Bulgarian Sound System

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Abstract
This paper analyzes the phonetic and phonological system of Bulgarian. It specifically examines Bulgarian vowel qualities and percentage voicing of obstruents in intervocalic and word-final positions using data collected from two native Bulgarian speakers in a phonetic experiment. During the experiment, speakers were asked to utter a list of 14 identical words into a microphone under Slow and Fast Conditions. The first and second formant values of the vowel tokens were derived using Praat and plotted in vowel charts unique to the speaker. Percentage voicing was calculated by dividing the time the consonant was voiced over its total duration.

Keywords: Bulgarian, phonology, formants, experiment, Cyrillic, field methods
Bulgarian Phonetic and Phonological System

1 Introduction

This paper provides an analysis of the rich phonetic and phonological system of Bulgarian, a Slavic language spoken in Bulgaria. A detailed discussion of the methodology and data collection procedure used in the acoustics experiment, upon which the analysis is heavily based, is provided in section 2. A comprehensive survey of the vowel inventory, a comparison of vowel phonemes to typological expectations, and an analysis amalgamating the experimentally obtained formant frequencies of vowels as uttered by two native speakers are provided in section 3. An overview of the Bulgarian consonant system complete with a description of the inventory, comparison of consonant phonemes to typological expectations, and a discussion of voicing assimilation are given in section 4. Section 5 compares the vowel and consonant inventories described herein to those detailed in Elmar Ternes and Tatjana Vladimirova-Buhtz's analysis of Bulgarian in the Handbook of the International Phonetic Association (2015). Section 6 summarizes the information discussed, section 7 offers a list of abbreviations used in the glossed examples, and section 8 lists all references either consulted or suggested for further research.

2 Methodology and data collection

Much of the data presented in this analysis originate from traditional elicitation sessions in a semester-long Field Methods course with native Bulgarian consultant, Speaker 1 (S1) (female, 26). S1 is from Sofia, Bulgaria, a city of approximately two million people or one-third of the country's total population. S1 has been studying at a graduate school in
the United States for about a year, but she speaks Bulgarian with her mother daily. S1 learned English at her high school in Bulgaria and continued to practice the language by reading texts in various fields. Though highly fluent in English, she is a proud Bulgarian speaker. S1 has also studied French and Serbian.

Data collected from a small-scale acoustics experiment guide the phonetic discussions of vowels and consonants in sections 3 and 4, respectively. S1 and S2 (female, 19) were the participants. S2 is also from Sofia, Bulgaria, and has been studying as an undergraduate student in the United States for under one year. Unlike S1, S2 attended an English-speaking high school in Bulgaria. The frequency with which S2 has been speaking Bulgarian since arriving to the United States and the number of languages she speaks/has studied were not determined.

The inability of the field linguists to produce the final back vowel in *dervó* 'tree' to the satisfaction of S1 throughout the course of the semester and the intriguing patterning of distinct vowel sounds to the same letter in the Cyrillic alphabet inspired the experiment; it was designed to determine the appropriate formant frequencies for each vowel identified in Bulgarian as well as to capture the percentage voicing of obstruents undergoing voicing assimilation.

At the start of the experiment, the participant was presented with a laptop displaying a timed PowerPoint; it was ambiguously titled "Bulgarian Pronunciation." Note that the participants were met with in separate sessions. The first session was conducted with S1 in a private, library study room, and the second session was conducted with S2 in a medium-sized office. No ambient noise was collected in the recording of S1,
but frequencies from the fan did influence the recording of S2.

Throughout the course of the experiment, the participant read a series of 14 Bulgarian words aloud twice. Table 1 presents the word list tested in the order found on the PowerPoint slides with the Bulgarian word in IPA, the English gloss, the word in Cyrillic script, and the target phenomena. Ultimately, only vowels from words uncolored by surrounding consonants were used in the formant frequency calculations.

Utterances were recorded into a microphone with a frequency setting of 44,100 Hz. The microphone stood vertically for a surround-sound effect and was positioned on a table six-to-ten inches from the participant's chest. PowerPoint slides ran ten inches behind the microphone. A metronome was placed about four inches to the right of the laptop so that the participant could easily manipulate her eye gaze, or see either the prompted slide or metronome light in her periphery. The purpose of the metronome was to help the participant pace repetitions of the desired word or sentence.

The participant first read the instructions slide that stated the following: "Thank you for helping me conduct this experiment on Bulgarian pronunciation! You will be reading a list of 14 Bulgarian words aloud twice. The first time, read the word presented on the screen three times. Begin the word when the metronome light flashes red. The second time, the words will reappear within the context of the sentence, Моля, кажи _ на български. Read each statement three times, beginning each repetition when the metronome light flashes red. Please remember to speak clearly and confidently into the microphone!" This instruction slide was also orally explained.

