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Russian elision as lenition to zero

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Abstract. While there has been extensive documentation of elision in colloquial Russian speech (Iskandari et al. 2020; Vorob'eva 2019; Evtjugina 2019; Andrjushhenko 2011; Pugh 1993; Dahl 1909), there is minimal phonetic research on its underlying causes. The present study performs an exploratory acoustic analysis on spontaneous Russian speech and ties its phonetic correlates to previously described lenition processes by demonstrating their continuous nature. Special attention is given to /v/ due to its sonorant-like qualities in Russian. Furthermore, the study uses the results of this analysis to propose a framework for predicting elided forms using both language-general processes alongside word frequency.

Keywords. Russian; elision; phonetics; acoustics; fast speech phenomena

1. Introduction. Elision is a natural language process in which certain sounds – typically individual segments or partial syllables – are deleted during speech, especially in fast or relaxed speech.[1] It is closely tied to increased speech rate, word frequency, word informativity and hyperspeech (isolated, focused and emphasized words). In Russian, elision is markedly different from morphophonogical vowel-zero alternations (e.g. yer-deletion, see Gouskova & Becker (2013)); instead, elision is understood to be an optional phenomenon that typically occurs in fast speech. The existing Russian literature assumes elision to be an unpredictable, lexically-specific process (e.g., Musatov 2012), where certain words exhibit numerous, apparently distinct, surface realizations in fast speech with instances of consonant elision, vowel elision, or both. The ultimate goal of this work is to suggest that elision is instead a realization at the extreme of a continuum of hyper- to hypo-articulated productions in fast speech.

In fact, the majority of Russian elision literature is limited to descriptions of speech as opposed to phonetic studies; notable examples of the former are Vorob'eva's recent work on Russian colloquial speech which details some intervocalic consonant and weak vowel deletion as well as Andrjushhenko's documentation of elision in contemporary fiction dialogues (Vorob'eva 2019; Andrjushhenko 2011). Iskandari et al. (2020) classify Russian elision into the following categories: word-final vowel deletion, consonant cluster simplification, word-initial consonant deletion, word-medial syncope, and haplology. The present study will forgo this categorization, focusing instead on individual consonants and vowels. The patterns illustrated in the data below come from Andrjushhenko (2011) and Vorob'eva (2019); both authors include only orthographic transcriptions, which are rewritten in IPA below.

The following examples illustrate a variety of types of Russian elision. The underlying form of each word is on the left followed by two possible surface forms: one canonical production and one with at least one elided segment. A gloss is provided on the right.

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[1] This paper uses the definition of acoustic reduction given by Ernestus (2014): acoustic reduction is a fast speech phenomenon where "words are produced with fewer or lenited segments compared to their citation forms." The following additional terminology is used: *elision* refers to the apparent categorical deletion of entire segments or groups of segments. *(Consonant) lenition* refers to the gradient weakening of a variety of consonants. *Vowel reduction* refers to the analogous weakening of vowels. Although these processes are not necessarily fast speech phenomena, this paper will examine them within fast speech production.

(1) Reduced vowel elision

a. /sapogʲi/ [sə.pa.ˈgʲi] or [spa.ˈgʲi] *boots*

b. /mʲesʲats/ [ˈmʲe.sʲɪts] or [ˈmʲe.sʲts] *month*

(2) Consonant cluster simplification

a. /kogda/ [kə.ˈgda] [kə.ˈda] *when*

b. /skolʲko/ [ˈskolʲ.kə] [ˈsko.kə] *how much/many*

(3) Intervocalic consonant elision

a. /budʲeʃ/ [ˈbu.dʲɪʃ] [ˈbu.ɪʃ] *be (2.sing.fut)*

b. /plʲevatʲ/ [plʲɪ.ˈvatʲ] [plʲɪ.ˈatʲ] *spit (inf.)*

Certain words appear to exhibit both vowel and consonant elision; in fact, the consonant /v/ appears to be especially prone to elision, both individually and alongside a neighboring vowel (Bjorndahl 2018; Kulikov 2013; Padgett 2002; Pugh 1993).

(4) Elision with /v/ and /vʲ/

a. /spraʃɨvajet/ [ˈspra.ʃɨ.və.jet] [ˈspra.ʃɨ.jet] *ask (3.sing.pres)*

b. /prʲivʲet/ [prʲɪ.ˈvʲet] [prʲet] *hello (informal)*

Words with the potential for elision of more than one segment are the main focus of the present study. The examples in (4) illustrate a general curiosity about intervocalic /v/: the elision of the consonant may be accompanied by the deletion of a neighboring unstressed vowel either within the same syllable (4a, b) or the syllable immediately preceding it (4c, d). These forms suggest that the properties of weaker segments in the sequence could govern their elision, which in turn demonstrates some systematicity in the elision process. We can examine (4d) in greater detail to see a specific pattern of productions:

(5) Surface forms of /sʲevodʲnʲa/ (*today*)

a. [sʲɪ.ˈvo.dʲnʲə]

b. [sʲɪ.ˈo.dʲnʲə]

c. [ˈsʲo.dʲnʲə]

d. *[sʲɪ.ˈvdʲnʲə], *[ˈsʲvo.dʲnʲə], *[ˈsʲɪ.dʲnʲə]

(5a) represents the canonical production of the word, typically seen in careful speech. (5b) has a /v/-elision, while (5c) has a weak vowel elision. The unacceptability of forms in (5d) suggest that the stressed vowel [o] cannot be deleted, and furthermore than the vowel elision does not occur without the /v/-elision alongside it.

