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ACOUSTIC CORRELATES OF WORD STRESS IN ENGLISH AND LATVIAN

VĀRDA UZSVARA AKUSTISKĀS ĪPAŠĪBAS ANGĻU UN LATVIEŠU VALODĀ

BACHELOR THESIS

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ABSTRACT

The thesis is an investigation in the area of acoustic correlates of word stress in English and Latvian; in particular, three acoustic correlates of word stress were researched in stressed and unstressed vowels: fundamental frequency, intensity and duration. The goal of the investigation was accomplished through (1) theoretical investigation: a review of academic literature on word stress and its acoustic correlates both as general concepts and as distinct phenomena in English and Latvian; (2) empirical investigation, comprising spectrographic, statistical and comparative analyses of the data obtained from audio recordings of native speakers of English and Latvian. The evidence found largely supports the hypothesis that word stress is expressed through different acoustic correlates to a differing degree, depending on its position in a word.

Keywords: acoustic phonetics, word stress, acoustic correlates, fundamental frequency, intensity, duration, spectrographic analysis.

ANOTĀCIJA

Šajā darbā tika pētītas vārda uzsvara akustiskās īpašības angļu un latviešu valodā. Sīkāka uzmanība pievērsta trim akustiskām īpašībām uzsvērtajos un neuzsvērtajos patskaņos: pamattoņa frekvencei, intensitātei un ilgumam. Pētījuma mērķis tika sasniegts, (1) analizējot teorētiskos materiālus par vārda uzsvaru un tā akustiskajām īpašībām kā vispārējām valodu parādībām un kā angļu un latviešu valodai raksturīgām parādībām; (2) veicot empīriskos pētījumus, proti, no angļu un latviešu runātāju ierakstu iegūto datu spektrogrammu analīzi, statistisko un salīdzinošo analīzi. Paveiktie pētījumi lielākoties pierādīja darbā izvirzīto hipotēzi: dažādām akustiskām īpašībām ir dažāda loma vārda uzsvara izpausmē, ko nosaka vārda uzsvara pozīcija vārdā.

Atslēgas vārdi: akustiskā fonētika, vārda uzsvars, akustiskās īpašības, pamattoņa frekvence, intensitāte, ilgums, spektrogrammu analīze.

CONTENTS

INTRODUCTION

Word stress is a linguistic phenomenon that serves a number of contrastive functions in many languages. It is a phenomenon of particular interest in phonetics, since word stress exhibits itself through prominence in sound articulation, in acoustic parameters ('acoustic correlates of word stress'), and in auditory perception. All three are subject to the discipline of phonetics. This study covers some of the acoustic correlates of primarily-stressed, secondarily-stressed and unstressed vowels in relation to word stress in English and Latvian.

The subject of this study is **significant**, since word stress is a pervasive suprasegmental phenomenon in both English and Latvian, and accumulating data and making conclusions on its acoustic correlates can provide a clearer picture of suprasegmental features in both the languages in general. The relevance of this study is particularly high for Latvian, which has not undergone a comprehensive study of acoustic correlates of word stress.

The **goal** of this investigation is to discover the correlation between word stress and three acoustic correlates (fundamental frequency, intensity, duration) in English and Latvian vowels.

In order to complete the goal, the following enabling **objectives** were set up and accomplished:

1) A review of academic sources was conducted to gather information on word stress in general, and on the acoustic correlates to be analysed (fundamental frequency, intensity, duration) in particular;
2) Furthermore, academic sources on English and Latvian phonetics were investigated for information on word stress, particularly its acoustic correlates in these languages;
3) Methodology was developed to obtain the sample of recordings, and extract and process acoustic data from them;
4) On the basis of the methodology developed, the obtained acoustic data were analysed in accordance with the set goal and hypothesis.

The study was conducted under the **hypothesis** that distinct acoustic correlates of vowels in relation to word stress are different in how much they contribute to the prominence created by word stress, and that the magnitude of this contribution depends on the position of word stress in a word, and is different in Latvian and English.

The **methods** employed in this investigation were:

1) The monographic method (a review and analysis of academic publications in acoustic phonetics);

2) The empirical methods (employed in experiment planning, and obtaining recordings from the informants);
3) The spectrographic and spectral analysis methods (extraction of data on acoustic correlates from recordings);
4) The statistical methods (used to calculate the central tendencies in the data, as well as their statistical significance).

The **data** were **collected** in two stages. First, the informants were asked to record their reading a word list and submit the recordings. Second, the recordings were cut into tokens (instances of pronunciation of each word), which were analysed with the use of automated pitch-tracking (to obtain fundamental frequency data points), intensity-tracking (intensity data points) tools, as well as with the use of spectrograms to ascertain the duration of vowels in the tokens.

The **sample** of the investigated data contains a total of 933 tokens obtained from 6 informants (3 per language), which yielded 5864 data points across all variables.

Chapter 1 makes a general description of word stress as a linguistic, phonological and phonetic phenomenon. Chapter 2 narrows the scope, focusing on the acoustic correlates of word stress that are investigated in this study. Chapters 3 and 4 provide a language-specific description (with the focus on the relevant acoustic data) of word stress in English and Latvian, respectively. Chapter 5 comprises the entirety of the empirical investigation: methodology employed, presentation of the obtained acoustic data, discussion.

General information on word stress, and acoustic parameters that correlate with it was found to a large degree in Laver (1994), Reetz and Jongman (2009), Lehiste (1970), Collins and Mees (2003). Data on word stress in English was collected primarily from Fry (1956), Lehiste (1970), Ladefoged and Johnson (2010); data on word stress in Latvian was supplied by Liepa (1979), Laua (1997), Grigorjevs (2008). The employed methods and analyses were constructed with the help of techniques described in Ladefoged (2003) and Fulop (2011).

1. NATURE OF WORD STRESS

In order to delineate the general area of research, it is necessary to make a theory-based description of the phenomenon to be investigated and its features. This chapter covers the basics of what word stress is, its relation to the concept of the syllable, its functions and its types.

1.1 Definition of word stress

Stress in general is considered by various scholars to be a feature of the syllable to attain relative prominence in comparison to other syllables (e.g. Reetz, Jongman, 2009:210; Ladefoged, Johnson, 2010:249). Since stress influences only the phonological structures larger than distinct segments, it is a suprasegmental phenomenon (Collins, Mees, 2003:109).

Word stress must be distinguished from another type of stress: sentence stress (ibid.). Word stress is 'a defining property of [a] word', the one that requires a certain syllable of the word to be stressed (Laver, 1994:511). Sentence stress, on the other hand, is additional stress that is superimposed over the stressed syllable of a word to ensure that it is the most prominent word in a sentence (ibid.:514). Thus, word stress is a feature that affects only the word in question and has little influence over a sentence (or an utterance) in general. Because word stress is the only phenomenon of the two investigated in this paper, sentence stress will not be considered in detail further, and will moreover be considered a confounding variable in the empirical analysis.

From the purely phonetic point of view, stress is a phenomenon that is achieved through 'greater physical effort [...] reflected in an increase in activity of the laryngeal muscles [and] an increase in subglottal air pressure' (Reetz, Jongman, 2009:211). The hightened subglottal pressure, in turn, means that more air is expelled from the vocal tract, which causes 'increases in the perceptual salience of segments' (Ladefoged, Johnson, 2010:250).

Since producing word stress requires a change in the articulation of sounds, particularly an increase in muscular tension and subglottal pressure (Laver, 1994:513), it is expected that there is an acoustic effect of this change. Five acoustic correlates are described to accompany word stress: (1) greater intensity, or loudness; (2) changes in F0, or pitch; (3) longer duration; (4) changes in vowel quality (i.e. the formant frequency pattern); (5) changes in the spectral tilt, as 'the amount of high-frequency energy [increases] in relation to the low frequency energy' (Ladefoged, Johnson, 2010:250), (Collins, Mees, 2003; 110-111; Roach, 2000:94-95). These acoustic phenomena are the main object of this investigation, and a more detailed treatment of each of them is done in Chapter 2.

1.2 Word stress and syllable

The previous section has established the suprasegmental nature of stress; particularly, its effect on entire syllables, and not separate sounds. Therefore, it seems necessary to make a brief outline of what a syllable is, its structure, and its relevance to investigating word stress.

A phonetic definition of the syllable appears to be elusive, and there are conflicting theories explaining the nature of the syllable in terms of acoustic phenomena and articulatory gestures: (1) sonority theory (Ladefoged, Johnson, 2010:245) suggests that all speech sounds have a different degree of sonority, and the syllable is formed by speech sounds with greatest sonority (such as vowels and sonorant consonants), with those with less sonority attaching to them; (2) prominence theory (ibid.:247) expands this view, by adding the notions of 'stress, length and pitch' (ibid.) as defining a speech sound as a syllable centre.

Phonologically, a syllable can be described as 'the smallest possible unit of speech' (ibid.:248).

A syllable is separated into a number of elements (ibid.; Collins, Mees, 2003:71-72). First, it can be divided into an onset and a rhyme. Second, the rhyme is further subdivided into a nucleus and a coda. The only element that is required in a syllable is the nucleus (Reetz, Jongman, 2009:208), which represents the most sonorous element of the syllable. The onset and the coda stand for the consonants that come before and after the nucleus, respectively (ibid.:209).

With respect to investigating word stress, the syllable structure with a vocalic nucleus in its centre suggests that particular attention must be paid to the nucleus, as being the the most sonorous element in the syllable, it is likely to bear the most of the prominence created by stress.

1.3 Degrees and placement of word stress

Regarding the degrees of stress, Laver (1994) suggests a 3-level distinction: 'primary stress, secondary stress, unstressed' (ibid.:516) and notes that the introduction of 'secondary stress' was initially made due to the 'graded differences of prominence that characterize individual syllables in words in English, such as [ˌrezɪgˈneɪʃn̩], [ˌsɪstəˈmætɪk]'. Furthermore, an even greater number of degrees of stress can be distinguished, as exemplified by Roach (2000:96), who shows that different unstressed vowels in English have a different degree of prominence, and the first syllable in [pəʊˈetɪk] is thus more prominent than that of [pəˈθetɪk].

The placement of word stress in a language can be fixed (i.e. always placed on the same syllable) or variable (with little to no constraints to stress placement). Laver (1994:518-522) reports on a study of 444 languages, of which the majority (306) turned out to show a predominantly fixed stressed pattern (with most of such languages demonstrating words stress fixed either on the first, or the last syllable), Tartar (final), Polish and Swahili (penultimate) are cited as fixed-stress languages. Among the variable-stress languages Laver puts English, Dutch, Russian, Greek.

Chapter 1, thus, reviews the most salient features of word stress: first, its definition, and its function as a source of prominence within a word; second, its relation to the syllable; finally, the different degrees of word stress, and the variety and the tendencies of its placement in world languages.

2. ACOUSTIC CORELATES OF STRESS

As described in Section 1.1 (p.3), stress has been found to be expressed acoustically through 5 correlates: fundamental frequency, intensity, duration, vowel quality and spectral tilt. Since this research is focused on the first three correlates, each of them receives a detailed description in the following sections.

2.1 Fundamental frequency

Fundamental frequency is described to be the sound frequency that corresponds to 'the rate of vibration of the vocal folds during the voicing of segments' (Laver, 1994:450). From the viewpoint of perception of speech, fundamental frequency is represented by the pitch of voice (ibid.). Thus, one can conclude that the fundamental frequency can be traced only in voiced sounds (since in voiceless sounds there is no work of the vocal folds), and that it is controlled by how fast or in what ways the vocal folds repeatedly open and close. The ability of the human ear to discern different sound frequencies is 'of the order of +/-1 Hz' (ibid.:451) within the 80-160 Hz range, which is particularly important for the perception of changes in fundamental frequency (see Section 2.1.1 (p.6)).

The function of fundamental frequency that is most relevant to this study, is, obviously, its occurrence as a feature of lexical stress. 'If one syllable [...] is said with a pitch that is noticeably different [i.e. higher, or lower] from that of the others, this will have a strong tendency to produce the effect of prominence.' (Roach, 2000:94). In (Collins, Mees, 2003:111), stressed syllables are said to exhibit a 'marked change in pitch'.

Additionally, changes in pitch are used for contrastive purposes in tone languages (with word-based tones, such as Swedish, and syllable-based tones, as in Mandarin and Thai (Laver, 1994:462-468)); the pitch is the tool of intonation, as 'as significant melodic patterns of pitch-movement are distributed over units larger than a single word' (ibid.:483).

2.1.1 Factors affecting fundamental frequency

The fundamental frequency of speech sounds can be influenced by a number of various phenomena: first, it is the sex- and age-dependent characteristics of the vocal apparatus; second, it is the intonational patterns of speech; third, it is the phenomenon of intrinsic fundamental frequency.

It is common knowledge that the range of the pitch of voice varies from person to person with men typically taking up the comparatively lower range, women -- the intermediate range, and children -- the highest range (Fry, 1979:68); with the average fundamental frequency being 120 Hz for men, 225 Hz for women and 265 Hz for children (Byrd, Mintz, 2010:55). The reported maximum speaking ranges vary, with Laver (1994:451) citing 50-250 Hz for men and 120-480 Hz for women, while in (Lieberman, Blumstein, 1988:36) men are said to phonate at 80-300 Hz, with the fundamental frequencies of women and children ranging up to 500 Hz.

As mentioned in Sections 1.1 and 2.1 (p. 3 and 5), intonation is a phenomenon that makes an extensive use of pitch (in fact, being defined by its change), producing a large variety of language-specific shifts in the fundamental frequency, such as falls, rises, rise-fall-rises, and so on (Laver, 1994:461), while at the same time intonation is completely independent of word stress. However, according to Reetz and Jongman (2009:224), 'as soon as the domain of investigation is larger than a single word, cues to stress, tone, and intonation begin to interact'. Due to the fact that the scope of this investigation is limited to single words and word stress, which rarely leaves the confines of the word it belongs to, intonation will be a phenomenon to be avoided or minimised in the empirical study.

Intrinsic fundamental frequency is a phenomenon that has been discovered in the fundamental frequency of different vowel sounds: each vowel sound in a language tends to be pronounced at a different fundamental frequency than the rest (with higher vowels having a higher pitch than the lower vowels), regardless of the suprasegmental influences, such as intonation (Reetz, Jongman, 2009:218). Laver (1994:454-455) reports that the difference in the average pitch of vowels due to their intrinsic fundamental frequency can be as big as 25 Hz (a difference that is well within the sensitivity range of the human ear), and -- on the basis of previous research on the basis of world languages -- makes the conclusion that this

phenomenon is likely to be language universal. Furthermore, an example from a study on American English is provided (ibid.) with [i], [ɪ], [e], [æ] reported to have the average frequency of 183, 173, 166 and 162 Hz, respectively.

There are a number of theories that explain what causes this phenomenon: (1) peculiarities of human anatomy, with higher muscular tension in the tongue possibly leading to higher muscular tension in the larynx, and, alternatively, a presumed mechanical connection which causes the raising of the larynx due to the raising of the tongue; (2) Bernoulli effect in high vowels due to the narrowing of the vocal tract and the lowering of air pressure; (3) speaker control, with the differences in the fundamental frequency increasing the contrasts among the vowels. (Reetz, Jongman, 2009:218)

Since the possible influence of intrinsic fundamental frequency on pitch is considerable, the awareness of it is necessary in this study, particularly in the cases wherein the effects of word-stress on fundamental frequency in different words (and different vowel sounds) are compared, as well as in any statistical analyses that involve words with different vowels.

Finally, Lehiste (1970:71-75) describes a cross-linguistic phenomenon, according to which the fundamental frequency of a vowel is influenced by the voicing of the preceding consonant. It can be exemplified by the fundamental frequency of [i] and [æ] after [p] and [b]: Lehiste reports that the mean fundamental frequency of [i] after [p] was 182 Hz, and after [b] — 178 Hz; for [æ] the effect was even larger, 170 Hz after [p] and 152 Hz after [b]; thus, it is large enough to counterbalance the intrinsic fundamental frequency of the vowel (ibid.:71). Consonant voicing is the key parameter that produces this effect, with such features as the place of articulation and nasality having little or no influence over it.

2.2 Duration

Duration is defined as 'the amount of time taken up by a speech event, usually expressed in thousands of a second' (Laver, 1994:431). While the duration of most segments is within the 30-300 msec, the minimal, just noticeable difference in duration between two segments is 10-40 msec (Lehiste, 1970:13).

Duration is described to be a critical feature to the perception of stress and that it may override the effect of loudness in stress for some languages (ibid.:126, for English). Otherwise, varying stress duration is typically used for phonological contrast (Laver, 1994:436. Laver cites Italian and Hungarian as examples of languages using consonant duration, Japanese and

Sinhalese — vowel duration, and Swedish and Finnish — both vowel and consonant duration for contrastive purposes).

2.2.1 Factors affecting duration

Apart from the influence of stress (asserted in, for example, (Collins, Mees, 2003:110; Roach, 2000:94) for English, and in (Liepa, 1979:12) for Latvian) the following factors affecting segment duration deemed to have some relevance to this study have been found: polysyllabic shortening, intrinsic vowel duration, speaking rate.

Polysyllabic shortening is the decrease in the duration of syllabic segments (i.e. vowels and syllabic consonants), caused by the elevated number of syllables in a word (Reetz, Jongman, 2009:217): the diminished duration of the [u] sound in 'fruitier' as compared to 'fruity' and, furthermore, 'fruit' is cited as an example of this phenomenon.

Different vowel sounds exhibit intrinsic duration, with open vowels being 20-25 msec longer than close vowels (ibid.:215). The size of the effect of vowel height on duration makes it thus perceptible to the human ear. The existence of this phenomenon in various languages suggests that it is language-universal, and the increased duration of open vowels is typically explained by the fact that these speech sounds require longer articulatory movements (ibid.).

Speaking rate is a global parameter, and is 'the rate of speech of the whole speaking turn' (Laver, 1994:158). Largely dependent on the speaker and the speaking environment, it has been found to be language-dependent, with Laver (ibid.:541-542) citing English speakers to have the rates in the range of 4.4-5.9 syllables per second, Spanish and Arabic -- between 4.6 and 7.0 syll/sec, and Dutch 5.5-9.3.

2.3 Intensity

Intensity is represented acoustically by amplitude, which is the parameter of a sound wave that represents the degree of deviation in air (in the case of human speech) pressure that is caused by the oscillations of the sound wave (Lieberman, Blumstein, 1988:20,27). From the viewpoint of perception of speech, amplitude is used to represent the sensation of loudness, the degree of which is commonly measured on the bel logarithmic scale based on the ratio between the measured sound pressure and a certain reference pressure value, which is usually taken to be 20 μPa (the lowest audible pressure fluctuation) (Johnson, 2003:47-50). The lowest average audible difference in intensity between two sounds is reported to be 1 dB (corresponding to a triplication in sound pressure) (Fry, 1979:92-92).

According to Laver (1994:505-506) intensity has few linguistic functions, and is 'exploited by linguistic communication to a much smaller degree than pitch'. Relegating its purpose mainly to paralinguistic ends (such as expressing emotion and competitiveness), Laver (ibid.) suggests two main linguistic functions of intensity: (1) the correlation of intensity and pitch in intonation in many languages (including English) that use it (e.g. used to mark the beginning of a new topic within an utterance (ibid.)); (2) more relevantly, the function of intensity as one of the acoustic correlates of stress. Several authors (e.g. Roach, 2000:94; Lehiste, 1970:113-119; Ladefoged, Johnson, 2010:111-112) concede that intensity often appears superficially to be the main or the only parameter that defines stress, although the evidence demonstrates that it is neither the only one (as shown above), nor a necessary feature of stress.

Similarly to fundamental frequency and duration, there is the intrinsic intensity phenomenon described for speech sounds. Lehiste (1970:120-122) reports on the studies that showed an average difference of up to 4-5 db between different vowel sounds in American English, and 6-7 dB in Hungarian. Fry (1979:117,127) observes that close vowels tend to be less loud than open vowels, and compares the intensity of vowel and consonant sounds in English, with the average gap in intensity being as high as 22 db (between [o:] and [f]).

Thus, Chapter 2 provides a detailed description of each of the acoustic correlates associated with lexical stress and investigated in this work, i.e. fundamental frequency, duration and intensity, and establishes that all of them have linguistic functions beyond marking the prominence of word stress (e.g. phonological contrast for duration and intonation for fundamental frequency). Furthermore, for each correlate, a number of phenomena, other than word stress, have been found that influence the respective fundamental frequency, duration and intensity of segments (such as the intrinsic values of these correlates of different vowels and consonants).

All of the reviewed factors influencing acoustic correlates of word stress have the potential to introduce error in an analysis that is focused on word stress and involves words with different numbers of syllables, stimuli based on different vowel sounds, and recordings of different native speakers. Therefore, a probable influence of these phenomena must be considered and, if possible, minimised when constructing the experiment and conducting the analysis of its results.

3. WORD STRESS IN ENGLISH

Since investigating the acoustic correlates of word stress in English is one of the goals of this paper, it is necessary to examine information on them provided in academic sources. Additionally, making an outline of the role and nature of word stress in English phonetics is necessary in order to construct a more precise and comprehensive experiment on its acoustic correlates. Therefore, the first section of this chapter includes general information about word stress in English: its function, tendencies in its distribution in polysyllabic words, different degrees. The second section covers information on previous research in the acoustic correlates of word stress, particularly fundamental frequency, intensity and duration, and magnitude of the effect of each feature on the perception of word stress.

3.1 A general description of word stress in English

The distribution of word stress in English is summarised by Gimson (1989:223), who considers it to be fixed 'in the sense that the main accent always falls on a particular syllable of any given word [with certain suprasegmentally caused exceptions]', and free 'in the sense that it is not tied to any particular situation in the chain of syllables constituting a word' (ibid.). Thus, while typically invariable within a particular word, word stress in English is not fixed if all words are taken into account.

Despite the absence of strict rules governing the placement of word stress in English, there are limitations to the positions that word stress can take, as well as certain patterns that can be discerned in its placement on the basis of word class, morphology, origin and meaning.

The limitations of the placement of word stress in English words concern the final and medial syllable positions. No word that comprises more than 4 syllables has been found to have stress on the final syllable, even though words of 4 syllables and shorter permit any word stress position (['kaʊədlɪnəs], [ə'nju:məreɪt], [ʌnɪm'pɔ:tənt], [mɪsˌreprə'zent], Gimson, 1989:229-230). Furthermore, if primary stress is on the third syllable, the first syllable must take secondary stress ([ˌentə'teɪn], [ˌʌndə'stænd]), and if primary stress is on the fourth, fifth and further syllables, secondary stress is placed two or three syllables before it ([əˌfɪlɪ'eɪʃn̩] (2), [pəˌsɒnɪfɪ'keɪʃn̩] (3)) (ibid.).

The patterns of distribution of word stress are a complex and extensive field that will only receive limited attention in this chapter. Roach (2000:97) distinguishes a set of points that need to be considered in placing word stress: (1) the morphological structure of the word: whether it is simple or compound, affixed, or not; (2) the word class that the word belongs to;

(3) the number of syllables, and (4) the phonological structure of the syllables. Roach further cites the separation of all syllables in English according to their phonological structure into strong and weak, strong syllables being the ones that (1) contain a long vowel or a diphthong, regardless of syllable coda ([haɪt, siː]), or (2) contain a short syllable and have a coda ([pʊl, bæt]); weak syllables are those that have [ɪ,ʊ] without coda (['leɪzɪ, 'ɪnflʊəns]), and [ə], regardless of coda (['draɪvə]); additionally, syllables with syllabic consonants as peaks are considered weak (['sʌdn̩]). While strong syllables are also able to occur in an unstressed position, only strong syllables can be stressed (ibid.). The patterns based on this approach are the following (all based on (Roach, 2000:97-100,103-107)):

(a) for two-syllable words, verbs and adjectives (and most other classses), the first syllable is stressed if the second is weak: ['əʊpn̩], ['iːvn̩], the second syllable is stressed if it is strong: [kə'rekt], [meɪn'teɪn]. However, for nouns the word stress is always on the first syllable, unless it is weak and the second is strong: ['prəʊdəkt], ['hʌnɪ], but [bə'luːn].

(b) for three-syllable simple words, verbs tend to be stressed on the final syllable if it is strong ([ˌentə'teɪn], with a secondary stress on the first syllable, as established above), if the final syllable is weak, then the word stress is on the penultimate ([dɪ'tɜːmɪn]), and if they both are weak — on the antepenultimate (['mɒnɪtə]). Nouns and adjectives seem to produce a partly opposite tendency, with the first syllable being stressed if it is strong (['ɒpətjuːn], ['empərə]), but if it is weak, the second syllable is stressed ([sɪ'nɒpsɪs]).

(c) patterns of word-stress in affixed and compound words are far more complex than those of the above two groups, and a detailed account of them would be too large and excessive for the purposes of this study. Therefore, only a few relevant points are provided: first, affixes can have different effect on the stress pattern of the stem, they can take the primary stress (such as '-ee' in [ˌemplɔɪ'iː] and 'semi-' in ['semiˌsɜːkl̩]); they can remain unstressed, but cause a stress shift in the stem (e.g. ['mægnɪt] > [məg'netɪk]); they can have no influence on word stress (['maːkɪt] > ['maːkətɪŋ]); second, the placement of primary stress in compounds depends on the word class of their constituent stems, with noun-noun compounds typically stressed on the first stem (['tiːkʌp], ['stɒpˌwɒtʃ]); compound words in which the second element receives the primary stress are typically those that

function as adverbs ([ˌdaʊnˈstriːm]), those that function as verbs and have an adverb as the first element ([ˌdaʊnˈgreɪd]), those in which the first element is a numeral ([ˌsekn̩ˈhænd]), and those that are formed with an adjective and an '-ed' form of a verb (ˌheviˈhændɪd).

The earliest source found to discuss the notion of degree of word stress in English is Jones (1909), who distinguishes 'many degrees of stress' (ibid.:57), providing the word 'opportunity' [ˌɒpəˈtjuːnɪti] as an example. Each syllable in it is given a number from 1 to 5, with 1 representing the strongest stress level, and 5 as the weakest, producing the following: "opp2-or4-tu1-ni5-ty3". Jones essentially views stress as a scale (this is confirmed by his definition of stress: 'the force of breath with which a syllable is pronounced' (ibid.)), and not as a discrete variable with firmly defined levels that does not allow variation. However, he notes that for practical purposes it is sufficient to distinguish the categories of stressed and unstressed syllables only (with only the third syllable cites as being 'stressed' in 'opportunity' [ˌɒpəˈtjuːnɪti] (ibid.)).

More modern sources show similarities to Jones' views, with some differences. The degree of word stress is asserted to represent a relative prominence, e.g. Carr (1999:87) provides the word 'kangaroo' [ˈkæŋgəˌruː] as an example: the first syllable is said to have more stress than the second, and the third — more than the first. At the same time, the descriptions of the degrees of word stress draw a division between unstressed and stressed syllables, with only the latter described as exhibiting different levels of prominence. Roach (2000:95-96) describes (as opposed to primary) secondary stress as that which 'is weaker than primary stress, but stronger than [that of the unstressed syllables]'. Secondary stress is commonly mentioned by other scholars (e.g. Carr (1999), Collins, Mees (2003), and others).

It can be said each polysyllabic word in English has word stress, and along with a certain set of constituent phonemes, word stress creates an 'additional identity' to these words (Gimson, 1989:223). However, word stress has only a limited set of contrastive functions in English. First, there is a set of simple words in which word stress defines their word class: for example, 'insult' as a noun, and 'insult' as a verb are distinguished by the placement of primary stress on the first syllable in the former case, and on the second syllable -- in the latter; further examples of the same phenomenon, among others, are [ˈəʊvəˌfləʊ] (n) and [ˌəʊvəˈfləʊ] (v), [ˈɪnˌkriːs] (n) and [ˌɪnˈkriːs] (Ladefoged, Johnson, 2010:112). Second, compound words exhibit a similar pattern, in which the noun has the primary stress on the first syllable, while

the corresponding verb has word stress on both parts of the compound: ['pʊʃˌəʊvə] 'a pushover', [ˈpʊʃˈəʊvə] 'to push over'; ['wɔːkaʊt] 'a walkout', ['wɔːkaʊt] 'to walk out' (ibid.).

3.2 Acoustic correlates of word stress in English

According to Reetz and Jongman (2009:211), 'a stressed syllable in English typically has a higher fundamental frequency, greater duration, greater intensity and a less reduced ("schwa-like") quality. Stressed syllables may be characterized by any one or more of these correlates.' The same set of acoustic correlates is attributed to English word stress by Cutler (2012:230): 'The [investigated] stressed syllables were longer, they were louder, they had higher fundamental frequency, and their vowels were less likely to be centralised'. Therefore, this section covers the presence, degree and importance of changes in duration, intensity and fundamental frequency in word stress in English. Since vowel quality change is not subject to this study, it receives cursory attention here.

Duration as an acoustic correlate of stress was described in a pioneering study by Fry (1955), who based his study on a small number of such word pairs as ['pɜːmɪt] and [pəˈmɪt] (see Section 3.1, p. 10). The difference in the duration of the first syllable, stressed and unstressed, proved to be considerable, though varied: as high as 2.66:1 in the ['ɒbdʒəkt]–[əbˈdʒekt] pair and 2.19:1 in the ['pɜːmɪt]– [pəˈmɪt] pair, and as low as 1.34:1 for the ['daɪdʒəst]–[daɪˈdʒest] pair (Fry, 1955:768). Additionally, Fry conducted a perception experiment on the basis of the duration ratio between the first and the second vowels of a disyllabic word, which showed a precipitously increasing recognition of the first syllable as stressed with the increase of the ratio (20% at 0.8:1, 40% at 1:1, 80% at 1.67:1) (ibid.:767), which demonstrates the high value of duration in the perception of word stress. With respect to the duration differences between syllables under primary and secondary stress, Mattys (2000:258-259) reports that duration is higher for the first syllable in word pairs like ['prɒsəˌkjuːtə]–[ˌprɒsəˈkjuːʃn̩], with the mean primary-to-secondary duration ratio of 1.19:1.

The correlation of word stress and intensity in English was also investigated by Fry (1955), who measured the peak intensity in the vowels investigated, demonstrating a correlation between the presence of word stress and increased intensity (which was weaker, however, than that between word stress and duration). The range of the increase in intensity was comparatively wide, with the intensity ratio between stressed and unstressed vowels of

2.04:1 in the ['ɒbdʒəkt]–[əb'dʒekt] pair, 1.72 in the ['pɜːmɪt]– [pə'mɪt] pair, 1.17 in the ['daɪdʒəst]–[daɪ'dʒest] pair. The gradual increase of the intensity of the first vowel in a disyllabic word somewhat increased its recorgnition as stressed: 63% at 0 dB, 68% at +5 dB, 74% at +10 dB (ibid.:765-768). Mattys (2000:259) reports a small mean difference in the intensity of syllables under primary and secondary stress (in such words as ['prɒsəˌkjuːtə]–[ˌprɒsə'kjuːʃn̩]): with the primary-to-secondary ratio of only 1.03:1 (1.8 dB). He concludes that intensity is not a significant cue in discerning primary and secondary stress.

Fundamental frequency appears to have a slightly different relation to word stress than duration and intensity, since its influence on the perception of word stress depends not on the degree of change in fundamental frequency in a stressed syllable, but rather on the presence of such change in it (Lehiste, 1970:127). The degree of change in fundamental frequency chiefly influences the following syllables (Collins, Mees, 2003:111). A somewhat significant difference in fundamental frequency between primary- and secondary-stressed initial syllables was found by Mattys (2000:259), with a primary-to-secondary ratio (as in ['prɒsəˌkjuːtə]–[ˌprɒsə'kjuːʃn̩]) of 1.07:1.

According to Plag et al.(2011:371), the position of word stress within the word significantly influences the fundamental frequency and intensity, but not the duration of the stressed syllable. The initially-stressed syllables show considerable differences in fundamental frequency and intensity when compared to the following unstressed syllables. The finally-stressed syllables show much smaller (yet still significant) differences (ibid.)

Finally, although there apparently is an order in how strongly the reviewed acoustic correlates produce the prominence of word stress (e.g. the higher influence of duration over intensity found by Fry (1955)), Cutler (2012:232) reports on studies that demonstrate the priority of vowel quality (i.e. the F1, F2 and F3 pattern) change in the perception of words stress.

Thus, the fundamental frequency, intensity and duration are acoustic correlates of word stress in English, even though their influence is not equal, with reports of greater correlation of duration than intensity with word stress, and a high influence of position in how fundamental frequency correlates with it.

