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PHONETIC IMITATION OF L2 VOWELS IN A RAPID SHADOWING TASK

Arkadiusz Rojczyk, University of Silesia

The current study investigates the production of L2 vowels in rapid shadowing task. A number of studies have demonstrated that talkers converge with the model on a variety of acoustic properties as a result of imitative tendencies in humans. Such tendencies should be also observed in second-language speech in which acquisition of new sound categories results from efficient imitation of nonnative articulatory patterns. Twenty-two Polish learners of English produced tokens of the English low front vowel /æ/ in word-list reading and immediate imitation of the model. This vowel is reported to be difficult to acquire for Polish learners because it can be accommodated by two Polish neighbouring vowels /e/ and /a/. The magnitude of convergence with the model productions of /æ/ was expressed in Euclidean distance values. The results reveal that participants significantly modified their productions as a result of exposure to the model and that they diverged from their articulatory habits shaped by the influence of L1 vowel categories.

INTRODUCTION

Human beings have an inborn ability to imitate a wide range of actions and intentions (Hauser, 1996; Honorof, Weihing, & Fowler, 2011; Nagell, Olguin, & Tomasello, 1993; Whiten & Custance, 1996). This imitative tendency begins immediately after birth (Meltzoff & Moore, 1999) and continues into adulthood (McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985). Speech appears to be a human activity in which imitation is most likely to play a significant role. Children acquire language from their caretakers and peers (Chambers, 1992; Payne, 1980). Adults acquire elements of the new dialect after moving to a new area (Delvaux & Soquet, 2007; Evans & Iverson, 2007; Munro, Derwing & Flege, 1999; Trudgill, 1986). All this points to the conclusion that language users constantly interact with and imitate patterns occurring in the ambient language.

Sources of such imitative tendencies among speakers are explained from different perspectives relating to human behaviour and cognition. Sociolinguistic theories such as Communication Accommodation Theory (Shepard, Giles, & Le Poire, 2001) assume that individuals accommodate speech features of interacting partners in order to manipulate social distance. Accordingly speakers can both converge with and diverge from interacting partners by subconscious manipulation of attributes such as accent, speaking rate, intensity, utterance duration and frequency of pauses (Giles, Coupland & Coupland, 1991; Gregory & Webster 1996). Meltzoff and Moore (1999) suggest that imitation allows infants to develop the view of self as part of social cognition built on reciprocal imitation of other people. Finally, neurological accounts ascribe imitative tendencies to the architecture of mirror neurons in the human brain (Arbib & Rizzolatti, 1997).

Phonetic imitation (also phonetic convergence or phonetic accommodation) is the process by which a talker takes on acoustic characteristics of the individual that he or she is interacting with (Babel, 2012). This interaction is captured by exemplar-based models (Hintzman, 1986; Nosofsky, 1986), which assume that detailed information in the speech is preserved as exemplars that form a perceptual category. For example, Pierrehumbert (2006) argues that speech production and perception are not, as traditionally viewed, modular but rather that allophonic details as well as speaker information are actively communicated both in production and perception. Such imitative processes are especially important in second-language speech, which is characterised by strong and complex influences from native sound categories on target L2 categories (e.g., Best, 1995; Best & Tyler, 2007; Escudero & Boersma, 2004; Flege, 1987; 1995). Only effective imitation of nonnative properties will lead to formation of new sound categories. The current study investigates how and to what extent imitation in rapid shadowing after the model speech can lead to the production of more native-like vowels. Immediate imitation in shadowing is characterised by a minimum time-lag between hearing the model and actual imitation. This paradigm should be most conducive to attaining approximation of target formant frequencies of L2 vowels because the auditory input is immediately fed to imitative production. In other words, episodic traces of perceived model speech will be reflected in production (Goldinger, 1996, 1998). Moreover, the specificity of the task itself, in which learners are instructed to imitate the model speech without reference to semantics of words, is captured by phonetic as opposed to phonemic perception (Werker & Logan 1985). The phonetic perceptual mode is sensitive to allophonic variation as well as acoustic properties which are absent in the native language.