Interestingly, the segments undergoing elision also frequently appear in studies of vowel reduction and consonant lenition. Russian unstressed vowel reduction affects vowels that surface as [ɪ] and [ə] – the same vowels that elided in (1). Russian consonant lenition tends to affect the first non-stop in clusters and intervocalic [v, j, l] and palatalized stops – again, the same consonants eliding in (2) and (3). Similarly to elision, lenition is associated with increased speech rate, word frequency, word informativity and hyperspeech. Unlike elision, however, lenition is commonly treated as a gradient phenomenon (instead of a categorical one) across speech registers; in fact, many studies (eg. Priva & Gleason (2020); Bauer (2008); Priva (2015); Kirchner (2013)) assume lenition to be phonologically general rather than lexically specific. With these insights on lenition, the present project uses data from a corpus of spoken colloquial Russian to examine phonetic realization of elision in order to argue that elision is a point along a continuum of possible acoustically reduced productions in fast speech – and furthermore that the elided form of a word can be predicted from its underlying representation.

2. Research questions. The ultimate goal of this work is to claim that elision may result from vowel reduction or consonant lenition rather than a system of unpredictable allomorphs – and to present a schema for how complex elided surface forms may surface from systematic simultaneous elision processes. This goal is represented with the following three questions:

1. Is segment deletion better described as the result of a gradient weakening process?
2. Which factors that have been mentioned in the existing lenition literature actually have the greatest impact on the elision process?
3. Is there a general phonetic pattern that can account for idiosyncratic surface forms?

In **RQ1**, we investigate whether there are continuous patterns across various phonetic correlates of reduction and lenition that result in reduction to zero. If there are, then there is evidence that elision is a point along a continuum. In **RQ2**, we investigate which independent factors (speech rate, word frequency, etc.) best predict the degree of segment reduction. In **RQ3**, we investigate whether it is possible to extend the results of the first two research questions to explain how certain surface forms arise in Russian speech. If such an analysis is possible, then it provides evidence that there are lexically-general processes that cause the same segments in different words to reduce to zero; otherwise, there is evidence that Russian elision is a lexically-specific process.

3. Background. In order to address the first two research questions, we need to know which segments may already be susceptible to weakening and which phonetic correlates are most representative of that weakening. In order to address the third research question, we need to know which elision processes are already well-documented in the existing literature. We will review some theoretical accounts of acoustic reduction, followed by details of Russian phonology and studies on reduction in Russian specifically.

3.1. ACCOUNTS OF ACOUSTIC REDUCTION. Recall the definition of acoustic reduction given by Ernestus (2014): acoustic reduction is a fast speech phenomenon where "words are produced with fewer or lenited segments compared to their citation forms." This reduction is commonly analyzed as a combination of categorical and gradient processes as well as both memorized and non-specific factors. Lindblom (1990), for example, proposes a continuum of productions from

hyperspeech (articulated speech that reaches acoustic targets) to *hypospeech* (reduced speech with phonetic undershoot) to account for individual inter- and intra-speaker differences in production. The theory suggests that speech is constrained by both speaker production (physiologically and cognitively) and listener perception (socially and communicatively); if production is less constrained than perception, such as when there are fewer physiological limits than communicative ones, a speaker produces hyperspeech; if production is more constrained than perception, a speaker produces hypospeech. Thus, the speaker balances prioritizing lowering production effort without negatively impacting listener understanding.

Similarly, Baker & Bradlow (2009) claim that word duration is influenced by a combination of phonetic and language-specific factors, focusing specifically on probability, speech style and prosody in American English. They found that more frequent words are more likely to have more reduced durations than less frequent words; this property could result from a word's more frequent activation in a speaker's mental lexicon. They also found that word durations were more likely to be shorter in casual speech than in careful speech and that certain prosodic boundaries affected duration as well (e.g. that words immediately before a prosodic boundary are significantly shorter than those immediately following one, and that words under prosodic prominence are more likely to be hyperarticulated). These factors did not act independently; instead, they found "second mention reduction effects in both clear and plain speech, indicating that while clear speech is hyper-articulated, this hyper-articulation does not override probabilistic effects on duration." These results suggest that not only is there a relationship between factors within a speaker's control - such as speech style and prosodic prominence - but also that word frequency directly mediates word duration as well.

Pierrehumbert (2002) also proposes a combined model for predicting variation in word production, implementing both abstract phonological rules and lexically-specific factors and claiming that individual word production is influenced not only by general phonological processes but also by the properties of the word itself, such as frequency and context. Pierrehumbert suggests that listeners store detailed phonetic representations of words in their mental lexicon, which can influence their perception and production. She also observes that high frequency words have more stable and consistent phonetic realizations compared to low-frequency words since they are encountered more frequently and thus have more robust representations in the mental lexicon.

3.2. UNSTRESSED VOWEL REDUCTION. Russian has five vowel phonemes: /a, i, e, o, u/. [ɨ] surfaces as an allophone of /i/ after non-palatalized consonants, while [i] surfaces only after palatalized consonants. [ɪ, ə] surface during vowel reduction. Diphthongs are uncommon within the language and only appear in interactions with /j/; vowel hiatus is rare and dispreferred. Stress in Russian is morphologically conditioned and lexically determined; it is indicated mostly by the duration, intensity and quality of the stressed vowel.

Russian vowel reduction directly influences vowel duration realization, so a comprehensive description of reduction allows us to characterize the relative duration of vowels in any word. There are three factors that influence vowel reduction: the segment itself, its position relative to the stressed syllable, and the palatalization of the preceding consonant (Crosswhite 2000; Barnes 2007; Iosad 2012). Vowels in syllables under primary stress never undergo reduction. The high vowels /ɨ/ and /u/ never undergo changes in quality that could lead to neutralization. The high front vowel /i/ may surface as [ɪ] in unstressed position. The mid front vowel /e/ undergoes reduction in any unstressed position. /e/ surfaces as [ɪ], regardless of the preceding consonant. Thus,

underlying /i, e/ can neutralize to surface [ɪ]. The mid back vowel /o/ undergoes reduction in any unstressed position. In the immediately pretonic position, /o/ surfaces as [a]; in most other unstressed syllables, /o/ surfaces as [ə]. The low vowel /a/ undergoes reduction in any unstressed position. In the immediately pretonic position, if the preceding consonant is palatalized, /a/ surfaces as [ɪ]; otherwise, /a/ surfaces as [a]. In every other unstressed syllable, /a/ surfaces as [ə]. The degree of vowel reduction appears to be closely tied to word frequency and register. Van Son et al. (2004) found that word frequency correlated with reduction of vowel duration, quality, and intensity in both read and spontaneous speech, although spontaneous speech had more instances of reduction, as expected. Bolotova (2003) similarly found that not only did consonant and vowel durations reduce during spontaneous speech, but also that this reduction in duration is more extreme for more reduced vowels.

