control received training on consonants.

Table 1. Number of Participants in Each Phase of the Experiment

	EG	CG	Total
Pretest	n=22	n=12	n= 34
Training Vowels	n=22	-	n= 22
Training Consonants	-	n=12	n= 12
Posttest	n=22	n=12	n= 34
Generalization Test	n= 22	n= 12	n= 34
Delayed Posttest	n=19	n=11	n= 30

Note. EG = experimental group; CG = control group.

This group of adult learners of English was attending the first year of a Language and Literature degree course (English major and English monolingual) at a state university where they attended English as a foreign language (EFL) lessons four hours a week. Although they had been exposed to English mainly through formal instruction for an average of eight years (range=5-12 years, SD= 1.70), the level of English proficiency was intermediate (B1). [1]

Seven native speakers (NS) of American English – five women (71.4%) and two men (28.6%) — with ages ranging from 26 to 55 years old (mean= 39.71 years, SD=11.28), also participated as a baseline group. They validated the testing and training materials by performing all the perception tasks that were used in the experiment, thus, providing baseline data. The overall perceptual performance of the baseline group of American English NSs was above 95% accurate in all tasks, ranging from 96.59% to 100%.

All L1 and L2 participants reported having no hearing or speech-related impairments.

Perception Tests

Perceptual performance in the identification of the target American English vowel contrasts was assessed three times (pretest, posttest, and delayed posttest) in isolated CVC (C=consonant; V=vowel) words to study

[1] According to the *Common European Framework of Reference for Languages* (CEFR), there are six reference levels: A1, A2 (Basic User); B1, B2 (Independent User); C1, and C2 (Proficient User). [http://www.coe.int/t/dg4/linguistic/Source/Framework_EN.pdf].

the effect of training, and in (C)CV(C)(C) words to investigate the robustness of learning in generalizing to untrained tokens and talkers (generalization test) with seven-alternative forced-choice (7AFC) identification tests.

The stimuli of the identification test comprised naturally spoken words with six target vowels (/i/-/ɪ/, /æ/-/ɛ/, /u/-/ʊ/) and a distractor /ʌ/, which appeared twice in the contexts /pVt/, /tVt/, /tVk/, /kVt/, and /bVt/ (see Appendix). Six NSs of American English produced the 210 tokens (7 vowels x 5 contexts x 6 speakers), which were presented once in a randomized order. The generalization test consisted of 84 new words with the seven AE vowels produced by five novel NSs (see Appendix). In the 7 AFC identification and generalization tests participants listened to a series of natural stimuli with one of the seven AE vowels, and identified them by pressing labeled buttons (heed [i], hid [ɪ], head [ɛ], had [æ], who'd [u], hood [ʊ] and hud [ʌ]) on a computer screen.

The perception tests were set up in TP, version 1.0 (Rauber, Rato, Kluge & Santos, 2011), and administered in a quiet computer lab at the university. Each participant performed the test individually with NGS MSX6 Pro stereo headphones.

The identification pretest was administered one week before the training, the posttest and generalization tests were done immediately after the training was over, and the delayed posttest two months later.

Perception Training Tasks

Two similar high variability phonetic training (HVPT) programs with identification and discrimination tasks were designed for both groups. Two types of perception tasks were included because they develop different perceptual abilities. Identification tasks promote the formation of new perceptual categories that are robust to acoustic variability, whereas discrimination exercises focus listeners' attention on between-category differences. The training tasks included immediate trial-by-trial feedback and cumulative feedback, which was provided at the end of each session. Contrarily to the perception tests, in the training tasks listeners could hear the same stimulus up to three times before choosing a label.

