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DESCRIPTIVE ANALYSIS OF THE PERCEPTION AND PRODUCTION OF ENGLISH VOWELS BY SERBIAN SPEAKERS

The most influential models on foreign language perception and its effects on foreign language sound acquisition suggest that sounds which are perceived as sufficiently new will be adopted easily by foreign language learners, but those which are like the native sound category tend to be assimilated into it. Furthermore, the effects of speaker perception on sound production are still actively debated, as some research claims that there is a correlation between speaker perception and production, while others propose that the link between perception and production remains complex and is subject to speaker variability. This paper set out to determine if Serbian English language and literature students and bachelors had adequately acquired English vowels, and this was tested through both a perception and production task. The goal was to see if the English vowel categories were different from the Serbian vowel categories in tested speakers. To accomplish this, 50 participants were tested on their perception abilities, and a selection of 12 speakers were subsequently asked to produce English and Serbian vowels for the production task. The results indicated that speakers had a good overall perception of nearly all English vowels except for /ʌ/. The production task showed that speakers had adequately acquired most of the English vowels and that they were different from their Serbian vowels.

Keywords: perception, production, vowel quality, vowel quantity, English, Serbian

Introduction

Over the past several decades many contrastive analyses between languages have been conducted and many of them have sought to bring into focus the differences across languages in the hope of making foreign language learning and translation easier and more intuitive. The core concepts of contrastive analysis stem from Lado's (1957) 'Contrastive Analysis Hypothesis', which proposes that speakers will adopt elements of the foreign language that are similar to those of their native language more easily than elements which are completely new or different. Contrastive analysis is typically carried out on elements which are equal or similar across languages, and in the case of phonology, what can be compared are individual distinctive features, phonemes or even intonation.

Therefore, this study sought to investigate the perception and production of English vowels in native speakers of Serbian. The hypothesis was that some degree of native category assimilation was bound to have occurred. Thus, the first goal of this paper was to investigate how Serbian EFL speakers perceived English vowels when they were pro-

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duced by a native British speaker. The second goal was to conduct a contrastive analysis of the Serbian and English vowel pairs by using the contrastive methodology outlined in Marković (2012) in order to ascertain the level of native category assimilation that had happened between Serbian and English vowels. The findings of this study may help contribute to a better understanding of how Serbian speakers acquire English vowels and the extent to which native phonological categories influence their perception and production.

Previous Research

Difficulties in Perception and Production of Foreign Language Sounds

Despite the core presupposition of the contrastive analysis theory, more modern research has shown that the acquisition of a non-native vowel system is typically very difficult for non-native speakers and L2 learners. Previous research by Cutler et al. (2005) indicates that non-native speakers have a harder time identifying the correct phonemes in the phonetic system of their second language than native speakers of the same language. Similarly, research by Flege et al. (1997) showed that the experience of non-native speakers with the second language also had a direct effect on how accurately they would be able to identify the vowels of the second language, with results indicating that more experienced learners showed a much higher degree of accuracy than less experienced learners. Studies (BEST 1995, BOHN 1995, FLEGE 1997) have shown that, when acquiring a new phonological system, most non-native L2 learners will rely on adopting different strategies and using different phonetic cues, such as vowel duration, as opposed to strategies adopted by native speakers. Flege's *Speech learning Model* – SLM (FLEGE 1995) and Best's *Perceptual Assimilation Model* – PAM (BEST 1995) remain the most influential models for testing L2 vowel perception. Flege's SLM specifies that L2 sounds which are different enough from the sounds of the speaker's L1 will be perceived as new, and therefore will be adopted more easily by non-native speakers. A revised version of this model, the SLM-r proposed that the mechanisms which are needed to adopt the L1 remain accessible for the learning of L2 throughout the learner's life. Flege and Bohn (2021) further state that whether new phonetic categories of L2 sounds will be formed depends on how precisely L1 categories have been acquired when the learning of a new language begins. Based on the revised model, the phonetic categories of the two languages interact with each other dynamically and are updated whenever the properties defining these categories change. Best's PAM, however, states that the discriminability of L2 vowels depends on L1 vowel possibilities, and if the vowel categories of L1 and L2 are similar enough, then the non-native speaker is likely to assimilate similar-sounding L2 vowels into their L1 category. An example study using these models is one conducted by Marković (2009) of native Serbian speakers' perception and production of the English vowel categories /e/ and /æ/. This study indicated that native Serbian speakers showed poor discrimination between their /æ/ and /e/ vowels, and that they occupied the same vowel space for Serbian speakers of English as they had assimilated /æ/ with the native /e/ category. Another study by Krebs-Lazendić & Best (2007) of Serbian Bilinguals in Australia tested the perception and production of the /æ/ and /ɛ/, as well as the /i/ and /ɪ/ vowel pairs. This research indicated that while Serbian speakers did show a good discrimination between /i/ and /ɪ/ pairs, the discrimination of /æ/ and /ɛ/ proved to be quite poor, with speakers

often assimilating it with a native vowel category.

Moreover, the relationship between non-native speakers' perception, acquisition, and production of foreign language vowels remains an important question, as the nature of their correlation is still not entirely clear. While Flege (1999) found a modest correlation between perception and production, more recent research, such as Flege's revised Speech Learning Model (2021), suggests a more dynamic bidirectional relationship. Rather than perception strictly determining production, the SLM-r proposes that production practice can also shape perception, and other studies, such as those by Levy and Law (2010) and Song and Eckman (2024), further support the idea that the exact mechanism governing the links between perception and production remain complex and are subject to variability among learners.