4. WORD STRESS IN LATVIAN

In similarity to Chapter 3, this chapter comprises a description of both general and acoustic correlates of word stress in Latvian. While the former provides a firmer foundation for the construction of the empirical investigation of word stress in Latvian, the latter acts as a reference point in the analysis of the experimental results. Thus, the first section of this chapter includes general information about word stress in Latvian: tendencies in its distribution in polysyllabic words, the presence and distribution of different degrees of word stress. The second section covers the information on previous research in the acoustic correlates of word stress, particularly fundamental frequency, intensity and duration, and magnitude of the effect of each feature on the perception of word stress. The existence of syllable tones in Latvian is seen as a phenomenon that can influence the results of an empirical investigation of word stress, and, therefore, a brief account of it is provided as well.

4.1 A general description of word stress in Latvian

Word stress in polysyllabic words in Latvian is fixed on the first syllable (Laua, 1997:108). Despite this, there are certain, well-defined groups of words that do not follow this, almost universal, rule, and permit word stress, on the second, third and fourth syllable (ibid.). Among these words are the following: (1) these are superlative forms of adjectives and adverbs ([visˈlæːnaːk]); (2) some words, primarily numerals, with the 'pus-' prefix ([pusˈdivi]); (3) pronouns and adverbs with the 'ik-' and 'ne-' prefixes ([neˈkas], [ikˈreiz]); (4) some adverbs formed with a prefix attached to a non-nominative case form of a word ([paˈvisam]); (5) compound words used as greetings ([labˈriːt]); (6) indeclinable borrowings, particularly proper nouns ([espeˈrantɔː], [nagaˈsaki]); (7) there are certain words with non-initial stress that do not fit into any of the above categories ([vienˈalga], [taːˈpat], [turˈpretim]). (ibid.:108-109; Muižniece, 2002:73-74)

With respect to the degree of word stress, apart from primary stress, Laua (1997:110) also points out the existence of secondary (or 'auxiliary') stress and defines it simply as 'word stress that is weaker than primary stress'. In an analysis of polysyllabic words, Brēde (2003:76) finds and distinguishes three degrees of word stress: along with primary stress, there are two subtypes of secondary stress, 'auxiliary' and 'weak auxiliary' stress (for consistency, they will be called, respectively, 'secondary' and 'tertiary' further on). Unlike primary stress, the latter

two types demonstrate a considerable degree of positional variability, which depends on the number of syllables in the word, its morphological and phonological structure (ibid.:76-81).

Although in the reviewed publications the structure of non-primary stress has been described for words comprising as many as ten syllables, this level of comprehensiveness is deemed excessive for the purposes of this work, and this subsection will only exemplify the occurrence of secondary and tertiary stress in three-, four- and five-syllable words (the following points are based on (Brēde, 2003:76-81); all examples assume the placement of the primary stress on the first syllable).

1) Three-syllable words tend to exhibit one secondary or tertiary stress on the final syllable: if it contains a long monophthong or a diphthong, it receives secondary stress (['ɑbɑˌʒuːrs]), if it contains a short monophthong — tertiary stress (['ɑfo.risms]). There are exceptions to these rules, e.g. ['briːnumˌdarps].

2) Four-syllable words usually receive non-primary stress on the third syllable, maintaining the alternation of stressed and unstressed syllables (['ɑbsɔˌluːti]). There are exceptions to this rule with non-primary stress on the second or the fourth syllable (['aizkaitiˌnɑːt]) as well as with secondary and tertiary stress on the third and the fourth syllable (['ilgspeːˌleː.juoʃː]). In all these situations, syllables with long vowels and diphthongs take secondary stress, and with monophthongs — tertiary stress.

3) Five-syllable words typically receive non-primary stress on the fourth syllable (['ɑdvɔkɑˌtuːrɑ]), with a tertiary stress on the second syllable if the word has a prefix (['nuo.tsieti,nɑːjums]). Secondary stress is often placed on the third syllable in compound words, if the second element starts with the third syllable (['blɑkusˌrezul.tɑːts]). There are also affixed and compound words with a long monophthong and secondary stress on the final syllable, with a tertiary stress on the penultimate syllable (['eksperi,menˌtɑːls]). In other cases, secondary stress tends to fall on the third syllable if it has a long monophthong, or a diphthong, with tertiary stress on one of the final syllables (['aizkaˌveːʃɑ.nɑs]).

4.2 Acoustic correlates of word stress in Latvian

Little information has been found on the acoustic means that convey word stress in Latvian. Although intensity, duration, and fundamental frequency are described to constitute the set of acoustic correlates of word stress (Liepa, 1979:19), the correlate that receives the most

attention is duration; intensity, while commonly attributed to word stress in academic sources, does not receive a thorough account that would include an analysis of physical measurements. No direct information on the influence of fundamental frequency on word stress has been found, but this section provides certain data on the fundamental frequency of Latvian speech sounds that are considered instrumental in the empirical analysis described in further chapters.

Since vowel quantity is a feature employed for phonological contrast in Latvian, both short and long vowels must be considered in separation. According to data presented by (Grigorjevs, 2008:34) there is a considerable difference in average vowel duration depending on what class the vowel belongs to (the data were based on the investigation of monosyllabic nonsense words): for example, [iː] exhibits the duration of 458-487 ms, while [i] is considerably shorter with 207-224 ms, which means that the long vowel is 2.17-2.21 times longer than the short one. Similar contrast in quantity is demonstrated for other long/short vowel pairs as well (e.g. 1.94-2.31 for [eː] and [e], 1.94-2.19 for [aː] and [a] (ibid.:34-35)).

Whether stressed or unstressed, short and long vowels appear to behave differently: short stressed vowels are 1.1-1.9 (typically, around 1.5) longer than unstressed short vowels; at the same time, long stressed vowels are reported to differ little in quantity from their unstressed counterparts, showing only a 1.1-1.2 times' increase in duration (Liepa, 1979:19). For example, the ratio between the first (stressed) and the second (unstressed) vowel in ‘panna’ is 1.6:1, in ‘elle’ — 1.8:1, in ‘mirklis’ — 1.1:1 (Liepa demonstrates that for at least one of his informants this ratio can be as high as 3.8:1 in ‘spirgti’ (ibid.:31)); the difference in duration between the long vowels was reported to be, on average, 1.05 in ‘kājā’, 1.1:1 in ‘'sēnē’ ‘pīķī’. Higher ratios between certain stressed and unstressed long vowels were found in words with more syllables: on average, 1.4-1.55 for [iː] in ‘tīrība’, ‘vīrišķība’; however, other vowels do not exhibit different ratios, e.g. 1.05-1.1 for [eː] in ‘vēlēju’, ‘vērtējumā’. (ibid.:48-54, 219-221) Difference in syllable tone does not appear to significantly influence the ratio between stressed and unstressed vowels (ibid.:54-60). Finally, Liepa explains the fact that short vowels gain much more duration when stressed than long vowels by assuming that in long vowels prominence is achieved primarily through an increase in intensity and fundamental frequency modulations, and not duration (ibid.:19-20).

According to a number of authors, intensity change is an acoustic correlate of stress in Latvian and it is the decisive one, making word stress dynamic (Endzelīns, 1938:16, Laua, 1997:108; Brēde, 2003:73). Unfortunately, none of the sources found provide numerical data comparable to those found on duration.

Fundamental frequency is described to be an acoustic correlate of word stress (Liepa, 1979:19); however, there appears to be no data on how it differs in stressed and unstressed syllables. The only partly relevant information on fundamental frequency has been found in the aforementioned investigation of Latvian vowels by Grigorjevs (2008), who includes the average fundamental frequencies for all Latvian vowels (ibid.:34). Since, as mentioned above, this investigation was conducted on monosyllabic words these data can be used as a reference for the findings on the fundamental frequency of monosyllabic words, as well as to some extent — of stressed syllables in polysyllabic words. Table 4.1 contains the data on fundamental frequency based on Grigorjevs' results (ibid.:34-35).

Table 4.1 **Recorded fundamental frequencies of the Latvian vowels**

	m	SD	f	SD
i:	117	11	223	29
i	128	7	226	25
e:	114	14	217	26
e	118	9	221	27
ae:	113	16	215	27
ae	111	9	218	32
a:	110	12	211	25
a	108	9	218	30
o:	112	11	214	26
o	112	10	216	33
u:	120	10	213	28
u	120	8	215	27

4.3 Pitch accent in Latvian

The phenomenon of pitch accent is a distinctive feature of Latvian phonetics, which affects vowels and sonorants, and occurs in syllables with long monophthongs, diphthongs and short monophthongs followed by a sonorant (Laua, 1997:103). Three types of pitch accent can be distinguished in Standard Latvian, according to the influence of each type on the fundamental frequecy and intensity of the corresponding sounds.

1) Level accent is characterised by no change or a slight gradual increase in fundamental frequency. Intensity shows a slight increase in the beginning of the sound and a slight decrease by its end (mãsa, lãime, mãnta). (ibid.:104-105)

2) Falling accent exhibits a sharp decrease in fundamental frequency. The shift in intensity is the same as for the level accent (brìdis, gàiss, tùmšs). (ibid.:105)

3) Broken accent shows an initial increase in fundamental frequency, which can be followed by a fall, a lack of change, or by a further increase. Intensity increases in the beginning, then rapidly falls, then inreases again (kâpt, gâilis, cêlms). (ibid.)

The presence or absence of pitch accent does not depend on the stress level.

Thus, the theoretical investigation shows that word stress is a linguistic phenomenon with considerable variety of features, such as degree, position and distribution. A number of acoustic parameters are distinguished as correlating with word stress. The review of sources on word stress in English and Latvian has shown considerable differences in the distribution of word stress, although both languages distinguish a number of basic degrees of word stress. Furthermore, word stress in both languages is described to exhibit itself through duration and intensity in both languages, while fundamental frequency is described as a correlate only for English.

5. RESULTS OF THE EMPIRICAL INVESTIGATION

This chapter covers the entirety of the empirical investigation conducted for this paper, and comprises four sections: a description of the methodology employed at each stage of the investigation; the findings from the English recordings based on the methodology; the findings from the Latvian recordings based on the methodology; finally, a discussion of the findings and a comparison of acoustic correlates of vowels in relation to word stress in English and Latvian.

5.1 Methods employed

The empirical investigation was conducted using two methods: quantitative analysis of the recordings of native speakers' speech, and statistical analysis of the raw data obtained. In general terms, the investigation can be described as a succession of the following tasks accomplished: (1) specific texts, namely word lists, were created on the basis of English and Latvian words to provide the source material for recording; (2) native speakers (3 per language) were recruited as informants to produce the recordings; (3) the recordings obtained from the informants were prepared and analysed with the use of sound editing and analysis software; (4) the raw numerical data were combined and graphically presented in accordance with the goal of this investigation, and statistical methods were employed to provide foundation for any conclusions based on the obtained data.

5.1.1 Recorded texts

The texts used for recordings are word lists specifically designed for the purposes of this investigation. The use of a list of words instead of a list of phrases or a connected text was considered beneficial, as it allowed to avoid the influence of sentence stress as well as to facilitate greater control over what is recorded, so that only, or mostly, the necessary data would be produced.

Since word stress is a phenomenon that makes a certain syllable in a polysyllabic word more prominent than the others, and according to what has been established in Chapter 1, vowel sounds function as the central and most prominent elements of the syllable. Thus, the entries in the word lists were taken on the basis of word stress position, and the vowel sounds that occur in a stressed or unstressed syllable. Attention to different degrees of word stress was also paid.

The word lists for both English and Latvian (found in Appendix 1 and 2, respectively) comprise groups of words, each of which containing a particular vowel sound pertaining to the sound system of the investigated language. Thus, the English word list presents words that contain [iː, ɪ, e, æ, ʌ, uː, ɔː, ɑː, eɪ, aʊ, əʊ] in different positions and under different degrees of stress. The Latvian word list contains words with the following vowels [i, iː, e, æ, u, o, a, ei, ai, au]. As it can be seen, neither of the lists covers the entire vowel systems of the investigated languages; however, an attempt to create a set of vowels representative of the entire vowel system was made. Both monophthongs and diphthongs were used, with both long and short vowels, and a positional variety introduced, including close, mid, and open vowels as well as front, central and back. In addition to the intention to create an adequate representation of the vowel system of each language, other points were considered: the openness of a vowel is closely related with such phenomena described Chapter 2 as intrinsic fundamental frequency and intrinsic duration; furthermore, the inclusion of /i , æ, o/ (or similar sounds) in the lists was prompted additionally because these vowels present extremes in the arrangement of formant frequencies (Fulop, 2011:72).

Furthermore, attention was paid to the vowel phonetic environments. Only voiced consonants (or no consonants) were allowed to precede each of the vowels, as, according to the findings in Chapter 2, the voicing of the preceding consonant affects the fundamental frequency of the vowel, and, therefore, either voiced or voiceless consonants had to be chosen and consistently selected. The English list contains only words in which the vowels under analysis are followed by a voiced consonant (or no consonant), since voiceless consonants are known to shorten the preceding vowels; the post-vocal [l] was also avoided due to the awareness of the ‘l-vocalisation’.

The positions of the vowels selected are as follows:

1. In the only syllable in a monosyllabic word;
2. Under initial primary stress in a disyllabic word;
3. Under final primary stress in a disyllabic word;
4. Under initial primary stress in a trisyllabic word;
5. Under medial primary stress in a trisyllabic word;
6. Under final primary stress in a trisyllabic word;
7. For *English*: under initial secondary stress;
8. For *English*: under non-initial secondary stress (in words where secondary stress occurs after the primary stress);

9. For *Latvian*: in the unstressed medial position in a trisyllabic word;
10. For *Latvian*: in the unstressed final position in a trisyllabic word;
11. For *Latvian*: under initial primary stress in a five-syllable word;
12. For *Latvian*: under secondary stress in the third syllable of a five-syllable word.

No positions for unstressed syllables for English were provided due to the extensive vowel reduction in the unstressed position. Five-syllable words for Latvian were introduced to investigate the degrees of stress. Some of the positions for some of the vowels remained unfilled for the lack of appropriate words, although this was partly remedied by the inclusion of small phrases in which a stressed word is preceded by an unstressed particle, which phonetically can be regarded as a single word (e.g. 'to believe' was used to fill the 'final primary stress in a trisyllabic word' position in the English list). All of the pronunciations and stress positions of the included words were based on their entries in the pronunciation dictionaries, namely Wells (2008), Jones (2006) and Ceplītis et al. (1995).

5.1.2 Informants

All of the informants for this study were recruited on the voluntary basis. Informants for the English part of the investigation were selected at a public forum for linguistics enthusiasts. Out of the initial 11 candidates 3 were selected (8 candidate recordings were removed due to external noise present, excessive creaky voicing, accent issues), all female:

1. F1, aged 25, Melbourne, Australia
2. F2, aged 34, East Midlands, UK
3. F3, aged 35, West Midlands, UK

Latvian informants were selected through personal acquaintance. Although 3 were selected as well, there was no need for an excessive number of candidates, since due to the proximity of the informants it was possible to correct occasional mistakes and solve technical issues. The informants were as follows (all three lived in Riga at the moment of recording):

1. F1, aged 23, Madona
2. F2, aged 29, Cēsis
3. M1, aged 29, Līvāni

Since all informants had to make the recordings on their own, and with their own equipment, they were issued detailed instructions on how to prepare and conduct the recording. The instructions in English and Latvian are provided in Appendix 4.

5.1.3 Preparation and analysis of the recordings

The recordings of the word lists received from the informants were prepared for further analysis with the use of the *Audacity* sound editing software suite (Audacity Team, 2000). The preparation primarily involved the segmentation of the long recordings provided by the informants into small chunks that contained only one word from the list. Low quality chunks, with noise and clear pronunciation errors, were removed on this stage. The rest were catalogued and grouped according to the analyses they would be employed in. These chunks will further be referred to as **tokens**: i.e. each instance of the pronunciation of the word by the particular speaker recorded and accepted. In most analyses, each token involved undergoes two measurements per variable (usually on the stressed and an unstressed vowel). In some analyses (specifically, F0 tests and per-vowel analyses, described below), the two measurements are made on pairs of tokens (i.e. not a single word, but on two different words). In these analyses the pairs of tokens are referred to as tokens as well.

In order to extract the necessary data from the tokens, *Praat* software was used (Boersma, Weeink, 2009). Pitch-tracking and intensity-tracking tools were employed to ascertain the fundamental frequency and intensity of the vowels within the tokens. Narrowband spectrograms of all tokens were drawn in order to select the vowel sound within the recorded word, measure its duration, and make sure that the measurements made by the pitch-tracking tool were accurate. The settings used to generate the spectrograms were as follows: Gaussian window length 30-50 ms (depending on the speaker), dynamic range 55 dB, frequency range 0-400 Hz. Examples of the spectrograms are included in Appendix 4 (note that the provided examples were recreated in a wider frequency range, 0-1000 Hz, for better illustration).

Thus, three data points were extracted for each vowel: mean fundamental frequency (further referred to as F0), mean intensity, and duration. Overall, during the English part of this investigation, 502 tokens were analysed (from the initial 537, with 35 bad tokens removed), which yielded the total of 3259 data points in all three variables. The analysis of Latvian recordings produced 431 tokens (44 tokens removed), and the total of 2605 data points in all three variables (the full list of all tokens, laid out according to their use in particular analyses is provided in Appendix 5).

5.1.4 Analysis of the raw data

The raw data analysed were put into groups according to the stress positions included in the word lists (see Section 5.1.1, p. 20) and presented with scatter plots. Each position received a general description and included a relative (in ratios) and absolute (in Hertz, decibels or

seconds) characterisation of how stressed and unstressed (or primarily and secondarily stressed) vowels corresponded to each other.

All scatter plots shown in this study follow the same template. Y-axis represents the variable (acoustic correlate of word stress) under analysis. X-axis represents the ordinal number of the token in the group of tokens analysed. This can be further illustrated by a simplified sample scatter plot (Figure 5.1), based on the data from the recordings:

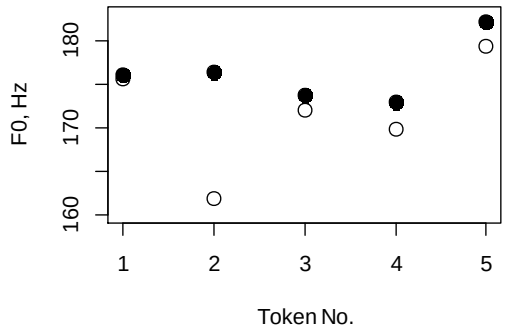

Figure 5.1 **Sample scatter plot**

Filename	Token No.	Stressed F0, Hz	Unstressed F0, Hz
10-10-1.wav	1	176.183	175.672
10-10-2.wav	2	176.428	161.805
10-18-1.wav	3	173.794	172.028
10-18-2.wav	4	173.014	169.773
10-2-1.wav	5	182.190	179.387

Table 5.1 **Data represented in the scatter plot**

Table 5.1 demonstrates the values of F0 in stressed and unstressed syllables in 5 recordings of disyllabic words. 'Token No.' shows the ordinal number of each recording in the group. The 'filename' column provides the filename of the token, which yields three pieces of information. The first number in the name stands for the speaker (in this case, it is always the English F3, whose number is 10), the second stands for a particular word in the word list (10 for 'digger', 18 for 'beggar', and 2 for 'greedy'), and the third stands for the particular instance of pronunciation of this word (since the informants were asked to pronounce each word twice), so two words were used in this analysis twice, and one — only once. Full legends, along with the token filenames and token numbers are included in Appendix 5. Enlarged versions of all scatter plots employed in Sections 5.2 and 5.3 (p. 26 and 34) are found in Appendix 6.

It should be noted at this point that the data for comparison for some of the analyses conducted was not taken from one and the same word in each instance (like shown in Table 5.1), but from two different words (i.e. in the case of Table 5.1 the 'Stressed F0' value for entry (since it is not just one token anymore) No. 1 would be provided by one word, and the

‘Unstressed F0’ value for the same entry would be provided by another, specifically selected, word). Such analyses are as follows:

1) For both *English* and *Latvian*, the influence of the stress structure of disyllabic words on F0 is evaluated (Sections 5.2.1 and 5.3.1 (p. 26 and 34)). Since avoiding changes in F0 due to intonation is difficult, the informants were asked to pronounce the words with an affirmative (i.e., falling) intonation. Thus the purpose of this test was to ascertain if the registered changes in F0 can be attributed to word stress, or they are caused by other factors only.

   In each instance two disyllabic words with the same stressed vowel, but different stressed syllable (e.g. ‘digger’ and ‘forbid’) were taken. For each word, a ratio was obtained, based on the acoustic data of its vowels, using the following formula:

   $r = \frac{F0a - F0b}{F0a}$;

   where ‘F0a’ is the mean fundamental frequency of the first syllable, ‘F0b’ is the mean F0 of the second syllable. The formula requires calculating the difference between the mean F0 in both syllables, and divides it by the F0 of the first syllable to produce a relative value. Ratios from both words are then compared, and statistical methods are applied to find out if the difference between the ratios is significant.

2) For *Latvian*, the five-syllable words that contain primary and secondary stress were analysed on the per-vowel basis (Section 5.3.3 (p. 40)). This means that a word with a certain vowel in the initial position under primary stress is compared to a word that has the same vowel in the medial position (3rd syllable) under secondary stress (e.g. ‘d**i**plomātija’ and ‘papild**i**zrāde’). Otherwise, the analysis was similar to those that consider degrees of stress. This was done for all the available combinations and tokens.

3) For *Latvian*, the three-syllable words were compared on the per-vowel basis, according to whether the vowel is stressed or unstressed, and its position in the word (Section 5.3.4 (p. 41)). Thus, a word, in which a certain vowel is stressed in a certain position is compared to a word in which the same vowel is unstressed in the same position (e.g. ‘pav**i**sam’ and ‘nem**i**tīgs’ for medial, ‘un gandrī**z**’ and ‘nevērī**g**s’ for final positions).

Finally, statistical methods were used to ascertain the significance of the differences found. First, **Null-Hypothesis Significance Test** was employed, with the **α-level** of **0.05.**

Second, in order to supply the NHST with p-values, all relevant data were subjected to **repeated measures Student's t-tests;** this particular type of t-tests was chosen because it allows to test the difference between two dependent variables, which exactly met the requirements of this study.

All statistical measurements were done with the use of specifically-written scripts in *R* software (R Foundation, 1997). The scatter plots for the raw data were generated in *R* as well.

5.2 Data on the acoustic correlates of vowels in relation to word stress based on the English word list

The exposition of the findings is presented in three parts, according to the positions of word stress considered. Namely, subsections are devoted to both positions in disyllabic words, all three positions in trisyllabic words, and the positions reviewed for the comparison of acoustic correlates of primary and secondary stress.

Each subsection is supplied with appropriate scatter plots that illustrate the data points collected, with the y-axis representing each acoustic correlate, and the x-axis — the ordinal number of each token in the reviewed group. Black dots stand for stressed vowels, and white dots stand for unstressed vowels (in Section 5.2.3 (p. 32) — primarily-stressed and secondarily-stressed vowels, respectively). Furthermore, in each subsection there are data on the mean difference in the acoustic correlate values between stressed and unstressed (or primarily- and secondarily-stressed) vowels, the results of the paired-samples t-tests on that difference, and a general evaluation of the data. All given ratios are based on the data from all three informants.

5.2.1 Analysis of vowels in the disyllabic words

In disyllabic words with initial stress, the ratio between the mean **F0** for stressed and unstressed vowels is **1.14:1**, with stressed vowels having on average 24.64 Hz higher fundamental frequency. The ratio for **intensity** is **1.11:1** (~6.57 dB mean difference), and for **duration 1.36:1** (~0.04 sec mean difference). The difference in all three variables is statistically significant (including duration, whose scatter plot makes an appearance of a more random distribution), with p-values considerably below the α-level set.

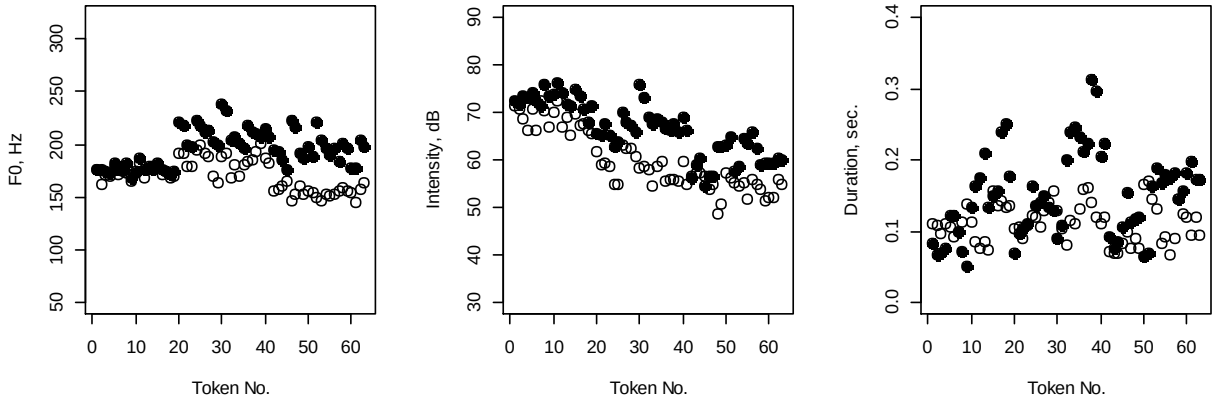

Figure 5.2 **Comparison of stressed and unstressed vowels in the initially-stressed disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	10.5203	$\mathbf{2.026 \times 10^{-15}}$	24.64481 Hz
Intensity	13.1495	$\mathbf{< 2.2 \times 10^{-16}}$	6.557127 dB
Duration	5.0068	$\mathbf{4.86 \times 10^{-6}}$	0.03842857 sec

Table 5.2 **Significance testing results for the initially-stressed disyllabic words (df = 62)**

The analysis of the vowel data obtained from finally-stressed disyllabic words (Figure 5.3, Table 5.3) demonstrates somewhat distinct results. The **fundamental frequency** in stressed vowels actually is lower than that of unstressed vowels, with the ratio of **0.9:1** (~19.8 Hz). The difference in **duration** is far more pronounced than in the previous case: **3.8:1** (~0.179 sec) (the high discrepancy can clearly be seen on the duration scatter plot in Figure 5.2). At the same time, the difference in **intensity** is negligible, **1.02:1** (~1.37 dB); moreover, unlike the other two variables, intensity turned out a p-value above the α-level, reinforcing the impression that it is not an acoustic correlate that marks word stress in this position.

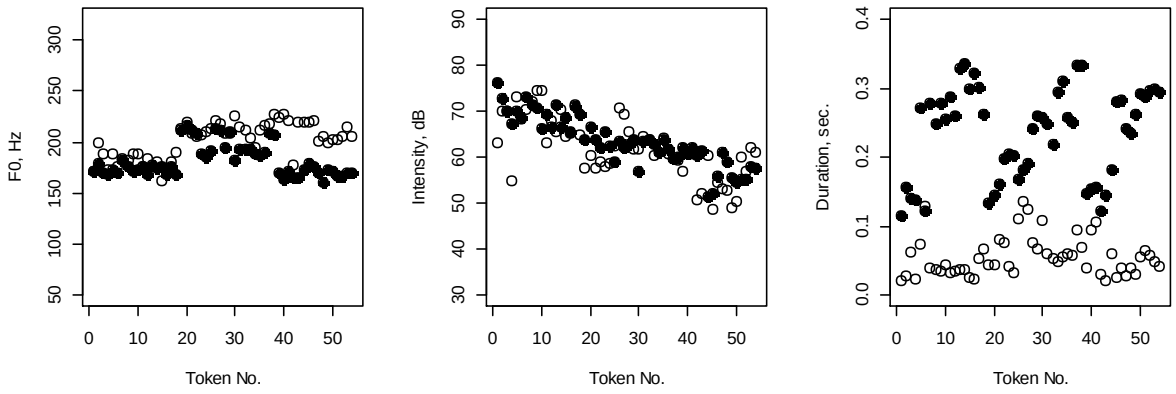

Figure 5.3 **Comparison of stressed and unstressed vowels in the finally-stressed disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	8.0608	$\mathbf{8.949\times10^{-11}}$	-19.8035 Hz
Intensity	1.9966	0.05102	1.371185 dB
Duration	17.1862	$< \mathbf{2.2\times10^{-16}}$	0.1790556 sec

Table 5.3 **Significance testing results for the finally-stressed disyllabic words (df = 53)**

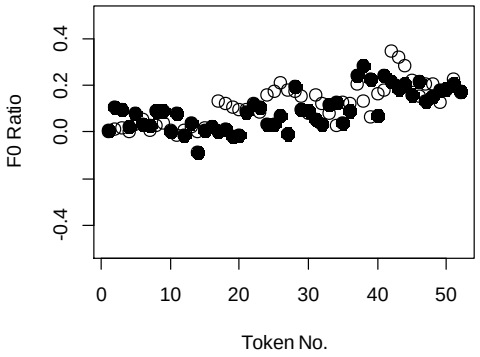

Figure 5.4 **F0 analysis of vowels in the disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	1.7487	0.08635	-0.01985442

Table 5.4 **Significance testing results for the finally-stressed disyllabic words (df = 55)**

The analysis of the F0 in disyllabic words (refer to Section 5.1.4 (p. 23) for the description of the test), shows a very slight mean difference in F0 ratios in both types of disyllabic words (black dots stand for words with initial stress, clear dots — for words with final stress): only **-0.02** (the negative means that stress-final words on average had a higher ratio, and

experienced more drop in F0 than stress initial ones). The significance test produces a p-value that is above the alpha level.

5.2.2 Analysis of vowels in the trisyllabic words

An analysis of the acoustic data obtained from trisyllabic words requires a more complex approach than that made on disyllabic words, due to the presence of two, and not one, unstressed syllable. Therefore, in this subsection stressed vowels are contrasted with both unstressed vowels separately.

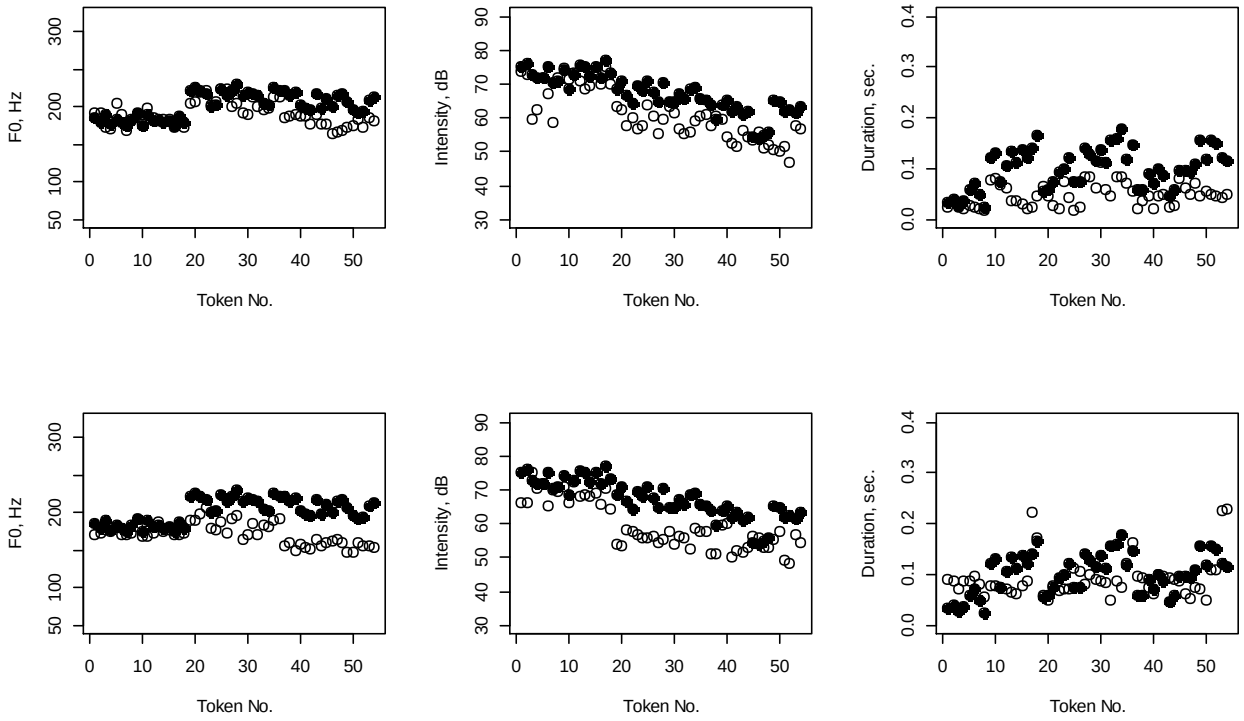

Figure 5.5 **Comparison of stressed and unstressed vowels in the initially-stressed trisyllabic words**

In initially-stressed trisyllables, the comparison of stressed vowels and second-syllable unstressed vowels (top row in Figure 5.5), yields the following ratios: **1.06:1** (~11.29 Hz average difference) for **fundamental frequency**, **1.1:1** (~6.24 dB) for **intensity**, and **2:1** (~0.05 sec) for **duration**. The difference in all three variables is well below the α-level, and is statistically significant. The comparison of stressed and 3rd-syllable vowels (bottom row) shows similar ratios for **fundamental frequency** and **intensity**: **1.17:1** (~29.22 Hz, the absolute difference in Hertz is considerably and perceptibly higher than what is suggested by the ratio), **1,13:1** (~7.82 dB). **Duration** ratio is quite low in this case, **1.11:1** (only ~0.01 sec

mean difference between the stressed and unstressed vowel); furthermore, the t-test for this variable yielded a p-value that is marginally below the α-level.