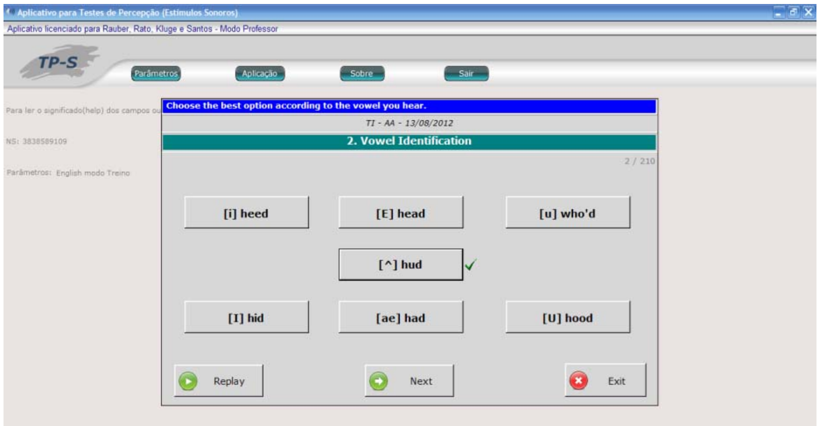

Figure 1. Example of an identification training task with immediate feedback

Immediate feedback was given by means of visual information (see Figure 1) after each response. If the identification of the target segment was correct, participants could listen to the next trial, but if they identified the vowel incorrectly, a message was displayed, and they had to listen to the stimulus again and select the correct answer.

Both groups undertook five 60-minute training sessions that followed the same order: (1) articulatory-visual description of the target segments; (2) instructions for each task; (3) discrimination task; and (4) identification task. Although brief articulatory information was provided in the training program, production of the target phonetic segments was not encouraged. The training tasks were administered in the software TP (Rauber et al., 2011) running in several computers simultaneously in a quiet computer lab. Participants trained individually, and heard the stimuli at a comfortable listening level over headphones.

Experimental group. The training program of the experimental group was divided into two blocks according to degree of difficulty. The first three sessions included AX discrimination and 2AFC identification tasks, each focusing on one of the three vowel contrasts, and the last two sessions consisted of oddity discrimination tasks and 7AFC labeling tasks with all the vowels. Similarly to the perception tests, the training stimuli included vowels embedded in words with four phonetic contexts (bVt, tVk, sVt, and hVd), which were produced by 12 American English NSs.

In the three AX categorial (same-different) discrimination exercises participants had to indicate whether or not two stimuli in randomized word pairs were from the same phonetic category; and in the two oddity discrimination tasks L2 learners heard three physically different stimuli in each trial and identified the position of the token that had a categorically different vowel segment from the other two. In each triad, the odd stimulus (with a different vowel) was presented in one of three positions, and listeners indicated whether it was in the first, second, or third position. The AFC identification tasks involved labeling a given vowel segment from two or more options.

Control group. The training of the control group was focused on two sets of consonantal segments that present perceptual difficulty to Portuguese L2 learners, viz. the dental fricatives /θ/ and /ð/ and the nasals /m/, /n/, and /ŋ/. The five training sessions consisted of closed-set identification and AX categorial discrimination tasks, and natural spoken stimuli were produced by seven (four male and three female) American English native talkers.

Perception Data Analysis

The percentage of correct identification scores of the perception pretest, posttest, delayed posttest and generalization test were compared, and statistical intragroup analyses were run to examine if there was improvement in the participants' perception of the target vowel contrasts and generalization of learning. Moreover, intergroup analyses were run to verify whether there were differences in performance between the trainees and the controls in the four identification tests.

RESULTS

Results of the Pretest, Posttest and Delayed Posttest

Statistical intragroup analyses were performed for the two groups, the experimental group (n=19) and the control group (n=11)[2] – to investigate whether perceptual training had an effect on the identification of the vowel contrasts, that is, whether there were differences in the perceptual performance of both groups before the training, immediately after the training and two months after the training was over. Therefore, two

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[2] The reduced number of participants included in this analysis reflects the attrition suffered from the posttest to the delayed posttest.

repeated measures analyses of variance were run, and their results are presented in Table 2.