IMITATION OF VOWELS

Many studies have reported the influence of imitated model speech on production of fine-grained speech properties. Shockley, Sabadini and Fowler (2004) reported that talkers imitate lengthened VOT values for voiceless /p, t, k/ in English. Nielsen (2011) expanded on this observation by showing that longer VOTs as a result of imitation are generalized to new instances of the target phoneme. Most recently, Rojczyk (2012) showed that imitation of VOT is also observed in talkers whose native language does not exploit long VOT values. Honorof et al. (2011) found imitative convergence with the model speech for different degrees of velarization of /l/, measured as the distance between F2 and F1.

A number of studies have found imitation of vowels understood as a reduced acoustic and perceptual distance between baseline to shadowed tokens. Most of these studies conclude that degree of such convergence may depend on both characteristics of the model as well as on which vowels are imitated. Babel (2010, 2012) reported that such convergence of vowels may be selectively modulated by implicit attitudes towards race and nationality of the model. Pardo (2010) and Pardo, Cajori and Krauss (2010) observed that vowel quality is a factor in imitation studies. Talkers may converge, diverge, or not change on some vowels. This tendency was later confirmed in a long-term exposure study on phonetic convergence in college roommates (Pardo, Gibbons, Suppes & Krauss, 2012). Babel (2012), in a lexical shadowing task, observed a greater tendency to imitate low vowels relative to /i/ or /u/. Most importantly for the current study, the vowel /æ/ exhibited the greatest imitative effect. While Babel (2012) ascribed this effect to greater regional variation of low /æ/ and /ɑ/ in American English, another explanation may be formulated by referring to articulatory specification of low and back vowels. Low vowels, unlike high vowels, are characterized by greater mouth opening and jaw lowering, which leaves more space for individual variability in their production. Such variability will contribute to more pronounced convergence effects observed in imitation.

THE CURRENT STUDY

The current study examines imitation of the English vowel /æ/ by Polish learners. This vowel is commonly reported to be one of the most difficult to acquire by nonnative learners of English (Bohn & Flege, 1997; Flege, Bohn & Jang, 1997; Strange, Akahane-Yamada, Kubo, Trent, & Nishi, 1997) and to be a marker of foreign-accentedness (Flege, 1992; Major, 1987). Polish learners of English, whose native language does not have low front vowels (Jassem, 2003), have difficulties with establishing a new vowel category for /æ/ (Gonet, Szpyra-Kozłowska and Święciński, 2010; Rojczyk, 2011; Sobkowiak, 2003). Applying the assimilatory metric, English /æ/ is equally likely to be assimilated by front mid /e/ and low central /a/ in Polish. However, the direction of assimilation may depend on many factors ranging from personal preferences (Sobkowiak, 2003) to spelling convention (Gonet et al., 2010).

The major goal is thus to investigate if and to what degree imitation in immediate shadowing will allow Polish learners to approximate target-like formant frequencies of nonnative vowel /æ/. As previously reported, this vowels provides the greatest imitative effect in imitation by native speakers (Babel, 2012); however it is not known if and to what extent this vowel will be imitated by talkers with a different language background. In order to quantify the imitative convergence in this scenario, formant frequencies of /æ/ vowels were compared between two tasks: word-list reading (baseline condition) and shadowing after the model voice. The metric of imitation was calculated as the Euclidean distance of individual productions in the two tasks to the model productions to reveal a change as a result of auditory exposure to the model talker (Babel, 2012). Lower Euclidean distance values in the shadowing task are expected to show the degree of convergence with the model and, accordingly, the articulatory approximation towards a nonnative vowel category. Moreover, gender will be incorporated in the statistical model as an independent variable, because of previous reports suggesting that gender may be a factor in the magnitude of imitation (Pardo, 2006).

Participants

Twenty-two native speakers of Polish (sixteen females and six males) were included in the study. All of them were recruited from the University of Silesia in Poland. Their mean age was 19.8 (*SD* = .03). Their self-reported proficiency in English ranged from intermediate to upper-intermediate. None of the participants reported any speech or hearing disorders.