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 2nd-syllable unstressed vowel			
F0	5.3906	**1.292×10^{-6}**	11.28708 Hz
Intensity	10.4742	**4.405×10^{-15}**	6.243717 dB
Duration	12.8175	< **2.2×10^{-16}**	0.05481667 sec
Stressed vowel vs. 3rd-syllable unstressed vowel			
F0	11.5264	< **2.2×10^{-16}**	29.22207 Hz
Intensity	11.9366	< **2.2×10^{-16}**	7.826667 dB
Duration	2.0659	**0.04324**	0.01356667 sec

Table 5.5 **Significance testing results for the initially-stressed trisyllabic words (df = 59)**

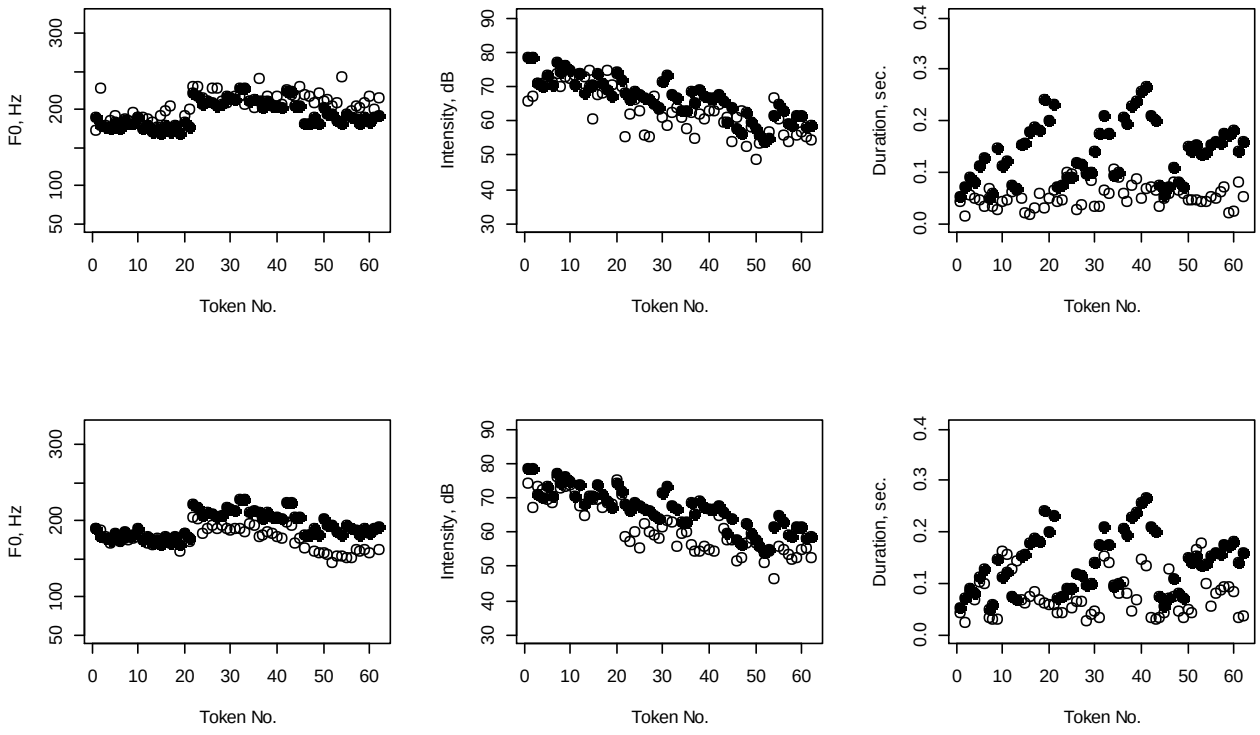

Figure 5.6 **Comparison of stressed and unstressed vowels in the medially-stressed trisyllabic words**

The analysis of trisyllabic words with stress on the second syllable yielded statistically highly significant results for all variables (this can be observed in most scatter plots in Figure 5.6, as

acoustic correlates of stressed vowels tend to be consistently substantially different from those of unstressed vowels). Compared to unstressed vowels in the first syllable (top row), stressed vowels have lower **fundamental frequency**, at **0.94:1** and ~-12.01 Hz, slightly higher **intensity**, **1.05:1** (~3.44 dB), and much longer **duration**: **2.8:1** (~0.09 sec). At the same time, the stressed vowels have higher **fundamental frequency** than the third-syllable unstressed vowels (bottom row): on average, **1.1:1** and ~17.79 Hz; **intensity** and **duration** are higher for unstressed vowels as well: **1.08:1** (~5.14 dB), and **1.75:1** (~0.06 sec) ratios.

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 1st-syllable unstressed vowel			
F0	6.2926	$\mathbf{3.747\times10^{-8}}$	-12.0054 Hz
Intensity	5.3946	$\mathbf{1.182\times10^{-6}}$	3.439334 dB
Duration	10.9903	$\mathbf{4.254\times10^{-16}}$	0.0855 sec
Stressed vowel vs. 3rd-syllable unstressed vowel			
F0	9.9267	$\mathbf{2.361\times10^{-14}}$	17.79258 Hz
Intensity	9.2167	$\mathbf{3.671\times10^{-13}}$	5.135318 dB
Duration	7.8885	$\mathbf{6.844\times10^{-11}}$	0.06308065 sec

Table 5.6 **Significance testing results for the medially-stressed trisyllabic words (df = 61)**

The results of the analysis of trisyllabic words with final stress point to a remarkable lack of correlation between word stress and **intensity**: comparison of stressed vowels with first- (top row in Figure 5.7) and second-syllable (bottom row) unstressed vowels does not yield p-values that would demonstrate statistical significance. The ratios support this notion, with **0.994:1** (stressed to 1st syllable unstressed) and **1.001:1** (stressed to 2nd syllable unstressed). With respect to the other variables, stressed vowels have a considerably lower **fundamental frequency** than both the first and the second unstressed vowels: **0.86:1** (~-29.47 Hz) and **0.89:1** (~-21.92 Hz), respectively. **Duration**, however, is much longer for stressed vowels: **4.2:1** (~0.16 sec), and **3:1** (~0.14 sec), respectively.

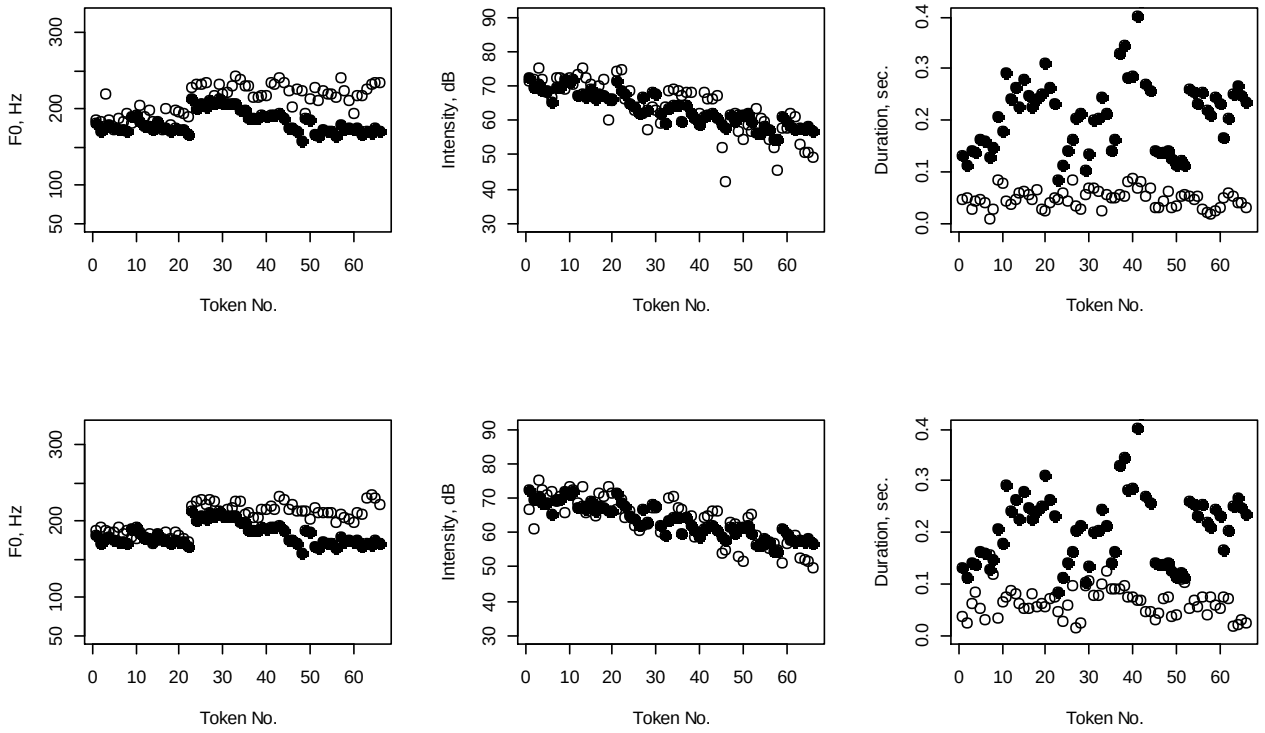

Figure 5.7 **Comparison of stressed and unstressed vowels in the finally-stressed trisyllabic words**

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 1st-syllable unstressed vowel			
F0	12.3961	< $\mathbf{2.2\times10^{-16}}$	-29.47365 Hz
Intensity	0.627	0.5328	-0.3783636 dB
Duration	18.5665	< $\mathbf{2.2\times10^{-16}}$	0.1610758 sec
Stressed vowel vs. 2nd-syllable unstressed vowel			
F0	9.8886	$\mathbf{1.389\times10^{-14}}$	-21.92041 Hz
Intensity	0.0873	0.9307	0.04604545 dB
Duration	14.8559	< $\mathbf{2.2\times10^{-16}}$	0.1439091 sec

Table 5.7 **Significance testing results for the finally-stressed trisyllabic words (df = 65)**

5.2.3 Comparison of vowels under primary and secondary stress

This subsection provides an analysis of the raw data obtained from words that contained not only primary, but also secondary stress. Therefore, unlike the above subsections, it contains comparisons of stressed vowels under different degrees of stress only, without considering unstressed vowels.

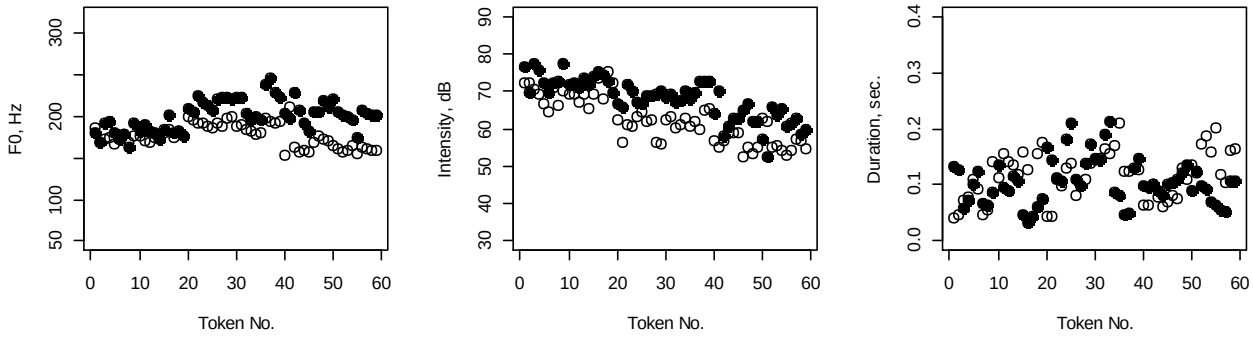

Figure 5.8 **Comparison of vowels under primary and secondary stress in the words with initial primary stress**

Figure 5.8 and Table 5.8 show results of the analysis of the words in which the primary stress is initial, while secondary is not (falling on the 3rd syllable). All of the investigated variables demonstrate statistically significant difference with respect to the degree of stress; primarily-stressed vowels have higher **fundamental frequency**, with **1.14:1** (~24.87 Hz), **intensity**, with **1.09:1** (~5.76 dB), and longer **duration**, with **1.36:1** (~0.04 sec).

Variable	t-value	p-value	Mean of differences
F0	10.9701	$\mathbf{4.586\times10^{-16}}$	24.873 Hz
Intensity	10.1344	$\mathbf{1.067\times10^{-14}}$	5.755889 dB
Duration	5.1141	$\mathbf{3.372\times10^{-6}}$	0.0395 sec

Table 5.8 **Significance testing results for the words with initial primary stress (df = 61)**

Figure 5.9 and Table 5.9 show the data on the words in which primary stress is not initial, and secondary is, show a picture quite different for the opposite position described above. Here, the **fundamental frequency** and **intensity** of the primarily-stressed vowels is lower than those of the secondarily-stressed vowels, with **0.91:1** (~-19.14 Hz) and **0.94:1** (~ -3.77 dB). In similarity to other groups of words with non-initial primary stress, **duration** is considerably longer for vowels under primary stress: **1.44:1** (~0.04 sec).

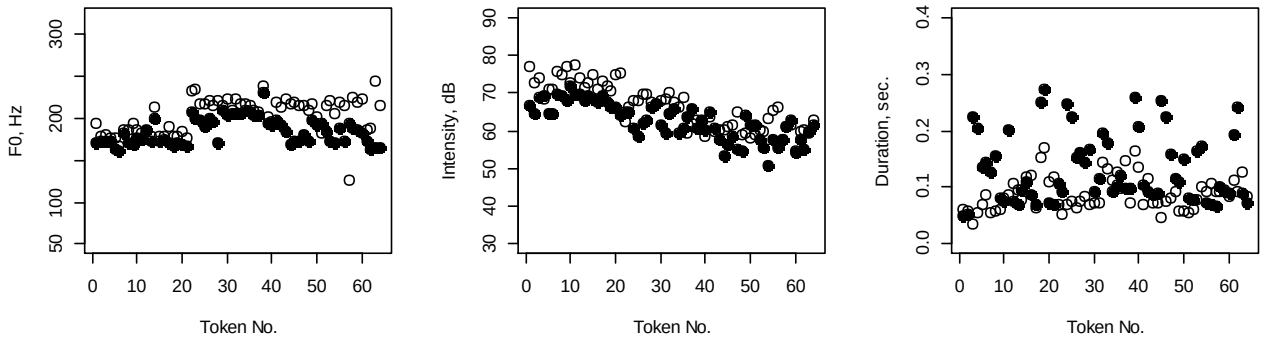

Figure 5.9 **Comparison of vowels under primary and secondary stress in the words with initial secondary stress**

Variable	t-value	p-value	Mean of differences
F0	7.7339	$\mathbf{1.042\times10^{-10}}$	-19.14291 Hz
Intensity	7.1366	$\mathbf{1.155\times10^{-9}}$	-3.771205 dB
Duration	5.5352	$\mathbf{6.438\times10^{-7}}$	0.043125 sec

Table 5.9 **Significance testing results for the words with initial secondary stress (df = 63)**

5.3 Data on the acoustic correlates of vowels in relation to word stress based on the Latvian word list

The data on the Latvian recordings were analysed in a similar fashion to the English ones, with certain differences discussed in the methodology. Thus, like the English section, the following subsections describe stress-initial and stress-final disyllables (with an additional F0 test), stress-initial, stress-medial and stress-final trisyllables, and the relation between primary and secondary stress in five-syllable words. Uniquely to the Latvian part of this investigation, a per-vowel analysis of the primary and secondary stress was conducted, as well as per-vowel and per-position analyses of trisyllables.

5.3.1 Analysis of vowels in the disyllabic words

Figure 5.10 and Table 5.10 show the acoustic data on the stress-initial two-syllable words. Only **intensity** and **duration** show statistically significant results, with **1.075:1** (~4.9 dB mean difference) and **1.5:1** (~0.05 sec) ratios, respectively.

Figure 5.11 and Table 5.11 show data for the stress-final disyllables, with all three acoustic correlates demonstrating statisically significant results. **F0** produces the ratio of **0.902:1** (~ -17.42 Hz), **intensity** — **1.019:1** (~1.35 dB), **duration** — **1.889:1** (~0.07 sec)

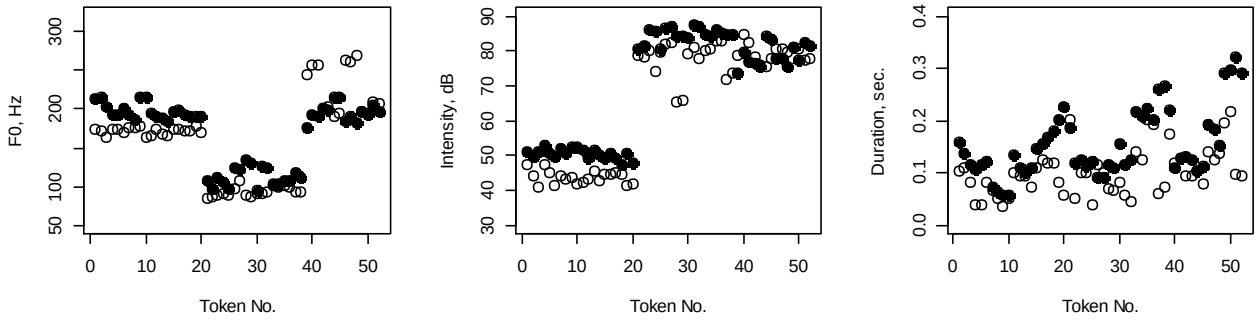

Figure 5.10 **Comparison of stressed and unstressed vowels in the initially-stressed disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	1.8572	0.06905	8.423365 Hz
Intensity	6.6175	**2.188×10^{-8}**	4.899788 dB
Duration	6.8362	**9.87×10^{-9}**	0.05371154 sec

Table 5.10 **Significance testing results for the initially-stressed disyllabic words (df = 51)**

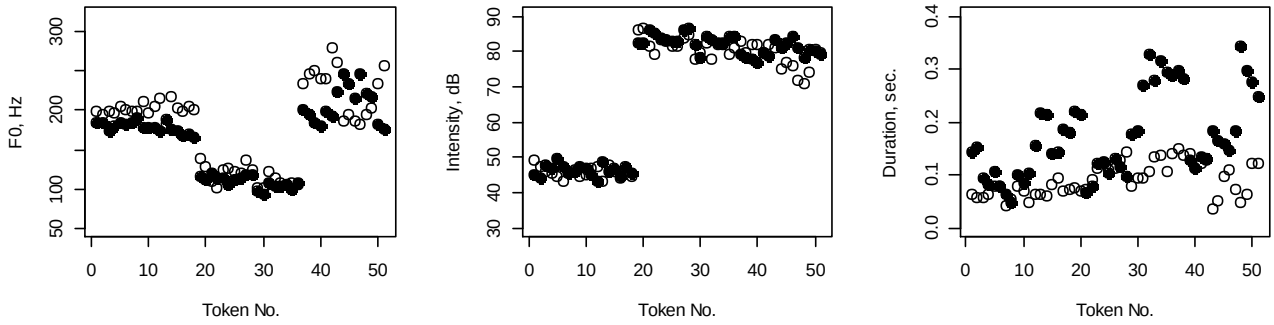

Figure 5.11 **Comparison of stressed and unstressed vowels in the finally-stressed disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	4.5459	**3.045×10^{-5}**	-17.41575 Hz
Intensity	2.8737	**0.005756**	1.346036 dB
Duration	7.0334	**3.326×10^{-9}**	0.07373214 sec

Table 5.11 **Significance testing results for the finally-stressed disyllabic words (df = 55)**

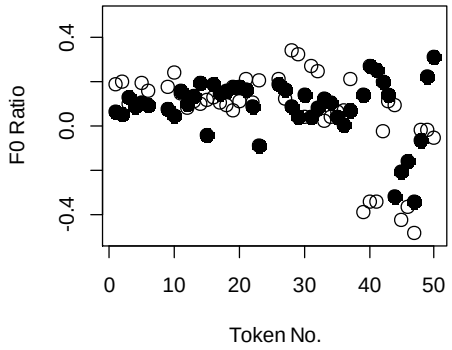

Figure 5.12 **F0 analysis of vowels in the disyllabic words**

Variable	t-value	p-value	Mean of differences
F0	0.5406	0.5913	0.01604418

Table 5.12 **Significance testing results for the finally-stressed disyllabic words (df = 49)**

The analysis of the F0 in disyllabic words (Figure and Table 5.12; refer to Section 5.1.4 (p. 23) for the description of the test), demonstrates a small average difference in F0 ratios in both types of disyllabic words: **0.016**. The significance test produces a p-value that is considerably above the alpha level, suggesting that even this small difference is not produced by stress patterns in the analysed words.

5.3.2 Analysis of vowels in the trisyllabic words

This subsection covers the data obtained from stressed and unstressed vowels in trisyllabic words, with initial, medial and final positions described separately. Data obtained from the trisyllabic words with initial stress are represented on Figure and Table 5.13: it can be seen that all statistical tests returned a p-value below the α-level. The comparison of the stressed vowel with the unstressed vowel in the 2nd syllable (top row on the scatter plots) shows the change in **F0** as **1.082:1** (~13.14 Hz difference), in **intensity** — **1.043:1** (~2.92 dB),

(**continued on page 666**)

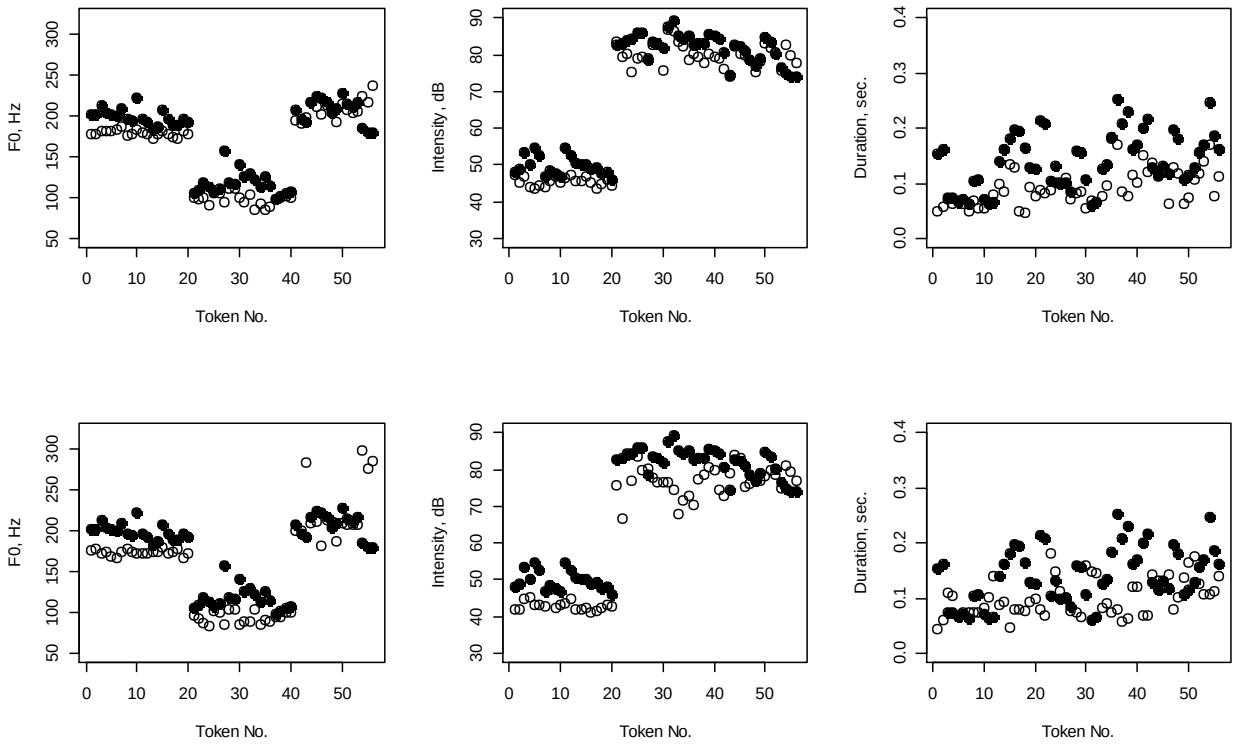

Figure 5.13 **Comparison of stressed and unstressed vowels in the initially-stressed trisyllabic words**

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 2nd-syllable unstressed vowel			
F0	5.252	**2.507×10^{-6}**	13.13879 Hz
Intensity	6.4753	**2.721×10^{-8}**	2.916875 dB
Duration	8.3785	**2.116×10^{-11}**	0.04839286 sec
Stressed vowel vs. 3rd-syllable unstressed vowel			
F0	2.5841	**0.01245**	12.13998 Hz
Intensity	8.2868	**2.98×10^{-11}**	5.599 dB
Duration	4.2513	**8.297×10^{-5}**	0.04039286 sec

Table 5.13 **Significance testing results for the initially-stressed trisyllabic words (df = 55)**

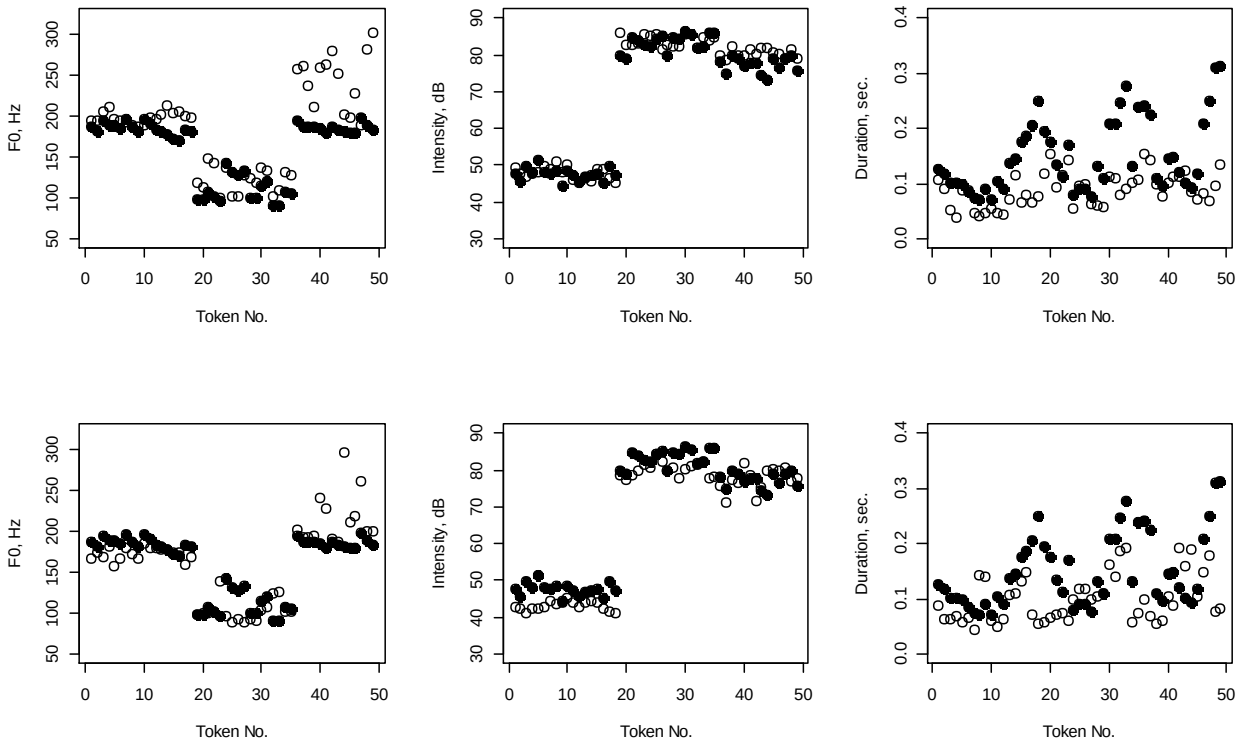

Figure 5.14 **Comparison of stressed and unstressed vowels in the medially-stressed trisyllabic words**

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 1st-syllable unstressed vowel			
F0	5.8996	**3.567×10^{-7}**	-25.97059 Hz
Intensity	-2.9617	**0.004746**	-1.14102 dB
Duration	7.3504	**2.139×10^{-9}**	0.06222449 sec
Stressed vowel vs. 3rd-syllable unstressed vowel			
F0	0.3707	0.7125	-1.567735 Hz
Intensity	5.6867	**7.52×10^{-7}**	2.799531 dB
Duration	4.9346	**1.007×10^{-5}**	0.05046939 sec

Table 5.14 **Significance testing results for the medially-stressed trisyllabic words (df = 48)**

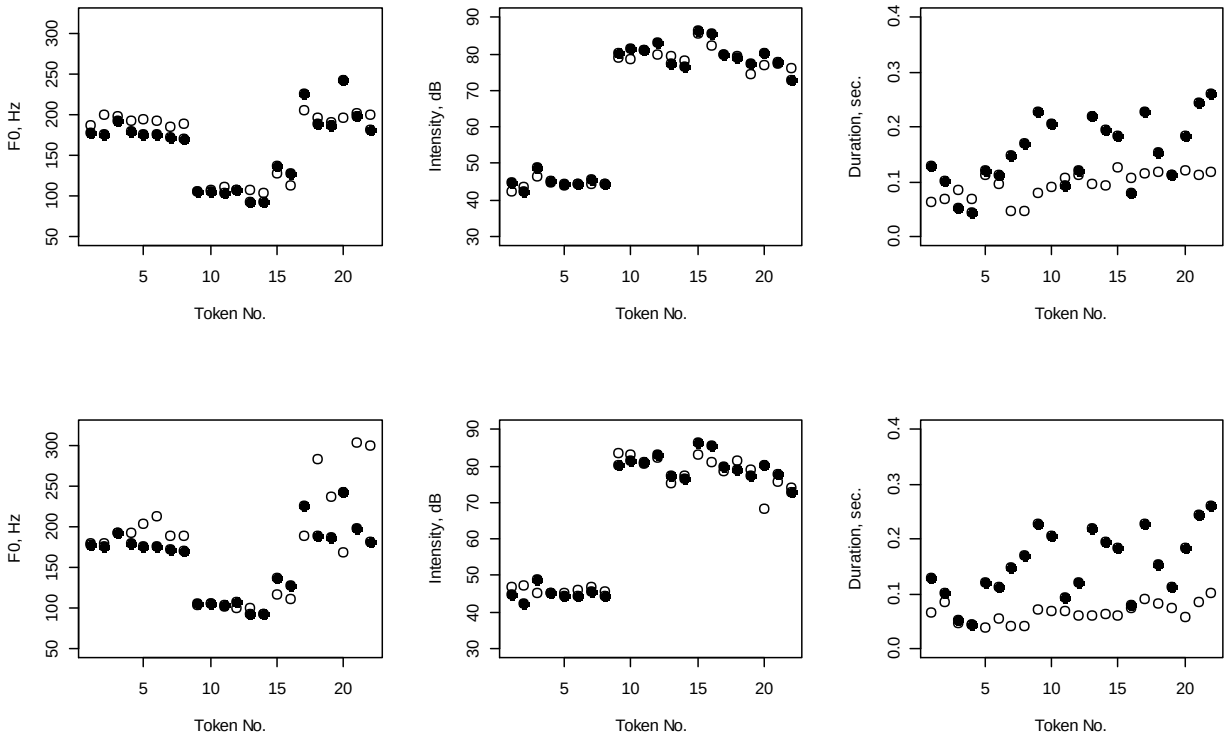

Figure 5.15 **Comparison of stressed and unstressed vowels in the finally-stressed trisyllabic words**

Variable	t-value	p-value	Mean of differences
Stressed vowel vs. 1st-syllable unstressed vowel			
F0	1.2484	0.2256	-4.218227 Hz
Intensity	1.8675	0.07585	0.7408182 dB
Duration	4.5568	**0.0001717**	0.05886364 sec
Stressed vowel vs. 2nd-syllable unstressed vowel			
F0	1.5996	0.1246	-15.309 Hz
Intensity	0.4704	0.6429	0.3469091 dB
Duration	7.3956	**2.833×10^{-7}**	0.08877273 sec

Table 5.15 **Significance testing results for the finally-stressed trisyllabic words (df = 21)**

and in **duration — 1.556:1** (~0.05 sec). The comparison of stressed vowel and the 3rd syllable (bottom row) unstressed vowel gives the following ratios: **1.076:1** (~12.14 Hz) for **F0**, **1.086:1** (~5.6 dB) for **intensity**, and **1.4:1** (~0.04 sec) for **duration**.