Additionally, some differences between male and female speakers are to be expected in the production task. Diehl et al. (1996) points out that the vocal tract of women tends to be shorter than that of men, and that this has an effect of women having higher F_0 frequencies (pitch), which subsequently leads to a higher dispersion of F_1 and F_2 frequencies in the vowel space. The study suggests that "the greater between-category dispersion of female vowels may be plausibly explained as a means of offsetting the deleterious effects on vowel identifiability of (typically higher F_0s" (DIEHL 1996: 205). Another study conducted by Henton (1992) on speakers of multiple languages and dialects indicated that women tend to produce vowels which are more open than that of men.

English and Serbian Vowel Systems

The vowel systems of the two languages are different in both the number of vowels and in the degree of openness or tongue raising in either system. The Serbian vowel system consists of only 5 vowels, putting it in the in the same category of languages such as Arabic, Spanish, Japanese, Hawai'ian and others, all of which also feature the five-vowel system, the most common vowel inventory found across languages. (ZSIGA 2013: 59). This inventory of vowels consists of 5 monophthongs which are the vowels /i/, /e/, /a/, /o/, and /u/. Additionally, these vowels have 3 degrees of openness: close, mid, and open (SIMIĆ 1996: 175-179). One distinction that sets Serbian apart, however, is that it has a complex system of accentuation where it uses pitch variations in conjecture with other prominence factors on the level of word-stress. Therefore, some words will have completely different meanings depending on the type of accent that was used in the stressed vowel (PAUNOVIĆ 2013: 266).

On the other hand, English is a system of 12 monophthongs (CRUTTENDEN 2014: 92). These monophthongs are further divided into 5 long or tense vowels (/iː/, /ɑː/, /ɔː/, /uː/, /ɜː/) and 7 short or lax vowels (/ɪ/, /e/, /æ/, /ʌ/, /ɒ/, /ʊ/ and /ə/). These vowels are further divided into front (/iː/, /ɪ/, /e/, /æ/), central (/ə/, / ɜː/, /ʌ/) and back (/uː/, /ʊ/, /ɔː/, /ɒ/, /ɑː/) vowels. In addition to this, English is a language that has 4 degrees of raising: close, close-mid, open-mid and open. This distinction places English in the 10% of languages that have a very complex vowel system, but the vowels are still distributed based on the principles of maximal dispersion, i.e., the vowels are dispersed in an equidistant fashion (PAUNOVIĆ 2013: 200).

It should be noted that Serbian and English vowels differ in terms of their overall F_1 and F_2 frequencies. A study conducted by Deterding (1997) on the vowel quality of

10 (5 male and 5 female) native British English speakers provided results on the median vowel quality of British English. Table 1 shows the average F_1 and F_2 frequencies of these speakers across all English monophthongs.

Table 1. *Median Formant Values for English Vowels (DETERDING 1997)*

	Male			Female		
	F1	F2	F3	F1	F2	F3
i:	280	2249	2765	303	2654	3203
ɪ	367	1757	2556	384	2174	2962
e	494	1650	2547	719	2063	2997
æ	690	1550	2463	1018	1799	2869
ʌ	644	1259	2551	914	1459	2831
ɑ:	646	1155	2490	910	1316	2841
ɒ	558	1047	2481	751	1215	2790
ɔ:	415	828	2619	389	888	2796
ʊ	379	1173	2445	410	1340	2697
u:	316	1191	2408	328	1437	2674
ɜ:	478	1436	2488	606	1695	2839

A similar study was undertaken on Serbian vowels (IVIĆ 1996), where the median F1, F2, and F3 values were presented for both short-accented and long-accented variations of Serbian vowels. Table 2 shows these results:

Table 2. *Average Formant Values for Serbian Vowels (IVIĆ 1996)*

Ivić (1996)							
Vowel	Short accented syllable			Vowel	Long accented syllable		
	F1	F2	F3		F1	F2	F3
/i/	410	2045	2595	/i/	385	2155	2730
/e/	550	1760	2420	/e/	480	1985	2470
/a/	780	1445	2070	/a/	900	1525	2100
/o/	560	1035	1920	/o/	495	960	1895
/u/	455	820	1920	/u/	455	775	1965

Therefore, because Serbian has a much smaller number of vowels than English, and since it does not have vowel length in the same sense that the English vowels do, the hypothesis of this research was that Serbian speakers of English, regardless of how skilled they are, would likely partially or fully assimilate some vowel categories such as /ɑ:/ into /a:/ and /ɒ/ into /o/.

Methodology

This research consisted of two experiments. The first task was a 3AFC experiment where participants were asked to identify 11 English vowels. The stimuli for this task were taken from a previous study conducted by Iverson (2006). These stimuli were

the following single syllable hVd words: *heed (/i:/), hid (/ɪ/), head (/e/), had (/æ/), HUD*[21] *(/ʌ/), hard (/ɑ:/), hod (/ɒ/), hoard (/ɔ:/), hood (/ʊ/), who'd (/u:/)* and *heard (ɜ:)*. While certain words are not used commonly (in the case of *hod)* or are acronyms (in the case of *HUD)*, these words were deemed suitable for the stimuli as they allowed all target words to be in a single syllable hVd environment and helped ensure that the primary focus remained on the vowel sounds. All words were recorded by a male native British English speaker who had lived in the UK his entire life.

The perception identification task involved 50 participants (25 male, 25 female) who had completed a course in English phonetics and phonology at the Faculty of Philosophy in Niš. Their ages ranged from 22 to 27, with a mean age of 25.6. The participants were all familiar with the 12 English monophthongs and the IPA symbols used to represent them, as they were all either students of English language and literature or had completed a bachelor's degree in this field.

For the perception identification task, participants heard the British speaker repeat the same sentence three times in a row, with a brief interval between each sentence. They were then given 15 seconds to select the vowel they thought they had heard from a selection of three options. The stimuli were presented in a randomized order for each participant. Before beginning, all participants received a brief refresher on the IPA symbols used in the study and completed a mock example to familiarize themselves with the task. Data retrieved from the perception identification task were subsequently analyzed statistically using the tool JASP (JASP TEAM 2024).