The participants were not given the opportunity to practice the experiment
procedure, however a sample enactment of the repetitions with the metronome was given to both S1 and S2 (e.g., "Try to say each repetition of the word when the metronome light flashes, like this: [flash] Apple, [flash] Apple, [flash] Apple"). Once the participant gave a clear indication that she did not have further questions about the experiment procedure, the metronome was started.

A slide indicating "WORD, 3 TIMES, RED LIGHT" was shown to remind the participant that the first part of the experiment involved reading the Bulgarian word on the slide, repeating the word three times with the red light on the metronome. The metronome was set at 60 bpm during this part of the experiment; this pace prevented the participant from speaking too carefully while allowing enough space between repetitions. If overly cautious, the vowel formant frequencies would not have been representative of the word in everyday speech. Note that 14% of words were one-syllabled, 71% were two-syllabled, and 14% were three-syllabled; these values do not add to 100% due to rounding.

After running through the sequence of words in isolation, a slide indicating "SENTENCE, 3 TIMES, RED LIGHT" was shown to remind the participant to read the word in the sentence Моля, кажи _ на български, 'Please say _ in Bulgarian'; the metronome was set at 40 bpm. Words were tested in a sentential context to approximate natural speech. Again, this pace was set to help the participant maintain a uniform pause between repetitions. It would otherwise be easy to clip the space between sentences when speaking naturally in one's native language. The metronome was unfortunately coordinated poorly to the pre-timed slides in sessions with both S1 and S2 during this
part of the experiment, so the slides were manually progressed after the participants completed three repetitions. Each session was six minutes long.

The experiment was successful as the appropriate vowel tokens were recorded in the sessions with S1 and S2. S1 spoke confidently into the microphone and consistently in conjunction with the pacing of the metronome. This was expected as S1 not only had experience using the microphone in various elicitation sessions throughout the semester, but also previewed the word list; S1 provided the Cyrillic script of the Bulgarian words (see table 1) before the experiment. Given the circumstances it would have been fair to allow S2 to preview the word list before beginning the experiment. S2 spoke somewhat hesitantly and softly. These qualities are likely either reflective of S2's idiolect or a result of uncertainty in regard to the expectations of the experiment.

Upon the completion of the experiment, the recordings were uploaded as sound files and edited to retrieve individual tokens of each word using Praat. Praat generated the first and second formants of the vowels and the voicing bar necessary to calculate the percentage voicing of stops. Formant values presented in the discussion of vowels in section 3 are taken from the middle of the vowel, a region likely uninfluenced by the qualities of surrounding consonants. Measurement of the middle of the vowel was customized for each token. The total duration of the vowel was highlighted in Praat, and a formant value table generated the first four formants as recorded every six milliseconds. The frequency of the first and second formants of the vowel was recorded at the central time; the average of two medial times was recorded in the event of an even-interval duration. List intonation lead to outliers in the data, thus only the most representative
formant frequencies are provided in the graphs in subsection 3.4. Percentage voicing was calculated using Praat by dividing time voiced by the total consonant duration. Frequencies have been rounded to the nearest whole number.

The data provided henceforth is from the experiment unless otherwise stated. Citations for supporting data collected by students in the Field Methods course follow this convention: (date of collection–data point in the session–student eliciting [letters are used in place of names for anonymity]).

3 Bulgarian vowels

This section is dedicated to surveying the vowel inventory of Bulgarian. Subsection 3.1 outlines the phonemic inventory of vowels; subsection 3.2 analyzes the relationship between vowel phonemes and Cyrillic script; subsection 3.3 discusses typological characteristics of the inventory; and, subsection 3.4 presents the formant frequencies derived from the experiment described in section 2.

3.1 Vowel inventory

Bulgarian appears to have nine phonemic vowels in its inventory /i, i, e, ɛ, a, u, o, o/, mapped in figure 1. The placement of vowels within the vowel space is an approximation. The language may have contrastive vowel lengths, however this has been interpreted as a tense and lax vowel distinction. More data is needed to determine the phonemic status of long and short vowels.

Minimal pairs proving the existence of certain phonemes were uncovered in the elicitation sessions with S1, though the relationships between the following vowels are admitted not proven in the data: i ≠ 1, i ≠ 0, i ≠ e, i ≠ ə/æ, i ≠ a, i ≠ o, i ≠ o, e ≠ ə/æ, e ≠ a,
Techniques such as rhyming and systematic trail-and-error methods (e.g., "Does Bulgarian have si, st, se, se, sa, sa, su, su, or so?") were tried. However, investigating agreement suffixes and pronouns, which are often comprised of vowels, proved most effective. Minimal pairs demonstrating phonemic contrast are provided in example (1).