Table 2. Repeated measures ANOVA results for the experimental and the control groups

Group	Vowel contrast	Pretest Mean (SD)	Posttest Mean (SD)	Delayed Posttest Mean (SD)	*F* (df)
EG (*n*= 19)	/æ/-/ɛ/	66.40 (7.10)	81. 32 (8.74)	83.77 (9.14)	35.65 (2,36) ***
	/i/-/ɪ/	55.79 (18.50)	85.00 (12.18)	87.63 (11.51)	45.18 (1.14, 20.57) ***
	/u/-/ʊ/	64.74 (13.38)	78.60 (11.96)	84.12 (10.01)	28.50 (1.36, 24.49) ***
CG (*n*= 11)	/æ/-/ɛ/	71.67 (9.43)	72.58 (10.60)	73.33 (9.13)	.209 (2,20)
	/i/-/ɪ/	68.03 (15.77)	70.61 (16.11)	66.82 (19.13)	.915 (2,20)
	/u/-/ʊ/	62.58 (19.22)	58.33 (24.29)	63.26 (19.05)	.732 (2,20)

Note. EG= Experimental group; CG = Control group; SD = Standard Deviation; F = result of the ANOVA; (df) = degrees of freedom; levels of significant: * $p < .05$; ** $p < .01$; *** $p < .001$.

The repeated measures ANOVA revealed that the high variability perceptual training had a significant effect on the identification of the three target vowel contrasts in relation to the moment it was tested (pretest, posttest and delayed posttest) by the experimental group, but no effect was found for the control group (Table 2).

The trainees' perception of the three vowel contrasts improved significantly after training, and learning remained two months after the HVPT was over (Figure 2), but the control group showed no perceptual improvement in the identification of the six vowels after the training with consonants (Figure 3).

The mean percentage scores of correct identification indicate that training significantly improved the perceptual performance of the experimental group. In comparison with the pretest scores, the highest improvement was observed for the high front vowel pair (29.21%), followed by the front low pair (14.92%) and then the high back pair (13.86%). The experimental group also showed a substantial improvement (5.52%) in distinguishing the back vowel pair two months after training was over (Table 3). The participants of the control group did not improve the perception of any of the three vowel contrasts, as expected. Their mean scores of correct identification of the three vowel contrasts after the training with consonants was similar to their results in the pretest phase. Therefore, no effect of training was observed for the control group.

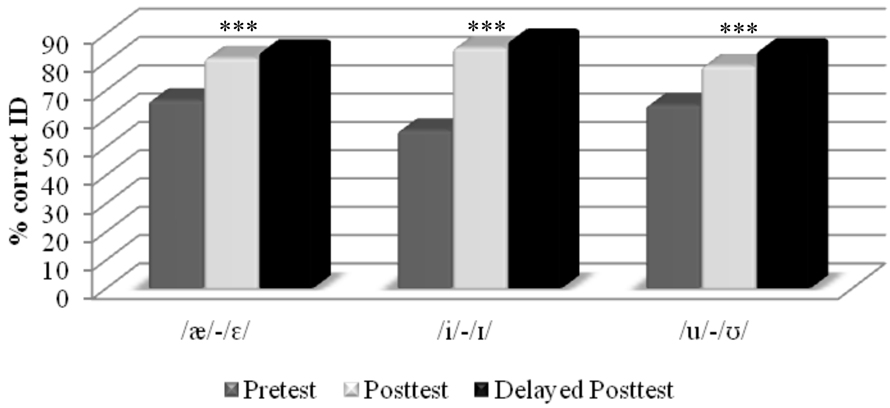

Figure 2. Mean % scores of correct identification in the pretest, posttest and delayed posttest by the experimental group.