For the production task, participants were requested to produce each of the English and Serbian vowels. A selection of 12 participants from the previous study (6 male and 6 female) were asked to produce 11 tokens containing English vowels – one for each of the vowels tested during the perception task. Additionally, in order to conduct a contrastive analysis of the Serbian and English vowel space, speakers were also required to produce 20 tokens in Serbian – one for each of the 5 Serbian vowels corresponding to the English equivalent in each of the 4 different accent types. These participants were relatively similar – they had completed a course in English phonetics and phonology at the Faculty of Philosophy in Niš, held a bachelor's degree in English language and literature, were from the same local area, and spoke the same dialect. Their ages ranged from 23 to 27, with a mean age of 24.3.

For the English data, participants were asked to produce the following tokens provided from Ladefoged (1993): *bard, bud, body, bawd, Buddhist, booed* and *bird.* All tokens were produced as part of the carrier sentence *"Say ____ please!"*

A similar process was undertaken for the Serbian data. The 20 Serbian tokens were provided in a study by Lončar Raičević & Sudimac (2017) and they were the following words: *farsa, testo, firma, gužva, doba, baka, seka, pismo, Boba, tuga, tata, tetka, kiša, koža, kuća, tašna, dugme, sestra, biser, kosa.* All tokens were pronounced as part of a carrier sentence „*To je ____ tamo.".*

The data were recorded using a HyperX Cloud 2 microphone using Praat (BOERSMA & WEENINK 2024) in a non-soundproof room and the acquired data on

2[1] The word hud does not exist in English, however the term heads up display is commonly abbreviated to HUD and is pronounced as /hʌd/ in connected speech. On the perception test this word was marked in all capital letters to indicate that it was an acronym.

vowel quality and quantity was subsequently input in Microsoft Excel 365 and then normalized and charted on the Bark scale. The template provided by Russell (2005) was used for normalizing F_1 and F_2 values. Due to having only 12 participants for the production task, tokens that were deemed unusable because of background interference or audio bugs were discarded and re-recorded until an acceptable recording was acquired.

For the contrastive analysis, it was decided to take the approach outlined in Marković (2012). This meant that the long and short English vowels were to be compared with the differently accented vowels in Serbian. As Serbian accents can either be long or short, the average data of the two long accents was compared with the data of English long vowels, and the average data of the two short accents was compared with the data of English short vowels. Naturally, only vowels that could be considered 'pairs' were compared. As /ɜ:/ has no equivalent in the Serbian language, this vowel was not contrasted with another vowel. Several t-tests were also undertaken using the tool JASP (JASP TEAM 2024) in order to get more statistically accurate results.

Results

Perception Task Results

The results of the perception task are as shown below in table 3:

Table 3. *Vowel Perception Results.*

Vowel	Male	Female	Both
i:	100%	96%	98%
ɪ	100%	92%	96%
e	96%	96%	96%
æ	96%	96%	96%
ɑ:	88%	92%	90%
ʌ	48%	56%	52%
ɔ:	100%	96%	98%
ɒ	92%	96%	94%
u:	96%	88%	92%
ʊ	84%	84%	84%
ɜ:	100%	100%	100%

As can be seen from the above results, most vowel perception by Serbian speakers was relatively accurate, with the main outliers being /ʊ/ at 84% and /ʌ/ at only 52%. Looking at the overall result, male and female speakers were roughly the same when it came to vowel perception, with the largest differences between genders being present in /ʌ/ and /u:/ - both around 8%. The following section provides a more detailed breakdown for individual vowels, with an additional statistical overview.

/i:/ perception analysis

Perception of the long /i:/ vowel did not appear to be difficult for most participants, as 98% (49/50) participants were able to accurately perceive this vowel, and only 1 female participant perceiving /ɪ/ instead of /i:/. Male participants, on the other hand, had

a 100% accuracy in long /iː/ perception.

/ɪ/ perception analysis

Perception results for the short /ɪ/ were only slightly worse than the long /iː/, as 96% (48/50) of participants were able to accurately perceive the short variant of the vowel. Male participants again had a 100% perception rate, while the two female participants who had difficulties perceiving this vowel accurately chose the long variant /iː/ as their alternative answer, indicating that perception of /i/ vowel quality is not the problem, but rather the length of the vowels.

/e/ perception analysis

Overall participant perception accuracy for the /e/ vowel was 96% (48/50), with both genders having 1 participant who made an error in vowel perception. Both participants who failed to perceive /e/ accurately selected /æ/ as their alternative answer.

/æ/ perception analysis

The results of /æ/ perception were identical to the results of /e/ perception, where 96% (48/50) of participants successfully perceived /æ/, while 2 participants, 1 of each gender, made an error in vowel perception. The alternative answer given by these participants was /e/, indicating that there may be lingering uncertainty between /e/ and /æ/ perception.

/ɑː/ perception analysis

Study participants had a 90% accuracy rating when perceiving the /ɑː/ vowel. Female participants were only slightly more accurate at perceiving this vowel (23/25 speakers doing so correctly) when compared to male participants who scored an 88% accuracy rating (22/25). The most common errors in perception were /ʌ/, where 4% (2/50) of participants selected this vowel, and /ɔː/, with 6% (3/50) participants choosing this option.

/ʌ/ perception analysis

The results of this vowel were quite surprising, as only 52% of participants were able to perceive this vowel correctly. Female participants fared slightly better in this perception task with 56% (14/25) perceiving the vowel correctly, whereas male participant perception was only 48% (12/25). However, a t-test revealed no statistically significant difference between genders ($t = -0.57$, $df = 48$, $p = 0.573$). The most common alternative results for this vowel's perception were /ʊ/, where 30% (15/50) of participants chose this vowel, and /ɜː/ with 18% (9/50) choosing this vowel.