(1) a. \( a \neq i \)
    
    'gwavá' 'head' (13jan–29–b)
    'gwavi' 'heads' (13jan–30–b)

b. \( i \neq u \)
    
    'sipə' 'pour' (11april–44–c)
    'súpə' 'soup' (11april–44–c)

c. \( i \neq e \)
    
    'i' 'and' (3feb–42–c)
    'ɛ' '3SG.COP.PRES' (16feb–6–d)

d. \( i \neq e \neq o \)
    
    'ti' '2SG.SUBJ' (1feb–72–e)
    'te' '3PL.SUBJ' (1feb–20–d)
    'to' '3SG.N.SUBJ' (3feb–22–a)

e. \( o \neq e \neq o \)
    
    'pot' 'road' (20jan–4–f)
    'pet' 'five' (20jan–41–c)
pot 'under' (17feb–67–b)

f. \( o \neq i \neq \partial \)

\( \text{swátko} \) 'sweet.N' (23mar–33–e)

\( \text{swátki} \) 'sweet.PL' (23mar–34–e)

\( \text{swátkə} \) 'sweet.F' (23mar–32–e)

Diphthongs /ao/ and /oi/ were also found in the data. These vowels were not tested in the phonetic experiment and have not been provided in figure 1. Proof of the existence of the diphthong /ao/ is found in the two-syllabled examples (2a-b) and of /oi/ in the one-syllabled examples (3a-b). Note that the mid back vowel /ɔ/, the base of the latter diphthong, has not been identified here as a Bulgarian phoneme. It is possible that the sound transcribed as /o/ would be better identified as /ɔ/, still leaving Bulgarian with a nine-vowel system.

(2) a. \([\text{sta}]_o[\text{pao}]_o\)

'foot' (13jan–47–b)

b. \([\text{mao}]_o[\text{ko}]_o\) \(\text{ŋ}a\)

little tea

'a little bit of tea' (27jan–34–c)

(3) a. \(g\text{r̥dut} \ e\ [\text{moi]}_o\)

city-DET 3SG.COP.PRES 1SG.POSS.PRO

'The city is mine.' (2mar–9–d)

b. \([\text{toi}]_o\)

3SG.M.SUBJ
'he' (1feb–17–d)

A number of vowels appear to be in free variation: /ɪ/ ~ /ɛ/, /u/ ~ /o/, /e/ ~ /ɛ/, and /a/ ~ /e/. Examples of each alternation are provided in (4). The respective sounds occur in the same environment, communicating that they are in free variation as opposed to allophones of the same phoneme. Interestingly, a pattern of pronunciation correction was observed in the elicitation sessions. Typically when S1 uttered a word in Bulgarian containing a segment in free variation with another, the pronunciation of the linguist repeating the word for clarity was corrected using the variant pronunciation. S1, for example, would say [jadúxme] 'eat-1PL.PAST', a linguist would repeat [jadúxme] 'eat-1PL.PAST', and the pronunciation would be corrected to [jadóxme] 'eat-1PL.PAST'. For this reason, the majority of alternations cited in example (4) occur precisely one after another.

(4)   a. ɪ ~ ɛ

\[ \text{swantfif} \]  'sunny' (11april–a)

\[ \text{swantfɛf} \]  'sunny' (11april–a)

b. u ~ o

\[ \text{jadúxme} \]  'eat-1PL.PAST' (29feb–55a–e)

\[ \text{jadóxme} \]  'eat-1PL.PAST' (29feb–55b–e)

c. e ~ ɛ

\[ e \]  '3SG.COP' (3feb–17–d)

\[ ɛ \]  '3SG.COP' (3feb–18–d)

d. a ~ e

\[ ja \]  '3SG.F.OBJ' (1feb–68–e)
3.2 Vowel phonemes and Cyrillic script

Bulgarian is written in Cyrillic script. A comparative analysis of the orthography and the IPA of words from the experimental word list (see table 1) derived the relationship of vowel-phoneme-to-letter in figure 2. The representation of six vowels in Cyrillic script, 'и', 'у', 'е', 'ъ', 'о', and 'а', supports that Bulgarian has at least six vowel phonemes in the high front, mid front, low central, high back, and mid back positions.

The writing system suggests that the front vowels /ɪ, e, ɛ/ may in fact be allophones of one phoneme in the set and that /ə/ could be allophones of one phoneme represented in the set. The correspondence of vowel-phoneme-to-letter deserves further consideration, though Bulgarian will be considered to have nine phonemic vowels, excluding diphthongs, in this paper.