Materials

The words used in the experiment were twelve monosyllabic sequences with the vowel /æ/ flanked by consonants (Table 1). They were recorded for the shadowing task by a male southern British English speaker using the recording equipment reported below. The model talker was instructed to use natural speaking tempo and falling intonation for each token. Each model vowel was measured as described below to obtain F1 and F2 formant frequencies of /æ/s in each token used for shadowing. The raw model values for /æ/ in each word are provided in the Table 1.

Table 1

Words Used in the Experiment with the Model Talker's Frequencies of the First and Second Formant Expressed in Hz

Word	F1	F2
back	749	1492
bad	697	1558
bat	683	1570
cab	696	1618
cap	785	1631
cat	688	1620
dad	706	1675
fat	802	1544
hat	676	1593
sad	720	1641
pack	673	1575
mad	727	1594

Procedure and Recording

The experiment took place in the Acoustic Laboratory at the Institute of English, University of Silesia. Data were collected in two blocks. The first block was reading the list of words to establish baseline productions of /æ/. The participants were instructed to read the words using natural intonation and articulatory rate. The words were presented sequentially on a monitor screen in 54-point black font in the middle of the screen. Twelve other foil words with different vowels were randomly dispersed among target words to distract the talkers' attention from the object of the experiment. The second block was used for immediate shadowing after the model talker. The participants were instructed that upon hearing a word spoken by the voice they were to immediately repeat it. The presentation of words was separated by a two-second interval after the cessation of imitations. Five foils were used at the beginning of this block to familiarize the participants with the procedure. At the end of the session, the participants read /bVt/ sequences with Polish vowels /i, e, a, o, u/ that were further used as landmark points to establish the acoustic space for each talker in normalization. Each session lasted approximately twenty minutes.

The recordings were made in a sound-proof booth, the signal was captured with a headset dynamic microphone Sennheiser HMD 26, preamplified with USBPre2 (Sound Devices), into .wav format with the sampling rate 48 kHz, 24 bit quantization. The model voice was provided by high quality headphones built in the headset.

Measurements

Formant frequencies of vowels were measured at vowel midpoint using the add-on vowel analysis software Akustyk 1.8 (Plichta, 2011) for Praat (Boersma, 2001). First, all recordings were downsampled to 10 kHz and vowel midpoint was located using wideband spectrograms. Formants were tracked using a 25-ms Hanning window with default 11 (female) and 12 (male) poles. If the tracker yielded spurious or missed formants, LPC spectral envelopes and FFT power spectra were compared in order to recompute a prediction order so that it would match a particular speaker's voice quality. The total number of measured target tokens was 528 (22 talkers x 24 vowels). In order to compare the distance of individual productions to model production, anatomical and physiological variation between talkers was normalized using the Lobanov transform (Lobanov, 1971; Adank, Smits & van Hout, 2004).

Analysis

In order to calculate how much participants modified their production as a result of exposure to the model production, the Euclidean distance was computed between the participants' and model's F1 and F2 frequencies. This shows how far apart individual vowels are on a vowel plane. As a result, the magnitude of the convergence was expressed in the distance values. In this metric, the lower the value the more similar the model and participants' values are in the acoustic space. The calculated distances in the word-list and shadowing conditions were used as repeated-measures dependent variables. Data were analysed using a two-way mixed ANOVA with task (word-list, shadowing) and gender (male, female) as independent variables. The dependent variable was Euclidean distance expressed in Hertz. Data for each word out of twelve stimulus words were used as separate rows in the analysis, which yielded 264 rows (22 participants x 12 words). Moreover, scatter plots for individual productions were used to inspect the clustering of participants' vowels with the model vowels.

RESULTS

Figure 1 shows the scattering of individual productions of /æ/ in word-list (black) and imitation (green) around the model production (red). It is evident that shadowed productions are more centered around the model. Unlike vowels from the word-list reading, they are also characterized by less extreme productions towards either Polish /e/ or /a/. This demonstrates that even participants who completely accommodated English /æ/ to either /e/ or /a/ in their native language reacted to the auditory input and modified their productions towards the model vowel. Moreover, the model auditory input generated a magnet effect by cancelling less extremely outlying productions in the imitation task, as demonstrated by better clustering of individual productions around the model in shadowing.