The difficulty that participants had with perceiving this vowel could be explained by several factors. One such factor being that the British speaker produced this vowel in a way similar to how /ə/ is articulated, though measurements of the speaker's /ʌ/ quality show that F_1 and F_2 frequencies for this vowel are just below average F_1 frequencies for /ʌ/, which could influence it to sound more like an open variant of /ə/. In this case, if /ɜː/ were accepted as a valid answer (disregarding the obvious differences in duration between /ʌ/ and /ɜː/) it would bring overall perception accuracy to 70% (35/50), though that accuracy rating would still be quite low compared to the other vowels. The reason for participants

choosing /ʊ/ as their answer may lie in the fact that they were influenced by the orthography of the word or were perhaps unaware of the meaning of the acronym.

/ɔ:/ perception analysis

This vowel had an exceptionally high perception accuracy. 98% of participants were able to perceive this vowel correctly (49/50), with only one female participant choosing /ɒ/ as the alternative likely due to an error in vowel duration perception.

/ɒ/ perception analysis

Most speakers were able to perceive this vowel correctly as well, with an overall accuracy of 94% (47/50). All mistakes in accuracy were based primarily on duration, since all provided alternative answers were /ɔ:/. In terms of gender differences, only 1 mistake was made by female participants, and 2 by male participants.

/u:/ perception analysis

This back vowel had a very high accuracy of perception, with the overall accuracy being 92% (46/50). In this case male participants showed a slight advantage in overall accuracy, with only 1 male participant perceiving the vowel incorrectly compared to 3 female participants who did so. A t-test comparing male and female accuracy rates found no significant difference, ($t = 1.05$, $df = 48$, $p = 0.297$) suggesting that gender did not significantly influence the perception of this vowel. Once again, all perception mistakes were based on duration, as /ʊ/ was the only alternative which was selected by the participants.

/ʊ/ perception analysis

This vowel is the only other vowel aside from /ʌ/ to have an accuracy rating under 90%, with the overall accuracy being at 84% (42/50). Male and female participants had an equal perception rating of this vowel, with both groups having 84% accuracy (21/25 each). Interestingly, aside from 3 participants making a mistake in perceiving vowel duration and choosing /u:/, the most common mishearing of this vowel was actually /ʌ/, where 10% (5/50) of participants chose this option. As mentioned in the /ʌ/ analysis section, the reason for this could likely be that participants were affected by the orthography of the utterances, or by the fact that the /ʊ/ vowel has shifted towards the center of the vowel space, thus making it more like /ʌ/ and /ə/ in overall quality.

/ɜ:/ perception analysis

All speakers who participated in the study showed remarkable perception of this vowel, as it had an overall perception rating of 100% (25/25 each).

Statistical analysis

Table 4. *Male vs female perception accuracy t-test results.*

Vowel	t-value	df	p-value
i:	1.02	48	0.313
ɪ	1.47	48	0.147
e	0.00	48	1.000
æ	0.00	48	1.000

ɑ:	-0.47	48	0.639
ʌ	-0.57	48	0.573
ɔ:	1.02	48	0.313
ɒ	-0.60	48	0.553
u:	1.05	48	0.297
ʊ	0.00	48	1.000
ɜ:	NaN	48	NaN

Section Conclusion

Overall, it appears that Serbian EFL speakers perceived long vowels more accurately than short vowels. This would align with previous research which suggests that foreign language learners rely on duration as one of the main cues when acquiring the vowels of a different language. The 100% accuracy rating in participant /ɜ:/ perception seems to confirm the hypothesis that speakers will perceive vowels which are sufficiently different as an entirely new category and thus have no problems incorporating them. Speakers showed that they had little difficulty perceiving the /i:/, /ɪ/, /e/, /æ/, /ɑ:/, /ɔ:/, /ɒ/ and /u:/ vowels, and only some minor difficulties in /ʊ/ perception. However, the problem remains with the case of /ʌ/ vowel quality. In theory, speakers should have few issues perceiving this vowel due to /a/ existing as a vowel in Serbian, but in this case, participants selected another vowel occupying the central area of the vowel space, or even one which lies further towards the back and is significantly more closed. The confusion may have been caused by the way in which the British speaker produced this vowel, or participants might have been misled by the orthography of the word or were perhaps unfamiliar with the acronym altogether.

Production Task Results

The following section discusses the overall state of vowel quality and duration for both Serbian and English vowels that the participants produced.

English Vowel Data

English vowel quality and duration for male and female speakers is represented in tables 5 and 6, while table 7 shows the average data for both genders. The combined data of male and female speakers after being normalized on the BARK scale is presented in Figure 1.

Table 5. *Average Male English Vowel Formant Frequencies and Duration*

English Vowels - Male Average			
Vowel	F1	F2	Duration
i:	286	2274	189
ɪ	425	1833	110
e	548	1681	131
æ	696	1582	260
ɑ:	630	1080	284
ʌ	614	1169	123

ɔ:	602	972	261
ɒ	605	1110	147
u:	329	1131	268
ʊ	406	1122	103
ɜ:	464	1334	241

Table 6. *Average Female English Vowel Formant Frequencies and Duration*

English Vowels – Female Average			
Vowel	F1	F2	Duration
i:	347	2586	228
ɪ	471	2166	110
e	703	1988	139
æ	869	1799	245
ɑ:	787	1241	259
ʌ	776	1413	127
ɔ:	722	1045	254
ɒ	758	1165	184
u:	384	1110	255
ʊ	460	1333	118
ɜ:	558	1573	205

Table 7. *Average Combined English Vowel Formant Frequencies and Duration*

English Vowels - Combined Average			
Vowel	F1	F2	Duration
i:	316	2430	208
ɪ	448	1999	110
e	625	1834	135
æ	783	1690	253
ɑ:	708	1160	271
ʌ	695	1291	125
ɔ:	662	1008	258
ɒ	681	1138	165
u:	356	1120	262
ʊ	433	1227	111
ɜ:	511	1453	223