3.3 Vowel typology

Bulgarian has a typologically typical number and types of vowels in its phonemic inventory. As described in subsection 3.1, the language has nine vowel phonemes: /i, ɪ, e, ɛ, ə/ u, o, a/. The average number of vowels found in languages of the world is 8.7, so Bulgarian is highly comparable. Similarly, the language contains eight of the nine most commonly identified vowel qualities; the mid back vowel /ɔ/ is missing from the Bulgarian inventory, however it is found in the diphthong /ɔi/ shown in example (3). If there were an inaccuracy in the transcription that misidentified the vowel as the back vowel /o/, Bulgarian would still have eight of the nine vowel qualities. As expected, Bulgarian makes use of the three vowels /i, a, u/, which together utilize the extreme areas
of the vowel space. There are no obvious gaps in the vowel inventory chart from a typological perspective, however it does not include the high central unrounded vowel /ɨ/ that is present in many nine-vowel systems.

3.4 Vowel formant frequencies

F1 and F2 values of the vowels [a, i, i, e, e, u, ə, o, ə, o, ə] were recorded in the experiment. The most representative token of the vowel is documented in table 2 by speaker and condition. Note that frequencies for the vowel [a] were recorded in the pronunciation of swátki 'sweet', [i, i] in sidi '(he) sits', [e] in edná 'one', [e] in swänse 'sun', [u, ə] in kūpə 'bowl', [o] in muf 'man', [ə] in dervó 'tree', the final [o] in dervóto 'the tree', and [ə] in hlábát 'the bread'.

Vowel frequencies in the Slow Condition, for which speakers uttered each word on the list in isolation three times, are charted in a scatter plot (see figure 3). A number of surprising observations can be made from the data. Generally, the F1 and F2 values of S1 are lower than those of S2. This variation may be due to anatomical differences, though the high front nature of S2's vowels might also relate to the delicate, careful manner of her speech.

The formant values of S1 and S2 for the vowel [u] were almost identical. An F1 of 422Hz and an F2 of 2220Hz were reported for S1, and an F1 of 428Hz and an F2 of 2205Hz were reported for S2. These F2 frequencies are uncharacteristically high for a back vowel. The fact that the F2 for S1 and S2 are lower at 423Hz and 859Hz in the Fast Condition, respectively, communicates that there are significant differences in vowel qualities at alternate speeds; thus, these results stress the importance of asking a language
consultant to repeat utterances at speed.

A comparison of vowel frequencies in the Fast Condition, for which speakers uttered the same words three times in a sentence, is also provided in a scatter plot (figure 4). The F1 and F2 values of S1 and S2 place the vowels where expected in the vowel space. While the frequency values of each speaker vary, the range of frequencies remains consistent. The difference between the F2 values of the high front vowel [i] and the high back vowel [u] is 1777Hz for S1 and S2. The difference between the F2 values of the high back vowel [u] and the low central vowel [a] is 508Hz for S1, and the range between the high front vowel [i] and the low central vowel [a] is 367Hz.

One of the most intriguing findings from the experiment is that the F1 values of the vowel [o] in Slow and Fast Conditions are almost identical to those of the high vowel [u]. The F1 of the vowel [o] for S1 is 340Hz, only 5Hz lower than that of the vowel [u]. The F1 values of both the vowels [o] and [u] for S2 are identical at 443Hz. Phonetic similarity may support that the vowel phonemes /o/ and /u/ are in fact in free variation as stated in subsection 3.1. The variant pronunciation may also explain why students were commonly corrected by S1. If the [u] vowel were repeated back to the consultant with F2 frequencies that are too low, the speaker may overcorrect and provide the form [o], and vice versa. It would perhaps be worth examining pronunciation corrections of speakers with words comprised of segments in free variation. Regardless, more data is needed to establish whether the vowels consistently have similar F1 frequencies in slow and casual speech.

4 Bulgarian consonants
This section describes the suspected phonemic consonant system in Bulgarian. An overview of the consonant inventory is provided in subsection 4.1, a comparison of the phonemes to typological expectations in subsection 4.2, and experimental data regarding obstruent voicing assimilation in subsection 4.3.

4.1 Consonant inventory

The consonant inventory of Bulgarian seems to be made up of at least 24 phonemes, which is appropriate given that there are nine vowel phonemes. A compilation of the suspected phonemic inventory is provided in table 3. Note that the labiovelar approximant is a phonetic segment that is an allophone of the phoneme /l/, and thus has not been included.

The list of minimal pairs provided in example (5) is by no means extensive, however it clearly communicates that there are distinct fricative, alveolar, and dorsal sounds.