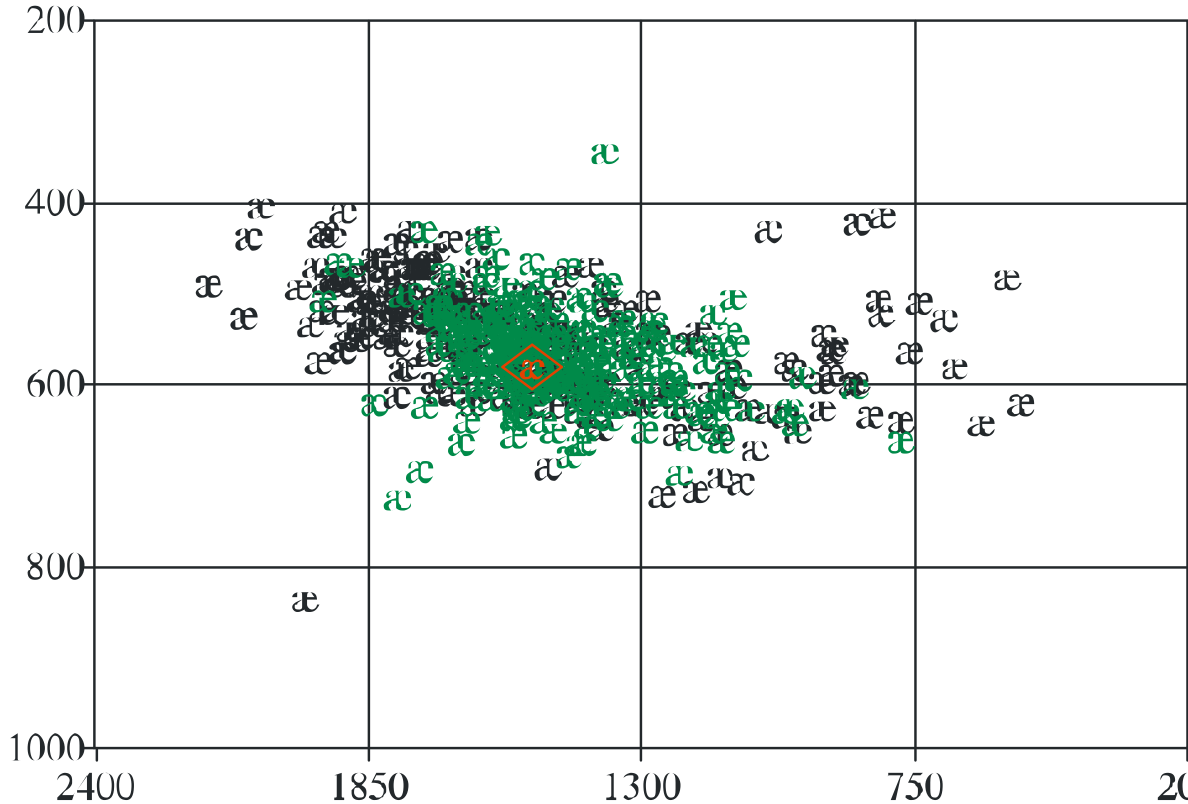

Figure 1. Scatter plot of vowels from read words (black) and imitated words (green) on an F1-F2 plane. Model vowels in a red diamond.

The analysis of Euclidean distances of individual productions to the model vowels in the two tasks revealed a highly significant main effect of task on the magnitude of convergence [F(1, 262) = 43.35, p < .001]. The participants modified the productions of the /æ/ vowels to approximate the model in imitation (*M* = 165; *SD* = 120) compared to baseline word reading (*M* = 264; *SD* = 199). The was no significant gender x task interaction [F(1, 262) = .11, p > .05], indicating that gender of the participants did not affect the magnitude of convergence.