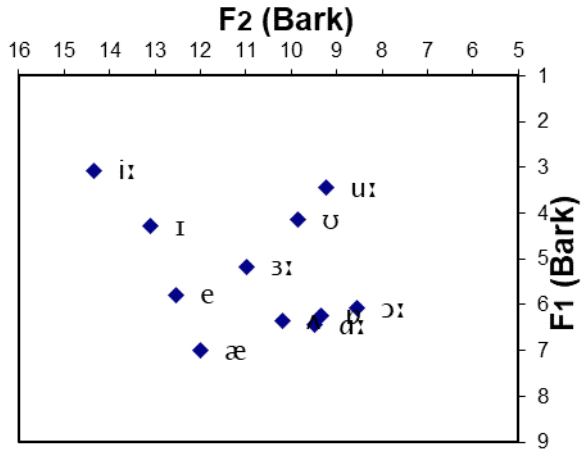

Figure 1. *Normalized English Vowel Data on BARK Scale*

The overall data for English vowels showed that Serbian speakers made a clear distinction between long and short vowel durations, as all long vowels were significantly longer than their short counterparts. In terms of quality, it is interesting to note that speakers made clear distinctions between their front vowels, especially since /e/ and /æ/ tend to be merged into one vowel by Serbian speakers. Additionally, Serbian speakers appeared to exhibit a merger of low back and central vowels. The overall qualities of /ɑː/, /ʌ/ and /ɒ/ were quite similar in both F_1 and F_2, while /ɔː/ was similar in F_1, but stood slightly further to the back of the vowel space in terms of F_2. Since quality appeared to be similar across several central and back vowels, it would support the various theories that state that non-native speakers will use different cues such as duration to distinguish between foreign language vowels. /uː/ and /ʊ/ appeared to be distinct from each other in both quality and duration, while /ɜː/ occupied a central position in the middle of the vowel space.

Serbian Vowel Data

This section presents the data on quality and duration of the Serbian long-accented and short-accented variations of several vowel pairs. Data for male and female speakers is presented in tables 8 and 9, while the combined data for both genders is shown in table 10. Figure 2 shows the combined data after being normalized on the BARK scale.

Table 8. *Average Male Serbian Vowel Formant Frequencies and Duration*

Serbian Vowels - Male Average			
Vowel	F1	F2	Duration
i:	329	2068	113
i	312	2092	85
e:	548	1736	115
e	540	1665	97
a:	714	1186	120
a	708	1296	113
o:	540	910	125

o	537	909	117
u:	355	799	137
u	350	868	95

Table 9. *Average Female Serbian Vowel Formant Frequencies and Duration*

Serbian Vowels - Female Average			
Vowel	F1	F2	Duration
i:	387	2459	116
i	366	2440	93
e:	601	2137	116
e	657	1963	107
a:	869	1396	130
a	850	1479	123
o:	579	954	138
o	654	1102	126
u:	392	887	126
u	389	950	102

Table 10. *Average Combined Serbian Vowel Formant Frequencies and Duration*

Serbian Vowels - Combined Average			
Vowel	F1	F2	Duration
i:	358	2263	114
i	339	2266	89
e:	575	1937	115
e	599	1814	102
a:	792	1291	125
a	779	1388	118
o:	559	932	131
o	596	1006	122
u:	374	843	131
u	369	909	99

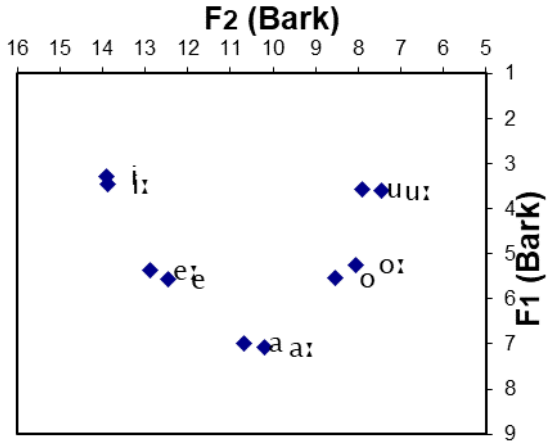

Figure 2. *Normalized Serbian Vowel Data on BARK Scale*

The combined data showed that these vowels form the 'Serbian vowel triangle'. The differences in duration between the long-accented and short-accented vowels were relatively small in the /a/, /e/, and /o/ vowels, as the differences in duration between long-accented and short-accented pairs measured less than 20 ms. Differences in duration were more pronounced in the /i/ and /u/ vowels where they measured more than 25 ms between the vowel pairs. Overall, the long-accented vowels were predictably longer than their short-accented pairs. In terms of quality, the vowel pairs were relatively close to each other, though the short-accented pairs skewed slightly more towards the center of the vowel space.

Contrastive Analysis of English – Serbian Vowel Pairs

Here the data of the Serbian and English vowels were contrasted against each other in order to establish if the speakers made a distinction between the vowels of the two languages. Each vowel was examined individually.