3.3. CONSONANT LENITION. Barry & Andreeva (2001) analyzed Russian spontaneous speech as part of an exploration of languages in different rhythmic groups. They found two possible productions of [l] in casual speech: vocoid and elided. Vocoid /l/ was produced with no obstruction in the speech stream in virtually all surface cases except for hyperspeech. Elision of /l/ was also fairly common and occurred regardless of underlying palatalization. Interestingly, when Davidson & Roon (2008) examined durational properties for different consonant clusters in Russian in word initial, interword, and epenthetic [ə] environments, they concluded that the first consonant is consistently shorter than the second (except stops, whose release prevents gestural overlap); this effect was especially strong for cluster-initial /v/.

The phoneme /v/ is infamous in Russian for its unusual phonological patterning with both obstruents and sonorants. Similarly to obstruents, /v/ undergoes word-final devoicing; however, /v/ does not trigger voicing assimilation in consonant clusters, similar to Russian sonorants (Padgett 2002). As a voiced non-sibilant fricative, /v/ is also notably short and highly reduced in casual speech (Bjorndahl 2018; Kulikov 2013), which is likely related to its propensity for elision. According to Padgett, some of this behavior may be explained by hypothesizing that surface [v] is underlyingly /w/. It is consistently produced with less frication than other fricatives and tends to show more formant structure and higher intensity as well - to the extent that it may surface fully as [w]. Additionally, unlike other voiced-voiceless obstruent pairs, [v] and [f] are rarely confused by native listeners (Padgett 2002). Pugh (1993) similarly concludes that /v/ and /j/ are most frequently elided intervocalically in Russian colloquial speech due to their semivowel-like nature; furthermore, De Silva et al. (2003) found that /j/-elision was extremely common in Russian in any position, but especially following front vowels and in intervocalic position.

3.4. WEAK VOWEL DELETION. Little work appears to have been done on phonetic vowel deletion in Russian, although there is a lot of attention given to phonological vowel-zero alternations. An immediate example are prepositions with vowel-zero alternations which tend to be phonologically conditioned so as to avoid a sequence of identical consonants - the preposition /s/ *with*, for example, is produced as [sə] before a word with initial [s], such as [sə stə.ri.ˈkom] *with the old man* (Blumenfeld 2011). The reemerging Russian vocative involves subtractive morphology in the form of final vowel deletion as a case marker (Yadroff 1996); interestingly, Andrjushhenko (2011) details this phenomenon in her list of elided words in orthography as well. Barry & Andreeva (2001) found that, in spontaneous speech, word-, phrase-, and utterance-final vowels were frequently elided so long as they were not stressed. They also found that in vowel hiatus across words, the more reduced of the two vowels, that is, the one realized with lower duration and more

centralized formants, is frequently elided.

3.5. CONSONANT CLUSTER REDUCTION. Russian phonotactics allow for onsets containing up to four consonants; however, these are frequently simplified to three segment clusters, which likely resulted from a historical shift from open to closed syllable structures. Pouplier et al. (2017) examined relative duration of consonants in Russian onset clusters composed of two segments, finding that speech rate had a direct effect on consonant duration. While both consonants have reduced duration, the first consonant is proportionally even shorter than the second consonant, which match the findings by Davidson & Roon (2008). High frequency clusters were even more likely to undergo some type of duration reduction (Pouplier et al. 2017).

3.6. SUMMARY. We can draw the following conclusions from the existing literature on segment weakening and deletion: vowel reduction and elision correlate with reduced duration, reduced intensity and formant centralization; consonant lenition and elision correlate with reduced duration, intensity and turbulence. All segments may be affected by the word frequency, speech rate, and register, and hyperspeech reduces the likelihood of any weakening processes. Thus, we expect a process related to acoustic reduction to have a relationship with speech rate and frequency.

4. Methodology. The present study used the open-access Russian corpus *Golos*, a 1240 hour collection of spontaneous speech files from various de-identified speakers annotated only for transcription (Karpov et al. 2021). The data is crowdsourced, and it is possible that the recordings were done on personal devices such as personal computers or mobile phones; this information is neither recorded in the metadata nor mentioned in the paper by the authors. The data set was originally created to train speech synthesizers on colloquial speech; it was chosen exclusively due to its accessibility. A Python script was written to search through the orthographic notations in the corpus to collect 50 randomly selected instances each of:

(6) a. /sʲe.ˈtʃas/ [sʲɪ.ˈtʃas] [ɕas] *now*
b. /sʲe.ˈvo.dʲnʲa/ [sʲɪ.ˈvo.dʲnʲa] [ˈsʲo.dʲnʲa] *today*
c. /trʲe.ˈvo.ʒnɨj/ [trʲɪ.ˈvo.ʒnɨj] [trʲɪ.ˈo.ʒnɨj] *anxious (m.s.nom)*
d. /gɔ.vo.ˈrʲit/ [gə.va.ˈrʲit] [ga.ˈrʲit] *says (3s.pres)*
e. /tʃe.lo.ˈvʲek/ [tʃɪ.la.ˈvʲek] [tʃek] *person*

for a total of 250 tokens. All five words have a weak vowel that can elide. Forms (6b)-(6e) all have an invervocalic /v/ that can elide. (6b) and (6c) were chosen as a high and low frequency pair of words with similar metrical structures. (6d) was chosen due to the similar quality of the vowels neighboring /v/. (6e) was chosen as there is evidence that the word has several (impressionistically) different surface forms. Note that all forms except (6c) are high frequency words; (6c) itself was included as a control.

