Phonetic Reduction of Adverbs in Icelandic

On the Role of Frequency and Other Factors

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1 Introduction: Phonetic Reduction

Hamse ma ne maak?

('Gotta mark?' – stereotypical begging for money in German)

Milk cartons in Iceland have traditionally featured advice on language use and information about the Icelandic language in general. While in recent years, cartons have mostly provided explanations for sayings and other language trivia, the advice printed on them used to be rather prescriptive. An older carton that is reprinted in Árnason (2005, 237) shows two boys talking to each other in an informal style. Their conversation is displayed in an orthography that tries to mimic actual speech and is intended to showcase how bad the speech of the younger generation is and how abundant their *óskýrmæli* ('unclear speech') has become.[1]

An excerpt of the conversation with a transliteration into standard Icelandic orthography is given in (1.1):

(1.1) *É* *frá* *hljónstrængu* – *Eddí* *hljónst?* *É* *vissaggi.*
Ég er að fara á hljómsveitaræfingu. – Ertu í hljómsveit? Ég vissi það ekki.
'I'm going to band practice.' – 'You're in a band? I didn't know that.'

As can be seen from the juxtaposition of standard orthography and the boys' speech, there is a vast difference between the standard realisation and what the boys are actually supposed to be saying. Several sounds, both vowels and consonants, are absent, longer words like *hljómsveitaræfingu* 'band practice.ACC' are heavily contracted and shorter words like *að* 'to' are missing entirely. In other words, what the boys are saying is heavily phonetically reduced.

[1] The reader is consequently asked to "translate" the conversation, and the advertisement ends with the slogan: "Tölum skýrt!" – "Let's speak clearly!".

The amount of reduction found in the above example is of course intentionally extreme in order to make a prescriptive point about language use. Still, less severe and even massive reduction of the kind seen above is a pervasive aspect of naturally occurring speech – not just of the younger generation and not just in Icelandic. In connected speech, words are often pronounced very differently from their canonical realisation that is for example described in pronunciation dictionaries.

Johnson (2004) finds that more than 60% of the words in the Switchboard corpus of American English telephone conversations are produced with at least one sound missing in comparison to their canonical citation form. Schuppler *et al.* (2011) obtain somewhat lower, but still comparable figures for spontaneous Dutch. In their study, roughly 40% of all words in a corpus are realised as reduced in comparison to their citation form.

The discrepancy between the canonical realisation of a word and the reduction that one frequently encounters in spontaneous speech raises interesting questions about the nature of spontaneous speech and the relationship between phonetic output and phonological representation. What are the environments where reduced forms appear most prominently, i.e. which factors influence the occurrence and shape of reduced forms? Are they solely a product of phonetic, i.e. articulatory implementation, or are they in some way represented alongside or even instead of the traditional "underlying form" of a lexeme? Under which circumstances are reduced forms perceived correctly?

In the last years, research on phonetic reduction has shed some light on these questions, with regard to both production and perception. With the notable exception of Barry & Andreeva (2001), however, there is still a lack of studies that compare reduction crosslinguistically, since most research has focused on English (e.g. Bell *et al.* , 2009), Dutch (e.g. Ernestus, 2000) and German (e.g. Rodgers *et al.* , 1997). In addition, a range of theoretically interesting factors that might influence phonetic reduction have not been fully investigated, if at all.

For Icelandic, the reductive processes that appear in the language have been catalogued and described by Helgason (1993) and Árnason (1980, 2005, 2011). It is, however, unclear under which circumstances these processes apply, i.e. what factors influence phonetic reduction in Icelandic. The present dissertation aims at closing this gap by investigating the production of reduced forms in Icelandic.

The following research questions form the basis for the present study:

1. Which factors influence the production of reduced forms in Icelandic?
2. How do these factors compare to the results of other studies?
3. Which (if any) conclusions can be drawn about the cognitive representation of reduced forms?