/i:/ vs /i:/ production analysis

F_1 measurements showed an average of 316 Hz in the English /i:/ and 358 Hz in the Serbian long-accented /i:/, and these differences were considered statistically significant (t = -2214, df = 22, p = 0.037). The English vowel F_2 values measured at 2430 Hz, while the Serbian vowel was measured at 2263 Hz, though statistical analysis did not find these differences to be significant. Finally, differences in /i:/ vowel duration were found to be significant at durations of 208 ms and 114 ms respectively (t = 5.633, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
i: F1	−2.214	22	0.037
i: F2	1.710	22	0.101
i: Dur	5.633	22	< .001

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
i: F1	ENG	12	316.250	43.107	12.444	0.136
	SRB	12	358.417	49.930	14.414	0.139
i: F2	ENG	12	2430.083	213.643	61.674	0.088
	SRB	12	2263.500	261.285	75.426	0.115
i: Dur	ENG	12	208.333	55.490	16.019	0.266
	SRB	12	114.417	16.020	4.624	0.140

Figure 3. */i:/ vs /i:/ t-test results*

/ɪ/ vs /i/ production analysis

Data for this vowel pair showed that they were produced differently. English /ɪ/ was more open, with an F_1 value of 448 Hz compared to the Serbian 339 Hz (t = 7.007, df = 22, p = <.001), and on the F_2 plane /ɪ/ lay more towards the center with a value of 1999 Hz compared to the Serbian short-accented /i/ which was more frontal with a value of 2266 Hz (t = -2.721, df = 22, p = 0.012). Finally, in terms of duration, the English /ɪ/ was produced longer at 110 ms compared to the Serbian counterpart which had a duration of 89 ms. These differences were found to be statistically significant (t = 3.068, df = 22, p = 0.006).

Independent Samples T-Test

	t	df	p
ɪ F1	7.007	22	< .001
ɪ F2	−2.721	22	0.012
ɪ Dur	3.068	22	0.006

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
ɪ F1	ENG	12	448.083	39.184	11.311	0.087
	SRB	12	339.250	36.876	10.645	0.109
ɪ F2	ENG	12	1999.250	252.560	72.908	0.126
	SRB	12	2266.500	227.936	65.799	0.101
ɪ Dur	ENG	12	109.750	20.118	5.808	0.183
	SRB	12	88.917	12.191	3.519	0.137

Figure 4. */ɪ/ vs /i/ t-test results*

/e/ vs /e/ production analysis

The F_1 and F_2 data for this vowel pair showed that they were not dissimilar in terms of vowel quality. However, the data on vowel duration did show that Serbian speakers produced the English /e/ as much longer, as duration measured at 135 ms in English

and 102 ms in Serbian. These differences were statistically significant (t = 4.523, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
e F1	0.698	22	0.493
e F2	0.261	22	0.796
e Dur	4.523	22	< .001

Note. Student's t-test.

Descriptives ▼

Group Descriptives ▼

	Group	N	Mean	SD	SE	Coefficient of variation
e F1	ENG	12	625.333	111.057	32.059	0.178
	SRB	12	599.000	69.020	19.924	0.115
e F2	ENG	12	1834.333	190.018	54.853	0.104
	SRB	12	1814.167	188.190	54.326	0.104
e Dur	ENG	12	135.083	22.265	6.427	0.165
	SRB	12	102.333	11.547	3.333	0.113

Figure 5. */e/ vs /e/ t-test results*

/æ/ vs /e:/ production analysis

F_1 data for this vowel pair showed that /æ/ was produced as more open at 783 Hz compared to long-accented /e:/ which had an F_1 value of 575 Hz (t = 6.097, df = 22, p = <.001). Additionally, F_2 data showed that /æ/ was located more towards the center of the vowel space at 1690 Hz, while long-accented /e:/ was far more frontal at 1937 Hz (t = -2.943, df = 22, p = 0.008). Speakers still produced /æ/ as longer, as its duration measured 253 ms compared to /e:/ which had a duration of 115 ms. These differences were statistically significant (t = 10.638, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
æ F1	6.097	22	< .001[a]
æ F2	−2.943	22	0.008
æ Dur	10.638	22	< .001[a]

Note. Student's t-test.
[a] Brown-Forsythe test is significant (p < .05), suggesting a violation of the equal variance assumption

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
æ F1	ENG	12	782.583	111.263	32.119	0.142
	SRB	12	575.000	39.099	11.287	0.068
æ F2	ENG	12	1690.167	158.830	45.850	0.094
	SRB	12	1937.000	243.228	70.214	0.126
æ Dur	ENG	12	252.500	42.496	12.268	0.168
	SRB	12	115.750	13.302	3.840	0.115

Figure 6. */æ/ vs /e:/ t-test results*

/ɑ:/ vs /a:/production analysis

Data for this vowel pair showed that Serbian EFL speakers produced the two vowels distinctly from each other. The average F_1 value for /ɑ:/ was 708 Hz, while for

long-accented /a:/ it was at 792 Hz. The F_2 value measured at 1160 Hz and 1291 Hz respectively. Statistical analysis of speaker data showed that both values for F_1 (t = -2141, df = 22, p = 0.044) and for F_2 (t = -2.764, df = 22, p = 0.011) were considered statistically significant. Duration wise, speakers produced the English vowel as much longer at 271 ms, while the Serbian vowel was produced with a duration of 125 ms. These differences in duration were statistically significant (t = 8.356, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
ɑ: F1	−2.141	22	0.044
ɑ: F2	−2.764	22	0.011
ɑ: Dur	8.356	22	< .001[a]

Note. Student's t-test.
[a] Brown-Forsythe test is significant (p < .05), suggesting a violation of the equal variance assumption

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
ɑ: F1	ENG	12	708.417	102.750	29.661	0.145
	SRB	12	792.000	87.920	25.380	0.111
ɑ: F2	ENG	12	1160.333	110.165	31.802	0.095
	SRB	12	1291.500	121.982	35.213	0.094
ɑ: Dur	ENG	12	271.167	58.752	16.960	0.217
	SRB	12	125.667	13.647	3.940	0.109

Figure 7. */ɑ:/ vs /a:/ t-test results*

/ʌ/ vs /a/ production analysis

Data for this vowel pair indicated that only the F_1 values showed significant differences, with the measurements being 695 Hz in /ʌ/ and 779 Hz in short-accented /a/. These differences were confirmed through statistical analysis (t = -2.179, df = 22, p = 0.040). F_2 values were not confirmed as significant as they were quite similar at 1291 Hz for /ʌ/ and 1388 Hz for short-accented /a/. The differences in duration were also not significant, though /ʌ/ was still longer at 125 ms compared to the duration of short-accented /a/ at 118 ms.