Each token was segmented by phoneme. Segmentation was performed manually for each token by the author, who is a heritage speaker of Russian with extensive training in phonetic segmentation. Plosives were segmented to include silences and bursts. In the case of two consecutive vowels, which always had transitioning formants, boundaries were temporarily placed at the offset of the first vowel's steady state and the onset of the second vowel's steady state, which were determined impressionistically using visible formant trajectories. Afterward, a boundary was

placed at the midpoint between the end of the first vowel and beginning of the second vowel, and the temporary boundaries were removed.

A Praat script collected vowel formant values (taken at the beginning, midpoint and end of the vowel), the frication of the consonant as measured by the Harmonics-to-Noise ratio (HNR) and the intensity contour and duration of the sequence. Global speech rate of each audio file was measured in syllables per second using De Jong & Wempe (2009)'s script; the interval chosen for the present experiment was the duration of each utterance, which was typically five seconds long. The frequency of each word was determined by logarithmically transforming its rank in a list of lemmas and their respective frequencies as given by Sharoff (2001). Prominent words were those that contained a phrase's pitch peak (which were confirmed impressionistically by the author).

5. Results. In order to argue that Russian elision can be reanalyzed as a lenition-like process, we expect not only that the process will have the same effect on segments as lenition does but also that the process will be affected by the same variables that affect lenition. We begin by examining the surface forms present for each token based exclusively on the audible presence or absence of segments. Then, we examine the duration of each segment in all tokens to examine the effects of speech rate. Next, in order to argue that /v/ elision is not a perfect deletion of all acoustic components of the segment, we analyze the HNR of /v/ and the formants and intensity of vowels in the words. Finally, we examine the effects of independent variables on weak segment durations to both evidence that the process is comparable to lenition as well as determine the best predictors of segment duration.

5.1. SURFACE FORMS. The traditional elision literature characterizes elided forms as well-defined surface variants of underlying forms. While it is not necessarily the case that the variants are categorically distinct – and indeed, it will be argued later in this paper that they are not – this classification depicts a general trend where segments may undergo enough weakening to become undetectable within native speaker productions. We begin by examining the surface forms found in the corpus to determine initial patterns of elision, summarized in **Table 1**.

underlying form	**/sʲetʃas/**			**/govorʲit/**		
surface forms	[sʲɪ.ˈtʃas]	[sʲː.ˈtʃas]	[ɕas]	[gə.va.ˈrʲit]	[gə.a.ˈrʲit]	[gaː.ˈrʲit]
count	17	9	24	12	5	33
underlying form	**/sʲevodʲnʲa/**			**/trʲevoʒnɨj/**		
surface forms	[sʲɪ.ˈvo.dʲnʲə]	[sʲɪ.ˈo.dʲnʲə]	[ˈsʲo.dʲnʲə]	[trʲɪ.ˈvo.ʒnɨj]	[trʲɪ.ˈo.ʒnɨj]	[ˈtrʲo.ʒnɨj]
count	22	18	10	29	20	1

Table 1. Surface forms of /sʲetʃas/ and three tokens containing intervocalic /v/.

Unlike the other tokens, /tʃelovʲek/ had seven variants: [tʃɪ.la.ˈvʲek] (3), [tʃɪ.la.ˈek] (7), [tʃla.ˈvʲek] (10), [tʃɪ.a.ˈek] (2), [tʃla.ˈek] (18), [tʃa.ˈek] (5), and [tʃek] (5). This means that 38 of 50 surface forms were missing the first vowel [ɪ], 12 were missing [l], 5 were missing the second vowel [a], and 37 were missing [v]. These results suggest that both /l/ and /v/ are especially susceptible to elision.

Thus, a general pattern emerges: /v/ and the weak vowels [ɪ, ə] can delete in the selected tokens.[2] Additionally, forms with elided vowels are all missing /v/ as well, adding evidence that

[2] Clearly, the segment /l/ can also delete as has been suggested by its identity as a weak consonant in the literature.

/v/-elision occurs before vowel elision.

5.2. SEGMENT DURATION. As is expected, when speech rate increased, all word durations decreased; however, individual segments of the words compressed at different rates (detailed below). This pattern was measured through relative duration, where the individual segment durations were normalized by dividing by the total word duration. There were several consistent patterns: the stressed vowel increases in relative duration, while the reduced vowels and [v] decrease in both absolute and relative duration. This result aligns with the elided forms that surfaced in the previous section.

In /sʲevodʲnʲa/, for example, as speech rate increased and word duration decreased, both the absolute and relative durations of the first consonant ([sʲ], $r = -.232, p \approx .01$), second consonant ([v], $r = -.357, p < .01$) and third vowel ([ə], $r = -.211, p < .05$) decreased significantly. Notably, while the relative duration of the second vowel ([o], r=.251, $p < .05$) increased, its absolute duration stayed relatively stable. The analogous segments had the same effects in /trʲevoʒnij/. In /govorʲit/, as speech rate increased and word duration decreased, the absolute and relative duration of the second consonant ([v], $r = -.251, p < .05$) decreased. Again, the relative duration of the stressed vowel ([i], $r = .264, p < .05$) increased while its absolute duration stayed relatively constant. In /sʲetʃas/, as speech rate increased and word duration decreased, the absolute and relative duration of the first vowel ([ɪ], $r = -.245, p < .05$) decreased and the relative duration of the second vowel ([a], $r = .308, p < .05$) increased. In /tʃelovʲek/, as speech rate increased and word duration decreased, the absolute and relative duration of the first vowel ([ɪ], $r = -.252, p < .05$) and third consonant ([vʲ], $r = -.276, p < .05$) decreased.