Figure 5.14 and Table 5.14 show the acoustic data taken from the vowels in trisyllables with the stress on the second vowel. The stressed vowels compared to the initial unstressed

vowels (top row), show the following: **0.86:1** ratio for **F0** (~ -25.97 Hz mean difference), **0.98:1** for **intensity** (~ -1.14 dB), and **1.67:1** for **duration** (~0.06 sec). All differences are statistically significant. In the other group, where stressed vowels are compared to final unstressed vowels (bottom row), the difference in F0 is not found to be significant. The ratio for intensity is 1.042:1 (~2.8 dB), and for duration — 1.5:1 (~0.05 sec).

Finally, Figure and Table 5.15 demonstrate the data obtained from the finally-stressed trisyllables, and the only acoustic correlate to show statistically significant differences is **duration**. When compared to the initial unstressed vowel (top row), the stressed vowel is **1.5:1** longer (~0.06 sec mean increase in duration). Compared to the medial unstressed vowel (bottom row), the stressed vowel returns the ratio of **2.142:1** (~0.09 sec).

5.3.3 Comparison of vowels under primary and secondary stress

In this section results of two analyses are presented. The first analysis is a simple comparison of the acoustic correlates of primarily- and secondarily-stressed vowels in a single word in each instance, the second is a per-vowel analysis made between words (see Section 5.1.4 (p. 23)). Black dots stand for primarily-stressed vowels, clear dots stand for secondarily-stressed vowels.

The results of the first analysis are shown on Figure 5.16 and Table 5.16. The difference in F0 has proven to be statistically insignificant, with the other correlates yielding the following ratios: **1.06:1** (~3.97 dB mean increase) for **intensity** and **0.8:1** (~ -0.017 sec mean decrease) for **duration**.

Figure 5.17 and Table 5.17 demonstrate the results of the second analysis, with the same vowels compared across different words. Here, F0 does not produce a statistically significant difference either. **Intensity** produces a result to that of the previous analysis: **1.062:1** (~4.06 dB mean increase), while the result for **duration** is somewhat different: **1.125:1** (~ 0.01 sec increase).

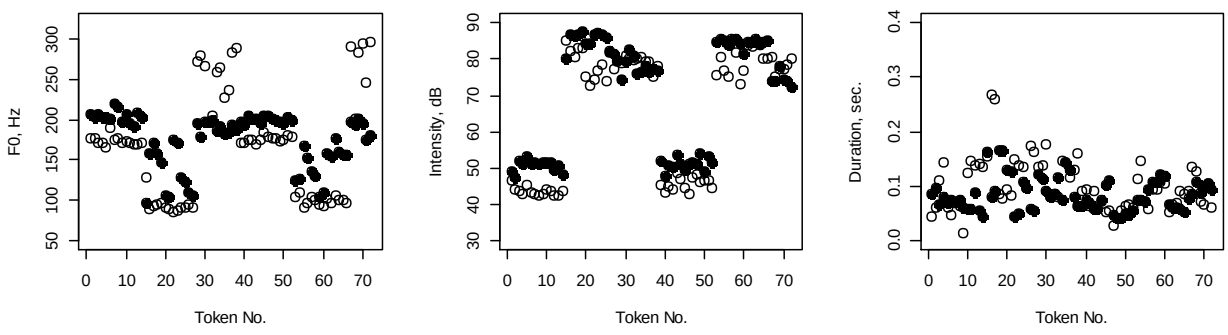

Figure 5.16 **Comparison of vowels under primary and secondary stress in words with the initial primary stress**

Variable	t-value	p-value	Mean of differences
F0	1.7544	0.08367	10.47624 Hz
Intensity	7.1695	**5.735×10^{-10}**	3.973574 dB
Duration	2.7419	**0.007724**	-0.01717778 sec

Table 5.16 **Significance testing results for primary and secondary stress (df = 71)**

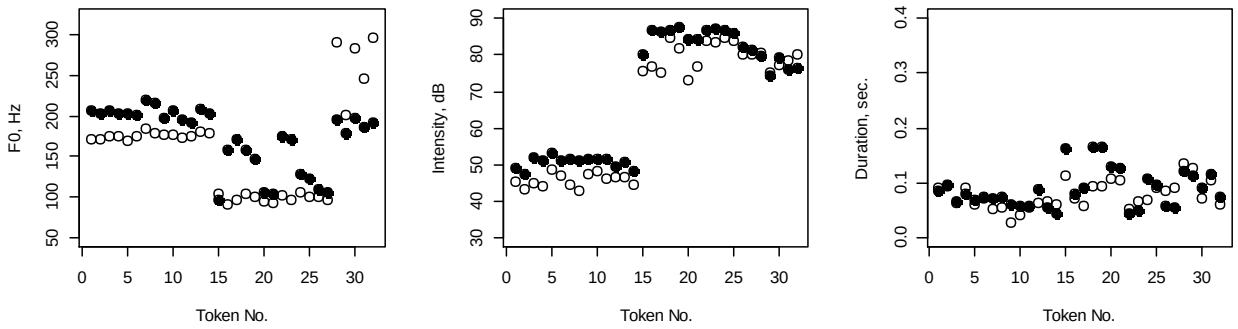

Figure 5.17 **Per-vowel comparison of vowels under primary and secondary stress in words with the initial primary stress**

Variable	t-value	p-value	Mean of differences
F0	1.9353	0.06212	15.3725 Hz
Intensity	6.6598	**1.906×10^{-07}**	4.056978 dB
Duration	2.4091	**0.02212**	0.01065625 sec

Table 5.17 **Significance testing results for primary and secondary stress per vowel (df = 31)**

5.3.4 Per-vowel comparison of stressed and unstressed vowels

This subsection is different from all others in that acoustic data for all of the comparisons made for both analyses were obtained from different words, but from the same positions and for the same vowels (see Section 5.1.4 for a detailed description (p. 23)).

Figure 5.18 and Table 5.18 show results of the analysis of the stressed and unstressed vowels in the medial position (2nd syllable). F0 and intensity show a very high p-value, far above the α-level. The insignificance of these correlates is supported by the low average differences they demonstrate. **Duration**, thus, is the only variable to turn out a statistically significant difference, with the ratio of **1.363:1** (~0.042 sec mean increase).

The results of the analysis of the stressed and unstressed vowels in the final position (3rd syllable) are shown in Figure 5.19 and Table 5.19. In this case, **intensity** and **duration** demonstrate statistically significant differences, with **1.031:1** (~2.07 dB mean increase), and **1.363:1** (~0.042 sec mean increase), respectively.

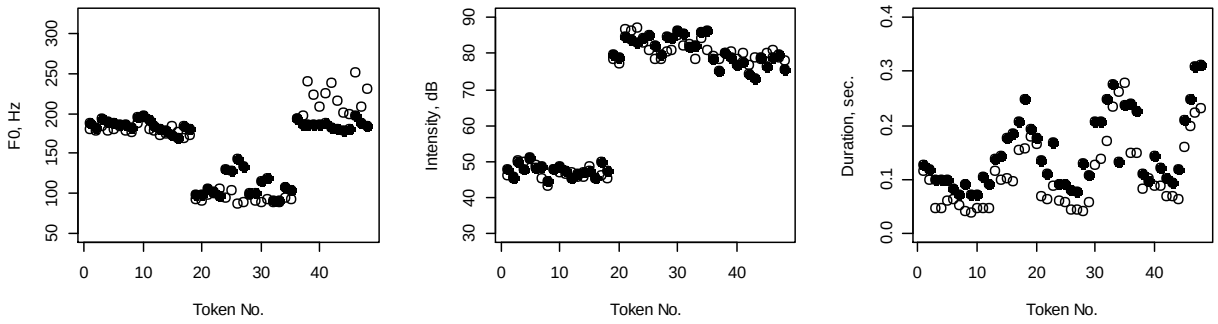

Figure 5.18 **Per-vowel comparison of stressed and unstressed vowels in the medial position of the trisyllabic words**

Variable	t-value	p-value	Mean of differences
F0	0.3625	0.7186	-1.262021 Hz
Intensity	0.7583	0.4521	0.2683958 dB
Duration	7.8127	**4.856×10^{-10}**	0.04252083 sec

Table 5.18 **Significance testing results for stressed and unstressed vowels in the medial position of the trisyllabic words (df = 47)**

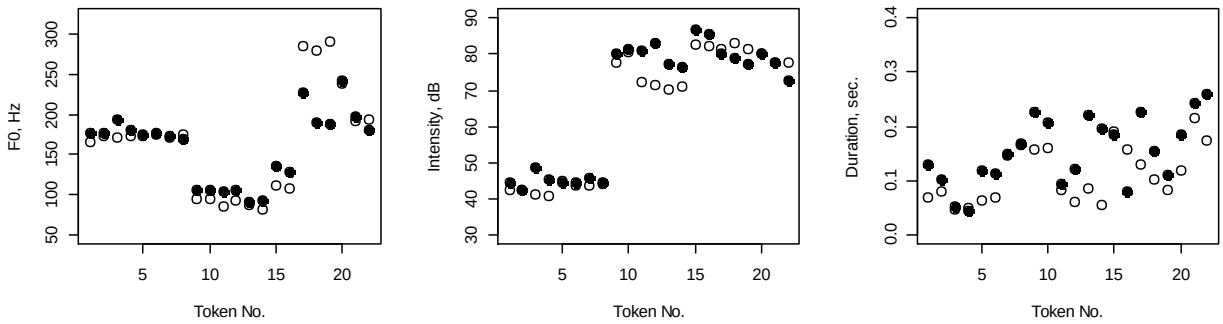

Figure 5.19 **Per-vowel comparison of stressed and unstressed vowels in the final position of the trisyllabic words**

Variable	t-value	p-value	Mean of differences
F0	0.5899	0.5616	-4.3195 Hz
Intensity	2.2823	**0.033**	2.066909 dB
Duration	3.9976	**0.0006534**	0.04177273 sec

Table 5.19 **Significance testing results for stressed and unstressed vowels in the medial position of the trisyllabic words (df = 21)**

5.4 Discussion of the results

The discussion of the results is based on the acoustic correlate average difference ratios obtained in all analyses. The choice of ratios as the vehicle for the discussion was made to dispense the absolute values of the analysed acoustic correlates, and, thus, avoid the inconsistencies caused by acoustic peculiarities in the speech of each informant, providing standardised data that is easier to compare across analyses, and across languages. The structure of this section reflects the structure of the two previous sections, with a separate discussion of the data obtained from disyllables, trisyllables, words with primary and secondary stress, and from the per-vowel, per-position analyses of stressed and unstressed vowels in the Latvian words.

The comparison of the difference ratios for the stressed and unstressed vowels in disyllabic words shows a similar pattern in English and Latvian. First, the stress-final disyllables in both languages present a considerably higher **duration** ratio than their stress initial counterparts: from 1.5:1 to 1.889 in Latvian and a precipitous increase from 1.36:1 to 3.8:1 in English. At the same time, the other two acoustic correlates show less change, with stress-initial disyllables generally showing higher values on both **F0** and intensity in both languages; moreover, the stressed vowel in stress-final words has actually a lower F0 than the unstressed vowel (0.9:1 in both languages), which can be attributed to the falling pattern of intonation. This is confirmed by the F0 test conducted across the two groups of the disyllabic words which did not show a statistically significant connection between the stress pattern and the F0 difference in vowels.

Stressed vowel	F0 Ratios		Intensity Ratios		Duration Ratios	
	English	Latvian	English	Latvian	English	Latvian
Initial	**1.14:1**	1.052:1	**1.11:1**	**1.075:1**	**1.36:1**	**1.5:1**
Final	**0.9:1**	**0.902:1**	1.02:1	**1.019:1**	**3.8:1**	**1.889:1**

Table 5.20 **Difference ratios for stressed and unstressed vowels in the disyllables in English and Latvian (statistically significant results in bold).**

A review of the ratios for the trisyllabic words demonstrates certain similarities to those of the disyllabic words. Particularly remarkable is the relation between the placement of stress and the difference in **duration** between the stressed and unstressed vowels: if a stressed vowel is non-initial, it is considerably longer than the unstressed vowels that precede it, more so than if the stressed vowel is initial (e.g. there are 2:1 and 1.556:1 in duration for initial stressed and medial unstressed, and 2.8:1 and 1.67:1 for medial stressed and initial unstressed). The data further show that the difference in duration is much greater between a stressed vowel and the unstressed vowels that precede it, than between the stressed vowel and the unstressed vowels that follow it: English provides striking examples of this, with finally-stressed words yielding such ratios as 4.2:1 and 3:1 for the stressed vowels compared with initial and medial unstressed vowels, respectively, with initially-stressed words showing considerable, but much lower ratios of 2:1 and 1.11:1 for the stressed vowels compared to the medial and final unstressed vowels. Latvian mostly exhibits the same trend. **Intensity** appears to correlate with stress only in the initial position, where both languages demonstrate heightened intensity (2-8 dB on average in absolute numbers); however, in the medially, and particularly the finally-stressed position there seems to be less connection between stress and intensity of the vowel, with finally-stressed words not exhibiting any significant relation between vowel intensity and word stress at all. **F0** ratios seem to follow the pattern of the disyllabic words, with their having more to do with the position in a word, and not the placement of stress in it (i.e. the vowel exhibits a higher ratio when it is compared to a following vowel, and a lower one — when it is compared to a preceding vowel).

Stressed vowel	Unstressed vowel	F0 Ratios		Intensity Ratios		Duration Ratios	
		English	Latvian	English	Latvian	English	Latvian
Initial	Medial	**1.06:1**	**1.082:1**	**1.1:1**	**1.043:1**	**2:1**	**1.556:1**
	Final	**1.17:1**	**1.076:1**	**1.13:1**	**1.086:1**	**1.11:1**	**1.4:1**
Medial	Initial	**0.94:1**	**0.86:1**	**1.05:1**	**0.98:1**	**2.8:1**	**1.67:1**
	Final	**1.1:1**	0.99:1	**1.08:1**	**1.042:1**	**1.75:1**	**1.5:1**
Final	Initial	**0.86:1**	0.974:1	0.994:1	1.011:1	**4.2:1**	**1.5:1**
	Medial	**0.89:1**	0.912:1	1.001:1	1.005	**3:1**	**2.142:1**

Table 5.21 **Difference ratios for stressed and unstressed vowels in the trisyllables in English and Latvian.**

The comparison of the data obtained from the analysis of the English vowels under primary and secondary stress shows a pattern similar to that established in the disyllabic

words (even though it was between stressed and unstressed vowels). A word in which the primary stress is not initial and secondary stress is, primarily- and secondarily-stressed vowels exhibit longer durations (albeit to a lesser extent than in disyllables), lower F0 and intensity than a word that has initial primary and medial secondary stress. Since the investigation of Latvian vowels only included the analysis of the latter type of words, it is not possible to make the same statement for Latvian here as well. However, the analysis of words with initial primary and medial secondary stress shows certain similarities to that of the English words: F0 and intensity appear notably higher, and so does duration, since in the per-vowel analysis only vowels of the same type were compared, which helped avoid clashes between short and long vowels (which probably produced the ratio of 0.8:1 in the first analysis).

Primary stress	Secondary stress	F0 Ratios		Intensity Ratios		Duration Ratios	
		English	Latvian	English	Latvian	English	Latvian
Initial	Medial	**1.14:1**	1.063:1	**1.09:1**	**1.06:1**	**1.36:1**	**0.8:1**
Medial	Initial	**0.91:1**	x	**0.94:1**	x	**1.44:1**	x
Per vowel analysis							
Initial	Medial	**x**	1.097:1	x	**1.062:1**	x	**1.125:1**

Table 5.22 **Difference ratios for primarily- and secondarily-stressed vowels in the English and Latvian words.**

Due to vowel reduction in English, the direct per-vowel and per-position comparison of acoustic correlates of vowels in relation to word stress was conducted only for Latvian. The initial position could not be included due to the near impossibility (caused by the mostly-fixed word stress) of finding all the necessary unstressed vowels in it. The results show that the only correlate that consistently and significantly distinguishes a stressed and an unstressed vowel is duration, with unusually similar levels: after rounding up, the ratio is 1.363:1 in both positions (the average absolute differences are very similar as well: 0.04252 sec for medial and 0.04177 sec — for the final position); thus, one can say that vowels on average tend to be some 36.3% longer if stressed. The analysis of F0 does not yield statistically significant results, and intensity shows a significant ratio only in the final position.

Position	F0 Ratios	Intensity Ratios	Duration Ratios
Medial	0.992:1	1.003:1	**1.363:1**
Final	0.973:1	**1.031:1**	**1.363:1**

Table 5.23 **Difference per-vowel ratios for stressed and unstressed vowels in the trisyllables in English and Latvian.**

Thus, vowels appear to exhibit word stress acoustically in similar ways in English and Latvian, with fundamental frequency being mainly affected by the position of the vowel in the word (and possibly intonation), rather than its stress. To a lesser extent, intensity depends on position as well, being higher in stressed vowels in the initial position and higher to a lesser degree in stressed vowels in the non-initial positions. On the other hand, duration seems to correlate strongly with stressed vowels, particularly in the medial and final positions where it not only is much greater in stressed vowels, but also in certain cases it can be the only acoustic correlate analysed to have a statistically significant connection to stress. Additionally, the comparison of vowels in primarily- and secondarily-stressed positions has shown similar, though less pronounced, patterns to how vowels differ in the stressed and unstressed positions, supporting the notion that secondary stress can be considered as a middle ground between primary stress and the absence of stress.

CONCLUSIONS

The results of the theoretical and the empirical investigation largely support the ideas expressed in the hypothesis. Differences have been found in how distinct acoustic parameters of vowels correlate with word stress appear to depend on the position of stress in the word, and there are certain differences in how word stress exhibits itself through the analysed acoustic correlates in English and Latvian (despite the mostly common general tendencies). Fry (1955) reports that increased duration has a greater effect on creating prominence than increased intensity (even though both correlates contribute to it), other sources such as Mattys (2000) suggest a very weak correlation between F0 and word stress in English. The results of the empirical investigation on English and Latvian vowels agrees with these notions, as F0 was found not to correlate with word stress, being defined more by position and intonation (in fact, a test controlled for intonation was conducted on vowels in disyllabic words, and it did not produce a statistically significant correlation between word stress structure and changes in F0 for both languages ($p = 0.08635$ for English, and 0.5913 for Latvian)), while the only acoustic correlate that consistently marks word stress in vowels across all positions is duration. Vowel intensity appears to have less correlation with word stress, with very small intensity differences between stressed and unstressed vowels if word stress is not initial. At the same time, duration is markedly higher in stressed vowels in the stress-initial position, and can be even greater if the stress position is not initial.

The latter phenomenon is a point where English and Latvian differ. Even though vowels in both the languages experience it, English appears to do so to a greater degree: the mean ratio of duration between stressed and unstressed vowels in the disyllabic words is 1.36:1 if word stress is initial, and 3.8:1 if final. Latvian shows an increase, but to a much lesser extent: 1.5:1 and 1.889:1 (these results are comparable to those found in Liepa (1979)). In most other positions, the pattern is similar: both languages have greater duration for stressed vowels, but English more so than Latvian (which can possibly be attributed to extensive vowel reduction in English).

Further research in this area should be done in four main directions. First, even though vowels normally occupy the syllable nucleus and are the most sonorous element of the syllable, word stress is a syllabic phenomenon, and so its acoustic correlates should be considered on the basis of syllables, and not only vowels. Second, auditory experiments would be necessary to ascertain the relative importance of acoustic correlates on the perception of word stress. Third, a greater sample of speakers could be analysed to produce more significant results, and minimise the variation caused by idiosyncrasies of particular

speakers. Fourth, other acoustic correlates of word stress that have not been investigated here experimentally should be taken into account: namely, vowel quality and spectral tilt.

THESES

1. Word stress is a suprasegmental phonetic feature that creates prominence on a syllable in a word through greater articulatory effort expended over it.
2. Depending on the language, the position of word stress in a word can be fixed or free. Additionally, two basic degrees of word stress are distinguished: primary and secondary.
3. Known acoustic correlates of word stress are: fundamental frequency, intensity, duration, vowel quality, spectral tilt. The acoustic correlates analysed are fundamental frequency, intensity and duration.
4. Apart from word stress, fundamental frequency, intensity and duration of vowels can be affected by a number of phenomena, such as: (1) intrinsic pitch, anatomic properties of the speaker, intonation, (2) intrinsic intensity, (3) intrinsic duration, polysyllabic shortening, speaking rate.
5. Word stress in English is mostly free. Typically, primary and secondary degrees are distinguished. Duration is described to be the most prominent acoustic correlate of word stress, with intesity being a weaker correlate, and fundamental frequency having a dubious connection with word stress.
6. Word stress in Latvian is mostly fixed. Primary and secondary degrees of stress are distinguished, although secondary can be subdivided into the (stronger) ‘secondary proper’ and ‘auxiliary’. Duration and intensity are acoustic correlates that mark word stress in Latvian.
7. Fundamental frequency of English and Latvian vowels appears not to correlate consistently with word stress and is mostly defined by the position of the vowel, and intonation.
8. Intensity of English and Latvian vowels demonstrates a slight, but mostly significant correlation with word stress, although the intensity is less important if word stress is not in the initial position.
9. Duration of English and Latvian vowels strongly correlates with word stress, as stressed vowels are considerably longer than unstressed vowels in all analysed positions.
10. The comparison of vowels under primary and secondary stress in English and Latvian shows a general similarity of the trends found in the analysis of stressed and unstressed vowels, with somewhat weaker effects of the acoustic correlates.

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Appendix 1
WORD LIST USED TO OBTAIN ENGLISH LANGUAGE DATA

All transcriptions to IPA are based on suggestions from Jones (2006) and Wells (2008).

/iː/

1.	bee	biː	**monosyllable**
2.	greedy	ˈgriːd.i	**disyllable–stress–initial**
3.	Dundee	dʌnˈdiː	**disyllable–stress–final**
4.	deviance	ˈdiːv.ɪ.əns	**trisyllable–stress–initial**
5.	libido	lɪˈbiː.dəʊ	**trisyllable–stress–medial**
6.	to believe	tə.bəˈliːv	**trisyllable–stress–final**
7.	egocentric	ˌiː.gəʊˈsen.trɪk	**4–syllable–secondary–initial, primary–non–initial**
8.	lipreader	ˈlɪpˌriː.d.ə	**trisyllable–primary–initial, secondary–non–initial**

/ɪ/

9.	bid	bɪd	**monosyllable**
10.	digger	ˈdɪg.ə	**disyllable–stress–initial**
11.	forbid	fəˈbɪd	**disyllable–stress–final**
12.	bigamous	ˈbɪ.gə.məs	**trisyllable–stress–initial**
13.	forbidden	fəˈbɪd.ən	**trisyllable–stress–medial**
14.	to forgive	tə.fəˈgɪv	**trisyllable–stress–final**
15.	idiomatic	ˌɪd.ɪ.əˈmæt.ɪk	**5–syllable–secondary–initial, primary–non–initial**
16.	gold–digger	ˈgəʊldˌdɪg.ə	**trisyllable–primary–initial, secondary–non–initial**

/e/

17.	bed	bed	**monosyllable**
18.	beggar	ˈbeg.ə	**disyllable–stress–initial**
19.	embed	əmˈbed	**disyllable–stress–final**
20.	beverage	ˈbev.ə.rɪdʒ	**trisyllable–stress–initial**
21.	unleaded	ʌnˈled.ɪd	**trisyllable–stress–medial**
22.	to embed	tʊ.əmˈbed	**trisyllable–stress–final**
23.	debonair	ˈdeb.əˌnɛə	**trisyllable–secondary–initial, primary–non–initial**
24.	bootlegger	ˈbuːtˌleg.ə	**trisyllable–primary–initial, secondary–non–initial**

/æ/

25.	bad	bæd	**monosyllable**
26.	dagger	ˈdæg.ə	**disyllable–stress–initial**
27.	kebab	kəˈbæb	**disyllable–stress–final**
28.	bagginess	ˈbæg.ɪ.nəs	**trisyllable–stress–initial**
29.	cadaver	kəˈdæv.ə	**trisyllable–stress–medial**
30.	the canal	ðə.kəˈnæl	**trisyllable–stress–final**
31.	admiration	ˌæd.mɪˈreɪ.ʃən	**4–syllable–secondary–initial, primary–non–initial**
32.	bandwagon	ˈbændˌwæg.ən	**trisyllable–primary–initial, secondary–non–initial**

/ʌ/

33. bug	bʌg	**monosyllable**
34. dugout (n)	ˈdʌg.aʊt	**disyllable-stress-initial**
35. outdone	aʊtˈdʌn	**disyllable-stress-final**
36. doublespeak	ˈdʌb.ᵊl.spiːk	**trisyllable-stress-initial**
37. redouble	rɪˈdʌb.ᵊl	**trisyllable-stress-medial**
38. to outgun	tʊ.aʊtˈgʌn	**trisyllable-stress-final**
39. otherworldly	ˈʌð.əˌwɜːld.lɪ	**4-syllable-secondary-initial, primary-non-initial**
40. godmother	ˈgɒdˌmʌð.ə	**trisyllable-primary-initial, secondary-non-initial**

/uː/

41. goo	guː	**monosyllable**
42. boogie	ˈbuː.gɪ	**disyllable-stress-initial**
43. taboos	təˈbuːz	**disyllable-stress-final**
44. dubious	ˈdjuːb.ɪ.əs	**trisyllable-stress-initial**
45. caboodle	kəˈbuːd.ᵊl	**trisyllable-stress-medial**
46. to occlude	tʊ.əˈkluːd	**trisyllable-stress-final**
47. rudimentary	ˌruː.dɪˈmen.tə.rɪ	**5-syllable-secondary-initial, primary-non-initial**
48. earthmover	ˈɜːθˌmuːv.ə	**trisyllable-primary-initial, secondary-non-initial**

/ɔː/

49. board	bɔːd	**monosyllable**
50. boarder	ˈbɔːd.ə	**disyllable-stress-initial**
51. indoors	ɪnˈdɔːz	**disyllable-stress-final**
53. Pandora	pənˈdɔːr.ə	**trisyllable-stress-medial**
54. to reward	tə.rɪˈwɔːd	**trisyllable-stress-final**
55. mortgagee	ˌmɔːg.əˈdʒiː	**trisyllable-secondary-initial, primary-non-initial**

/*ɑ*ː/

57. guard	g*ɑ*ːd	**monosyllable**
58. barber	ˈb*ɑ*ːb.ə	**disyllable-stress-initial**
59. cigar	sɪˈg*ɑ*ː	**disyllable-stress-final**
61. regardless	rɪˈg*ɑ*ːd.ləs	**trisyllable-stress-medial**
62. to regard	tə.rɪˈg*ɑ*ːd	**trisyllable-stress-final**
63. argumentative	ˌ*ɑ*ːg.jʊˈment.ət.ɪv	**5-syllable-secondary-initial, primary-non-initial**
64. plea-bargain	ˈpliːˌb*ɑ*ːg.ən	**trisyllable-primary-initial, secondary-non-initial**

/eɪ/

65. bade	beɪd	**monosyllable**
66. day-dream	ˈdeɪ.driːm	**disyllable-stress-initial**

67. brigade	brɪˈgeɪd	**disyllable-stress-final**
68. babysit	ˈbeɪ.bɪ.sɪt	**trisyllable-stress-initial**
69. engaging	ənˈgeɪdʒ.ɪŋ	**trisyllable-stress-medial**
70. to engage	tʊ.ənˈgeɪdʒ	**trisyllable-stress-final**
71. Asiatic	ˌeɪ.ʒɪˈæt.ɪk	**4-syllable-secondary-initial, primary-non-initial**
72. landlady	ˈlænd ˌleɪ.dɪ	**trisyllable-primary-initial, secondary-non-initial**

/aʊ/

73. loud	laʊd	**monosyllable**
74. lousy	ˈlaʊz.ɪ	**disyllable-stress-initial**
75. carouse	kəˈraʊz	**disyllable-stress-final**
76. dowdiness	ˈdaʊd.ɪ.nəs	**trisyllable-stress-initial**
77. carouses	kəˈraʊz.əz	**trisyllable-stress-medial**
78. to carouse	tə.kəˈraʊz	**trisyllable-stress-final**
79. download (v)	ˌdaʊnˈləʊd	**disyllable-secondary-initial, primary-non-initial**
80. rabble-rouser	ˈræb.əl ˌraʊz.ə	**4-syllable-primary-initial, secondary-non-initial**

/əʊ/

81. goad	gəʊd	**monosyllable**
82. odour	ˈəʊd.ə	**disyllable-stress-initial**
83. hellos	həˈləʊz	**disyllable-stress-final**
84. overload (n)	ˈəʊv.ə.ləʊd	**trisyllable-stress-initial**
85. ennoble	əˈnəʊb.ᵊl	**trisyllable-stress-medial**
86. to corrode	tə.kəˈrəʊd	**trisyllable-stress-final**
87. overactive	ˌəʊv.ərˈækt.ɪv	**4-syllable-secondary-initial, primary-non-initial**
88. bulldozer	ˈbʊl ˌdəʊ.zə	**3-syllable-primary-initial, secondary-non-initial**

Appendix 2
WORD LIST USED TO OBTAIN LATVIAN LANGUAGE DATA

All transcriptions to IPA are based on suggestions from (Grigorjevs, 2008:193,210).