Independent Samples T-Test

	t	df	p
ʌ F1	−2.179	22	0.040
ʌ F2	−1.896	22	0.071
ʌ Dur	1.140	22	0.267[a]

Note. Student's t-test.
[a] Brown-Forsythe test is significant (p < .05), suggesting a violation of the equal variance assumption

Descriptives ▼

Group Descriptives ▼

	Group	N	Mean	SD	SE	Coefficient of variation
ʌ F1	ENG	12	694.833	101.674	29.351	0.146
	SRB	12	779.417	88.002	25.404	0.113
ʌ F2	ENG	12	1290.750	137.932	39.817	0.107
	SRB	12	1387.833	111.539	32.198	0.080
ʌ Dur	ENG	12	125.250	19.731	5.696	0.158
	SRB	12	118.083	9.219	2.661	0.078

Figure 8. */ʌ/ vs /a/ t-test results*

/ɔ:/ vs /o:/ production analysis

Vowel data supports that these two vowels were different from each other. Measurements on quality showed that /ɔ:/ had overall F_1 and F_2 qualities of 662 Hz and 1008 Hz, while the qualities of long accented /o:/ were 559 Hz and 932 Hz. Statistical analysis confirmed that the differences in both F_1 (t = 3.480, df = 22, p = 0.002) and F_2 (t = 2.468, df = 22, p = 0.022) were significant. The duration of /ɔ:/ was more than double compared to long-accented /o:/, with values of 258 ms and 131 ms each (t= 9.239, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
ɔ: F1	3.480	22	0.002
ɔ: F2	2.468	22	0.022
ɔ: Dur	9.239	22	< .001

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
ɔ: F1	ENG	12	661.667	92.583	26.727	0.140
	SRB	12	559.500	42.120	12.159	0.075
ɔ: F2	ENG	12	1008.333	83.576	24.126	0.083
	SRB	12	932.167	66.675	19.248	0.072
ɔ: Dur	ENG	12	257.583	43.328	12.508	0.168
	SRB	12	131.750	18.675	5.391	0.142

Figure 9. */ɔ:/ vs /o:/ t-test results*

/ɒ/ vs /o/ production analysis

Measurements showed that speakers clearly differentiated between these two vowels in terms of quality and quantity. F_1 vowel quality showed a value of 681 Hz for /ɒ/ and a value of 596 Hz for short-accented /o/, and statistical analysis showed these differences to be significant (t = 2.461, df = 22, p = 0.022). Measurements of F_2 quality showed a value of 1138 Hz for /ɒ/ and 1006 Hz for short-accented /o/, which subsequent analysis of the differences also confirmed to be significant (t = 2.848, df = 22, p = 0.009). In terms of duration, the English /ɒ/ was still produced as longer on average at 165 ms, while the short-accented /o/ at a duration of 122 ms (t = 3.542, df = 22, p = 0.002)

Independent Samples T-Test

	t	df	p
ɒ F1	2.461	22	0.022
ɒ F2	2.848	22	0.009
ɒ Dur	3.542	22	0.002

Note. Student's t-test.

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
ɒ F1	ENG	12	681.167	94.378	27.245	0.139
	SRB	12	595.667	74.660	21.552	0.125
ɒ F2	ENG	12	1137.750	106.013	30.603	0.093
	SRB	12	1005.583	120.859	34.889	0.120
ɒ Dur	ENG	12	165.333	39.035	11.268	0.236
	SRB	12	121.667	17.317	4.999	0.142

Figure 10. */ɒ/ vs /o/ t-test results*

/u:/ vs /u:/ production analysis

F_1 data showed no significant differences between the two vowels, though the English /u:/ was just slightly more closed at 356 Hz than the Serbian long-accented /u:/ which measured 374 Hz. F_2 data indicated a more central location for the English /u:/ which measured 1120 Hz, and a back location for Serbian long-accented /u:/ which measured 843 Hz. Statistical analysis confirmed that differences in F_2 vowel quality were significant (t =4.342, df = 22, p = <.001). Likewise, differences in duration were also found to be significant with a duration of 262 ms in the English /u:/ and 131 ms in the Serbian /u:/ (t = 10.159, df = 22, p = <.001).

Independent Samples T-Test

	t	df	p
u: F1	−1.167	22	0.256
u: F2	4.342	22	< .001ª
u: Dur	10.159	22	< .001ª

Note. Student's t-test.
ª Brown-Forsythe test is significant (p < .05), suggesting a violation of the equal variance assumption

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
u: F1	ENG	12	356.250	41.289	11.919	0.116
	SRB	12	374.083	33.126	9.563	0.089
u: F2	ENG	12	1120.333	199.506	57.592	0.178
	SRB	12	843.417	94.887	27.392	0.113
u: Dur	ENG	12	261.833	41.030	11.844	0.157
	SRB	12	131.667	16.929	4.887	0.129

Figure 11. */u:/ vs /u:/ t-test results*

/ʊ/ vs /u/ production analysis

This vowel pair showed that /ʊ/ was both more open and central than short-accented /u/ which was more closed and back. Overall analysis of F_1 data showed that /ʊ/ measured an average F_1 of 433 Hz, while short-accented /u/ had a value of 369 Hz. Anal-

ysis of these differences showed that they were significant (t = 2.673, df = 22, p = 0.014). On the F_2 plane, /ʊ/ measured an average of 1227 Hz, while short-accented /u/ measured 909 Hz. These differences in quality were found to be significant (t = 4.046, df = 22, p = <.001). The same could not be said for vowel duration. While /ʊ/ was measured as longer with a duration of 111 ms compared to the Serbian vowel's 99 ms, these differences were not considered to be statistically significant.