These questions will be answered by examining a group of adverbs with the suffix -*lega* ('-ly'), both in spontaneous speech and under experimental conditions.

This dissertation is organised as follows: Ch. 1.1 explores the theoretical background of this study, starting with a definition of phonetic reduction (ch. 1.1.1) and continuing with the role of phonetic reduction in phonological theory (ch. 1.1.2). Previous research on the factors influencing reduction is presented in ch. 1.2. The methodology of the study is explained in ch. 2. This includes an presentation of the adverbs in focus and an introduction to the two methods, a corpus-based and an experimental study. Ch. 3 presents a corpus-based study of adverb reduction in spontaneous Icelandic using two different measures of reduction. In ch. 4.2, the factors of rhythm and frequency are explored further in two experiments, a shadowing and a reading task. The main results of the dissertation are summed up and discussed in ch. 5.

1.1 Theoretical background

1.1.1 Defining phonetic reduction

In general, the term "phonetic reduction" refers to the non-realisation or deviant realisation of a number of elements in a word in comparison to a given full(er) form. Phonetic reduction is thus an inherently relative concept (Plug, 2006). A given realisation is not reduced per se, but only when compared to another form that is in some acoustic and/or articulatory way considered to be less reduced. In the following, the different parts of this rather broad definition will be examined in more detail.

The "full form" referred to in the above definition is most often understood as a citation form, i.e. a careful realisation of a word in clear speech. Phonological theories differ with regard to the status this citation form has (cf. ch. 1.1.2). Generative theories usually only allow for one underlying form of a word to be stored in the lexicon. However, even in theories that recognise only one underlying form, the (phonetic) citation form does not need to be structurally identical with the (phonological) representation. Instead, the citation form is related to the abstract representation via a (one-step or multi-step) derivation that can alter segmental material in the string that makes up the underlying form.

The element a phonetically reduced form is to be compared with is therefore always a different, "fuller" phonetic output form that coexists synchronically with the reduced form. The definition thus excludes forms that were historically the product of phonetic reduction, but have now been lexicalised and have replaced the older citation form. The Faroese given name *Sjúrður*, for example, is historically derived from Old Norse *Sigurðr* (cf. Modern Icelandic *Sigurður*) with the first two syllables "sigu-" having coalesced into one syllable "sjúr-".[2] Synchronically, however, *Sjúrður* cannot be described as a phonetically reduced form as there is no modern pronunciation of the name that realises its first part as disyllabic. In the same vein, the greeting *Hi* represents, diachronically seen, a reduced variant of *How are you?*, but has now achieved independence from its former citation form.

While lexicalisations of reduced forms cannot be synchronically considered phonetically reduced forms, not every synchronic pronunciation variant, however, that differs from a given citation form can be classified as having undergone phonetic reduction. Obvious cases of non-reductive alternations include certain dialectal variants and cases of fortition. The latter can be of several different kinds. On the one hand segmental material is added in cases of epenthesis, e.g. vowel epenthesis in Finnish (Nieminen & O'Dell, 2010).[3] On the other hand, already present segmental material can be "extended" as in the ongoing diphthongisation of long mid vowels in Icelandic (Árnason, 2005, 144). Instead, phonetic reduction is a special case of pronunciation variation in production.

Processes that have been considered to be reductive can broadly be classified into three groups: deletion, lenition and assimilation. At the segmental level, deletion can be defined as the absence of a segment that is present in the citation form. Well-known deletion processes include schwa-deletion in German (Kohler, 1995) and Dutch (Booij, 1999) or t/d-deletion in English (Bybee, 2001). The term "lenition" is sometimes understood as a hyperonym for all reductive processes (e.g.

[2] Of course, the Modern Faroese name is disyllabic, just like the Old Norse name. However, this is due to u-epenthesis, a regular phonological process that used to be active in Icelandic and Faroese (Kristinsson, 1992). U-epenthesis affected all clusters of C+/r/.