(5)  a. \( v \neq s \)

\( \) dév\(v\)' (13jan–9–e)

\( \) dé\(s\)' (13jan–10–e)

b. \( v \neq s \neq l \)

\( v \) '2PL.IOBJ.PRO' (2mar–91–c)

\( s \) '2SG.COP' (14march–51–d)

\( l \) 'QP' (14mar–51–d)

c. \( n \neq v \)

\( n \) '1PL.SUBJ' (1feb–19–d)
4.2 Consonant typology

The phonemic consonant inventory of Bulgarian is typologically common. Nasals /m, n, ŋ/ occur at the same place of articulation as stops /b, d, g/. There is a three stop series of voiceless, voiced, and aspirated stops—though the voiceless aspirated stops like [pʰ, tʰ] are not phonemic. The language is missing only two consonants from the modal inventory /ʔ, ŋ/, but does contain the other 18 consonants: /p, b, t, d, f, k, g, f, s, j, m, n, ŋ, w, l, r, j, h/. While the labiovelar approximant does not have phonemic status in the language, it does appear in the phonetic inventory.
The only typologically uncommon phonetic characteristic of Bulgarian is the dental nasal represented in example (6). This place of nasal articulation is found in only 55 of UPSID languages.

(6) *jedósag*

'angry' (27jan-76-g)

A full description of the phonetic inventory of consonants is beyond the experimental focus of this paper, however, the phonemic inventory of consonants is typologically common and characteristic of an Eastern European language. For more information about the phonetic and phonemic composition of Bulgarian, please consult *The phonemic system of colloquial standard Bulgarian* (Klagstad, 1958) and *A reference grammar of Modern Bulgarian* (Scatton, 1984).

4.3 Voicing assimilation and percentage voicing

There is evidence of voicing assimilation in Bulgarian stops. The voiceless coda consonants in the singular form of some nouns become voiced when the plural morpheme marker [-uvɛ́] is suffixed because the consonants are intervocalic. Given the data in (7-8), it was reasonable to conclude that [t] and [d], and [k] and [g] are allophones of the same phonemes. This did not appear to be supported in the percentage voicing data from the phonetic experiment described in this subsection.

(7) a. *grat*

'city' (25jan-8-e)

b. *grad-uvɛ́*

city-PL
'cities' (25jan-9-e)

(8)  a.  *bok*
    'god' (25jan-15-e)

b.  *bog-uvê*
    god-PL

'gods' (25jan-14-e)

Further support of assimilation is provided in data points (9-10). The adjective *xubəf* 'pretty/handsome' in (9a) is suffixed by the feminine gender morpheme */-ə/* in (9b) to agree with the female subject *Desi*; the voiceless consonant [f] takes on the property of being voiced as [v] between two vowels. The adjective *dübr* 'good' in (10a), on the other hand, has a voiced consonant word-finally, which remains the same in the feminine form *dübrə* 'good' in (10b).

(9)  a.  *mitko e xubəf-ə.*
    Mitko 3SG handsome-MSG

'Mitko is handsome.' (25jan-104-d)

b.  *dēsi e xubən-ə.*
    Desi 3SG handsome-FSG

'Desi is pretty.' (25jan-103-d)

(10) a.  *mitkō e dübr-ə.*
    Mitko 3SG nice-MSG

'Mitko is nice.' (25jan-101-d)

b.  *dēsi e dübr-ə.*
Desi 3SG nice-FSG

'Desi is nice.' (25jan-102-d)

To determine the degree of voicing assimilation that obstruents in Bulgarian undergo, the words *hlap* 'bread', *hlábət* (or *hlábət* as the final vowel may occur in the unstressed position) 'the bread', *xúbəf* 'handsome', and *xúbəvo* 'handsome (plural)' were tested. The bilabial stop and labiodental fricative in *hlábət* 'the bread' and *xúbəvo* 'the man', respectively, were 100% voiced in the Fast and Slow Conditions for S1 and S2. The bilabial stop in the word *hlap* 'bread' produced by S1 was calculated to be 7.15% of the duration of the consonant on average for the Fast Condition. These results were expected as the consonant follows the voiced, low central vowel [a]. On the other hand, the average voicing of the bilabial stop in the Fast Condition of the word for S2 was 40.77% on average. It is likely that this difference of 33.62% is due to the reaction of Praat to the fan in the room where the experiment with S2 was conducted. A consistent burst of energy was oftentimes indiscernible in the spectrograms, and the noise from the fan was interpreted as high-level energy with what appeared to be a voicing bar even in periods of silence at the end of words. Due to the potential inaccuracy of the data from the Slow Condition for S2, and S1 for lack of comparison, they have been excluded from this discussion.