Independent Samples T-Test

	t	df	p
ʊ F1	2.673	22	0.014
ʊ F2	4.046	22	< .001[a]
ʊ Dur	1.326	22	0.198

Note. Student's t-test.
[a] Brown-Forsythe test is significant (p < .05), suggesting a violation of the equal variance assumption

Descriptives

Group Descriptives

	Group	N	Mean	SD	SE	Coefficient of variation
ʊ F1	ENG	12	433.250	67.646	19.528	0.156
	SRB	12	369.500	47.422	13.689	0.128
ʊ F2	ENG	12	1227.417	253.230	73.101	0.206
	SRB	12	909.167	100.665	29.059	0.111
ʊ Dur	ENG	12	110.667	25.882	7.471	0.234
	SRB	12	98.917	16.484	4.758	0.167

Figure 12. */ʊ/ vs /u/ t-test results*

/ɜ:/ production analysis

While there is no equivalent in Serbian with which to compare /ɜ:/, this section still provides a short overview of how this vowel was produced by speakers.

Data for /ɜ:/ showed an F_1 of 511 Hz and F_2 of 1453 Hz, showing that this vowel was the most central and middle vowel of the vowel space. The average duration of /ɜ:/ was measured at 223 ms.

Section Conclusion

Observing the overall data, most vowel pairs that were discussed in this section can be considered different from each other, which would imply that the participating Serbian speakers of English made a clear distinction between Serbian and English vowels. Nearly all the front vowels were considered distinct from each other in both quality and quantity, except for /e/ where the quality of the vowel was found to be quite similar between the two languages, though it differed in its duration. The Serbian short-accented /a/ and the English /ʌ/ only differed significantly in their F_1 quality, while the Serbian long-accented /a:/ and the English /ɑ:/ differed in both overall quality and quantity. Comparing /ɔ:/ and /ɒ/ to /o:/ and /o/ showed that the Serbian vowels were located further back in the vowel space, were produced as less open, and had a shorter duration. The long /u:/ vowels did not prove to be different in their F_1, however, their F_2 and duration were different. Lastly, data on /ʊ/ showed that it was different from short-accented /u/ in its quality, but in terms of duration the differences were not significant. It should also be noted that all English vowels were measured to be longer than their Serbian counterparts. From the data it can be claimed that there is partial native-category assimilation in the

/e/, /ʌ/, and /u:/ vowels.

Summary and Conclusion

This study sought to investigate how Serbian speakers perceived and produced English vowels. The hypothesis was that speakers had at least to some degree assimilated the English vowels with the native vowel category. The first goal was to investigate how Serbian speakers would perceive English vowels produced by a native British speaker, while the second goal was to conduct a contrastive analysis of the Serbian and English vowel pairs that Serbian speakers would produce. The results of the perception task showed that speakers had excellent accuracy when listening to /i:/, /ɪ/, /e/, /æ/, /ɑ:/, /ɔ:/, /ɒ/, /u:/, and /ɜ:/, slightly less success when listening to /ʊ/, and far less success when listening to /ʌ/. The problem with /ʌ/ perception accuracy could be explained through several factors, such as participants not being accustomed to the British speaker's pronunciation of this word or participants being confused by the word's orthography or acronym meaning. Data from the production task indicated speakers were able to produce most English vowels distinctly from how they would produce their Serbian counterparts, with the only outliers being the /e/, /ʌ/, and /u:/ vowels. The /e/ vowel was not produced as different in terms of quality, with the main difference between the Serbian and English vowels being that the English /e/ was produced as longer. Production data on the /ʌ/ vowel showed that speakers had partial success in acquiring this vowel, as the vowel varied in how it was produced from its Serbian counterpart in terms of F_1 quality, but statistical analysis did not confirm that the two vowels differed significantly in terms of F_2 and duration. The opposite is true for the long /u:/ vowel, where significant differences in F_1 quality were not confirmed, but significant differences were confirmed in F_2 and vowel duration. Finally, production data also showed that all English vowels were produced with a longer duration compared to the Serbian counterparts. Therefore, it can be concluded that there was partial native-category assimilation in the /e/, /ʌ/, and /u:/ vowels of tested participants.

Future research of this kind might benefit from having a larger number of participants for both the perception and the production task, as well as having speakers of different English accents provide recordings for the perception task to determine if the speaker's accent has a relevant effect on the perception of problematic vowels such as /ʌ/.

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ДЕСКРИПТИВНА АНАЛИЗА ПЕРЦЕПЦИЈЕ И ПРОДУКЦИЈЕ ЕНГЛЕСКИХ ВОКАЛА КОД СРПСКИХ ГОВОРНИКА

Резиме

Најутицајнији модели перцепције страног језика и њеног утицаја на усвајање гласова страног језика указују да ће гласови који се перципирају као довољно нови бити лако усвојени од стране ученика страног језика, док они који су слични категоријама гласова матерњег језика теже да се асимилују у те категорије. Даље, ефекти перцепције говорника на продукцију гласова и даље су предмет расправе, јер нека истраживања тврде да постоји корелација између перцепције и продукције гласова, док друга указују да је веза између перцепције и продукције сложена и подложна варијабилности говорника. Овај рад имао је за циљ да утврди да ли су српски студенти и дипломирани студенти енглеског језика и књижевности адекватно усвојили енглеске самогласнике. Ово је испитано кроз задатке перцепције и продукције гласова. Циљ је био да се утврди да ли су категорије енглеских вокала довољно различите код тестираних говорника. Да би се ово постигло, тестирано је 50 учесника у њиховим способностима перцепције, а затим је за задатак продукције одабрано 12 говорника да произведе енглеске и српске вокале. Резултати су показали да су говорници генерално добро перципирали готово све енглеске вокале, осим вокала /ʌ/. Задатак продукције је показао да су говорници усвојили већину енглеских смогласника и да су они различити од српских вокала.

Кључне речи: перцепција, продукција, квалитет вокала, квантитет вокала, енглески, српски