[3] The notion of "insertion" of consonants is rather phonological. As e.g. Ohala (1983, 2005) or Page (1995) show, cases of epenthesis often result from differences in the timing of speech gestures that make up a given sound.

Kohler, 1995). In a narrow sense, however, lenition refers to the weakening of an articulatory gesture in the pronunciation of a certain sound. The nature of this articulatory weakening is different for different classes of sounds and therefore has also different acoustic correlates. Lenition in stops results in the loss of the oral closure and the stop becoming a fricative (Kirchner, 2001). If the gesture is reduced even further so that friction is lost, the fricative becomes an approximant. Acoustically, lenition in consonants has a lot of different correlates, depending on the nature of the "original" consonant. For vowels, acoustic lenition is most often understood as involving centralisation (Kul, 2011).

Based on the above definitions, the difference between lenition and deletion could be stated as follows: Deletion is a categorical process and lenition is a gradual one. A sound is either deleted or not, but the weakening of an articulatory gesture can be partial and stepwise. This division, however, is not as clear-cut as it might seem at first sight. Firstly, processes that have been called "deletion" and might therefore be expected to be categorical in nature are in fact often gradual. In fact, one of the most famous deletion processes, t/d-deletion, has been shown to be gradual at times, resulting from gestural overlap (Browman & Goldstein, 1992). Similarly, schwa deletion in French, which had been assumed to be a categorical process, might sometimes be the result of gradient phonetic reduction (Buerki *et al.* , 2011).

Secondly, acoustic "deletion" does not always correlate with absence of an articulatory gesture. When a nasal stop in coda position is "deleted", for example, the preceding vowel is often nasalised (Bybee, 2001). The feature "nasality" is thus retained, and it is only the phase of oral closure that is omitted or reduced. In a study of rhoticity in British English, Sebregts & Scobbie (2011) find that gestural movement and acoustic output are not necessarily always completely aligned. They show that /r/ can be absent acoustically, but at the same time present articulatorily to a certain extent. Based on these findings, deletion could be more precisely defined separately for acoustic and articulatory reduction. Articulatorily, deletion is the absence of all articulatory gestures that make up a given segment. Acoustically, deletion is defined as the full absence of a segment and its features on the spectrogram of a recording.

While lenition and deletion undoubtedly represent cases of reduction, the literature is in disagreement about whether assimilation should be regarded as a reductive process. Assimilation can be defined as one sound taking over characteristics of a neighbouring sound with regard to place or manner of articulation. The disagreement over the status of assimilation is not always being made explicit, but can be deduced from the classification of reductive processes taken in the literature. Several studies contain separate chapters on "reductive processes" on the one hand and "assimilation" on the other hand. In her extensive study of casual Dutch, Ernestus (2000) treats assimilation and segmental reduction as distinct from one another. Schuppler *et al.* (2011) implicitly treat assimilation differently from "reduction proper" by including a chapter entitled "phonological, coarticulation and reduction rules".[4].

Similarly, the of reductive processes in Icelandic in Árnason (2005, 228-257) contains one chapter on "lenitions and deletions" (*veiklanir og brottföll*) and another one on "assimilations" (*samlaganir*). At the other end of the spectrum, Zimmerer's dissertation titled "Reduction in Natural Speech" includes place assimilation prominently among the reductive processes that are active in German (Zimmerer, 2009). Accordingly, he does not seem to classify reduction and assimilation as distinct processes. The disagreement about the status of assimilation, thus, to some extent seems to be a matter of terminology.

For the purpose of this dissertation, the term "reduction" will be understood as including lenition and deletion, but not assimilation. This decision, however, is not made on theoretical but on practical grounds as the quality of the recordings used for the corpus analysis in ch. 3 simply does not allow for a systematic analysis of assimilatory processes. For the same reasons, most of the reductive processes discussed in the following will be (categorical) deletions since the fine-grained comparison of gradual lenition processes would require a different data basis. Since articulatory measurements are beyond the scope of this dissertation, the term "deletion" will refer to the acoustic absence of a given speech sound.