/i/

1.	dilt	dilt	**monosyllable**
2.	bilde	'bil.de	**disyllable-stress-initial**
3.	un dilt	un'dilt	**disyllable-stress-final**
4.	izmeklēt	'iz.mek.leːt	**trisyllable-stress-initial**
5.	pavisam	pa'vi.sam	**trisyllable-stress-medial**
6.	nemitīgs	'ne.mi.tiːks	**trisyllable-/i/-medial-unstressed**
7.	nemieri	'ne.mie.ri	**trisyllable-/i/-final-unstressed**
8.	diplomātija	'dip.loˌmaː.ti.ja	**5-syl-/i/-primary-stressed-initial**
9.	papildizrāde	'pa.pildˌiz.raː.de	**5-syl-/i/-secondary-stressed-medial**

/iː/

10.	zīds	ziːts	**monosyllable**
11.	zīdains	'ziː.dains	**disyllable-stress-initial**
12.	gandrīz	gan'driːz	**disyllable-stress-final**
13.	dīzelis	'diː.ze.lis	**trisyllable-stress-initial**
14.	aiz dīķa	aiz'diː.ca	**trisyllable-stress-medial**
15.	un gandrīz	un.gan'driːz	**trisyllable-stress-final**
16.	nelīdzens	'ne.liː.dz.æns	**trisyllable-/iː/-medial-unstressed**
17.	nevērīgs	'ne.veː.riːks	**trisyllable-/iː/-final-unstressed**
18.	līdzatbildība	'liːdz.adˌbil.diː.ba	**5-syl-/iː/-primary-stressed-initial**
19.	pamatlīdzekļi	'pa.matˌliː.dzek.ʎi	**5-syl-/iː/-secondary-stressed-medial**

/e/

20.	degt	dekt	**monosyllable**
21.	bezdarbs	'bez.darps	**disyllable-stress-initial**
22.	un degt	un'dekt	**disyllable-stress-final**
23.	rezultāts	're.zul.taːts	**trisyllable-stress-initial**
24.	pusdesmit	pus'des.mit	**trisyllable-stress-medial**
25.	nederīgs	'ne.de.riːks	**trisyllable-/e/-medial-unstressed**
26.	saprante	'sa.prat.ne	**trisyllable-/e/-final-unstressed**
27.	metamorfoze	'me.taˌmor.foː.ze	**5-syl-/e/-primary-stressed-initial**
28.	pamatmetode	'pa.matˌme.to.de	**5-syl-/e/-secondary-stressed-medial**

/æ/

30.	degums	'dæ.gums	**disyllable-stress-initial**
32.	degungals	'dæ.gun.gals	**trisyllable-stress-initial**
33.	bez devas	bez'dæ.vas	**trisyllable-stress-medial**

34. neredzēts	'ne.ræ.dzæːts	**trisyllable-/æ/-medial-unstressed**
35. nelīdzens	'ne.liː.dzæns	**trisyllable-/æ/-final-unstressed**
36. dzeltensarkanais	'dzæl.tænˌsar.kanais	**5-syl-/æ/-primary-stressed-initial**
37. badadzeguze	'ba.daˌdzæ.gu.ze	**5-syl-/æ/-secondary-stressed-medial**

/u/

38. durt	durt	**monosyllable**
39. bruģis	'bru.ɟis	**disyllable-stress-initial**
40. nekurp	ne'kurp	**disyllable-stress-final**
41. bundulis	'bun.du.lis	**trisyllable-stress-initial**
42. un nekurp	un.ne'kurp	**trisyllable-stress-final**
43. nodubļot	'nuo.du.bʌuot	**trisyllable-/u/-medial-unstressed**
44. nodegums	'nuo.dæ.gums	**trisyllable-/u/-final-unstressed**
45. guļamistaba	'gu.ʌam'is.ta.ba	**5-syl-/u/-primary-stressed-initial**
46. palīguzņēmums	'pa.liːgˌuz.ɲæː.mums	**5-syl-/u/-secondary-stressed-medial**

/o/

47. bokss	boksː	**monosyllable**
48. bronza	'bron.za	**disyllable-stress-initial**
49. un bokss	un'boksː	**disyllable-stress-final**
50. gobelēns	'go.be.leːns	**trisyllable-stress-initial**
51. ar moto	ar'mot.toː	**trisyllable-stress-medial**
52. nobloķēt	'nuo.blo.ceːt	**trisyllable-/o/-medial-unstressed**
53. antidots	'an.ti.dots	**trisyllable-/o/-final-unstressed**
54. problemātika	'prob.leˌmaː.ti.ka	**5-syl-/o/-primary-stressed-initial**
55. pamatproblēma	'pa.matˌprob.leː.ma	**5-syl-/o/-secondary-stressed-medial**

/*a*/

57. daļa	'da.ʌa	**disyllable-stress-initial**
58. vismaz	vis'maz	**disyllable-stress-final**
59. aleja	'a.le.ja	**trisyllable-stress-initial**
60. pagalam	pa'ga.lam	**trisyllable-stress-medial**
61. un vismaz	un.vis'maz	**trisyllable-stress-final**
62. negatīvs	'ne.ga.tiu̯s	**trisyllable-/*a*/-medial-unstressed**
63. neparasts	'ne.pa.rasts	**trisyllable-/*a*/-final-unstressed**
64. balināšana	'ba.li.naː.ʃa.na	**5-syl-/*a*/-primary-stressed-initial**
65. pamatbarība	'pa.matˌba.riː.ba	**5-syl-/*a*/-secondary-stressed-medial**

/ei/

66. veids	veits	**monosyllable**
67. veidot	'vei.duot	**disyllable-stress-initial**
68. ikreiz	ik'reiz	**disyllable-stress-final**
69. Eiropa	'ei.roː.pa	**trisyllable-stress-initial**
70. un veidot	un'vei.duot	**trisyllable-stress-medial**

71. un ikreiz	un.ik'reiz	**trisyllable-stress-final**
72. neveiklums	'ne.veik.lums	**trisyllable-/ei/-medial-unstressed**
73. nepareizs	'ne.p*a*.reisː	**trisyllable-/ei/-final-unstressed**

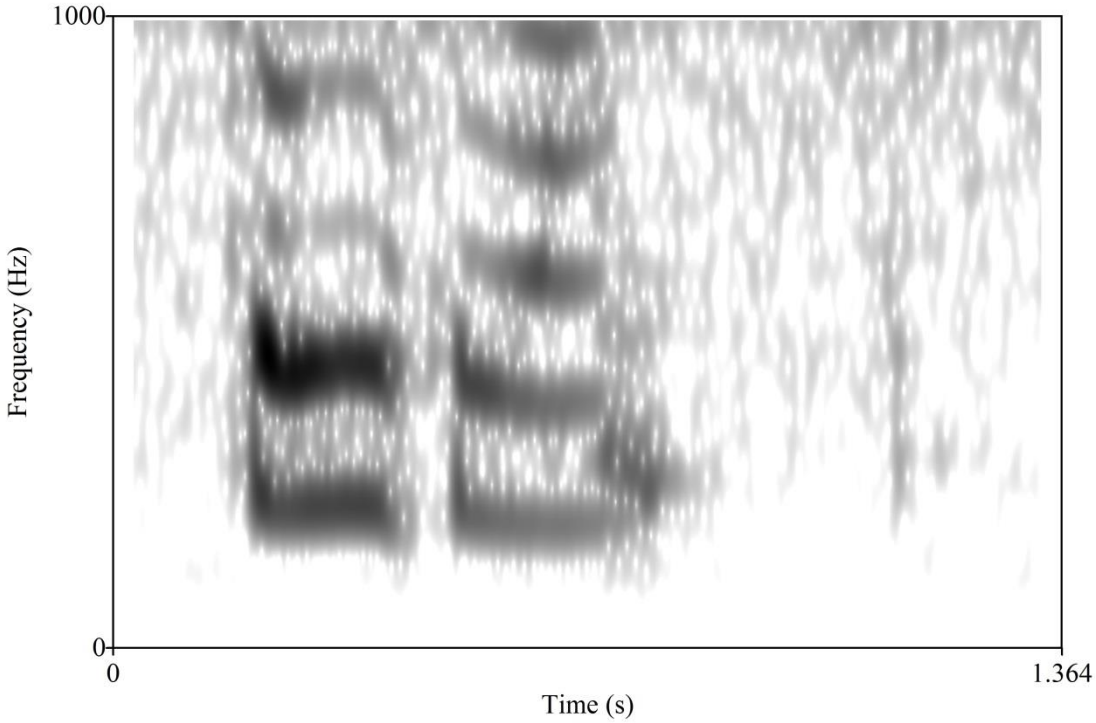
/ai/

74. laiks	laiks	**monosyllable**
75. vairāk	'vai.r*a*ːk	**disyllable-stress-initial**
76. un laiks	un'laiks	**disyllable-stress-final**
77. daiļrade	'daiʌ.r*a*.de	**trisyllable-stress-initial**
78. ne vairāk	ne'vai.r*a*ːk	**trisyllable-stress-medial**
79. nevainīgs	'ne.vai.niːks	**trisyllable-/ai/-medial-unstressed**
80. vainīgais	'vai.niː.gais	**trisyllable-/ai/-final-unstressed**

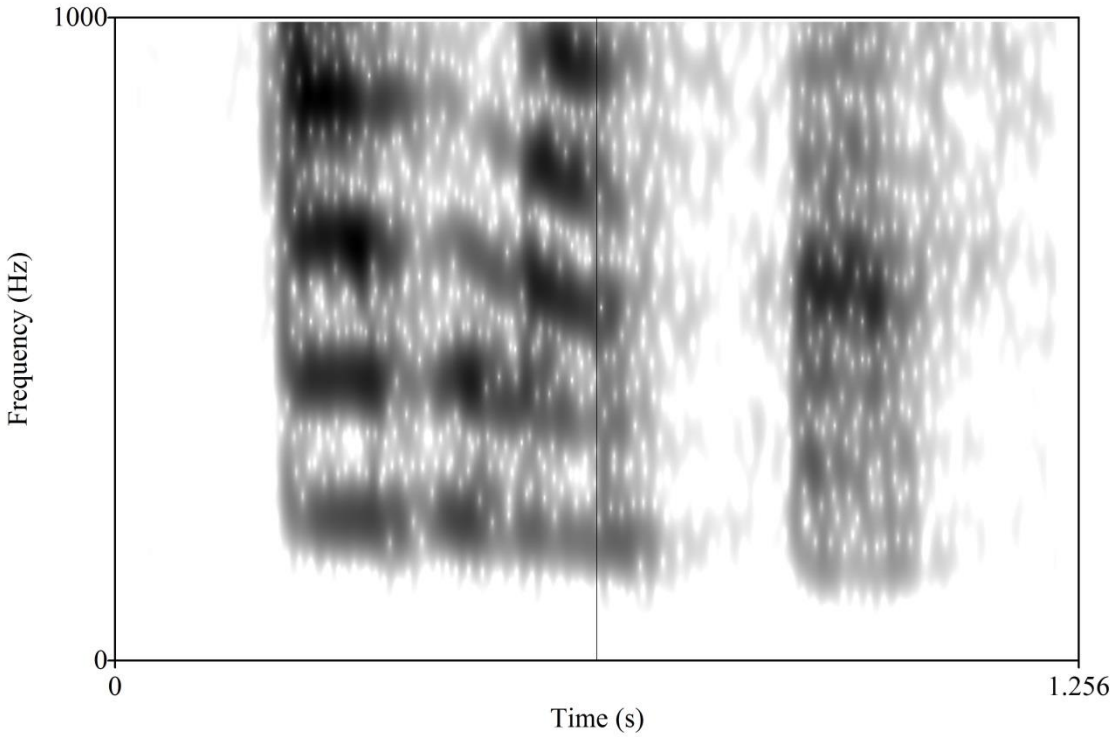
/au/

81. lauks	lauks	**monosyllable**
82. baumas	'bau.m*a*s	**disyllable-stress-initial**
83. un lauks	un'lauks	**disyllable-stress-final**
84. raudzīties	'rau.dziː.ties	**trisyllable-stress-initial**
85. un baumas	un'bau.m*a*s	**trisyllable-stress-medial**
86. nedaudzi	'ne.daudz.i	**trisyllable-/au/-medial-unstressed**
87. nepakļauts	'ne.p*a*.kʌauts	**trisyllable-/au/-final-unstressed**

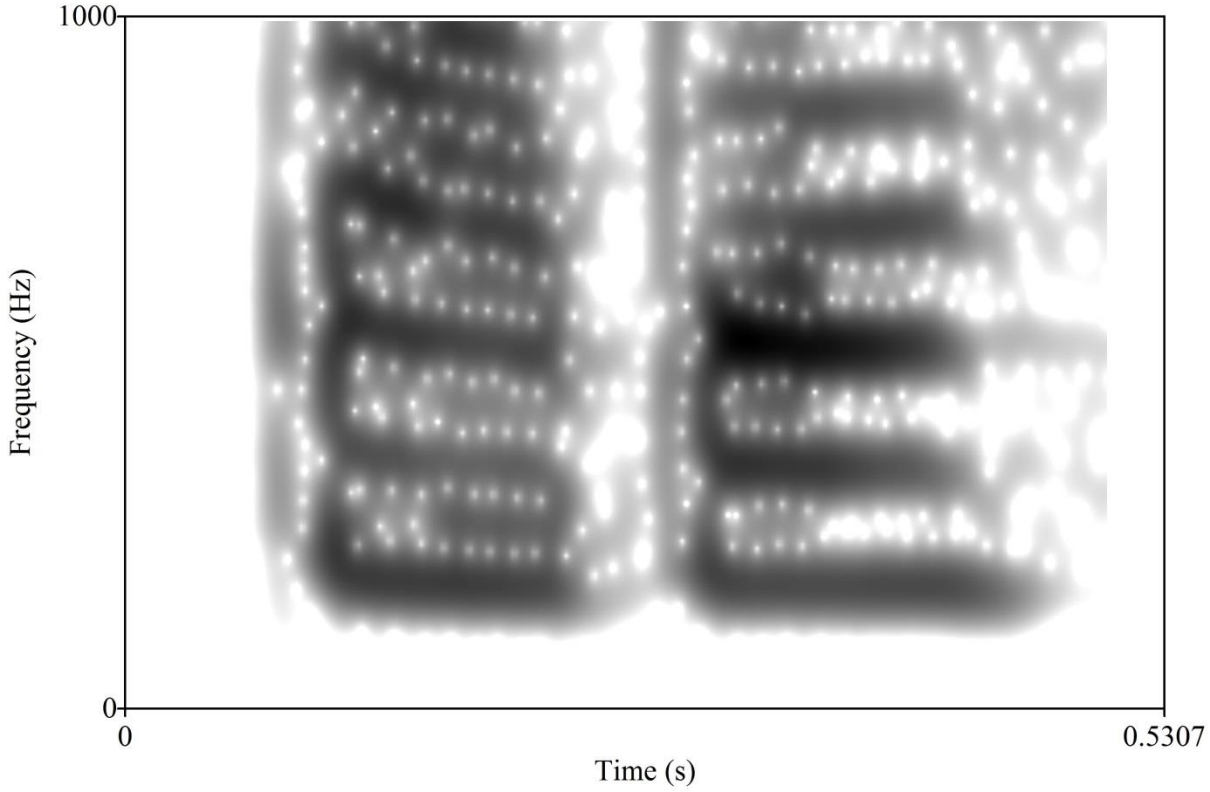
Appendix 3
EXAMPLES OF SPECTROGRAMS EMPLOYED



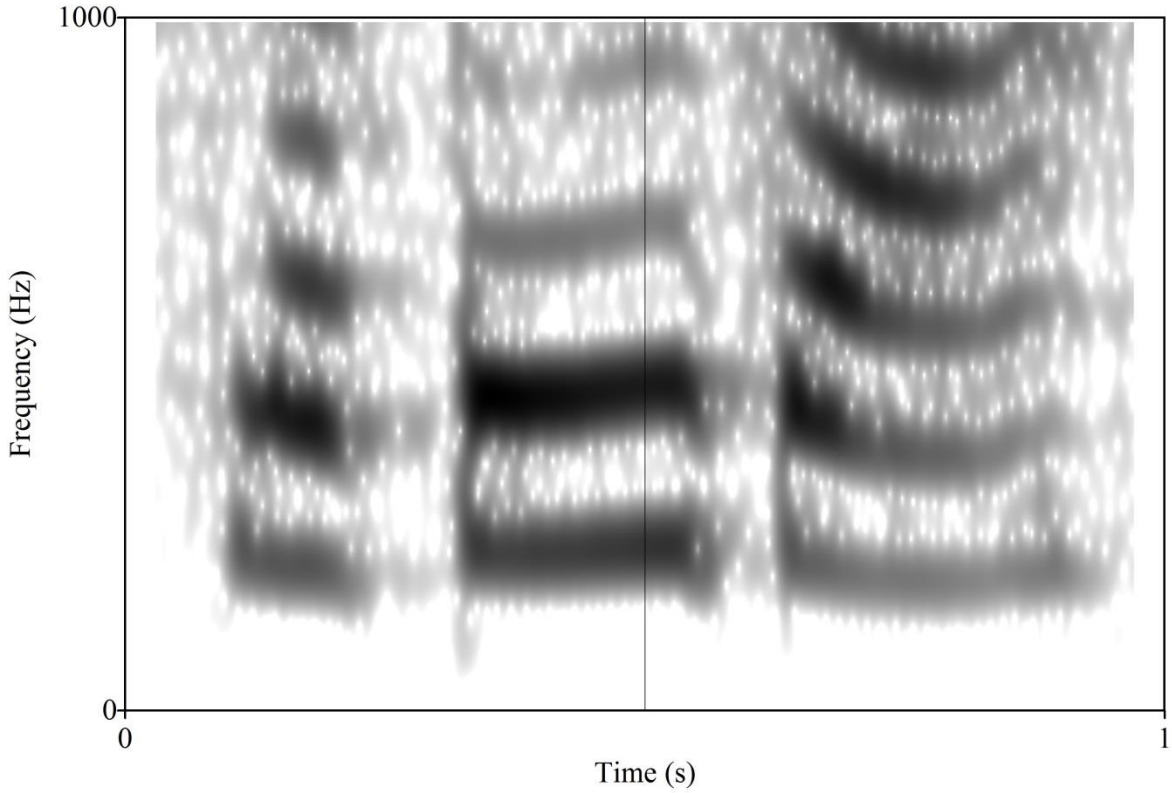
(En) 3-4-1: d iː v ɪ ə n s



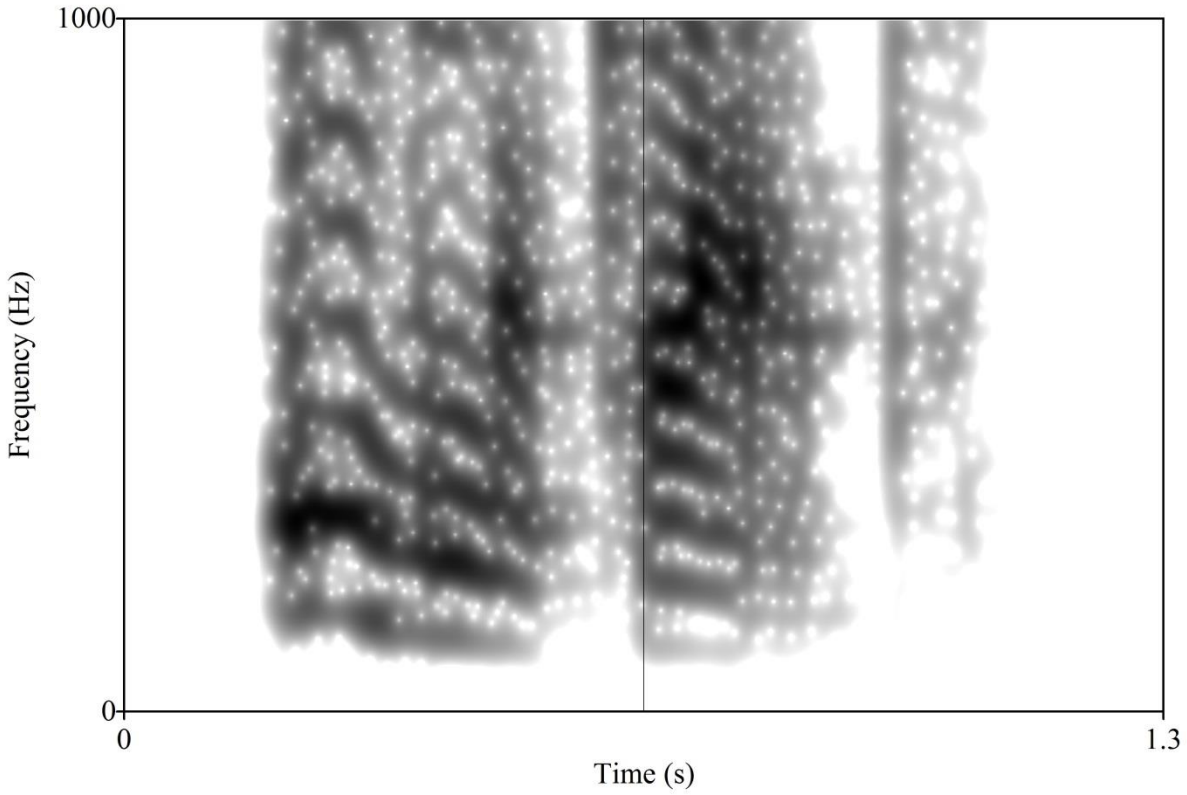
(En) 5-63-1: ɑː g j ʊ m e n t ə t ɪ v



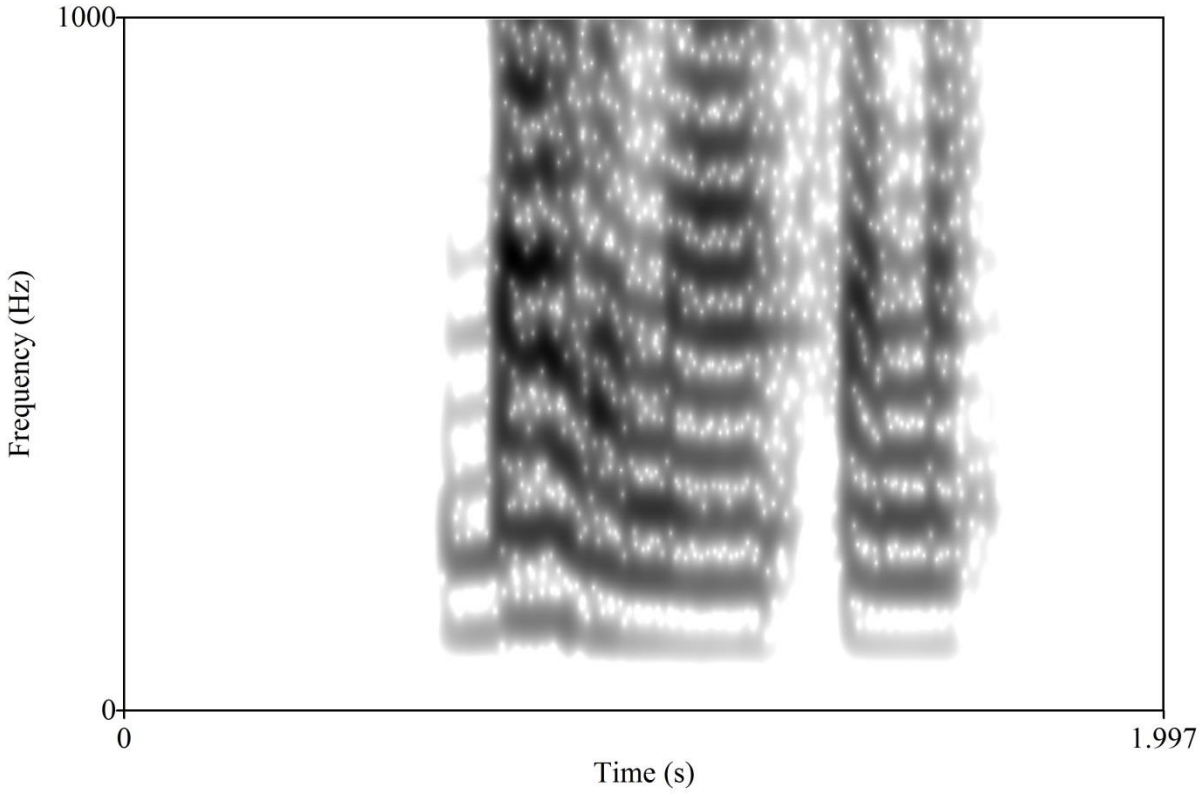
(En) 10-26-1: d æ g ə



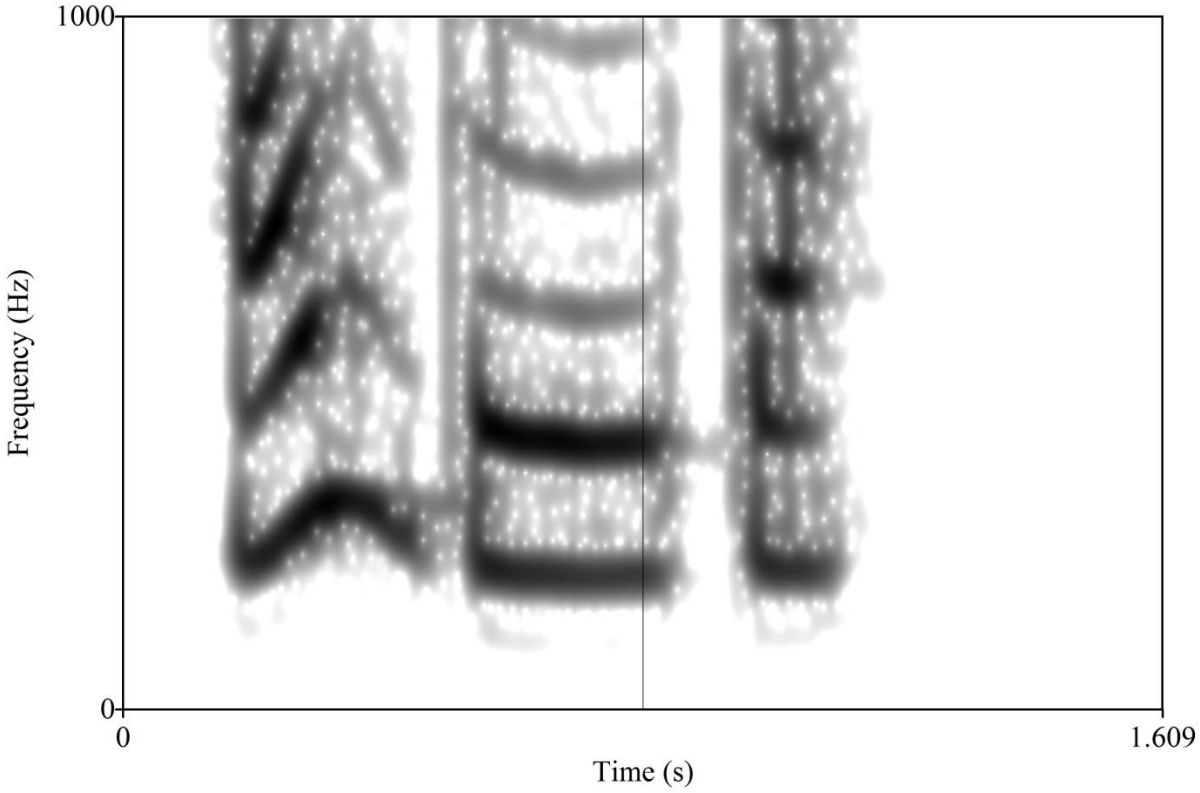
(En) 3-5-1: l ɪ b iː d əʊ



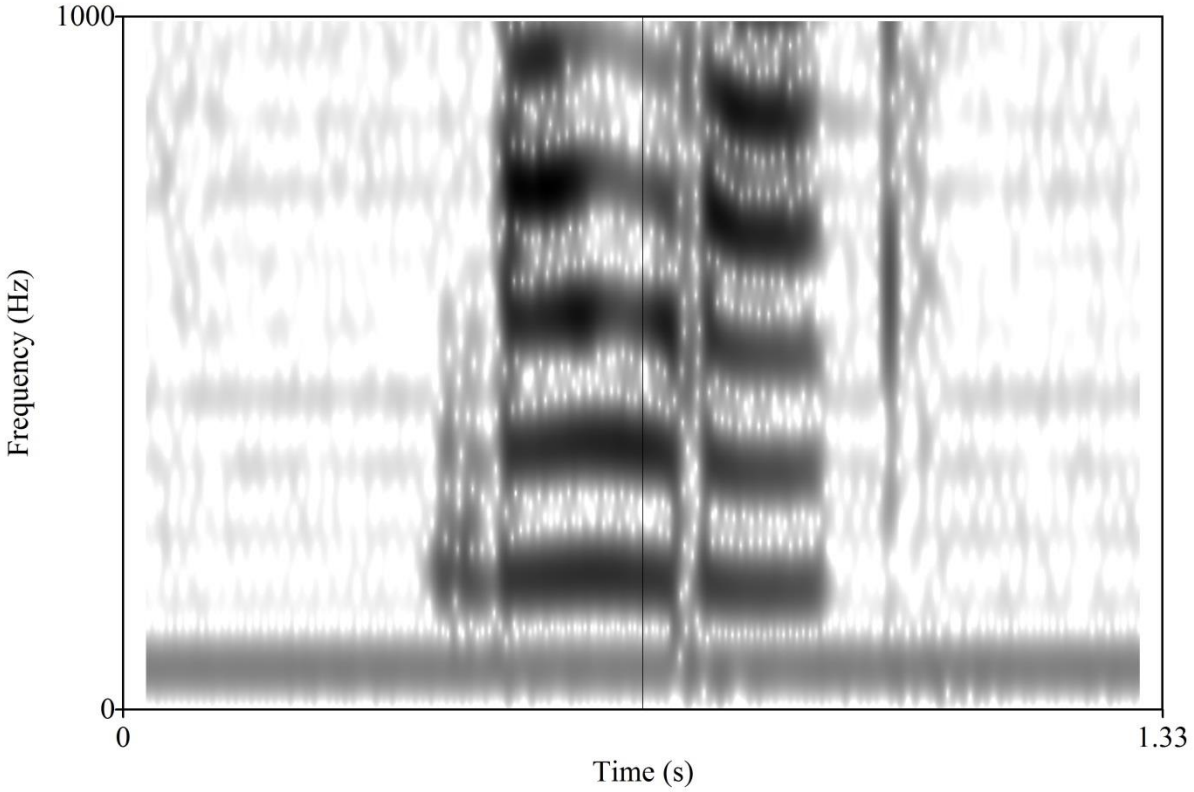
(Lv) 2-4-2: i z m e k l eː t



(Lv) 2-64-1: b a l i n aː ʃ a n a



(Lv) 3-14-1: ai z d iː c ɑ



(Lv) 3-14-1: d ɑ ʌ ɑ

Appendix 4
INSTRUCTIONS ISSUED TO ENGLISH AND LATVIAN INFORMANTS

English

Before recording:

1) Make sure that you record in a room that is as quiet as possible and that there is no echo in it (furniture, books, drawn curtains reduce its effect). Minimising noise is crucial.

2) Use the best microphone you have ready access to, and, if you can, set your recording device/software for the highest quality setting available (22 kHz, 16 bit is enough).

3) Test your recording setup. Adjust the volume setting if your normal voice: sounds too quiet in the recording, or if it is so loud that it produces distortions: both are undesirable.

4) Check the word list and ensure that you know all the words in it, and, more importantly, how they are pronounced, and which syllable the stress is on.

While recording:

1) Hold the microphone at about 5 cm (2 in) to the side of your mouth. Make sure that you do not hold it in front of your mouth (to avoid breathing noise).

2) Pronounce each word in the word list with the loudness you are most comfortable with (but don't forget about recording volume), and with the speed that is normal for your calm speech, do not hurry. Try to maintain this tempo, avoid changing the speed of your speech.

3) Try to avoid dramatic and emotional intonation in pronouncing the words, intonation should be neutral and affirmative. Check the following links for examples of good intonation for these purposes (click on the speaker icon to hear them):

http://dictionary.cambridge.org/dictionary/british/beggar_1?q=beggar
http://dictionary.cambridge.org/dictionary/british/dubious?q=dubious

4) Pronounce each word on the list TWO times. Leave a short silent pause between the two instances of the word.

5) Make sure that there is a short silent pause between the pairs of words that you pronounce. To clarify points 4 and 5, the first three words that you will see in the list will be 'egocentric', 'loud', 'barbarism'; you have to record them the following way 'egocentric [pause] egocentric [pause] loud

[pause] loud [pause] barbarism [pause] barbarism [pause] [...and so on]'.

Latvian

Pirms ierakstīšanas:

1) Pārliecinieties, ka ierakstāt visklusākajā jums pieejamajā telpā un ka tajā nav atbalss (mēbeles, grāmatas, aizvilkti aizkari palīdz to pazemināt). Troksnim jābūt minimālam.

2) Izmantojiet vislabāko jums pieejamo mikrofonu, un, ja ir tāda iespēja, izmantojiet visaugstākos ierakstīšanas ierīces/programmas iestatījumus (22 kHz, 16 bit ir pietiekami).

3) Pārbaudiet ierīces, kuras izmantosiet ierakstīšanai. Izmainiet skaļuma iestatījumus, ja jūsu normālā balss ierakstā ir pārāk klusa, vai ir tik skaļa, ka tajā rodas kropļojumi. Ierakstam jābūt diezgan skaļam, tomēr bez pārspilējuma.

4) Pārbaudiet sagatavoto vārdu sarakstu. Pārliecinieties, ka zināt visus vārdus (jautājiet man, vai pārbaudiet vārdnīcā pirms ierakstīšanas).

Ierakstīšanas laikā:

1) Turiet mikrofonu apmēram 5 cm pa labi vai pa kreisi no mutes. Neturiet to priekšā mutei, lai izvairītos no elpošanas trokšņa.

2) Izrunājiet katru vārdu jums visērtākajā skaļumā (tomēr neaizmirstiet par ierakstīšanas skaļumu) un tādā tempā, kas ir raksturīgs jūsu mierīgai runai. Nesteidzieties un mēģiniet uzturēt šo tempu ierakstīšanas laikā.

3) Izrunājot vārdus, izvairieties no pārāk dramatiskas un emocionālas intonācijas. Tai jābūt neitrālai (tādai kā neitrālā apgalvojumā).

4) Izrunājiet katru vārdu DIVAS reizes. Ievērojiet pauzi pēc katras reizes.

5) Pārliecinieties, ka starp vārdu pāriem arī ir neliela pauze. 4. un 5. punkta skaidrojums: pirmie trīs vārdi sarakstā ir "rezultāts", "zīdains", "palīguzņēmums". Jums jāieraksta tos pēc šī parauga: "rezultāts [pauze] rezultāts [pauze] zīdains [pauze] zīdains [pauze] palīguzņēmums [pauze] palīguzņēmums [pauze] [un tā tālāk ar visiem pārējiem vārdiem]".

6) Iegaumējiet, ka vārdu sarakstā ir arī daži vārdu savienojumi (piem. "un dilt", "un gandrīz"). Tie jāizrunā, bez pauzes starp vārdiem, piemēram, "un" un "gandrīz" ("un gandrīz [pauze] un gandrīz [pauze] utt."). Daži vārdu savienojumi var šķist jums savādi, tomēr mēģiniet tos izrunāt normālā veidā.

Appendix 5
LIST OF TOKENS EMPLOYED IN THE ANALYSIS

Legend

Each name of the token contains three numbers. The first number is the number of the informant, the second number is the number of the word, the third marks one of the two instances of the recorded word (since the informants were asked to record each word twice).