DISCUSSION

The study investigated to what extent nonnative vowels can be imitated in a shadowing task. The degree of imitation was calculated as the Euclidean distance of individual productions to the model vowels. In order to assess the magnitude of imitation, the productions from shadowing were compared to baseline reading of words for each participant. The vowel was low front /æ/ in English, which is difficult to acquire for Polish learners who accommodate it in production and perception to neighbouring /e/ and /a/.

The results revealed a significant convergence with the model in the task in which talkers were required to immediately repeat after the model voice compared to the task in which they read orthographic representations of the words. Accordingly, it suggests that foreign language learners are able to modify their productions of nonnative vowels as a result of exposure to the model. This is confirmed by significantly lower Euclidean distance values in the shadowing task. If /æ/ tokens from the word list are taken to represent participants' default exemplars of this vowel, the tokens from imitation show that learners' vowel categories are not without exception shaped by L1 categories. Obviously, the time-course of such convergence is probably limited, in that in order for a learner to modify their vowel production, the interval between exposure and the onset of imitation must be relatively short. This is suggested by research with nonnative imitation in immediate and distracted tasks (Rojczyk, 2012). In this study, Polish learners produced tokens with voiceless plosives in English and their VOT was measured. Polish, unlike English, does not use long-lag VOT for /p, t, k/ and, as a result, Polish learners have difficulties producing sufficiently long VOT values in English. Participants' VOT was measured in voiceless plosives in the word list, immediate and distracted imitation. In the distracted task learners were required to listen to the model, read the number on the screen, and then begin imitation. The results revealed that VOT values in this task were intermediate between baseline word-list reading and imitation, indicating that if the interval between exposure and imitation is lengthened or cognitively taxing, learners resort to their habitual production patterns. The same regularity may be expected to occur for vowel production, in that if participants are distracted or delayed in their imitation, they will produce tokens which diverge from the model vowels.

The current study did not find any influence of gender on the magnitude of convergence. Such possibility was suggested in previous studies (Pardo, 2006). There are two reasons why this may be the case. First, in the current study male participants were significantly underrepresented, which may have affected the results. Second, the study by Pardo (2006) observed gender differences in conversational interaction. Such interactions are characterized by more psychological and sociolinguistic influences which may trigger gender differences. The current study relied to a greater extent on psychoacoustic reactions to the auditory input, which does not necessarily have to be gender specific.

The current results also confirm previous observations that fine-grained phonetic details are not filtered out in speech perception, as demonstrated by plasticity in speech production (e.g., Nielsen 2011; Norris, McQueen & Cutler, 2003; Sancier & Fowler, 1997). If phonetic detail were discarded in production, participants in the current study would not have modified their production as a result of exposure to the model. By extension, this also suggests that L2 learners are able to restrict the assimilatory impact of native sound categories on target L2 categories, at least if the time interval between the model input and the onset of production is relatively short and undistracted. It is thus possible that the interference of native phonological and articulatory patterns is gradient and its magnitude may depend on circumstances and activity that a learner is engaged in.

Finally, yet another aspect that may have contributed to the current findings is the role of orthography. The effects of orthography in second-language pronunciation are evident (Young-Scholten & Archibald, 2000; Silveira, 2007), especially in the case of learners in the current study whose contact with L2 had relied greatly on written material. Since the target vowel /æ/ was orthographically represented by a letter 'a' in all tested words, it may be assumed that this letter may have caused more divergent productions towards vowel /a/ in the reading task. However, this prediction is not fully warranted. The inspection of individual productions in the reading task clearly shows that the distribution of /æ/ was relatively balanced between Polish /e/ and /a/. This reflects previous observations that the production of this vowel by Polish learners is not tied to its representation by a letter 'a' (Gonet et al., 2010). It is for future studies though to demonstrate the extent of influence of orthographic representation on imitation for this vowel by precise manipulations of tested words.

ABOUT THE AUTHOR

Arkadiusz Rojczyk is an Assistant Professor at the University of Silesia in Poland. His research concentrates on production and perception of second language speech, speech analysis and resynthesis. He is currently working on vowel perception and production in second-language speech

arkadiusz.rojczyk@us.edu.pl
Institute of English, University of Silesia
Grota-Roweckiego 5
41-205 Sosnowiec, Poland

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