5.3. HNR OF /V/. A noted pattern emerging frequently during segmentation was the consistent surfacing of /v/ – when it surfaced at all – as a semivowel-like phone. One way to characterize this perceived behavior is through HNR, which measures the ratio between the periodic (voicing) and aperiodic (turbulence) components of the speech stream over a given window. The higher the HNR measurement of a segment, the greater its degree of periodicity and the lesser its degree of aperiodicity; that is, an obstruent consonant with a higher HNR is more sonorant than one with a lower HNR. HNR measurements were taken for /v/ in /sʲevodʲnʲa/, /trʲevoʒnij/, and /govorʲit/ in order the quantify the perceived reduction in frication of the consonant. **Figure 1** illustrates the HNR of /v/ relative to absolute word duration, color-coded for an impressionistic analysis of the consonant performed during data segmentation (left) and for the identity of the word containing the consonant (right).

Figure 1 suggests that as word duration decreases (that is, when speech rate increases), the HNR of /v/ increases as well, suggesting that non-palatalized /v/ indeed becomes more sonorant as the likelihood of elision increases. This adds evidence for a continuum of productions – both through impressionistic and actually realized changes in production – since there is no apparent categorical change in HNR across speech rate. Interestingly, the absolute word durations align with the relative frequencies of the words, in that the more frequent words have lower spoken durations, as is expected.

5.4. VOWEL FORMANTS AND INTENSITY FOLLOWING /V/-ELISION. There was frequently apparent vowel hiatus resulting from surface /v/-elision. Vowel formant and intensity measurements were taken at the beginning, middle, and endpoint for every segmented vowel; as a result, we can

The analysis of /l/ is left as a topic for future investigation.

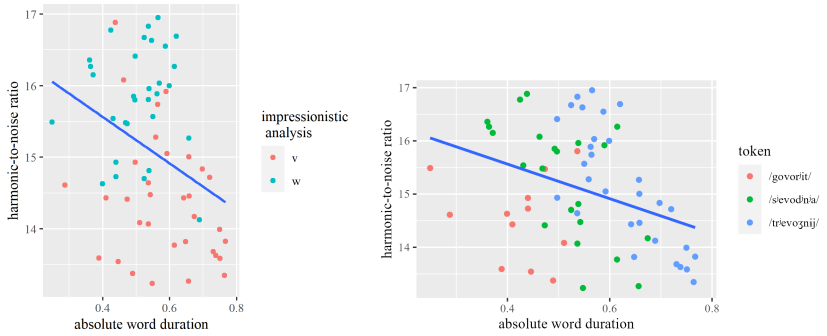

Figure 1. HNR of non-palatalized /v/ relative to absolute word duration, color-coded for impressionistic analysis (left) and token identity (right) ($r = -.351, p < .01$).

examine the formants of each vowel in vowel hiatus resulting from consonant elision. **Figure 2** illustrates the first two formant measurements at the midpoint of the first vowel, the midpoint of transitioning formants between the vowels, and the midpoint of the second vowel (left) and the analogous intensity measurements (right). Both formant and intensity measurements show a similar non-monotonic saddle shape, adding further evidence that /v/-elision is not a perfect, complete deletion of a segment.[3]

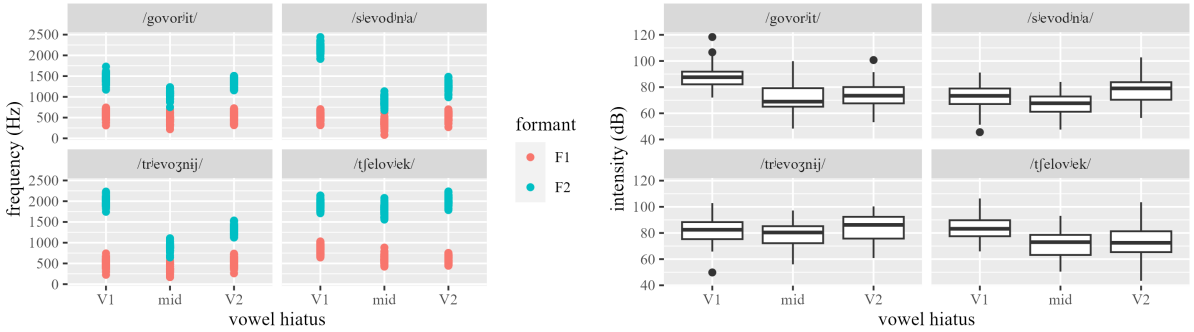

Figure 2. Formant (left) and intensity (right) measures across vowel hiatus following /v/-elision.

Returning to **RQ1**, we can now address whether segment deletion in Russian better described as the result of a gradient process of weakening. There is evidence that elision is the result of continuous weakening processes. As speech rate increases, the relative duration of weak vowels and /v/ decreases, while the relative duration of the stressed vowel increases. The HNR of /v/ continuously increases as speech rate increases and there appears to be some type of preservation of secondary articulation of /v/, where /v/ may surface as [w]. Finally, the formants and intensity of the vowels remaining after /v/ elision continue to show a decrease that could not surface without some presence of consonant production. Clearly, the word remaining following /v/ elision contains traces of the missing consonant – lowered intensity and formants between the two vowels – which can be explained by a covert consonantal gesture. The production of /v/ requires

[3] Interestingly, Cheng & Xu (2013) found a similar result for vowel hiatus following consonant elision in Taiwan Mandarin, where the midpoint of vowel hiatus of identical vowels maintained formant transitions and an intensity decrease.

constriction of the tongue and lips. While the consonant itself may be imperceptible due to the overlap of the consonant and the neighboring vowels, the lowered intensity can result from any degree of constriction between the two vowels, and the lowered formants could be caused by partial closure of the lips.

5.5. INDEPENDENT VARIABLE EFFECTS. Three independent variables were analyzed for effects on the lenition of /v/: speech rate, word frequency and word prominence. In **Figures 3-5**, we see that as speech rate increases, the absolute duration of /v/ decreases; interestingly, as word duration increases, so does the *relative* duration of /v/. The latter result suggests that /v/ undergoes a greater degree of durational compression than expected, since shorter-duration words have an especially short consonant (instead of a proportional consonant, which would have been represented by a line with a slope much closer to zero). Additionally, when we color code for word, we see that /trʲevoʒnij/ tends to have both a greater absolute duration and greater relative /v/ duration, which aligns with its status as a low-frequency word.