Informant numbers are:

a) For English, 3 = F1, 5 = F2, 10 = F3
b) For Latvian, 1 = F1, 2 = M1, 3 = F2

Word numbers in the token names are the same as those shown in the appropriate word lists.

English analysis

1) Disyllabic stress-initial

1. 10-10-1 *digger*
2. 10-10-2 *digger*
3. 10-18-1 *beggar*
4. 10-18-2 *beggar*
5. 10-2-1 *greedy*
6. 10-2-2 *greedy*
7. 10-26-1 *dagger*
8. 10-34-1 *dugout*
9. 10-34-2 *dugout*
10. 10-42-2 *boogie*
11. 10-50-1 *boarder*
12. 10-50-2 *boarder*
13. 10-58-1 *barber*
14. 10-58-2 *barber*
15. 10-66-1 *day-dream*
16. 10-66-2 *day-dream*
17. 10-74-1 *lousy*
18. 10-74-2 *lousy*
19. 10-82-2 *odour*
20. 3-10-1 *digger*
21. 3-10-2 *digger*
22. 3-18-1 *beggar*
23. 3-18-2 *beggar*
24. 3-2-1 *greedy*
25. 3-2-2 *greedy*
26. 3-26-1 *dagger*
27. 3-26-2 *dagger*
28. 3-34-1 *dugout*
29. 3-34-2 *dugout*
30. 3-42-1 *boogie*
31. 3-42-2 *boogie*
32. 3-50-1 *boarder*
33. 3-50-2 *boarder*
34. 3-58-1 *barber*
35. 3-58-2 *barber*
36. 3-66-1 *day-dream*
37. 3-66-2 *day-dream*
38. 3-74-1 *lousy*
39. 3-74-2 *lousy*
40. 3-82-1 *odour*
41. 3-82-2 *odour*
42. 5-10-1 *digger*
43. 5-10-2 *digger*
44. 5-18-1 *beggar*
45. 5-18-2 *beggar*
46. 5-2-1 *greedy*
47. 5-2-2 *greedy*
48. 5-26-1 *dagger*
49. 5-26-2 *dagger*
50. 5-34-1 *dugout*
51. 5-34-2 *dugout*
52. 5-42-1 *boogie*
53. 5-42-2 *boogie*
54. 5-50-1 *boarder*
55. 5-50-2 *boarder*
56. 5-58-1 *barber*
57. 5-58-2 *barber*
58. 5-66-1 *day-dream*
59. 5-66-2 *day-dream*
60. 5-74-1 *lousy*
61. 5-74-2 *lousy*
62. 5-82-1 *odour*
63. 5-82-2 *odour*

2) Disyllabic stress-final

1. 10-11-2 *forbid*
2. 10-19-1 *embed*
3. 10-19-2 *embed*
4. 10-27-1 *kebab*
5. 10-3-1 *Dundee*
6. 10-35-1 *outdone*
7. 10-43-1 *taboos*
8. 10-43-2 *taboos*
9. 10-51-1 *indoors*
10. 10-51-2 *indoors*
11. 10-59-1 *cigar*
12. 10-59-2 *cigar*
13. 10-67-1 *brigade*
14. 10-67-2 *brigade*
15. 10-75-1 *carouse*
16. 10-75-2 *carouse*
17. 10-83-1 *hellos*
18. 10-83-2 *hellos*
19. 3-11-1 *forbid*
20. 3-11-2 *forbid*
21. 3-19-1 *embed*
22. 3-19-2 *embed*
23. 3-27-1 *kebab*
24. 3-27-2 *kebab*
25. 3-3-2 *Dundee*
26. 3-35-1 *outdone*
27. 3-35-2 *outdone*
28. 3-43-1 *taboos*
29. 3-43-2 *taboos*
30. 3-51-2 *indoors*
31. 3-59-1 *cigar*
32. 3-59-2 *cigar*
33. 3-67-1 *brigade*
34. 3-67-2 *brigade*
35. 3-75-1 *carouse*
36. 3-75-2 *carouse*
37. 3-83-1 *hellos*
38. 3-83-2 *hellos*
39. 5-11-1 *forbid*
40. 5-19-1 *embed*
41. 5-19-2 *embed*
42. 5-27-1 *kebab*
43. 5-27-2 *kebab*
44. 5-3-1 *Dundee*
45. 5-43-1 *taboos*
46. 5-43-2 *taboos*
47. 5-59-1 *cigar*
48. 5-59-2 *cigar*
49. 5-67-1 *brigade*
50. 5-67-2 *brigade*
51. 5-75-1 *carouse*
52. 5-75-2 *carouse*
53. 5-83-1 *hellos*
54. 5-83-2 *hellos*

3) Trisyllabic stress-initial

1. 10-12-1 *bigamous*
2. 10-12-2 *bigamous*
3. 10-20-1 *beverage*
4. 10-20-2 *beverage*
5. 10-28-1 *bagginess*
6. 10-28-2 *bagginess*
7. 10-36-1 *doublespeak*
8. 10-36-2 *doublespeak*
9. 10-4-1 *deviance*
10. 10-4-2 *deviance*
11. 10-44-1 *dubious*
12. 10-44-2 *dubious*
13. 10-68-1 *babysit*
14. 10-68-2 *babysit*
15. 10-76-1 *dowdiness*
16. 10-76-2 *dowdiness*
17. 10-84-1 *overload*
18. 10-84-2 *overload*
19. 3-12-1 *bigamous*
20. 3-12-2 *bigamous*
21. 3-20-1 *beverage*
22. 3-20-2 *beverage*
23. 3-28-1 *bagginess*
24. 3-28-2 *bagginess*
25. 3-36-1 *doublespeak*
26. 3-36-2 *doublespeak*
27. 3-4-1 *deviance*
28. 3-4-2 *deviance*
29. 3-44-1 *dubious*
30. 3-44-2 *dubious*
31. 3-68-1 *babysit*
32. 3-68-2 *babysit*
33. 3-76-1 *dowdiness*
34. 3-76-2 *dowdiness*
35. 3-84-1 *overload*
36. 3-84-2 *overload*
37. 5-12-1 *bigamous*
38. 5-12-2 *bigamous*
39. 5-20-1 *beverage*
40. 5-20-2 *beverage*
41. 5-28-1 *bagginess*
42. 5-28-2 *bagginess*
43. 5-36-1 *doublespeak*
44. 5-36-2 *doublespeak*
45. 5-4-1 *deviance*
46. 5-4-2 *deviance*
47. 5-44-1 *dubious*
48. 5-44-2 *dubious*
49. 5-68-1 *babysit*
50. 5-68-2 *babysit*
51. 5-76-1 *dowdiness*
52. 5-76-2 *dowdiness*
53. 5-84-1 *overload*
54. 5-84-2 *overload*

4) Trisyllabic stress-medial

1. 10-13-1 *forbidden*
2. 10-13-2 *forbidden*
3. 10-21-1 *unleaded*

4. 10-21-2 *unleaded*
5. 10-29-1 *cadaver*
6. 10-29-2 *cadaver*
7. 10-37-1 *redouble*
8. 10-37-2 *redouble*
9. 10-45-1 *caboodle*
10. 10-5-1 *libido*
11. 10-5-2 *libido*
12. 10-53-1 *Pandora*
13. 10-53-2 *Pandora*
14. 10-61-1 *regardless*
15. 10-61-2 *regardless*
16. 10-69-1 *engaging*
17. 10-69-2 *engaging*
18. 10-77-1 *carouses*
19. 10-77-2 *carouses*
20. 10-85-1 *ennoble*
21. 10-85-2 *ennoble*
22. 3-13-1 *forbidden*
23. 3-13-2 *forbidden*
24. 3-21-1 *unleaded*
25. 3-21-2 *unleaded*
26. 3-29-1 *cadaver*
27. 3-29-2 *cadaver*
28. 3-37-1 *redouble*
29. 3-37-2 *redouble*
30. 3-45-1 *caboodle*
31. 3-45-2 *caboodle*
32. 3-5-1 *libido*
33. 3-5-2 *libido*
34. 3-53-1 *Pandora*
35. 3-53-2 *Pandora*
36. 3-61-1 *regardless*
37. 3-61-2 *regardless*
38. 3-69-1 *engaging*
39. 3-69-2 *engaging*
40. 3-77-1 *carouses*
41. 3-77-2 *carouses*
42. 3-85-1 *ennoble*
43. 3-85-2 *ennoble*
44. 5-13-1 *forbidden*
45. 5-13-2 *forbidden*
46. 5-21-1 *unleaded*
47. 5-21-2 *unleaded*
48. 5-37-1 *redouble*
49. 5-37-2 *redouble*
50. 5-45-1 *caboodle*
51. 5-45-2 *caboodle*
52. 5-5-1 *libido*
53. 5-5-2 *libido*
54. 5-53-2 *Pandora*
55. 5-61-1 *regardless*
56. 5-61-2 *regardless*
57. 5-69-1 *engaging*
58. 5-69-2 *engaging*
59. 5-77-1 *carouses*
60. 5-77-2 *carouses*
61. 5-85-1 *ennoble*
62. 5-85-2 *ennoble*

5) Trisyllabic stress-final

1. 10-14-1 *to forgive*
2. 10-14-2 *to forgive*
3. 10-22-1 *to embed*
4. 10-22-2 *to embed*
5. 10-30-1 *the canal*
6. 10-30-2 *the canal*
7. 10-38-1 *to outgun*
8. 10-38-2 *to outgun*
9. 10-46-1 *to occlude*
10. 10-46-2 *to occlude*
11. 10-54-1 *to reward*
12. 10-54-2 *to reward*
13. 10-6-1 *to believe*
14. 10-6-2 *to believe*
15. 10-62-1 *to regard*
16. 10-62-2 *to regard*
17. 10-70-1 *to engage*
18. 10-70-2 *to engage*
19. 10-78-1 *to carouse*
20. 10-78-2 *to carouse*
21. 10-86-1 *to corrode*
22. 10-86-2 *to corrode*
23. 3-14-1 *to forgive*
24. 3-14-2 *to forgive*
25. 3-22-1 *to embed*
26. 3-22-2 *to embed*
27. 3-30-1 *the canal*
28. 3-30-2 *the canal*
29. 3-38-1 *to outgun*
30. 3-38-2 *to outgun*
31. 3-46-1 *to occlude*
32. 3-46-2 *to occlude*
33. 3-54-1 *to reward*
34. 3-54-2 *to reward*
35. 3-6-1 *to believe*
36. 3-6-2 *to believe*
37. 3-62-1 *to regard*
38. 3-62-2 *to regard*
39. 3-70-1 *to engage*
40. 3-70-2 *to engage*
41. 3-78-1 *to carouse*
42. 3-78-2 *to carouse*
43. 3-86-1 *to corrode*
44. 3-86-2 *to corrode*
45. 5-14-1 *to forgive*
46. 5-14-2 *to forgive*
47. 5-22-1 *to embed*
48. 5-22-2 *to embed*
49. 5-30-1 *the canal*
50. 5-30-2 *the canal*
51. 5-38-1 *to outgun*
52. 5-38-2 *to outgun*
53. 5-46-1 *to occlude*
54. 5-46-2 *to occlude*
55. 5-54-1 *to reward*
56. 5-54-2 *to reward*
57. 5-6-1 *to believe*
58. 5-6-2 *to believe*
59. 5-62-1 *to regard*
60. 5-62-2 *to regard*
61. 5-70-1 *to engage*
62. 5-70-2 *to engage*
63. 5-78-1 *to carouse*
64. 5-78-2 *to carouse*
65. 5-86-1 *to corrode*
66. 5-86-2 *to corrode*

6) Primary-stress-initial, secondary-stress-medial

1. 10-16-1 *gold-digger*
2. 10-16-2 *gold-digger*
3. 10-24-1 *bootlegger*
4. 10-24-2 *bootlegger*
5. 10-32-1 *bandwagon*
6. 10-32-2 *bandwagon*
7. 10-40-1 *godmother*
8. 10-40-2 *godmother*
9. 10-48-1 *earthmover*
10. 10-48-2 *earthmover*
11. 10-64-1 *plea-bargain*
12. 10-64-2 *plea-bargain*
13. 10-72-1 *landlady*
14. 10-72-2 *landlady*
15. 10-80-1 *rabble-rouser*
16. 10-8-1 *lipreader*
17. 10-8-2 *lipreader*
18. 10-88-1 *bulldozer*
19. 10-88-2 *bulldozer*
20. 3-16-1 *gold-digger*
21. 3-16-2 *gold-digger*
22. 3-24-1 *bootlegger*
23. 3-24-2 *bootlegger*
24. 3-32-1 *bandwagon*
25. 3-32-2 *bandwagon*
26. 3-40-1 *godmother*
27. 3-40-2 *godmother*
28. 3-48-1 *earthmover*
29. 3-48-2 *earthmover*
30. 3-64-1 *plea-bargain*
31. 3-64-2 *plea-bargain*
32. 3-72-1 *landlady*
33. 3-72-2 *landlady*
34. 3-80-1 *rabble-rouser*
35. 3-80-2 *rabble-rouser*
36. 3-8-1 *lipreader*
37. 3-8-2 *lipreader*
38. 3-88-1 *bulldozer*
39. 3-88-2 *bulldozer*
40. 5-16-1 *gold-digger*
41. 5-16-2 *gold-digger*
42. 5-24-1 *bootlegger*
43. 5-24-2 *bootlegger*
44. 5-32-1 *bandwagon*
45. 5-32-2 *bandwagon*
46. 5-40-1 *godmother*
47. 5-40-2 *godmother*
48. 5-48-1 *earthmover*
49. 5-48-2 *earthmover*
50. 5-64-1 *plea-bargain*
51. 5-64-2 *plea-bargain*
52. 5-72-1 *landlady*
53. 5-72-2 *landlady*
54. 5-80-1 *rabble-rouser*
55. 5-80-2 *rabble-rouser*
56. 5-8-1 *lipreader*
57. 5-8-2 *lipreader*
58. 5-88-1 *bulldozer*
59. 5-88-2 *bulldozer*

7) Primary-stress-medial, secondary-stress-initial

1. 10-15-1 *idiomatic*
2. 10-15-2 *idiomatic*
3. 10-23-1 *debonair*
4. 10-23-2 *debonair*
5. 10-31-1 *admiration*
6. 10-31-2 *admiration*
7. 10-39-1 *otherworldly*
8. 10-39-2 *otherworldly*
9. 10-47-1 *rudimentary*
10. 10-47-2 *rudimentary*
11. 10-55-1 *mortgagee*
12. 10-63-1 *argumentative*
13. 10-63-2 *argumentative*
14. 10-7-1 *egocentric*
15. 10-71-1 *Asiatic*
16. 10-71-2 *Asiatic*
17. 10-7-2 *egocentric*
18. 10-79-1 *download*
19. 10-79-2 *download*
20. 10-87-1 *overactive*
21. 10-87-2 *overactive*
22. 3-15-1 *idiomatic*
23. 3-15-2 *idiomatic*
24. 3-23-1 *debonair*
25. 3-23-2 *debonair*
26. 3-31-1 *admiration*

27. 3-31-2 *admiration*
28. 3-39-1 *otherworldly*
29. 3-39-2 *otherworldly*
30. 3-47-1 *rudimentary*
31. 3-47-2 *rudimentary*
32. 3-55-1 *mortgagee*
33. 3-55-2 *mortgagee*
34. 3-63-1 *argumentative*
35. 3-63-2 *argumentative*
36. 3-71-1 *egocentric*
37. 3-71-2 *egocentric*
38. 3-7-2 *Asiatic*
39. 3-79-1 *download*
40. 3-79-2 *download*
41. 3-87-1 *overactive*
42. 3-87-2 *overactive*
43. 5-15-1 *idiomatic*
44. 5-15-2 *idiomatic*
45. 5-23-1 *debonair*
46. 5-23-2 *debonair*
47. 5-31-1 *admiration*
48. 5-31-2 *admiration*
49. 5-39-1 *otherworldly*
50. 5-39-2 *otherworldly*
51. 5-47-1 *rudimentary*
52. 5-47-2 *rudimentary*
53. 5-55-1 *mortgagee*
54. 5-55-2 *mortgagee*
55. 5-63-1 *argumentative*
56. 5-63-2 *argumentative*
57. 5-7-1 *Asiatic*
58. 5-71-1 *egocentric*
59. 5-71-2 *egocentric*
60. 5-7-2 *Asiatic*
61. 5-79-1 *download*
62. 5-79-2 *download*
63. 5-87-1 *overactive*
64. 5-87-2 *overactive*

8) F0 test in disyllables

1.	10-10-1	10-11-2	*digger/forbid*
2.	10-18-1	10-19-1	*beggar/embed*
3.	10-18-2	10-19-2	*beggar/embed*
4.	10-26-1	10-27-1	*dagger/kebab*
5.	10-2-2	10-3-1	*greedy/Dundee*
6.	10-34-1	10-35-1	*dugout/outdone*
7.	10-42-2	10-43-2	*boogie/taboos*
8.	10-50-1	10-51-1	*boarder/indoors*
9.	10-50-2	10-51-2	*boarder/indoors*
10.	10-58-1	10-59-1	*barber/cigar*
11.	10-58-2	10-59-2	*barber/cigar*
12.	10-66-1	10-67-1	*day-dream/brigade*
13.	10-66-2	10-67-2	*day-dream/brigade*
14.	10-74-1	10-75-1	*lousy/carouse*
15.	10-74-2	10-75-2	*lousy/carouse*
16.	10-82-2	10-83-1	*odour/hellos*
17.	3-10-1	3-11-1	*digger/forbid*
18.	3-10-2	3-11-2	*digger/forbid*
19.	3-18-1	3-19-1	*beggar/embed*
20.	3-18-2	3-19-2	*beggar/embed*
21.	3-26-1	3-27-1	*dagger/kebab*
22.	3-26-2	3-27-2	*dagger/kebab*
23.	3-2-2	3-3-2	*greedy/Dundee*
24.	3-34-1	3-35-1	*dugout/outdone*
25.	3-34-2	3-35-2	*dugout/outdone*
26.	3-42-1	3-43-1	*boogie/taboos*
27.	3-42-2	3-43-2	*boogie/taboos*

28. 3-50-1	3-51-2	*boarder/indoors*
29. 3-58-1	3-59-1	*barber/cigar*
30. 3-58-2	3-59-2	*barber/cigar*
31. 3-66-1	3-67-1	*day-dream/brigade*
32. 3-66-2	3-67-2	*day-dream/brigade*
33. 3-74-1	3-75-1	*lousy/carouse*
34. 3-74-2	3-75-2	*lousy/carouse*
35. 3-82-1	3-83-1	*odour/hellos*
36. 3-82-2	3-83-2	*odour/hellos*
37. 5-10-1	5-11-1	*digger/forbid*
38. 5-18-1	5-19-1	*beggar/embed*
39. 5-18-2	5-19-2	*beggar/embed*
40. 5-26-1	5-27-1	*dagger/kebab*
41. 5-26-2	5-27-2	*dagger/kebab*
42. 5-2-1	5-3-1	*greedy/Dundee*
43. 5-42-1	5-43-1	*boogie/taboos*
44. 5-42-2	5-43-2	*boogie/taboos*
45. 5-58-1	5-59-1	*barber/cigar*
46. 5-58-2	5-59-2	*barber/cigar*
47. 5-66-1	5-67-1	*day-dream/brigade*
48. 5-66-2	5-67-2	*day-dream/brigade*
49. 5-74-1	5-75-1	*lousy/carouse*
50. 5-74-2	5-75-2	*lousy/carouse*
51. 5-82-1	5-83-1	*odour/hellos*
52. 5-82-2	5-83-2	*odour/hellos*

Latvian analysis

1) Disyllabic stress-initial

1. 1-11-1 *zīdains*
2. 1-11-2 *zīdains*
3. 1-2-1 *bilde*
4. 1-21-1 *bezdarbs*
5. 1-21-2 *bezdarbs*
6. 1-2-2 *bilde*
7. 1-30-1 *degums*
8. 1-30-2 *degums*
9. 1-39-1 *bruģis*
10. 1-39-2 *bruģis*
11. 1-48-1 *bronza*
12. 1-48-2 *bronza*
13. 1-57-1 *daļa*
14. 1-57-2 *daļa*
15. 1-67-1 *veidot*
16. 1-67-2 *veidot*
17. 1-75-1 *vairāk*
18. 1-75-2 *vairāk*
19. 1-82-1 *baumas*
20. 1-82-2 *baumas*
21. 2-11-2 *zīdains*
22. 2-2-1 *bilde*
23. 2-21-1 *bezdarbs*
24. 2-21-2 *bezdarbs*
25. 2-2-2 *bilde*
26. 2-30-1 *degums*
27. 2-30-2 *degums*
28. 2-39-1 *bruģis*
29. 2-39-2 *bruģis*
30. 2-48-2 *bronza*
31. 2-57-1 *daļa*
32. 2-57-2 *daļa*
33. 2-67-1 *veidot*
34. 2-67-2 *veidot*
35. 2-75-1 *vairāk*
36. 2-75-2 *vairāk*
37. 2-82-1 *baumas*
38. 2-82-2 *baumas*
39. 3-11-2 *zīdains*
40. 3-21-1 *bezdarbs*
41. 3-21-2 *bezdarbs*
42. 3-30-1 *degums*
43. 3-30-2 *degums*
44. 3-39-1 *bruģis*
45. 3-39-2 *bruģis*
46. 3-48-1 *bronza*
47. 3-48-2 *bronza*
48. 3-57-2 *daļa*
49. 3-75-1 *vairāk*
50. 3-75-2 *vairāk*
51. 3-82-1 *baumas*
52. 3-82-2 *baumas*

2) Disyllabic stress-final

1. 1-12-1 *gandrīz*
2. 1-12-2 *gandrīz*
3. 1-22-1 *un degt*
4. 1-22-2 *un degt*
5. 1-3-1 *un dilt*
6. 1-3-2 *un dilt*
7. 1-40-1 *nekurp*
8. 1-40-2 *nekurp*
9. 1-49-1 *un bokss*
10. 1-49-2 *un bokss*
11. 1-58-1 *vismaz*
12. 1-58-2 *vismaz*
13. 1-68-1 *ikreiz*
14. 1-68-2 *ikreiz*
15. 1-76-1 *un laiks*
16. 1-76-2 *un laiks*
17. 1-83-1 *un lauks*
18. 1-83-2 *un lauks*
19. 2-12-1 *gandrīz*
20. 2-12-2 *gandrīz*
21. 2-22-1 *un degt*
22. 2-22-2 *un degt*
23. 2-3-1 *un dilt*
24. 2-3-2 *un dilt*
25. 2-40-1 *nekurp*
26. 2-40-2 *nekurp*
27. 2-49-1 *un bokss*
28. 2-49-2 *un bokss*
29. 2-58-1 *vismaz*
30. 2-58-2 *vismaz*
31. 2-68-1 *ikreiz*
32. 2-68-2 *ikreiz*
33. 2-76-1 *un laiks*
34. 2-76-2 *un laiks*
35. 2-83-1 *un lauks*
36. 2-83-2 *un lauks*
37. 3-12-1 *gandrīz*
38. 3-12-2 *gandrīz*
39. 3-22-1 *un degt*
40. 3-22-2 *un degt*
41. 3-3-1 *un dilt*
42. 3-3-2 *un dilt*
43. 3-40-1 *nekurp*
44. 3-40-2 *nekurp*
45. 3-49-1 *un bokss*
46. 3-49-2 *un bokss*
47. 3-58-2 *vismaz*
48. 3-68-2 *ikreiz*
49. 3-76-2 *un laiks*
50. 3-83-1 *un lauks*
51. 3-83-2 *un lauks*

3) Trisyllabic stress-initial

1. 1-13-1 *dīzelis*
2. 1-13-2 *dīzelis*
3. 1-23-1 *rezultāts*
4. 1-23-2 *rezultāts*
5. 1-32-1 *degungals*
6. 1-32-2 *degungals*
7. 1-4-1 *izmeklēt*
8. 1-41-1 *bundulis*
9. 1-41-2 *bundulis*
10. 1-4-2 *izmeklēt*
11. 1-50-1 *gobelēns*
12. 1-50-2 *gobelēns*

13. 1-59-1 *aleja*
14. 1-59-2 *aleja*
15. 1-69-1 *Eiropa*
16. 1-69-2 *Eiropa*
17. 1-77-1 *daiļrade*
18. 1-77-2 *daiļrade*
19. 1-84-1 *raudzīties*
20. 1-84-2 *raudzīties*
21. 2-13-1 *dīzelis*
22. 2-13-2 *dīzelis*
23. 2-23-1 *rezultāts*
24. 2-23-2 *rezultāts*
25. 2-32-1 *degungals*
26. 2-32-2 *degungals*
27. 2-4-1 *izmeklēt*
28. 2-41-1 *bundulis*
29. 2-41-2 *bundulis*
30. 2-4-2 *izmeklēt*
31. 2-50-1 *gobelēns*
32. 2-50-2 *gobelēns*
33. 2-59-1 *aleja*
34. 2-59-2 *aleja*
35. 2-69-1 *Eiropa*
36. 2-69-2 *Eiropa*
37. 2-77-1 *daiļrade*
38. 2-77-2 *daiļrade*
39. 2-84-1 *raudzīties*
40. 2-84-2 *raudzīties*
41. 3-13-1 *dīzelis*
42. 3-13-2 *dīzelis*
43. 3-23-2 *rezultāts*
44. 3-32-1 *degungals*
45. 3-32-2 *degungals*
46. 3-4-1 *izmeklēt*
47. 3-41-1 *bundulis*
48. 3-41-2 *bundulis*
49. 3-4-2 *izmeklēt*
50. 3-50-1 *gobelēns*
51. 3-50-2 *gobelēns*
52. 3-59-1 *aleja*
53. 3-59-2 *aleja*
54. 3-69-2 *Eiropa*
55. 3-77-2 *daiļrade*
56. 3-84-2 *raudzīties*

4) Trisyllabic stress-medial

1. 1-14-1 *aiz dīķa*
2. 1-14-2 *aiz dīķa*
3. 1-24-1 *pudesmit*
4. 1-24-2 *pudesmit*
5. 1-33-1 *bez devas*
6. 1-33-2 *bez devas*
7. 1-5-1 *pavisam*
8. 1-51-1 *ar moto*
9. 1-51-2 *ar moto*
10. 1-5-2 *pavisam*
11. 1-60-1 *pagalam*
12. 1-60-2 *pagalam*
13. 1-70-1 *un veidot*
14. 1-70-2 *un veidot*
15. 1-78-1 *ne vairak*
16. 1-78-2 *ne vairak*
17. 1-85-1 *un baumas*
18. 1-85-2 *un baumas*
19. 2-14-1 *aiz dīķa*
20. 2-14-2 *aiz dīķa*
21. 2-24-1 *pudesmit*
22. 2-24-2 *pudesmit*
23. 2-33-2 *bez devas*
24. 2-5-1 *pavisam*
25. 2-51-1 *ar moto*
26. 2-51-2 *ar moto*
27. 2-5-2 *pavisam*
28. 2-60-1 *pagalam*
29. 2-60-2 *pagalam*
30. 2-70-1 *un veidot*
31. 2-70-2 *un veidot*
32. 2-78-1 *ne vairak*
33. 2-78-2 *ne vairak*
34. 2-85-1 *un baumas*
35. 2-85-2 *un baumas*
36. 3-14-1 *aiz dīķa*
37. 3-14-2 *aiz dīķa*
38. 3-24-1 *pudesmit*
39. 3-24-2 *pudesmit*
40. 3-33-1 *bez devas*
41. 3-33-2 *bez devas*
42. 3-51-1 *ar moto*
43. 3-51-2 *ar moto*
44. 3-5-2 *pavisam*
45. 3-60-2 *pagalam*
46. 3-70-2 *un veidot*
47. 3-78-2 *ne vairak*
48. 3-85-1 *un baumas*
49. 3-85-2 *un baumas*

5) Trisyllabic stress-final

1. 1-15-1 *un gandrīz*
2. 1-15-2 *un baumas*
3. 1-42-1 *un nekurp*
4. 1-42-2 *un nekurp*
5. 1-61-1 *un vismaz*
6. 1-61-2 *un vismaz*
7. 1-71-1 *un ikreiz*
8. 1-71-2 *un ikreiz*
9. 2-15-1 *un baumas*
10. 2-15-2 *un baumas*
11. 2-42-1 *un nekurp*
12. 2-42-2 *un nekurp*
13. 2-61-1 *un vismaz*
14. 2-61-2 *un vismaz*
15. 2-71-1 *un ikreiz*
16. 2-71-2 *un ikreiz*
17. 3-15-2 *un baumas*
18. 3-42-1 *un nekurp*
19. 3-42-2 *un nekurp*
20. 3-61-2 *un vismaz*
21. 3-71-1 *un ikreiz*
22. 3-71-2 *un ikreiz*

6) Primary-stress-initial, secondary-stress-medial

1. 1-18-1 *līdzatbildība*
2. 1-18-2 *līdzatbildība*

3. 1-27-1 *metamorfoze*
4. 1-27-2 *metamorfoze*
5. 1-36-1 *dzeltensarkanais*
6. 1-36-2 *dzeltensarkanais*
7. 1-45-1 *guļamistaba*
8. 1-45-2 *guļamistaba*
9. 1-54-1 *problemātika*
10. 1-54-2 *problemātika*
11. 1-64-1 *balināšana*
12. 1-64-2 *balināšana*
13. 1-8-1 *diplomātija*
14. 1-8-2 *diplomātija*
15. 2-18-2 *līdzatbildība*
16. 2-27-1 *metamorfoze*
17. 2-27-2 *metamorfoze*
18. 2-36-1 *dzeltensarkanais*
19. 2-36-2 *dzeltensarkanais*
20. 2-45-1 *guļamistaba*
21. 2-45-2 *guļamistaba*
22. 2-54-1 *problemātika*
23. 2-54-2 *problemātika*
24. 2-64-1 *balināšana*
25. 2-64-2 *balināšana*
26. 2-8-1 *diplomātija*
27. 2-8-2 *diplomātija*
28. 3-18-1 *līdzatbildība*
29. 3-18-2 *līdzatbildība*
30. 3-27-2 *metamorfoze*
31. 3-36-1 *dzeltensarkanais*
32. 3-36-2 *dzeltensarkanais*
33. 3-45-2 *guļamistaba*
34. 3-54-1 *problemātika*
35. 3-64-1 *balināšana*
36. 3-64-2 *balināšana*
37. 3-8-1 *diplomātija*
38. 3-8-2 *diplomātija*
39. 1-19-1 *pamatlīdzekļi*
40. 1-19-2 *pamatlīdzekļi*
41. 1-28-1 *pamatmetode*
42. 1-28-2 *pamatmetode*
43. 1-37-1 *badadzeguze*
44. 1-37-2 *badadzeguze*
45. 1-46-1 *palīguzņēmums*
46. 1-46-2 *palīguzņēmums*
47. 1-55-1 *pamatproblēma*
48. 1-55-2 *pamatproblēma*
49. 1-65-1 *pamatbarība*
50. 1-65-2 *pamatbarība*
51. 1-9-1 *papildizrāde*
52. 1-9-2 *papildizrāde*
53. 2-19-1 *pamatlīdzekļi*
54. 2-28-1 *pamatmetode*
55. 2-28-2 *pamatmetode*
56. 2-37-1 *badadzeguze*
57. 2-37-2 *badadzeguze*
58. 2-46-1 *palīguzņēmums*
59. 2-46-2 *palīguzņēmums*
60. 2-55-1 *pamatproblēma*
61. 2-55-2 *pamatproblēma*
62. 2-65-1 *pamatbarība*
63. 2-65-2 *pamatbarība*
64. 2-9-1 *papildizrāde*
65. 2-9-2 *papildizrāde*
66. 3-19-1 *pamatlīdzekļi*
67. 3-19-2 *pamatlīdzekļi*
68. 3-28-1 *pamatmetode*
69. 3-46-2 *palīguzņēmums*
70. 3-55-2 *pamatproblēma*

7) Primary-stress-initial, secondary-stress-medial (per vowel analysis)

1.	1-18-1	1-19-1	*līdzatbildība/pamatlīdzekļi*
2.	1-18-2	1-19-2	*līdzatbildība/pamatlīdzekļi*
3.	1-27-1	1-28-1	*metamorfoze/pamatmetode*
4.	1-27-2	1-28-2	*metamorfoze/pamatmetode*
5.	1-36-1	1-37-1	*dzeltensarkanais/badadzeguze*
6.	1-36-2	1-37-2	*dzeltensarkanais/badadzeguze*
7.	1-45-1	1-46-1	*guļamistaba/palīguzņēmums*
8.	1-45-2	1-46-2	*guļamistaba/palīguzņēmums*
9.	1-54-1	1-55-1	*problemātika/pamatproblēma*
10.	1-54-2	1-55-2	*problemātika/pamatproblēma*
11.	1-64-1	1-65-1	*balināšana/pamatbarība*
12.	1-64-2	1-65-2	*balināšana/pamatbarība*