S1 and S2 were found to have comparable rates of voicing for the labiodental fricative in *xúbəf* 'handsome'. The fricative was voiced 18.77% of its duration on average for S1, and the fricative was voiced 16.30% on average for S2. Voicing lasted only 11.68% of the duration for S1 in the Slow Condition while voicing lasted almost twice
the amount of time at 22.46% for S2. Again, the audible fan in the recording with S2 may have falsified these accounts; sound waves from the fan were likely perceived as voiced glottal pulses in Praat, which lead to the high percentage of voicing in the Slow Condition.

The results of the experiment did not reveal a strong pattern in regard to the voicing assimilation of obstruents like the bilabial stops and labiodental fricatives in the word-final and intervocalic positions. As expected, though, the obstruents in the intervocalic position were voiced to a variable degree because the glottis takes longer to turn off voicing than the other articulators spend to begin producing the desired voiceless sound. Considering that the average percentage voicing for the consonants was low at $\leq 25\%$, it is unlikely that the voiced stop and fricative are simply allophones of their voiceless counterparts. This topic should be further explored as the pattern appears in a number of other words, like the relationship between lef' 'Bulgarian currency' and лева 'Bulgarian currency (pl)' (13march–62-3–e), for example. In a reading of a folk song from 1892, S1 commented that Old Bulgarian contained voiced stops such as the velar [g] which are produced today as voiceless, [k] (13march–e). The systematic change of voiced stops to voiceless is also worthy of investigation.

5 Comparing results

Though no outside sources were consulted to determine the vowel and consonant phoneme inventories (see subsections 3.1 and 4.1), a comparison of the collected data to that compiled by Ternes and Vladimirova-Buhtz (2015) in the Bulgarian chapter of the International Handbook of the IPA is made here.
The consultant referenced by Ternes and Vladimirova-Buhtz (2015:55) was a "33-year-old-speaker holding a post at the University of Sophia," which resembles in age and geographical background to S1 especially. Ternes and Vladimirova-Buhtz explain that there are eight phonemic vowels, /i, ɛ, a, ɣ, u, o, ɔ/ as compared to the nine phonemic vowels explored in this paper, /i, ɪ, e, ɛ, ə/ʌ, u, o, a/. The symbols used to describe the phonemic inventories differ, however the general placement of sounds within the vowel space remains fairly consistent. A glaring distinction between the accounts is the number of phonemic high front vowels. Ternes and Vladimirova-Buhtz indicate that there is only one high front vowel, the tense /i/, while the data suggested that there may be two, the tense vowel /i/ and the lax vowel /ɪ/; notably, there are no minimal pairs to confirm the allophones belong to separate phonemes, though [i] and [ɪ] do map to different Cyrillic letters.

It was argued in subsection 3.4 that the phonemes /o/ and /u/ may be in free variation as either can be uttered without changing word meaning. Support for the idea came from an analysis of the almost identical F1 values of [o] and [u] for S1 and S2 in the Fast Condition (see figure 4). Ternes and Vladimirova-Buhtz (2015:56) interpret this relationship as follows: "[o] is a neutralization of /u/ and /ɔ/…in unstressed syllables." This assertion is questioned by the experimental findings as the final, unstressed vowel /o/ in the word dervótó 'tree' is realized as [o] and [u].

While there were 24 consonant phonemes /p, b, m, f, v, t, d, n, r, θ, z, s, ʃ, ʒ, ʧ, ʤ, l, j, k, g, ɲ, x, h/ declared with hesitation in this paper, Ternes and Vladimirova-Buhtz claim there are 22 consonant phonemes, /p, b, m, f, v, t, d, n, s, z, ʃ, ʒ, ts, dz, ʃ, ʒ, r, l, j,
k, g, x/. Their comment that "/b, d, g/ are fully voiced," appears accurate as the percentage voicing data (see subsection 4.3) indicated that /d/ and /g/ remain voiced for their entire segments (2015:56). The question of whether or not voiceless stops found in modern-day Bulgarian emerged from voiced stops still stands.

6 Conclusion

This paper has provided an analysis of the phonetic and phonological system of Bulgarian using data collected from elicitation sessions with native speaker S1 (female, 26), and experimental data from participants S1 and S2 (female, 19). In a phonetic experiment, participants were presented with a six-minute-long PowerPoint containing a sequence of Bulgarian words from a predetermined word list. Participants were directed to read through the word list twice, repeating each word three times with the flash of a metronome. The first series of the words read aloud in isolation constituted the Slow Condition, and the second series of the same words read aloud in the sentence, Моля, кажи _ на български 'Please say _ in Bulgarian', formed the Fast Condition. Recording tokens were uploaded into Praat for analysis of the first two formant frequencies of select vowels including /ɚ, ʌ/, which do not have a phonemic status in the language. Percentage voicing of intervocalic and word-final obstruents in an attempt to determine a voicing assimilation pattern was also studied.