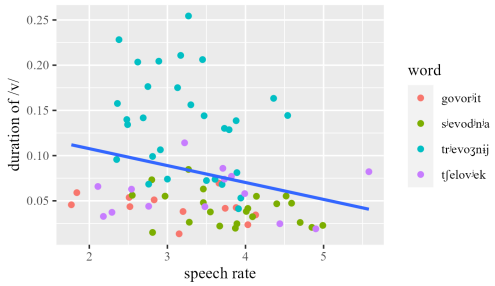

Figure 3. Absolute duration of /v/ as a function of speech rate ($r = -.256, p < .05$).

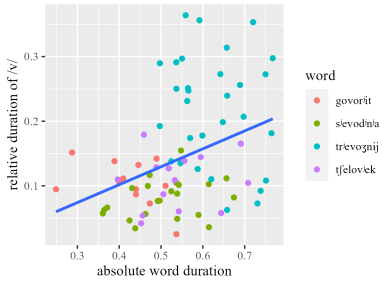

Figure 4. Relative duration of /v/ as a function of absolute word duration ($r = .365, p < .001$).

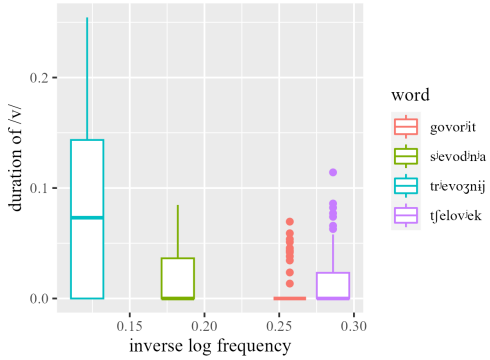

Figure 5. Duration of /v/ as a function of lemma frequency (zero durations included).

It may be the case that there is a categorical effect of frequency, where 'high-frequency' and 'low-frequency' words have different effects on segment duration, but this topic requires more thorough examination. Word prominence also appears to have an effect on /v/ duration, wherein words in positions of prominence tend to have longer durations of the consonant; this suggests that prosodic prominence results in a more carefully articulated word, as is expected. Additionally, no words in positions of prominence have a fully elided /v/, suggesting that the use of word prominence prohibits segment elision.

The same analysis was performed for the degree of weak vowel duration reduction for the first vowels in /sʲetʃas/, /sʲevodʲnʲa/, /trʲevoʒnij/ and /govorʲit/ and the first two vowels in /tʃelovʲek/. All of the vowels were realized as either [ɪ] or [ə], but no insights were gained when splitting the data by vowel quality. The effects are illustrated **Figures 6-8** below. Again, we see that the absolute duration of the weak vowels decreases with speech rate and increases with word duration. Frequency also has an effect on vowel duration; there is a more gradual change in vowel duration relative to frequency, suggesting instead that frequency has a continuous effect, not a discrete one.

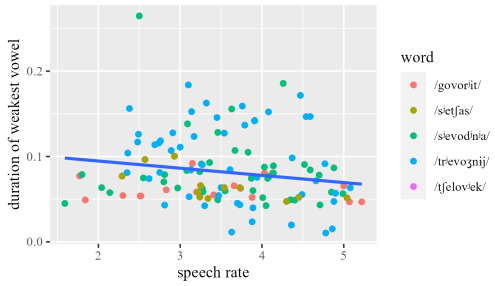

Figure 6. Absolute duration of weak vowels as a function of speech rate ($r = -.279, p < .05$).

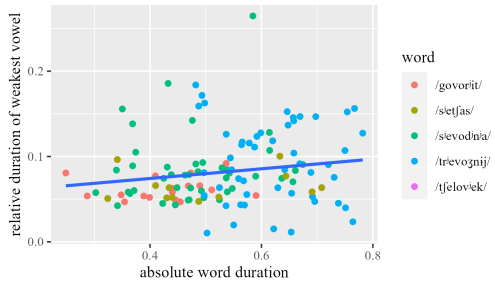

Figure 7. Relative duration of weak vowels as a function of absolute word duration ($r = .159, p < .05$).

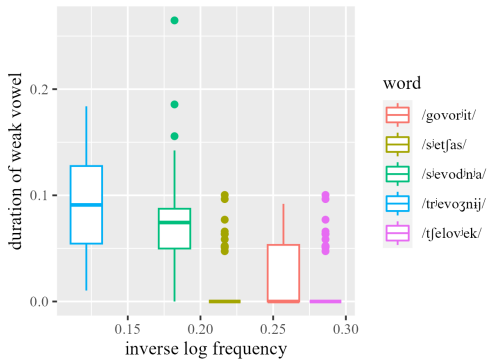

Figure 8. Duration of weak vowels as a function of lemma frequency (zero durations included).

Next, a fixed effects linear regression model was created in R to analyze which effects different factors had on the presence of /v/ and weak vowels; these results are represented in **Tables 2 - 5**. Since the corpus did not have labeled speaker IDs, there was no way to examine the effect of speaker identity.

	v duration		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.31	0.23 – 0.39	**<0.001**
speech rate	-0.07	-0.09 – -0.04	**<0.001**
freq	-1.12	-1.47 – -0.77	**<0.001**
prominence [1]	0.39	0.19 – 0.58	**<0.001**
speech rate × freq	0.24	0.15 – 0.34	**<0.001**
speech rate × prominence [1]	-0.07	-0.13 – -0.02	**0.007**
freq × prominence [1]	-1.09	-1.95 – -0.22	**0.014**
(speech rate × freq) × prominence [1]	0.24	0.00 – 0.48	**0.050**
Observations	200		
R^2 / R^2 adjusted	0.621 / 0.607		

Table 2. Linear model results with all duration values of /v/.

	v duration		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.51	0.37 – 0.64	**<0.001**
speech rate	-0.11	-0.15 – -0.07	**<0.001**
freq	-1.69	-2.29 – -1.09	**<0.001**
prominence [1]	0.05	0.03 – 0.07	**<0.001**
speech rate × freq	0.36	0.18 – 0.54	**<0.001**
Observations	78		
R^2 / R^2 adjusted	0.582 / 0.559		

Table 3. Linear model results with null values deleted.