13.	1-8-1	1-9-1	*diplomātija/papildizrāde*
14.	1-8-2	1-9-2	*diplomātija/papildizrāde*
15.	2-18-2	2-19-1	*līdzatbildība/pamatlīdzekļi*
16.	2-27-1	2-28-1	*metamorfoze/pamatmetode*
17.	2-27-2	2-28-2	*metamorfoze/pamatmetode*
18.	2-36-1	2-37-1	*dzeltensarkanais/badadzeguze*
19.	2-36-2	2-37-2	*dzeltensarkanais/badadzeguze*
20.	2-45-1	2-46-1	*guļamistaba/palīguzņēmums*
21.	2-45-2	2-46-2	*guļamistaba/palīguzņēmums*
22.	2-54-1	2-55-1	*problemātika/pamatproblēma*
23.	2-54-2	2-55-2	*problemātika/pamatproblēma*
24.	2-64-1	2-65-1	*balināšana/pamatbarība*
25.	2-64-2	2-65-2	*balināšana/pamatbarība*
26.	2-8-1	2-9-1	*diplomātija/papildizrāde*
27.	2-8-2	2-9-2	*diplomātija/papildizrāde*
28.	3-18-1	3-19-1	*līdzatbildība/pamatlīdzekļi*
29.	3-18-2	3-19-2	*līdzatbildība/pamatlīdzekļi*
30.	3-27-2	3-28-1	*metamorfoze/pamatmetode*
31.	3-45-2	3-46-2	*guļamistaba/palīguzņēmums*
32.	3-54-1	3-55-2	*problemātika/pamatproblēma*

8) Trisyllabic, stressed-unstressed comparison, medial position (per vowel analysis)

1.	1-14-1	1-16-1	*aiz dīķa/nelīdzens*
2.	1-14-2	1-16-2	*aiz dīķa/nelīdzens*
3.	1-24-1	1-25-1	*pusdesmit/nederīgs*
4.	1-24-2	1-25-2	*pusdesmit/nederīgs*
5.	1-33-1	1-34-1	*bez devas/neredzēts*
6.	1-33-2	1-34-2	*bez devas/neredzēts*
7.	1-51-1	1-52-1	*ar moto/nobloķēt*
8.	1-51-2	1-52-2	*ar moto/nobloķēt*
9.	1-5-1	1-6-1	*pavisam/nemitīgs*
10.	1-5-2	1-6-2	*pavisam/nemitīgs*
11.	1-60-1	1-62-1	*un vismaz/negatīvs*
12.	1-60-2	1-62-2	*un vismaz/negatīvs*
13.	1-70-1	1-72-1	*un veidot/neveiklums*
14.	1-70-2	1-72-2	*un veidot/neveiklums*
15.	1-78-1	1-79-1	*ne vairāk/nevainīgs*
16.	1-78-2	1-79-2	*ne vairāk/nevainīgs*
17.	1-85-1	1-86-1	*un lauks/nedaudzi*
18.	1-85-2	1-86-2	*un lauks/nedaudzi*
19.	2-14-1	2-16-1	*aiz dīķa/nelīdzens*
20.	2-14-2	2-16-2	*aiz dīķa/nelīdzens*
21.	2-24-1	2-25-1	*pusdesmit/nederīgs*
22.	2-24-2	2-25-2	*pusdesmit/nederīgs*
23.	2-33-2	2-34-1	*bez devas/neredzēts*
24.	2-51-1	2-52-1	*ar moto/nobloķēt*
25.	2-51-2	2-52-2	*ar moto/nobloķēt*
26.	2-5-1	2-6-1	*pavisam/nemitīgs*

27.	2-5-2	2-6-2	*pavisam/nemitīgs*
28.	2-60-1	2-62-1	*un vismaz/negatīvs*
29.	2-60-2	2-62-2	*un vismaz/negatīvs*
30.	2-70-1	2-72-1	*un veidot/neveiklums*
31.	2-70-2	2-72-2	*un veidot/neveiklums*
32.	2-78-1	2-79-1	*ne vairāk/nevainīgs*
33.	2-78-2	2-79-2	*ne vairāk/nevainīgs*
34.	2-85-1	2-86-1	*un lauks/nedaudzi*
35.	2-85-2	2-86-2	*un lauks/nedaudzi*
36.	3-14-1	3-16-1	*aiz dīķa/nelīdzens*
37.	3-14-2	3-16-2	*aiz dīķa/nelīdzens*
38.	3-24-1	3-25-1	*pusdesmit/nederīgs*
39.	3-24-2	3-25-2	*pusdesmit/nederīgs*
40.	3-33-1	3-34-2	*bez devas/neredzēts*
41.	3-51-1	3-52-1	*ar moto/nobloķēt*
42.	3-51-2	3-52-2	*ar moto/nobloķēt*
43.	3-5-2	3-6-1	*pavisam/nemitīgs*
44.	3-60-2	3-62-1	*un vismaz/negatīvs*
45.	3-70-2	3-72-1	*un veidot/neveiklums*
46.	3-78-2	3-79-1	*ne vairāk/nevainīgs*
47.	3-85-1	3-86-1	*un lauks/nedaudzi*
48.	3-85-2	3-86-2	*un lauks/nedaudzi*

9) Trisyllabic, stressed-unstressed comparison, final position (per vowel analysis)

1.	1-15-1	1-17-1	*un gandrīz/nevērīgs*
2.	1-15-2	1-17-2	*un gandrīz/nevērīgs*
3.	1-42-1	1-44-1	*un nekurp/nodegums*
4.	1-42-2	1-44-2	*un nekurp/nodegums*
5.	1-61-1	1-63-1	*un vismaz/neparasts*
6.	1-61-2	1-63-2	*un vismaz/neparasts*
7.	1-71-1	1-73-1	*un ikreiz/nepareizs*
8.	1-71-2	1-73-2	*un ikreiz/nepareizs*
9.	2-15-1	2-17-1	*un gandrīz/nevērīgs*
10.	2-15-2	2-17-2	*un gandrīz/nevērīgs*
11.	2-42-1	2-44-1	*un nekurp/nodegums*
12.	2-42-2	2-44-2	*un nekurp/nodegums*
13.	2-61-1	2-63-1	*un vismaz/neparasts*
14.	2-61-2	2-63-2	*un vismaz/neparasts*
15.	2-71-1	2-73-1	*un ikreiz/nepareizs*
16.	2-71-2	2-73-2	*un ikreiz/nepareizs*
17.	3-15-2	3-17-1	*un gandrīz/nevērīgs*
18.	3-42-1	3-44-1	*un nekurp/nodegums*
19.	3-42-2	3-44-2	*un nekurp/nodegums*
20.	3-61-2	3-63-1	*un vismaz/neparasts*
21.	3-71-1	3-73-1	*un ikreiz/nepareizs*
22.	3-71-2	3-73-2	*un ikreiz/nepareizs*

10) F0 test in disyllables

1. 1-11-1 1-12-1 *zīdains/gandrīz*
2. 1-11-2 1-12-2 *zīdains/gandrīz*
3. 1-21-1 1-22-1 *bezdarbs/un degt*
4. 1-21-2 1-22-2 *bezdarbs/un degt*
5. 1-2-1 1-3-1 *bilde/un dilt*
6. 1-2-2 1-3-2 *bilde/un dilt*
7. 1-39-1 1-40-1 *bruģis/nekurp*
8. 1-39-2 1-40-2 *bruģis/nekurp*
9. 1-48-1 1-49-1 *bronza/un bokss*
10. 1-48-2 1-49-2 *bronza/un bokss*
11. 1-57-1 1-58-1 *daļa/vismaz*
12. 1-57-2 1-58-2 *daļa/vismaz*
13. 1-67-1 1-68-1 *veidot/ikreiz*
14. 1-67-2 1-68-2 *veidot/ikreiz*
15. 1-75-1 1-76-1 *vairāk/un laiks*
16. 1-75-2 1-76-2 *vairāk/un laiks*
17. 1-82-1 1-83-1 *baumas/un lauks*
18. 1-82-2 1-83-2 *baumas/un lauks*
19. 2-11-2 2-12-1 *zīdains/gandrīz*
20. 2-2-1 2-3-1 *bilde/un dilt*
21. 2-21-1 2-22-1 *bezdarbs/un degt*
22. 2-21-2 2-22-2 *bezdarbs/un degt*
23. 2-2-2 2-3-2 *bilde/un dilt*
24. 2-39-1 2-40-1 *bruģis/nekurp*
25. 2-39-2 2-40-2 *bruģis/nekurp*
26. 2-48-2 2-49-1 *bronza/un bokss*
27. 2-57-1 2-58-1 *daļa/vismaz*
28. 2-57-2 2-58-2 *daļa/vismaz*
29. 2-67-1 2-68-1 *veidot/ikreiz*
30. 2-67-2 2-68-2 *veidot/ikreiz*
31. 2-75-1 2-76-1 *vairāk/un laiks*
32. 2-75-2 2-76-2 *vairāk/un laiks*
33. 2-82-1 2-83-1 *baumas/un lauks*
34. 2-82-2 2-83-2 *baumas/un lauks*
35. 3-11-2 3-12-1 *zīdains/gandrīz*
36. 3-21-1 3-22-1 *bezdarbs/un degt*
37. 3-21-2 3-22-2 *bezdarbs/un degt*
38. 3-39-1 3-40-1 *bruģis/nekurp*
39. 3-39-2 3-40-2 *bruģis/nekurp*
40. 3-48-1 3-49-1 *bronza/un bokss*
41. 3-48-2 3-49-2 *bronza/un bokss*
42. 3-57-2 3-58-2 *daļa/vismaz*
43. 3-75-2 3-76-2 *vairāk/un laiks*
44. 3-82-1 3-83-1 *baumas/un lauks*
45. 3-82-2 3-83-2 *baumas/un lauks*

Appendix 5
ENLARGED GRAPHS

Figure 5.2

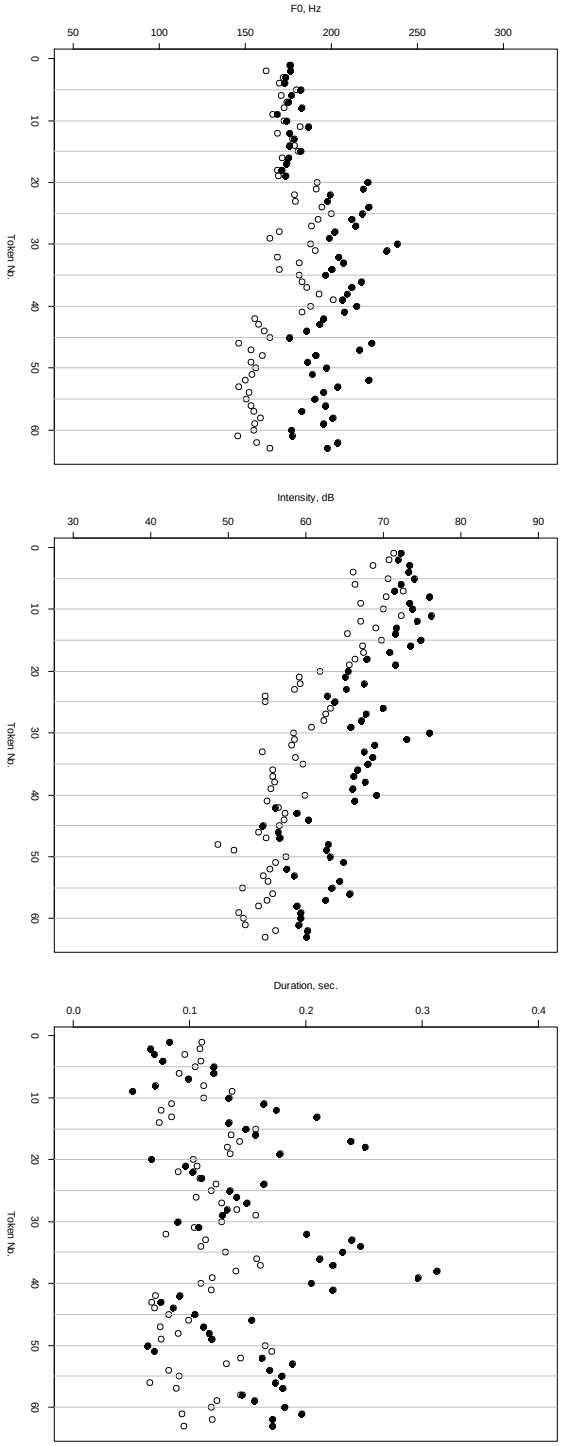


Figure 5.3

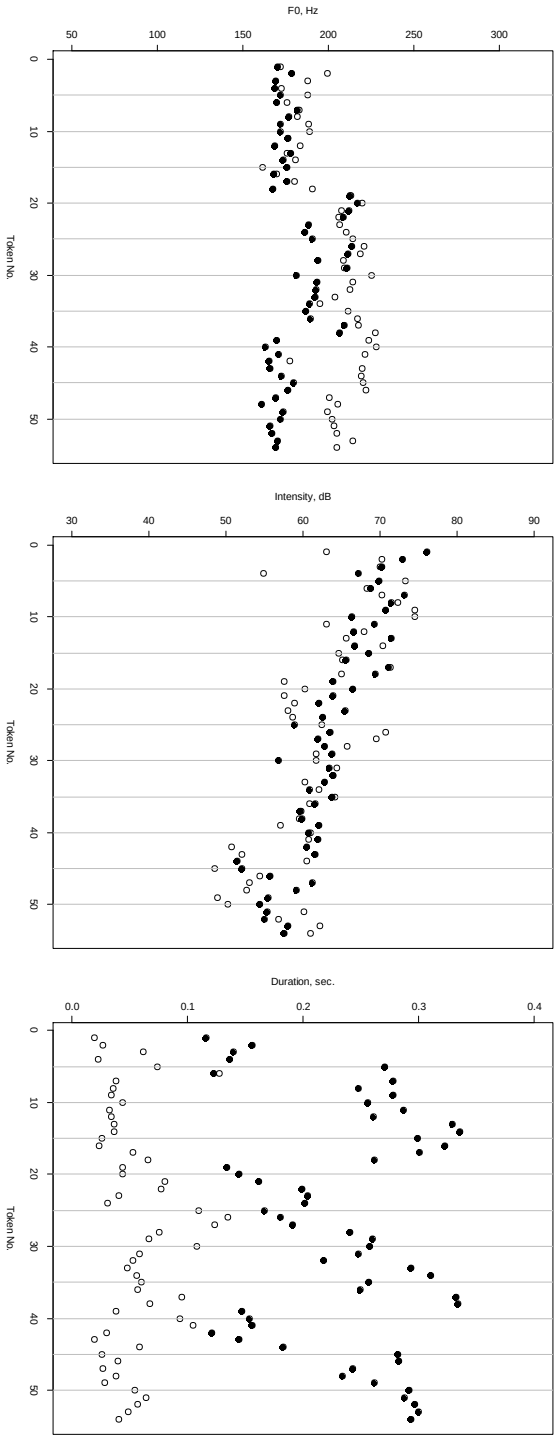


Figure 5.4

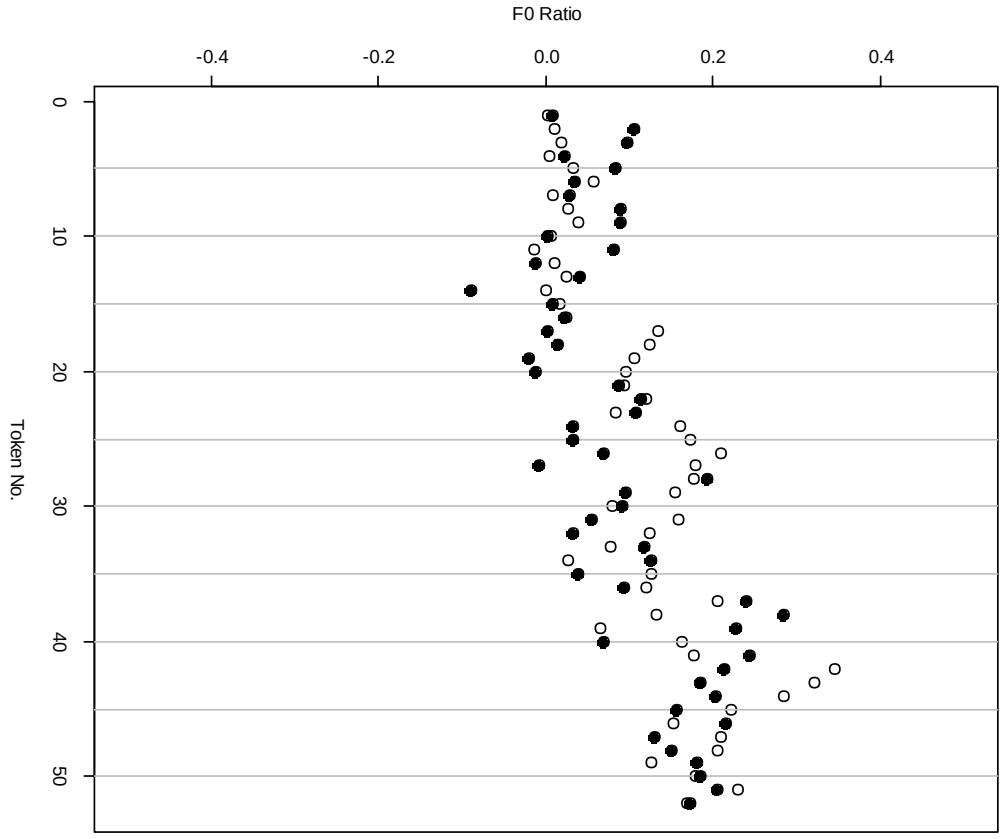


Figure 5.5

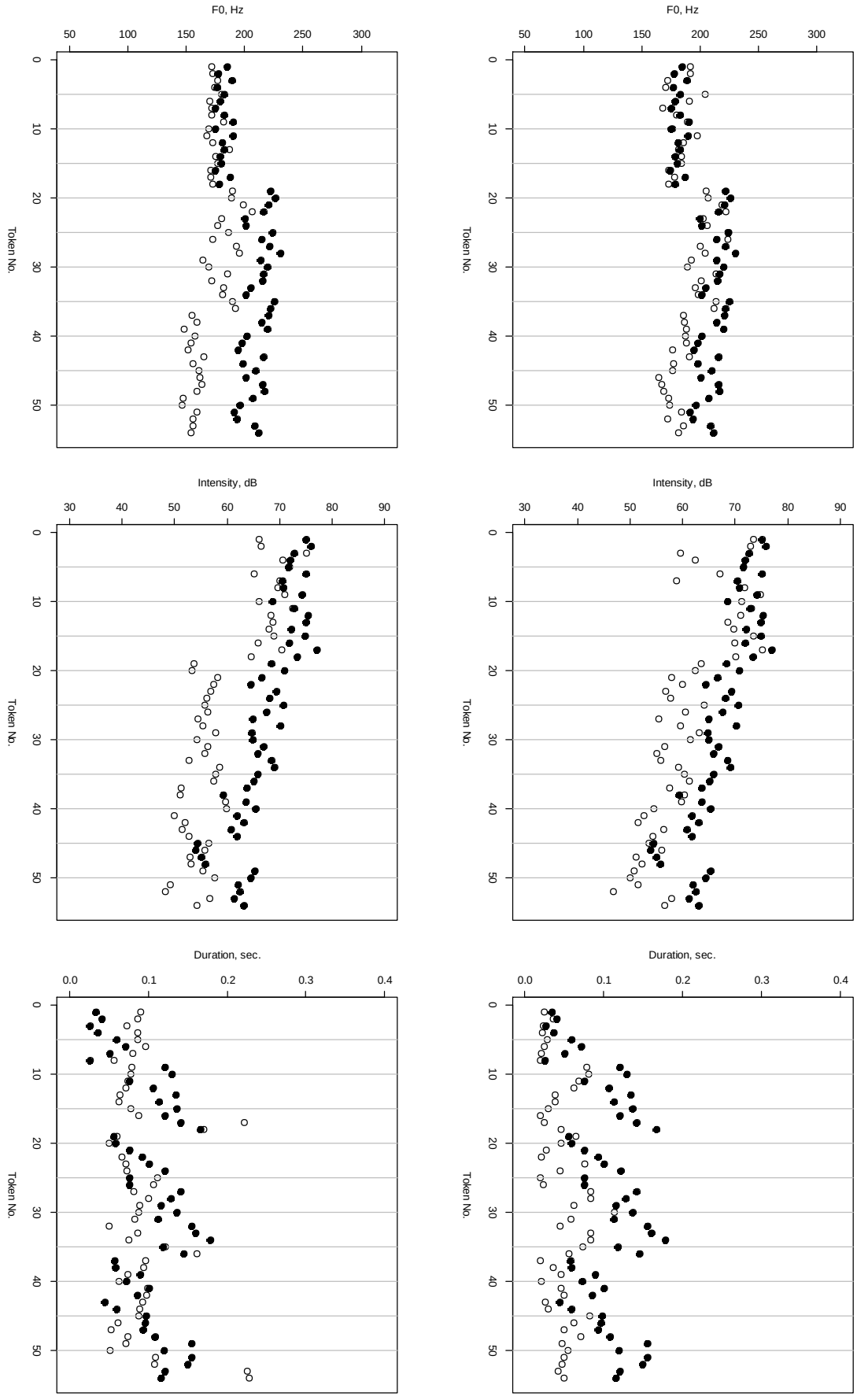

F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50
F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50

Figure 5.6

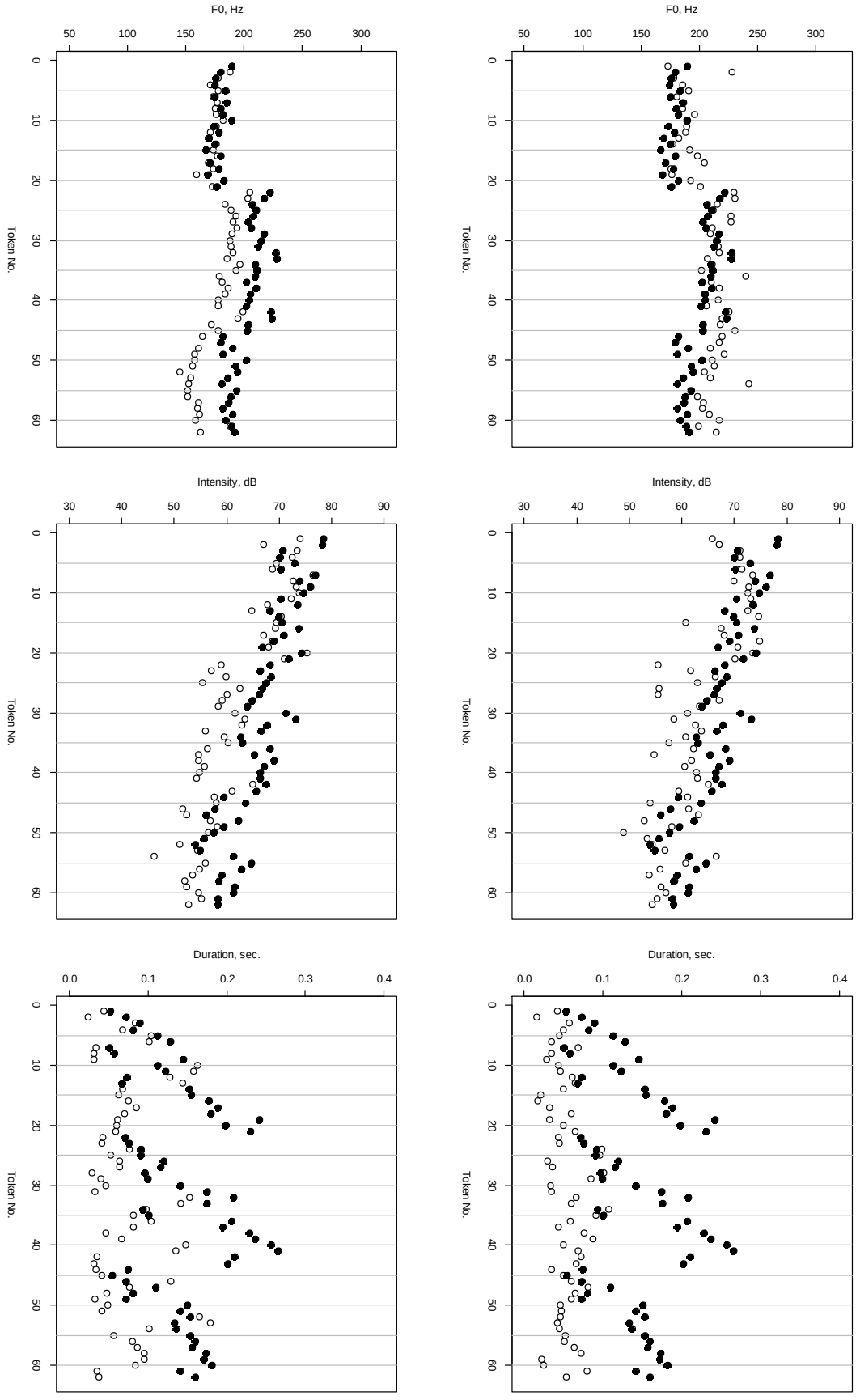

F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50 60
F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50 60
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50 60
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50 60
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50 60
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50 60

Figure 5.7

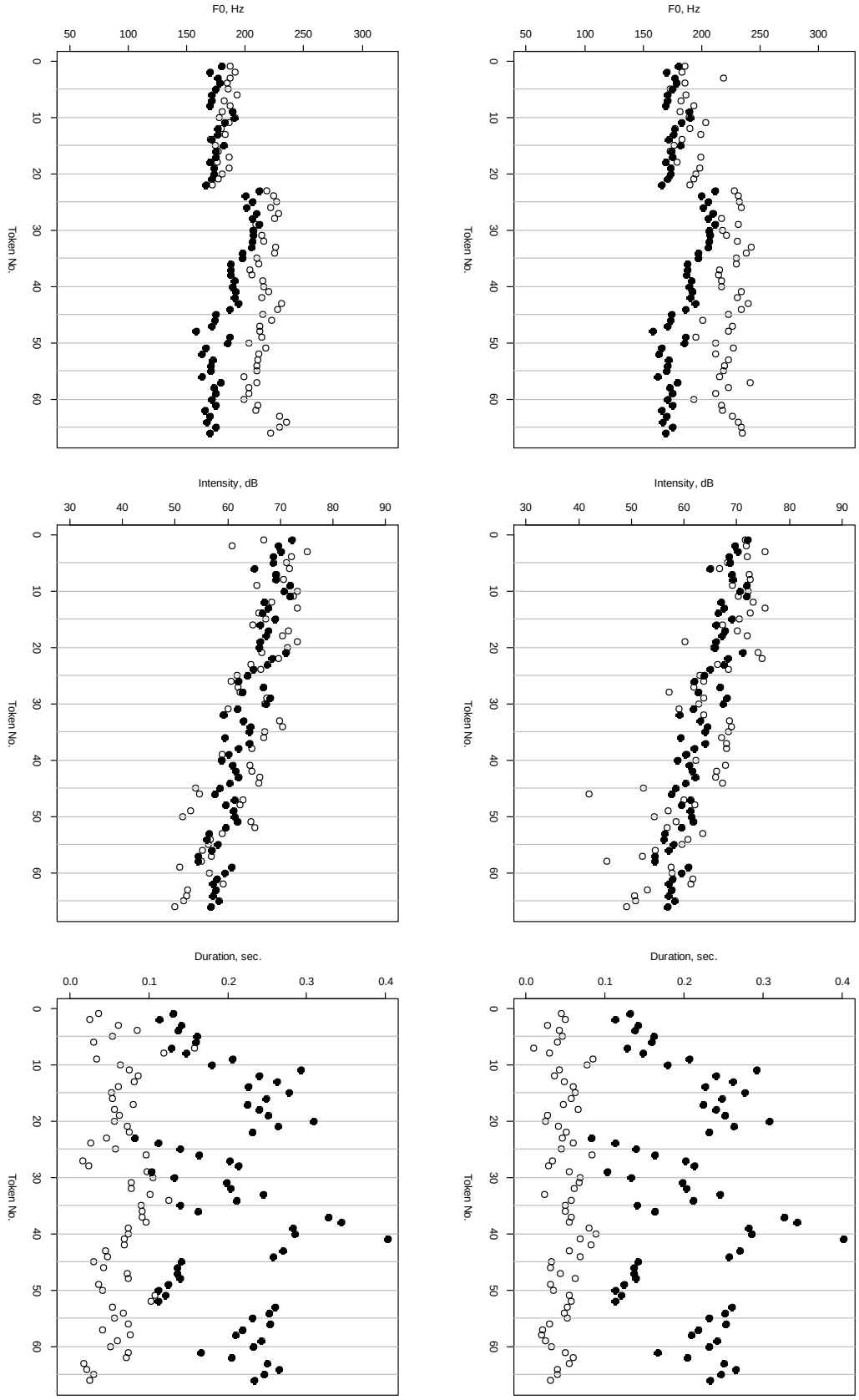

F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50 60
Intensity, dB
30 40 50 60 70 80 90
Duration, sec.
0.0 0.1 0.2 0.3 0.4