Bulgarian is suspected to have nine phonemic vowels /i, ɪ, e, ɛ, ə/ʌ, ʊ, o, a/. Evidence of the existence of each vowel phoneme with minimal pairs was not determined in the course nor in the experiment, though there did appear to be contrast between a \( \neq i, i \neq u, i \neq e, i \neq e \neq o, o \neq e \neq o, \) and \( o \neq i \neq ə \) (see example (1)). Diphthongs such as
/aʊ/ and /ɔɪ/ were present in the language, though neither the phonemic status of the vowels nor their formant values were tested in the experiment. Vowels /u/ ~ /ɛ/, /u/ ~ /o/, /e/ ~ /ɛ/, and /a/ ~ /e/, appeared to be in free variation with one another as the vowel pairs occurred in the same environments of words without changing word meanings. The six vowels present in the Cyrillic script supported that there are at least six vowel phonemes in the language that make use of the entire vowel space. The patterning of one letter to more than one phoneme—/ɪ, e, ɛ/ to 'e' and /ɔ/Λ, ʊ/ to 'ъ'—alluded that some vowels identified as phonemes may actually be allophones of one phoneme in the set. The following relationships needed to be tested to support the phonemes identified in this paper: i ≠ ɪ, i ≠ o, i ≠ e, ɪ ≠ ɛ/Λ, ɪ ≠ a, ɪ ≠ o, ɪ ≠ e, e ≠ ɛ/Λ, e ≠ a, ɛ ≠ u, ɛ ≠ ɛ/Λ, a ≠ ɛ/Λ, a ≠ e, a ≠ o, a ≠ u, a ≠ o, ʊ ≠ ɛ/Λ, o ≠ e, o ≠ u, ɛ/Λ ≠ u, u ≠ e, u ≠ e, u ≠ a, and u ≠ o.

Bulgarian was found to have a typical number of vowels, the nine-vowel system rivaling the UPSID average of 8.7 vowels. The inventory also contained eight of the nine vowels most commonly found in the world's languages. Supposedly missing from the Bulgarian inventory was the mid back vowel /ɔ/, however there were no other conspicuous gaps.

The first and second formant frequencies of the vowels [a, ɪ, i, ɛ, e, u, ɑ, ʊ, ɚ, ʊ, Λ] tested in the phonetic experiment were presented in table 2. These values roughly estimated the formant frequencies produced by young, female Bulgarian speakers native to the language. In a comparison of vowel frequencies for S1 and S2 in the Slow Condition, it could be seen that the F1 of S1 in most cases was higher and the F2 was lower than S2. The source of the difference may have been anatomical or due to the level
of confidence with which each speaker uttered the words. While the formant values in the Slow Condition were highly variable, those recorded in the Fast Condition were representative of placements found on a standard vowel chart. The perceived difference in accuracy cautioned field linguists to ask their informants to repeat words at least once at speed to be certain that qualities have not been manipulated. The range of F1 and F2 values used by S1 and S2 were found to be almost identical, communicating that sounds may be produced anatomically differently but are perceived by the listener based on the relative frequencies of the speaker's other sounds. Specifically, the difference between the F2 values of the high front vowel [i] and the high back vowel [u] was 1777Hz for S1 and S2. The difference between the F2 values of the high back vowel [u] and the low central vowel [a] was 508Hz for S1, and the range between the high front vowel [i] and the low central vowel [a] was 367Hz. Results from the Fast Condition supported that the vowels /o/ and /u/ are in free variation (see example (4)). The F1 of the vowel [o] as produced by S1 was 340Hz, only 5Hz lower than that of the vowel [u]; the F1 values of both the vowels [o] and [u] for S2 were identical at 443Hz.

In addition to having nine vowel phonemes, Bulgarian is suspected to contain at least 24 consonant phonemes, which were displayed in table 3. Like its vowels, the consonant inventory of Bulgarian was typologically common. Eighteen consonants from the modal inventory, /p, b, t, d, ʧ, k, g, f, s, ʃ, m, n, ɲ, w, ɹ, r, ɟ, h/ were found; the consonants /ʔ, ɲ/ were not found. Details of the phonetic inventory of consonants were excluded from this paper, however the presence of the typologically uncommon dental nasal [ɾ] was briefly discussed.
Voicing assimilation and percentage voicing of Bulgarian stops and fricatives were identified using data from the elicitation sessions and the phonetic experiment. Given the morphological relationship between words like *grat* 'city' and *graduve* 'cities' (25jan-8-9-e) as well as *lef* 'Bulgarian currency' and *lev* 'Bulgarian currency (pl)' (13march–62-3–e), it was first suspected that voiceless stops like /t/ and voiceless fricatives like /f/ became voiced intervocally. Voiced phonemes becoming devoiced word-finally seemed another plausible explanation.