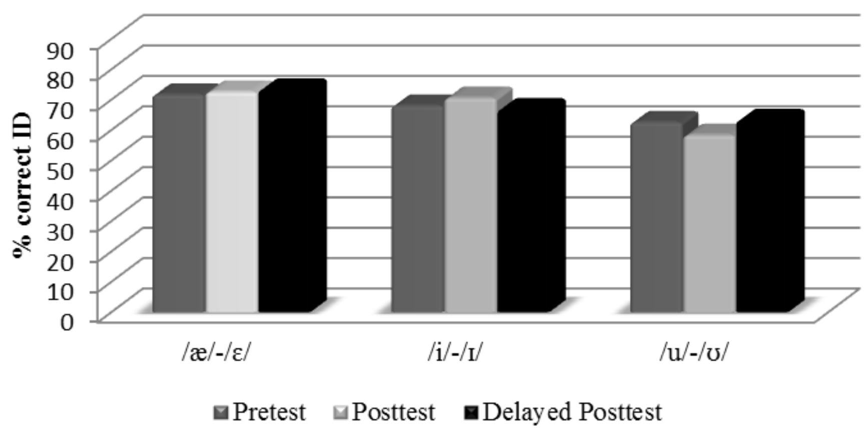

Figure 3. Mean % scores of correct identification in the pretest, posttest and delayed posttest by the control group.

The effects of training were further assessed through a calculation of differences in the participants' identification scores between pretest and posttest, posttest and delayed posttest, and pretest and delayed posttest. If the training was effective, the experimental group should reveal a significant increase in the identification scores in the posttest, while the control group should not exhibit such improvement. Moreover, if learning was maintained, the delayed posttest correct identification scores should not be significantly lower than the posttest scores.

Post-hoc tests that consisted of Bonferroni pairwise comparisons were run for the two groups. For the experimental group, results of the post-hoc test revealed significant differences between the pretest and posttest, and between the pretest and delayed posttest identification scores. Table 3 shows that the identification of the three vowel pairs was significantly better not only immediately after training (posttest) but also two months later (delayed posttest). Furthermore, the identification accuracy of the back vowel pair also improved from the posttest to the delayed posttest. No significant differences were found for the control group.

Table 3. Pairwise Comparisons and Mean % of Improvement

Group	Vowel Contrast	Pretest *vs.* Posttest	% imp.	Posttest *vs.* Delayed Posttest	% imp.	Pretest *vs.* Delayed Posttest	% imp.
Experimental	/æ/-/ɛ/	***	14.92	ns	2.45	***	17.37
	/i/-/ɪ/	***	29.21	ns	2.63	***	31.84
	/u/-/ʊ/	***	13.86	**	5.52	***	19.38
Control	/æ/-/ɛ/	ns	.91	ns	.75	ns	1.66
	/i/-/ɪ/	ns	2.58	ns	-3.79	ns	-1.21
	/u/-/ʊ/	ns	-4.25	ns	4.93	ns	.68

Note. ns= non-significant; * < .05; ** < .01; *** < .001; imp = improvement.

In order to verify whether the two groups performed differently in the three test phases, a comparison was done between the experimental and the control groups' mean scores for each vowel contrast with a *t test for independent samples*. If there were training effects, significant differences between the performances of both groups should be found in the posttest and delayed posttest, but not in the pretest.

Table 4. Mean % scores in the Pretest, Posttest and Delayed Posttest and t test Results

ID test	Vowel Contrast	EG (*n*=22) Mean (SD)	CG (*n*=12) Mean (SD)	*t* (df)
Pretest	/æ/-/ɛ/	66.59 (7.98)	70.69 (9.60)	-1.33 (32)
	/i/-/ɪ/	56.67 (17.41)	66.53 (15.91)	-1.62 (32)
	/u/-/ʊ/	63.79 (13.30)	62.78 (18.34)	.18 (32)
Posttest	/æ/-/ɛ/	81.44 (8.67)	71.81 (10.45)	2.88 (32) **
	/i/-/ɪ/	83.71 (13.68)	69.17 (16.15)	2.78 (32) **
	/u/-/ʊ/	77.42 (12.48)	59.58 (23.56)	2.90 (32) **
		EG (n=19)	CG (n=11)	
Delayed Posttest	/æ/-/ɛ/	83.77 (9.14)	73.33 (9.13)	3.01 (28) **
	/i/-/ɪ/	87.63 (11.51)	66.82 (19.13)	3.74 (28) ***
	/u/-/ʊ/	84.12 (10.01)	63.26 (19.05)	3.95 (28) ***

Note. EG = experimental group; CG = control group, * < .05; ** < .01; *** < .001.