Figure 5.8

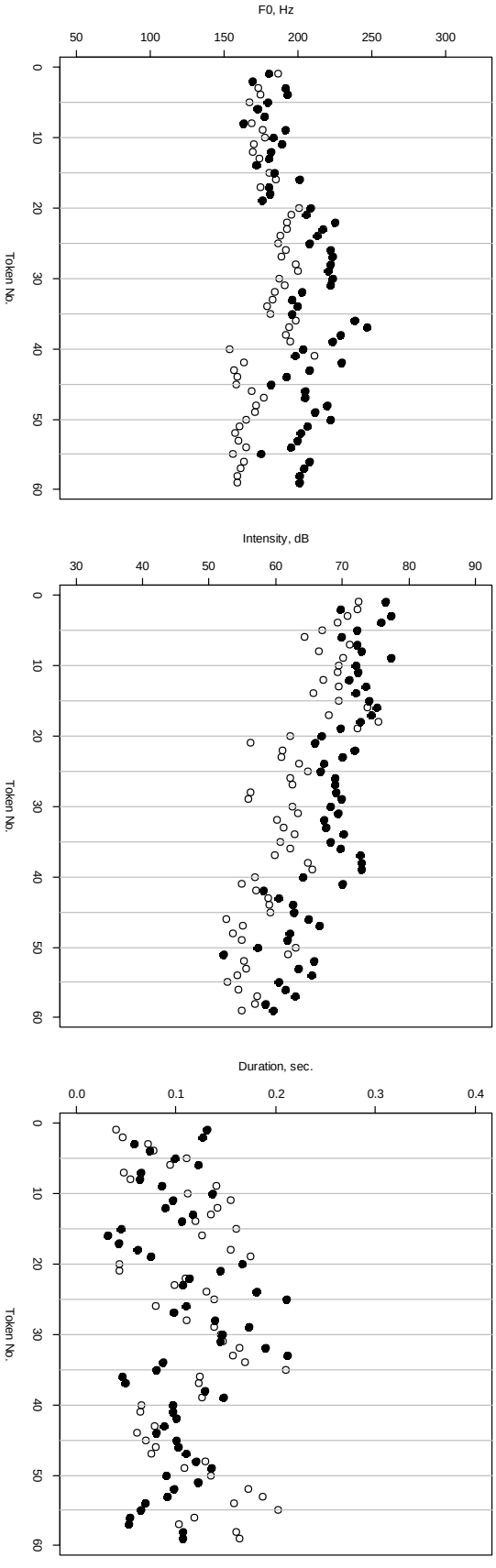


Figure 5.9

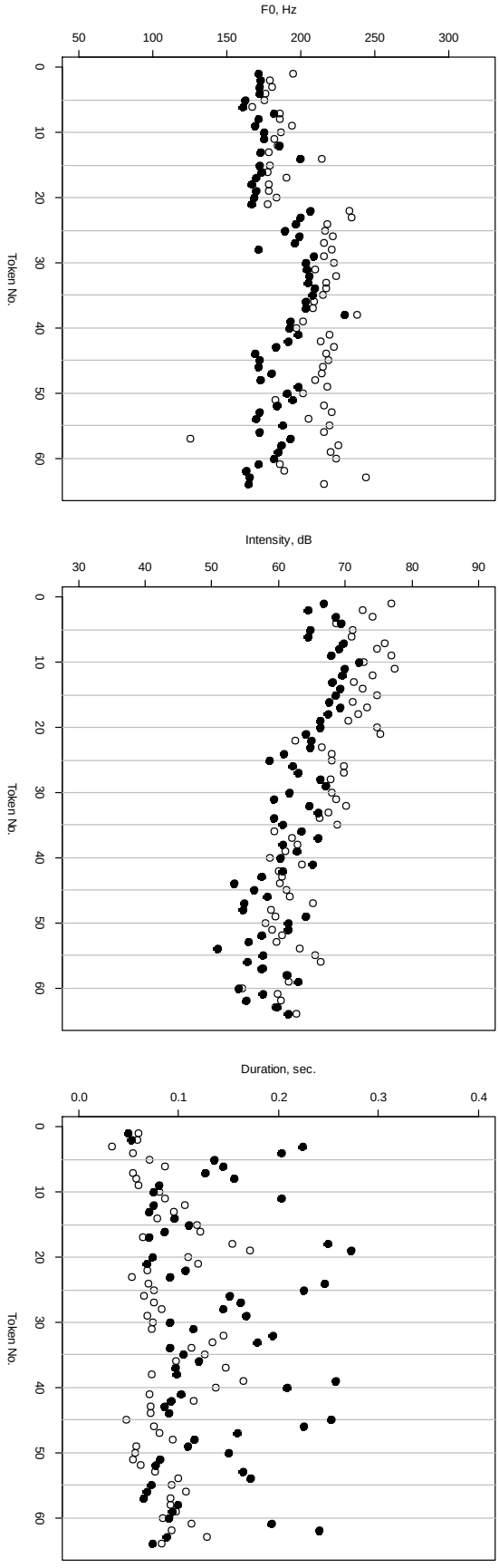


Figure 5.10

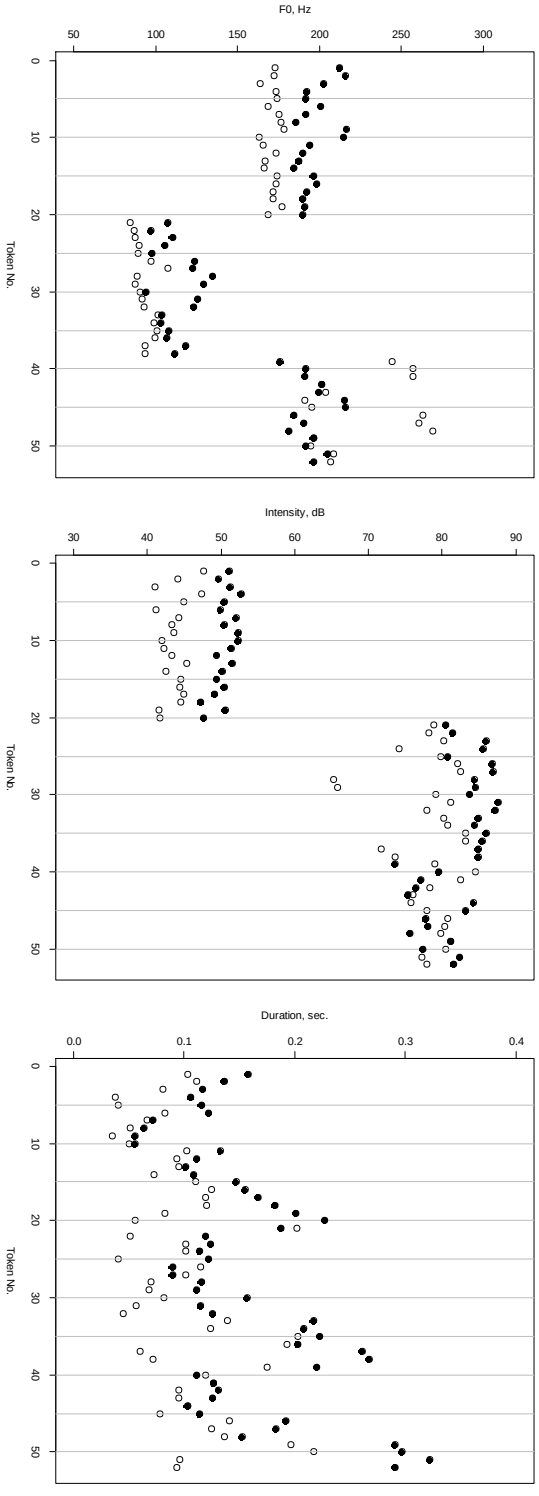


Figure 5.11

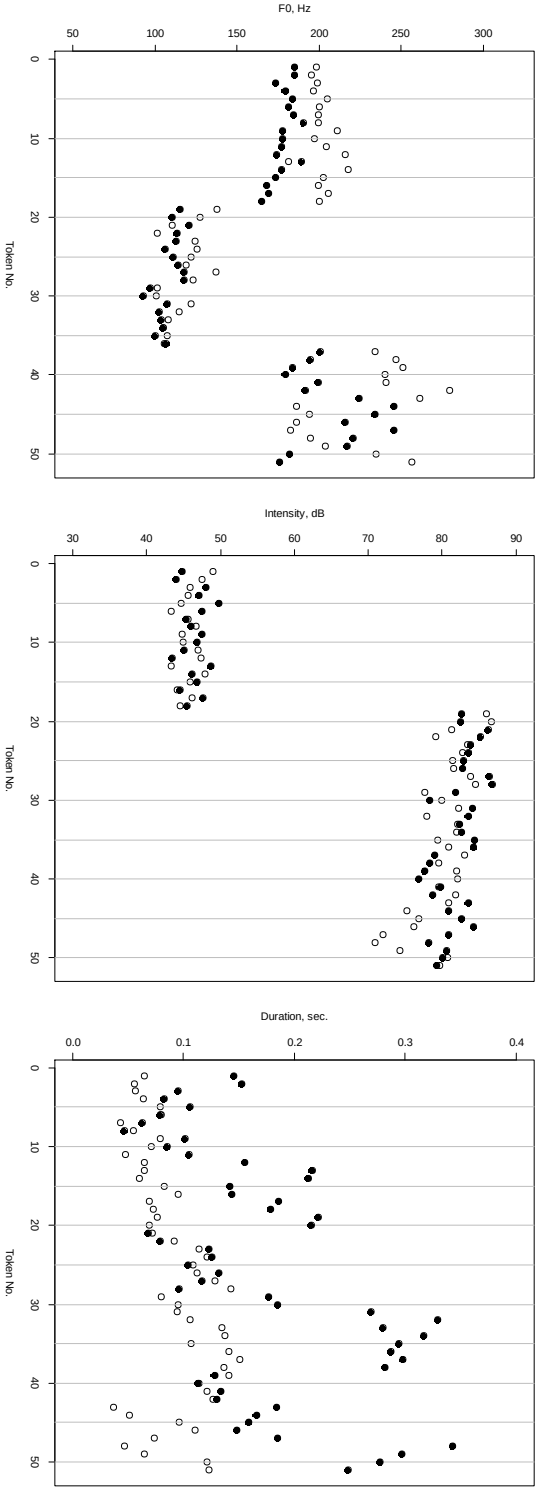


Figure 5.12

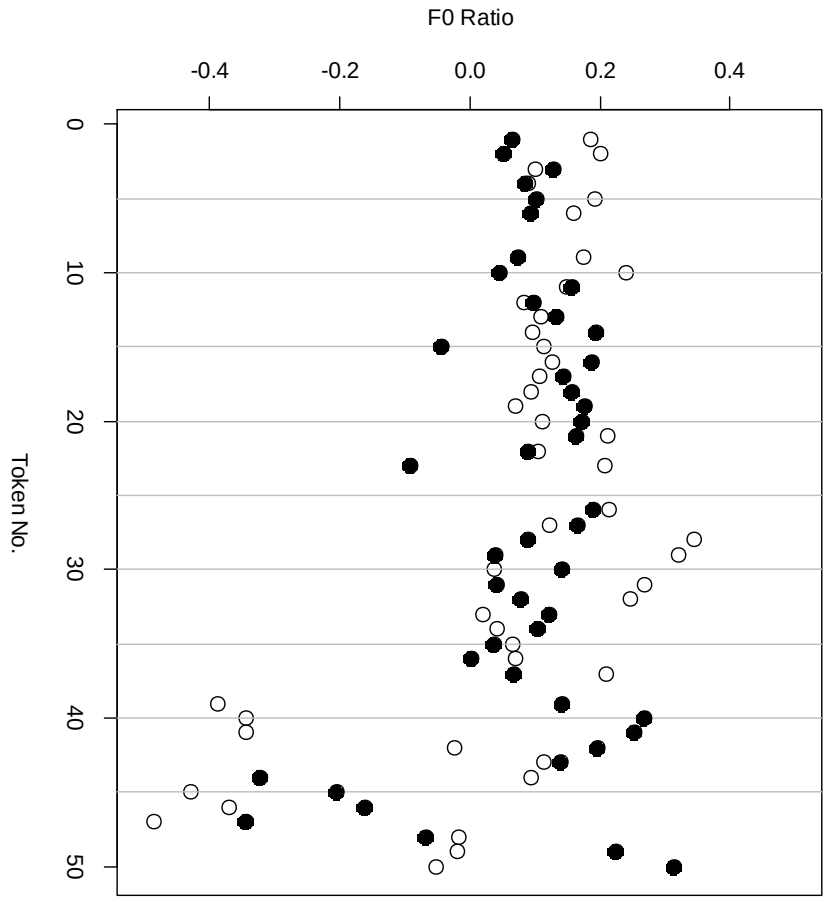


Figure 5.13

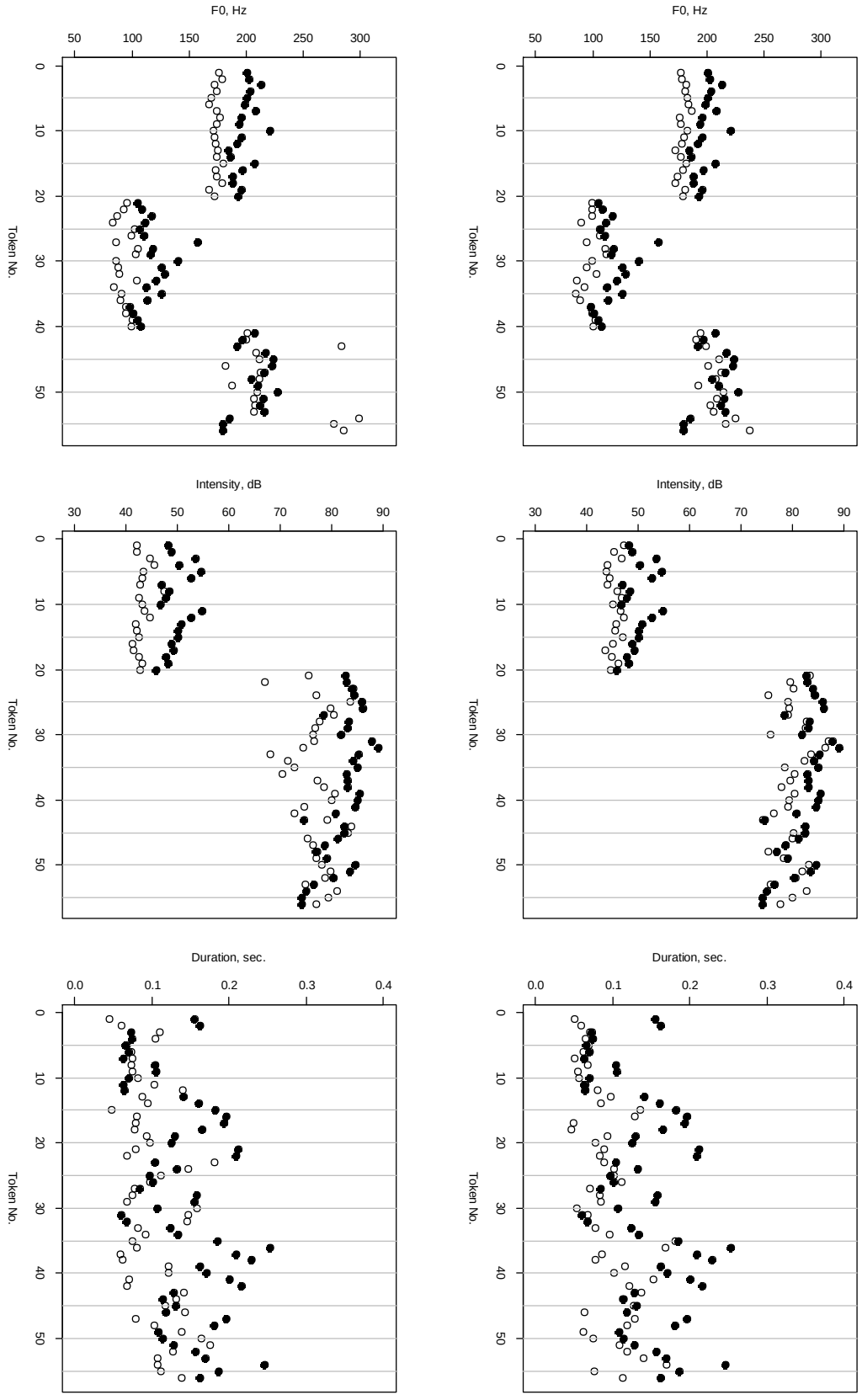

F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50
Intensity, dB
30 40 50 60 70 80 90
Duration, sec.
0.0 0.1 0.2 0.3 0.4

Figure 5.14

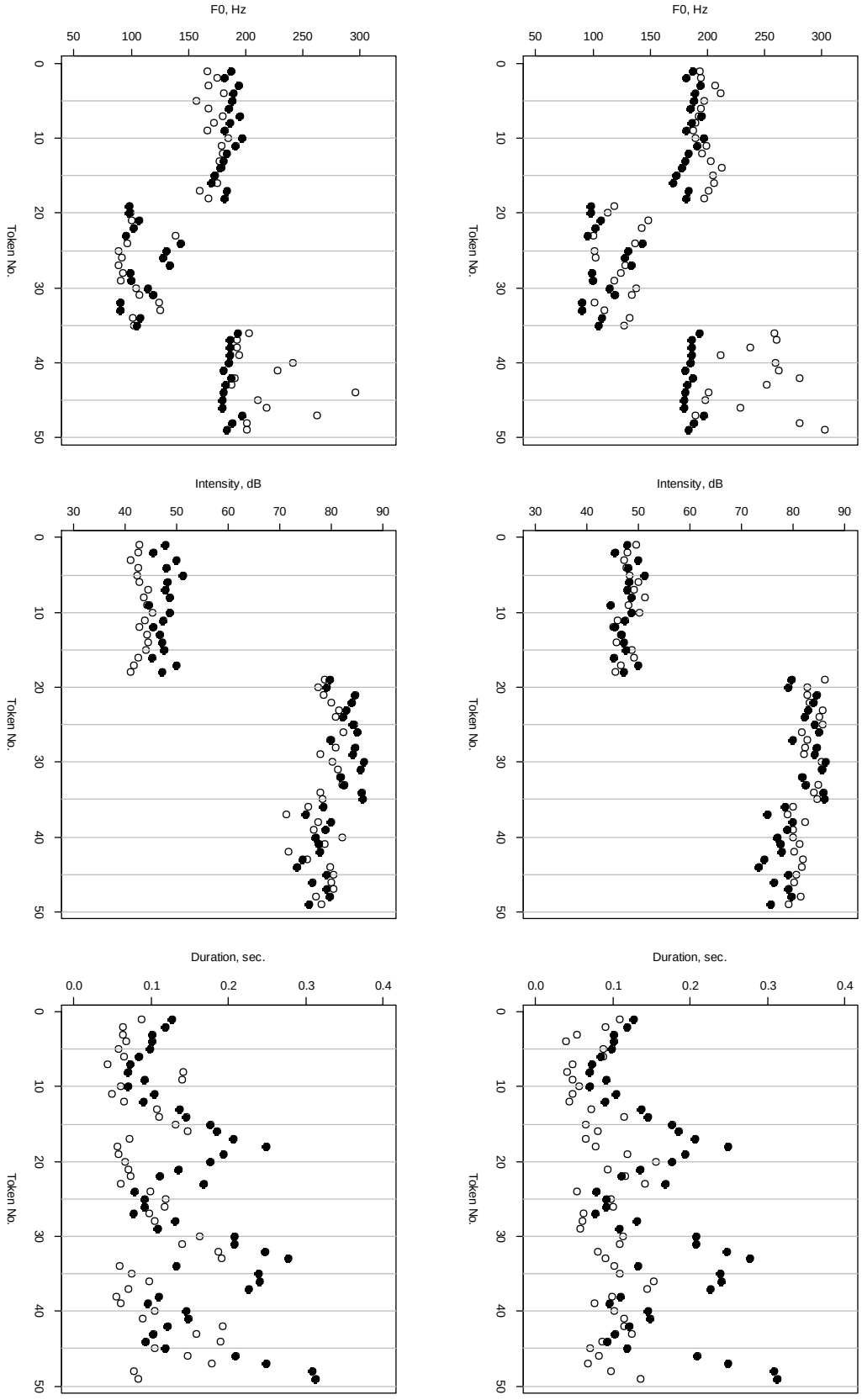

F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50
F0, Hz
50 100 150 200 250 300
Token No.
0 10 20 30 40 50
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50
Intensity, dB
30 40 50 60 70 80 90
Token No.
0 10 20 30 40 50
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50
Duration, sec.
0.0 0.1 0.2 0.3 0.4
Token No.
0 10 20 30 40 50

Figure 5.15

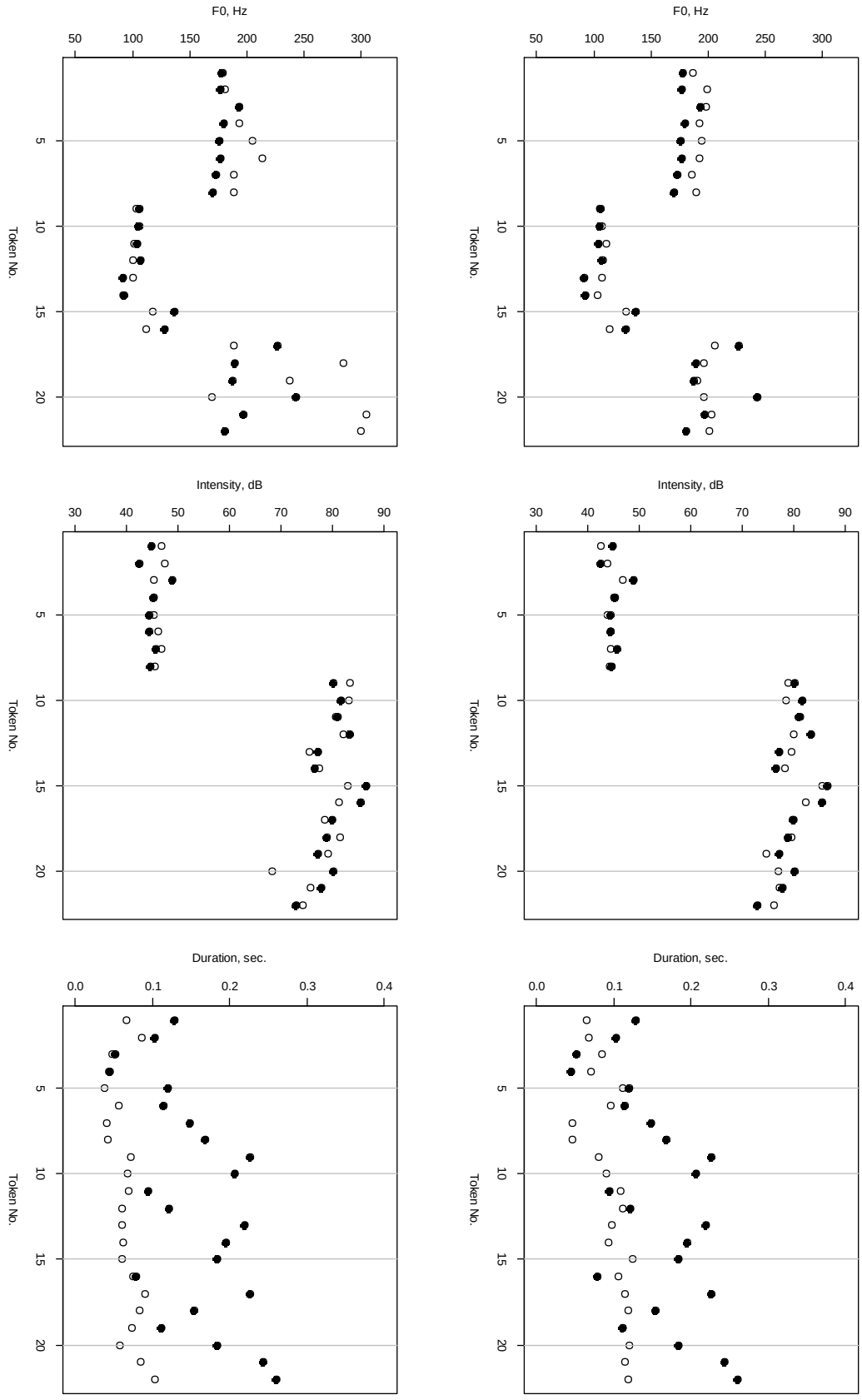

F0, Hz
50 100 150 200 250 300
Token No.
5 10 15 20
Intensity, dB
30 40 50 60 70 80 90
Duration, sec.
0.0 0.1 0.2 0.3 0.4

Figure 5.16

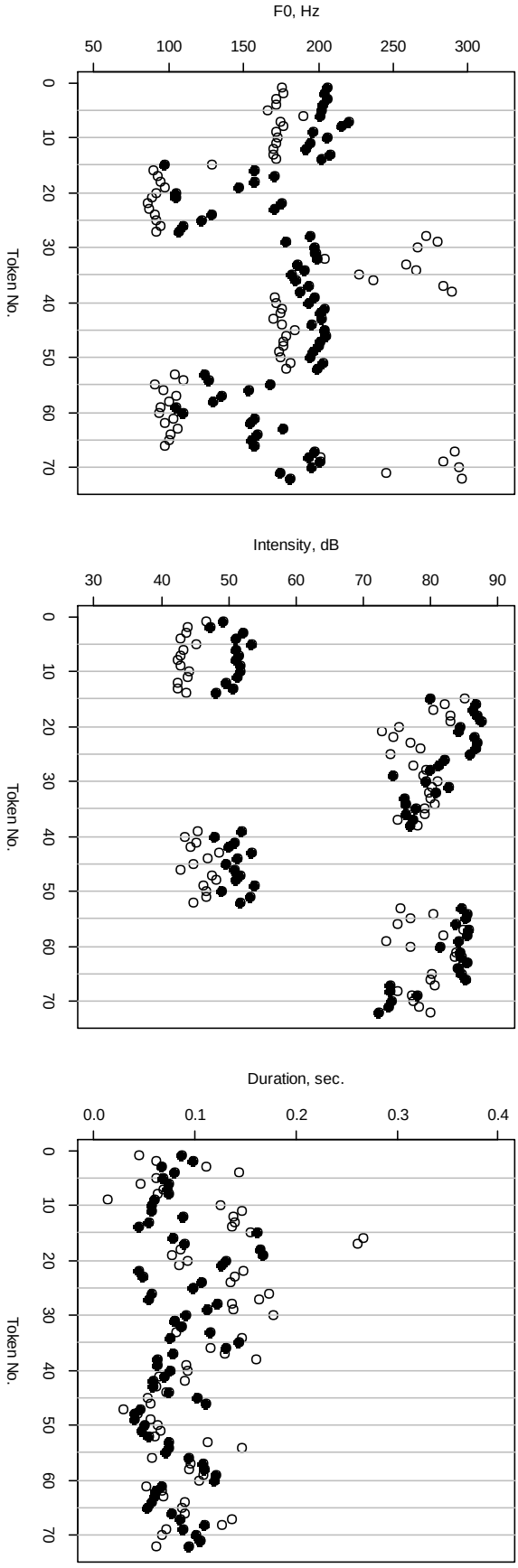


Figure 5.17

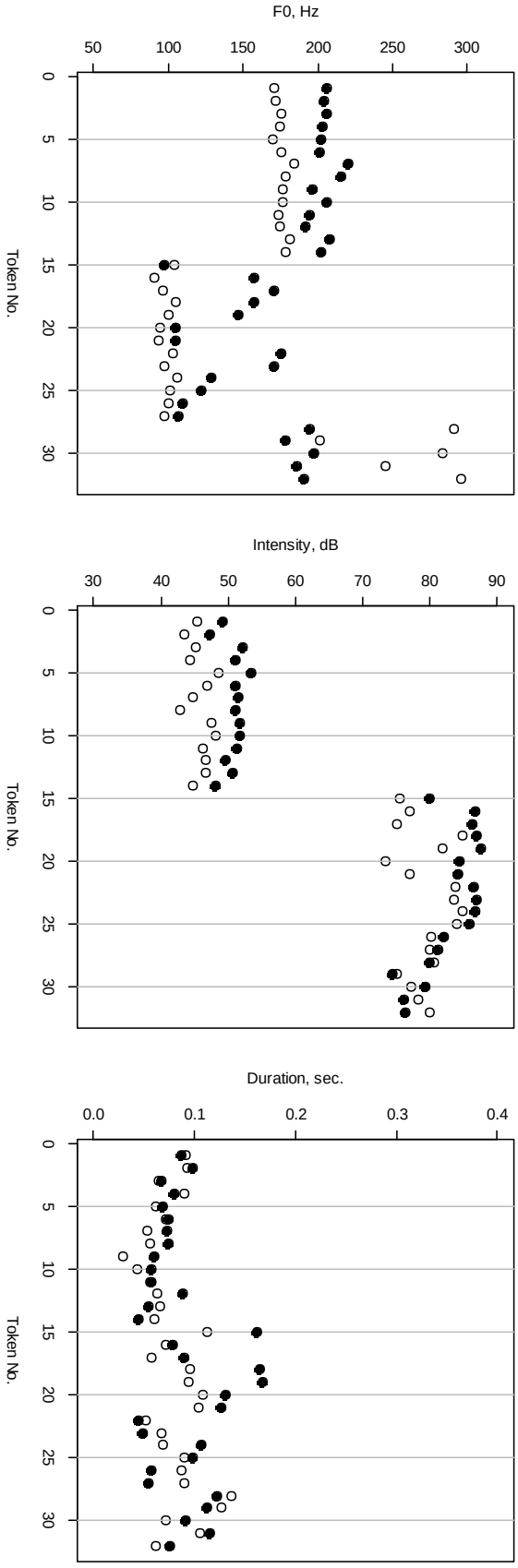


Figure 5.18

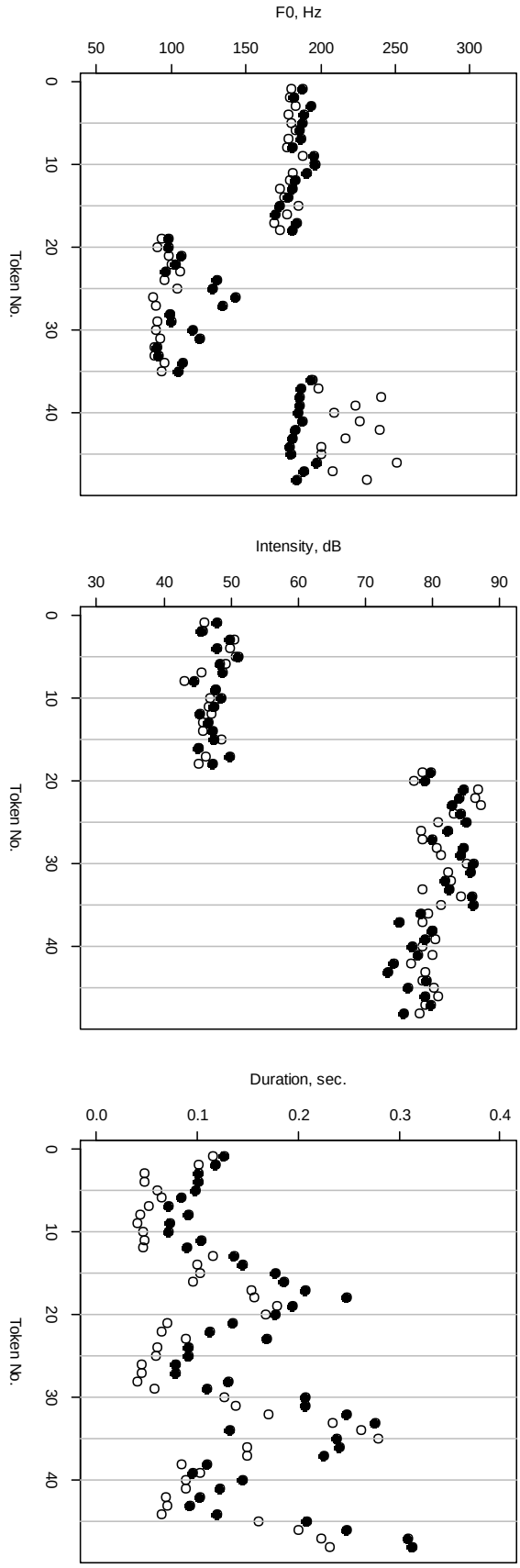
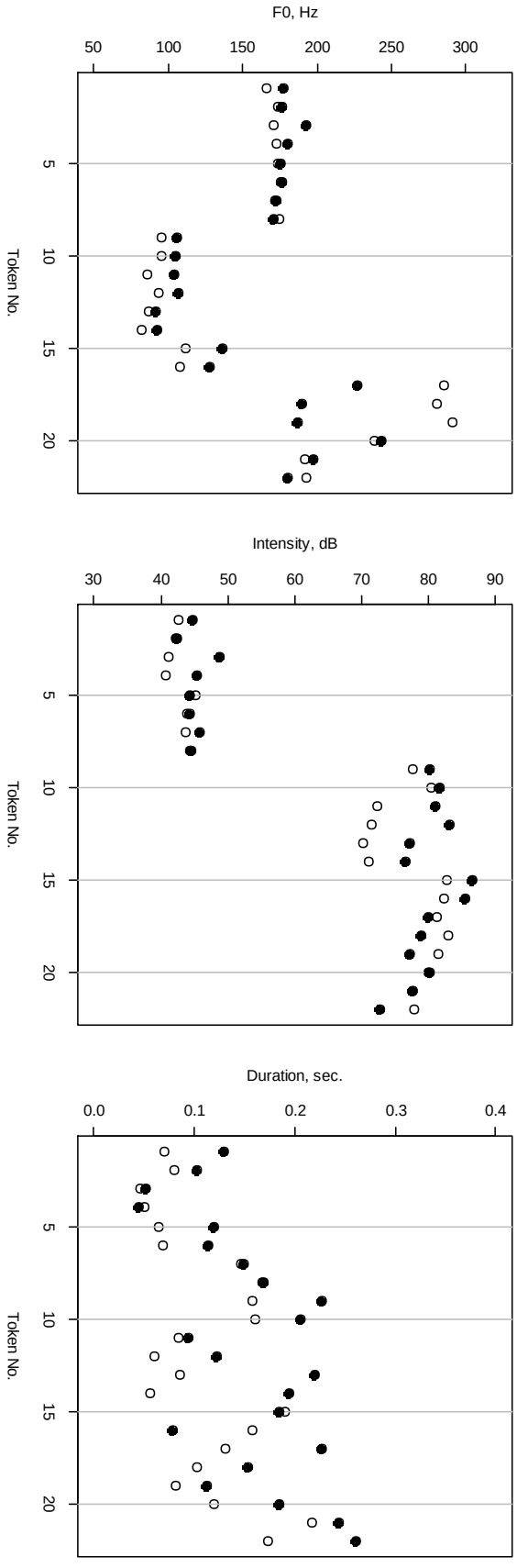


Figure 5.19



DOKUMENTĀRĀ LAPA

Bakalaura darbs „Vārda uzsvara akustiskās īpašības angļu un latviešu valodā” izstrādāts LU Sastatāmās valodniecības un tulkošanas nodaļā.

Ar savu parakstu apliecinu, ka pētījums veikts patstāvīgi, izmantoti tikai tajā norādītie informācijas avoti un iesniegtā darba elektroniskā kopija atbilst izdrukai.

Autors: _____ (*paraksts, datums*)

Rekomendēju/nerekomendēju darbu aizstāvēšanai

Vadītāja: _____ (*paraksts, datums)*

Recenzents: _____

Darbs iesniegts Anglistikas nodaļā 22.05.2013.

Dekāna pilnvarotā persona: bakalaura/maģistra gala pārbaudījuma komisijas sekretāre/s _____ (*paraksts)*

Darbs aizstāvēts bakalaura gala pārbaudījuma komisijas sēdē

_____ prot. Nr. _____

Komisijas sekretāre/s: _____ (*paraksts)*