In **Table 2**, every independent variable and interaction has a significant effect on the duration of /v/. When predicting the duration of /v/, we see that as speech rate increases, /v/ duration decreases; as word frequency increases, /v/ duration decreases; and if the word is in a position of prosodic prominence, /v/ duration increases. The interaction of all variables confirms claims made about acoustic reduction - that both phonetically general and lexically specific factors directly affect segment duration. In **Table 3**, which excludes cases where /v/ did not audibly surface, all three variables significantly affect /v/ duration, although only the interaction between speech rate and frequency reaches statistical significance. In **Table 4**, in contrast to the results for /v/, speech rate, word frequency and position have significant effects on the relative duration of the vowels. This means that when predicting the relative duration of a weak vowel, as speech rate increases, relative vowel duration decreases and as word frequency increases, vowel duration decreases. **Table 5** shows similar effects when the zero values are removed.

	weak vowel duration		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.18	0.15 – 0.21	**<0.001**
speech rate	-0.01	-0.01 – -0.00	**0.022**
freq	-0.52	-0.60 – -0.43	**<0.001**
Observations	250		
R^2 / R^2 adjusted	0.370 / 0.364		

Table 4. Linear model results with all duration values of weak vowels.

	weak vowel duration		
Predictors	*Estimates*	*CI*	*p*
(Intercept)	0.15	0.12 – 0.19	**<0.001**
speech rate	-0.01	-0.02 – -0.00	**0.019**
freq	-0.22	-0.33 – -0.10	**<0.001**
Observations	134		
R^2 / R^2 adjusted	0.124 / 0.111		

Table 5. Linear model results with null values deleted.

Returning to **RQ2**, we can examine which factors that have been mentioned in the existing lenition literature actually have the greatest impact on the elision process. The absolute duration of /v/ is predicted significantly by speech rate, word frequency, and whether the word is in a position of prominence. The relative duration of /v/ decreases as speech rate increases, decreases as word frequency increases, and decreases when the word is not in a position of prominence. In simpler terms: faster spoken words, especially those that are more frequent, are more likely to exhibit /v/ elision, while words in positions of prominence are less likely to exhibit /v/ elision. Similarly for vowels, the duration is predicted significantly by speech rate and word frequency. The duration of the vowel decreases as speech rate and word frequency increase. Speech reduction phenomena have typically been analyzed as resulting both from word-specific and otherwise general properties, such as word frequency, prosodic structure and speech rate. This result adds further evidence to using a combined model due to the significant effects of both speech rate (a general property) and frequency (a word-specific property).

6. Extending the results. It is clear that there is a great degree of asymmetry of durational compression across segments. We can examine this property by looking at the different surface variants described for /sʲevodʲnʲa/ in **Section 5.1**. **Figure 9** illustrates the durations of each segment in every production of /sʲevodʲnʲa/ that surfaced with a detectable weak vowel and /v/. **Figure 10** illustrates the durations of each segment in every production of /sʲevodʲnʲa/ that surfaced with a detectable weak vowel but no perceptible /v/. Finally, **Figure 11** illustrates the durations of each segment in every production of /sʲevodʲnʲa/ that surfaced with no detectable weak vowel or /v/. The latter two figures include instances of word-final [a] duration equal to zero; otherwise, all other values are positive.

In **Figure 9**, we see that /v/ not only has the shortest duration of all the segments in the word but also that its duration decreases with the second greatest slope as speech rate increases; the first greatest slope is associated with the duration of word-final [a]. In **Figure 10**, we see that /e/ has both the shortest duration and greatest negative slope. These factors suggest the following conclusion: that most segments in a word are decreasing in duration, and they decrease at different rates, so the segments that fail to surface are those that have compressed to zero the fastest. If we consider the forms in **Figures 9-11** to be categorically distinct allomorphs, we would need to develop at least two phonological rules: first, an intervocalic /v/ deletion rule, and second, a vowel hiatus resolution rule. However, we do not actually need phonological rules such as vowel hiatus resolution. Instead, we claim that the intervocalic consonant has both the lowest duration and greatest decrease with speech rate, so it elides "first" only because it is always the shortest segment in the word. Similarly, the hiatus resolution is the next shortest segment – the more reduced of the two vowels – becoming imperceptible.

Interestingly, Iskandari et al. (2020) mention the mysterious presence of "word-medial syncope" in Russian, that is, the deletion of segments across syllable boundaries instead of within them. Phonologically, this behavior is accounted for through intervocalic consonant deletion combined with vowel hiatus resolution,[4] as the deleted vowel is determined by vowel reduction and may not necessarily align with syllable boundaries. A phonetic explanation is even simpler: the two shortest segments are reducing to zero in fast speech.

[4] There is evidence that a similar vowel hiatus resolution property - in which the weaker of the two vowels deletes - surfaces crosslinguistically (Casali 2011, 1997; Riggsby 1991).

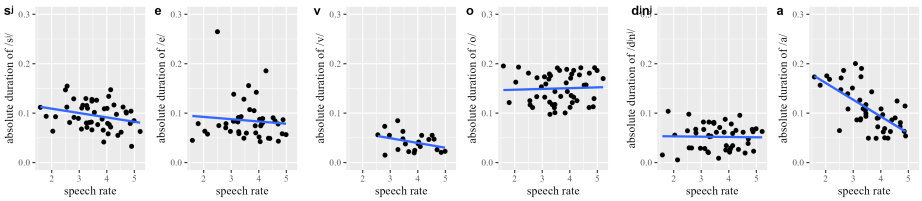

Figure 9. Absolute duration patterns of each segment in /sʲevodʲnʲa/ as a factor of speech rate.