Simple percentages of the period of voicing for the bilabial stops in *hlap* 'bread' and *hlábət* 'the bread', and the labiodental fricatives in *xúbəf* 'handsome' and *xúbəvə* 'handsome (plural)' were derived using Praat. The results of the experiment concluded that the percentage voicing of the voiced stop and voiced fricative were 100% of the consonant duration for S1 and S2 in the Fast and Slow Conditions. The percentage voicing of voiceless bilabial stops and voiceless fricatives appeared to have been obscured in the case of S2 in the Slow Condition because Praat interpreted noise from the fan as voicing. Thus, the percentage voicing values for S1 and S2 were omitted. Percentage voicing was under 25% of the duration of the fricative for S1 and S2, a small percentage which did not support the hypothesis. More percentage voicing data should be studied along with an investigation of the supposed historical change of voiced-to-voiceless stops of words from Old Bulgarian to modern pronunciations.

The vowel and consonant inventories of Bulgarian in this paper were comparable to those presented by Ternes and Vladimirova-Buhtz (2015). It was fair to conclude that there are at least eight vowel phonemes in Bulgarian; however, it was not clear whether
[i] and [ɪ] are vowels of the same phoneme, nor if [o] and [u] are simply allophones of the same phoneme or neutralizations in unstressed environments. Consonant phonemes suggested here were not all supported undeniably with minimal pairs, however the majority of the sounds were deemed phonemes in Ternes and Vladimirova-Buhtz's (2015) analysis. Overall, the phonetic and phonological complexity of Bulgarian and the insightful comments from the consultants made the study of the language an enriching and rewarding experience.

7 List of abbreviations

1 first person PAST past
2 second person PL plural
3 third person POSS possessive
COP copula PREP preposition
F feminine PRO pronoun
M masculine QP question particle
N neuter REF reflexive
NEG negation SG singular
OBJ object SUBJ subject

8 References


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<table>
<thead>
<tr>
<th>Bulgarian Word</th>
<th>English Gloss</th>
<th>Cyrillic Script</th>
<th>Target(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>svátki</td>
<td>'sweet (pl)'</td>
<td>сладки</td>
<td>[a]</td>
</tr>
<tr>
<td>sidi</td>
<td>'(he) sits'</td>
<td>седи</td>
<td>[i, i]</td>
</tr>
<tr>
<td>pêsen</td>
<td>'song'</td>
<td>песен</td>
<td>[e]</td>
</tr>
<tr>
<td>stena</td>
<td>'wall'</td>
<td>стена</td>
<td>[ə]</td>
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<tr>
<td>cdná</td>
<td>'one'</td>
<td>една</td>
<td>[ɛ, a]</td>
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<tr>
<td>swôhnse</td>
<td>'sun'</td>
<td>сънче</td>
<td>[ɛ]</td>
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<td>kupə</td>
<td>'bowl'</td>
<td>купа</td>
<td>[u, ə]</td>
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<td>moj</td>
<td>'man'</td>
<td>мъж</td>
<td>[o]</td>
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<td>dervó</td>
<td>'tree'</td>
<td>дърво</td>
<td>[ə]</td>
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<td>dervóto</td>
<td>'the tree'</td>
<td>дървото</td>
<td>[o]</td>
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<td>hláp</td>
<td>'bread'</td>
<td>хляб</td>
<td>% voicing [p]</td>
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<tr>
<td>hlábət</td>
<td>'the bread'</td>
<td>хлябът</td>
<td>% voicing [b], and identification of [ə]</td>
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<td>xúbəf</td>
<td>'handsome (male)'</td>
<td>хубав</td>
<td>% voicing [f]</td>
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<tr>
<td>xúbəvə</td>
<td>'handsome (female)'</td>
<td>хубава</td>
<td>% voicing [v]</td>
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Figure 1: Bulgarian vowel chart

Figure 2: Vowel phonemes underlying Cyrillic script
Table 2  
Formant frequencies for S1 and S2 in Slow (left) and Fast (right) Conditions

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<thead>
<tr>
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Figure 3: S1 and S2 Slow Condition formant values

Figure 4: S1 and S2 Fast Condition formant values
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<tr>
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<th>Alveolar</th>
<th>Palatal</th>
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<td>Fricative</td>
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<td>v</td>
<td>θ d z s f ʒ</td>
<td>x</td>
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