As expected, there were no differences between the perceptual performances of the trainees and the controls in the pretest. However, significant differences were found between both groups in the two test phases after training. The trained group outperformed the control group both in the posttest and in the delayed posttest with significantly higher identification scores in the three vowel contrasts (see Table 4).

Results of the Generalization Test

To examine whether there was generalization of training to new tokens and new talkers, comparative analysis were done between the posttest and the generalization test mean percentage scores of correct identification, following a similar procedure as Wang (2008). Hence, *t tests for paired samples* were run. Results are displayed in Table 5.

Table 5. Posttest and Generalization Test Results from the t test for paired samples

Group	Vowel Contrast	Posttest Mean (SD)	Generalization test Mean (SD)	*t* (df)
Experimental (*n*=22)	/æ/-/ɛ/	81.44 (8.67)	90.28 (6.79)	- 5.93 (21) ***
	/i/-/ɪ/	83.71 (13.68)	89.27 (8.28)	-3.24 (21) **
	/u/-/ʊ/	77.42 (12.48)	67.42 (16.89)	4.00 (21) **
Control (*n*=12)	/æ/-/ɛ/	71.81 (10.45)	72.45 (12.50)	- .25 (11)
	/i/-/ɪ/	69.17 (16.15)	68.06 (16.35)	.32 (11)
	/u/-/ʊ/	59.58 (23.56)	57.17 (20.36)	.52 (11)

The results of the *t test* revealed that the experimental group had significantly higher identification scores for the two front vowel pairs (/i/-/ɪ/, /æ/-/ɛ/) in the generalization test than in the posttest, whereas the scores for the high back pair were considerably lower in the generalization test. This seems to indicate that generalization of learning to new tokens and new talkers occurred in relation to the former vowel contrasts but not for /u/-/ʊ/. For the control group, no differences were found between the posttest and the generalization test. Their performance in both tests was similar, which seems to suggest that their difficulties distinguishing the target vowel contrasts did neither better nor worsen. The results of the *t test for independent samples* confirmed that the trainees outperformed the controls in the identification of the vowel contrasts /æ/-/ɛ/ ($t(32) = 5.42$, $p < .001$), /i/-/ɪ/ ($t(32) = 5.05$, $p < .001$), and /u/-/ʊ/ ($t(32) = 1.57$, $p < .001$) in the generalization test.

DISCUSSION AND CONCLUSIONS

The pretest results suggest that formal classroom instruction was insufficient for this group of first-year undergraduate students to accurately learn the American English vowel contrasts /i/-/ɪ/, /ɛ/-/æ/, /u/-/ʊ/. After eight years of learning in an EFL context, these learners still had difficulty distinguishing /ɪ/, /æ/, and /ʊ/ from their counterparts /i/, /ɛ/, /u/

due to their high degree of perceived cross-language phonetic similarity. This expected result agrees with previous studies that have investigated the influence of instructional variables on L2 pronunciation accuracy (e.g., Flege et al., 1995). Researchers concluded that amount of formal FL instruction has no or only little influence on degree of foreign accent. However, the interaction of factors such as age of learning (AOL) and amount of input can positively (or negatively) influence L2 pronunciation learning in a FL classroom. Specific training on the perception and production of L2 sounds has also proved to help learners approximate a native-like pronunciation. In the case of this experiment, a high variability perceptual training effectively facilitated the learning of English vowels in a short period of time.

The preliminary analyses of results revealed that perceptual training significantly improved the Portuguese learners' performance in the identification of the three target vowels after three sessions (i.e., one in the first block, focused on one vowel contrast, and two in the second block with all the six target vowels and a distractor), and the knowledge gained during perceptual learning was still present two months after completion of the HVPT training program. In addition, the results of the generalization test indicate that there was robust learning of the two front vowel contrasts, but not of the high back contrast. This finding agrees with the posttest scores, because in both tests the most difficult vowel pair to identify was /u/-/ʊ/.