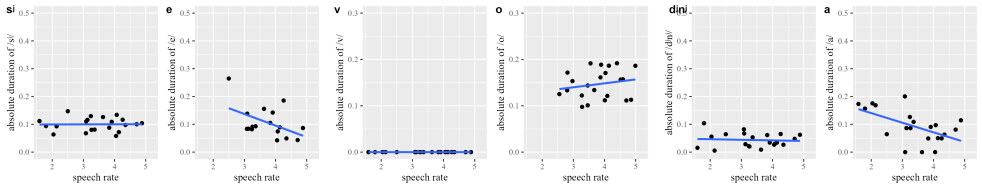

Figure 10. Absolute duration patterns of each segment in /sʲevodʲnʲa/ as a factor of speech rate.

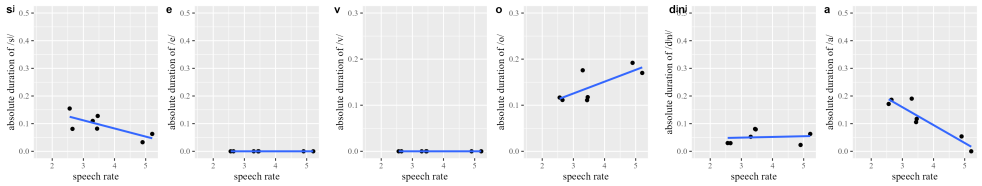

Figure 11. Absolute duration patterns of each segment in /sʲevodʲnʲa/ as a factor of speech rate.

This claim is further evidenced by **Figure 12**, which illustrates all of the durations of the whole word relative to speech rate, color coded for which segments are present.[5] Word duration decreases as speech rate increases, and the longest durations and lowest speech rates correlate with unelided words, while the shortest durations and highest speech rates correlate with the words that are missing both the consonant and the vowel.

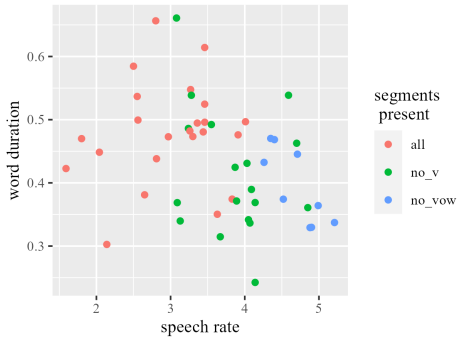

Figure 12. Duration of /sʲevodʲnʲa/ relative to speech rate, color coded for elided segments.

[5] `no_v` refers to instances of /sʲevodʲnʲa/ with an elided /v/ but a present weak vowel (such as those in **Figure 10**), while `no_vow` refers to instances of /sʲevodʲnʲa/ with an elided /v/ and weak vowel.

Returning to **RQ3**, there is in fact a general phonetic pattern in Russian that can account for idiosyncratic surface forms. Most segments shorten as speech rate increases. These segments compress at different rates, and some decrease in duration more sharply than others; their compressibility appears to be related to their identity, where weak consonants such as [v] and reduced vowels such as [ɪ, ə] undergo the greatest degree of compression. At some point, a segment becomes so short in duration that it is imperceptible, either through losing its frication or becoming devoiced; this is what we call elision. Since frequent words are shorter than less frequent words in any speech environment, they are more likely to have more instances of segments becoming reduced to zero. Thus, the 'idiosyncratic' forms are those high frequency words with certain short segments becoming imperceptible in fast speech. A larger corpus could, of course, confirm and generalize these findings across productions in the language.

7. Conclusion. Elision in Russian is a well documented but phonetically understudied phenomenon, sometimes considered to be an alternation of distinct surface forms in fast speech. The present paper presents a different account for elision, claiming instead that the deletion of /v/ and weak vowels results from the disappearance of acoustic cues for those segments in fast speech, thus reframing the phenomenon as a continuous reduction process. We demonstrate that elision, as it occurs in Russian, not only has the same effects on segments as other reduction processes but also is itself affected by the same factors as those processes. For all segments, duration, turbulence and vocalization continuously decrease as speech rate increases. Notably, the segments previously described as 'weak' in Russian are affected by these processes to a higher degree. Elision in turn is significantly affected by speech rate, prosodic prominence and word frequency, suggesting that it may be more appropriately described as a reduction process. This is further evidenced by the fact that the coarticulatory effects of /v/ remain on adjacent vowels, even when there is no frication present. In effect, the segments become imperceptible but do not disappear entirely. We propose the following explanation for the elided forms presented in the introduction to this paper. As speech rate increases, most segments exhibit a reduction in duration. The existing literature on acoustic reduction in Russian identifies certain segments as weak, namely the reduced frication and duration of /v/ or the centralization and short duration of unstressed vowels. Since reduced segments already have lowered durations, the compressing effect that fast speech has on all segments more quickly leads to their imperceptibility either through the complete loss of frication (for /v/) or vocalization (for vowels). Additionally, the likelihood of a segment being reduced to zero increases in higher frequency words because overall word duration tends to decrease as word frequency increases. Consequently, the elided surface forms are realizations of high-frequency words with specific short segments that become imperceptible in rapid speech. Thus, Russian elision is an extreme on a spectrum of reduced segment productions, resulting from a set of uniform phonetic reduction processes combined with the effect of frequency.

7.1. LIMITATIONS. Well-documented, open-access speech corpora are essential for linguistic research. Large collections of data, especially those that are extensively annotated, become accessible sources for researchers across all disciplines. While written corpora are relatively common and somewhat accessible, there are currently no segmented accessible speech corpora for Russian spontaneous speech. The *Golos* corpus (Karpov et al. 2021) is difficult to find and navigate online, and its only annotation is orthographic transcription. While I am grateful for its relative accessibility, the abundance of manual segmentation necessary forcibly limited the scope of this project.

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