Another relevant finding is related to the performance of the control group in the identification tests (posttest, delayed posttest and generalization test) after training because if perceptual improvement was solely caused by task effect, that is, if it resulted from the repetition of performing perceptual tasks, significant improvement should be observed in the controls after the training with consonants. However, no perceptual improvement was found for any of the three vowel contrasts, which seems to indicate that learning was not promoted by task repetition. The claim that phonetic training has to be centered on the target segments in order to be effective was supported by the finding that a vowel-centered training was beneficial for learning the three vowel contrasts, whereas the consonant-centered training was not. Although the natural stimuli used in the training program of the controls included the target vowels (e.g., <bass-bath>, <miss-myth>), their attention was directed to consonant contrasts.

Due to the similarity between the Brazilian Portuguese and European Portuguese vowel systems, the predictions about which vowel contrast would be most difficult or easiest to learn were based on Nobre-Oliveira (2007) and Rauber (2010) studies that investigated the perception and production of American English vowels by Brazilian EFL learners. Hence, if Portuguese learners followed the same pattern, the least difficult pair to perceive would be /i/-/ɪ/, followed by /u/-/ʊ/, and then /ɛ/-/æ/. However, before training the pattern observed in the Portuguese learners' was the opposite, being /ɛ/-/æ/ the most easily perceived contrast, and /i/-/ɪ/ the most difficult for the controls and /i/-/ɪ/ for the trainees. After training, the pattern altered only in the case of the trained group. The least difficult contrast to perceive was /i/-/ɪ/ followed by /ɛ/-/æ/, and then /u/-/ʊ/, which indicates that trainees' perceptual patterns changed immediately after training. Two months after the training was over, the experimental group identified the back vowel contrast (84.12%) marginally better than the low front contrast (83.77%), thus, performing similarly to the Brazilian participants in the aforementioned studies. In sum, the perceptual training contributed to increase the degree of perceived dissimilarity between the English vowels of the three target contrasts and, consequently, to the formation of new L2 phonetic categories.

The preliminary results of this experiment corroborate the claim that perceptual learning can occur in non-naturalistic environments (i.e., in a foreign language classroom) by means of specific high variability perceptual training, within a short period of time, and support previous findings on the malleability of L2 adult learners' perceptual systems.

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APPENDIX

Identification Test Stimuli					
Vowel	**bVt**	**tVk**	**tVt**	**kVt**	**pVt**
/æ/	bat	tack	tat	cat	pat
/ɛ/	bet	tech	Tet	Ket	pet
/ɪ/	bit	tick	tit	kit	pit
/i/	beat	teak	teat	keep	Pete
/ʊ/	book (2x)	took	-	cook	put
/u/	boot	tuke	toot	coot	poop
/ʌ/	but	tuck	tut	cut	putt

Training Tasks Stimuli				
Vowel	**bVt**	**tVk**	**sVt**	**dVd**
/æ/	bat	tack	sat	had
/ɛ/	bet	tech	set	head
/ɪ/	bit	tick	sit	hit
/i/	beat	teak	seat	heed
/ʊ/	book	took	soot	hood
/u/	boot	tuke	suit	hoot
/ʌ/	but	tuck	shut	hut

Generalization Test Stimuli			
Vowel	**CVC**	**CCV(C)(C)**	**CVCC**
/æ/	pad, back, sad, rack, mat	plaid	
/ɛ/	said, met, wreck	pled, bled, slept	
/ɪ/	fill, lick, mitt	slipped	fist, wrist
/i/	seed, feel, leak	bleed, ski	feast
/ʊ/	push, could, full, look	stood	wolf
/u/	cooed, fool, Luke	blue, flu, stewed	
/ʌ/	cud , bug, luck, rough	blood, flood	