1.1.2 Phonetic reduction and phonological theory

In the concluding remarks of his paper on connected speech processes in Icelandic, Árnason (1980, 220) asks a series of questions about the relation between phonetic output and phonological representation:

> "What should the abstract phonological representations [for reduced forms] look like? And what is their ontological status? And how are they related to the actual phonetic output? [. . .] Are the set pronunciations closer to the "underlying structure" that most of us assume is to be found behind the messy output?"

[4] The term "reduction" is in turn used synonymously with "lenition" in Schuppler *et al.* (2011).

Árnason's statement displays both elements of generative phonological theory (which were mainstream at the time), and connections to different, more usage-based theories. As did most phonologists at the time, on the one hand he assumes that there is one and only one underlying form that unites and abstracts away from all the different surface pronunciations. On the other hand, he wonders how close the abstract representation has to be to the actual phonetic output. These are the issues that current theoretical thinking still debates with regard to phonetic reduction. What is the relation between phonetic output and phonological representation, both in production and in perception? Does phonological representation include pronunciation variants, among them reduced forms?

Two basic theoretical schools can be identified that deal with reduction in very different ways. One strand of research is represented by formalist-abstractionist models in the broad tradition of Chomsky & Halle (1968). Models of this kind assume that for every word, there is only one underlying representation. Abstractionist models vary with regard to how explicit or underspecified this underlying form is taken to be. In one of the most prominent abstractionist models of production and perception, the Featurally Underspecified Lexicon (FUL, Lahiri & Reetz, 2002, 2010; Zimmerer, 2009), "phonological representations of morphemes [consist of] hierarchically structured features, not all of which are specified" (Lahiri & Reetz, 2002, 637). In production, the default value of a given feature is inserted. The production of reduced forms in those models is completely due to phonetic, i.e. articulatory implementation as reduced forms are not represented in any way.

A very different picture of representation and production of reduced forms is presented by usage-based exemplar models (Nosofsky, 1986; Bybee, 2001; Pierrehumbert, 2001, 2003; Wedel, 2004, 2007, 2011). These models are based on the notation of a "rich memory": every utterance that is produced or perceived leaves a trace in memory, a so-called "exemplar". This entails that reduced forms, too, are stored in memory and are linguistically represented. Memory traces are grouped and categorised into exemplars according to similarity. Linguistic categories like phonemes or the phonological representation of words are then formed on the basis of generalisations over exemplars. Exemplar models vary with regard to what status generalisations over exemplars have. In some versions of exemplar theory, generalisations are created "on the fly" whenever they are needed and have no special status in comparison to exemplars (Bybee, 2001). In other versions, abstract generalisations are stored alongside the exemplars from which they are derived (Pierrehumbert, 2001).

In a recent overview of the role of phonetic reduction in phonological theory, Ernestus (2014) critically evaluates the arguments for and against both exemplar-based and generative-abstractionist models. According to her, both exemplar models and abstractionist models are able to handle production data fairly well. Production of reduced forms in exemplar-based models is straight-forward as the gap between what is produced and what is represented is rather small. Reduced forms can be selected directly for production and are realised without much alteration in their shape. Abstractionist models need to put more weight on the role of phonetic-articulatory implementation in order to explain the production of reduced forms. As abstractionist models only allow for one underlying form to be represented, this form (or the one it is turned into through phonological derivation) needs to be altered significantly in the course of production in order to accommodate reduction phenomena. Still, abstractionist models are well able to handle reduction in production.

Arguments in favour of exemplar models come from evidence that speakers store fine phonetic detail. Goldinger (1996, 1998) shows that listeners retain detailed information about speaker characteristics, although this information is (strictly speaking) "not necessary". With regard to reduction, Ernestus (2009) shows that speakers retain a trace of a reduced form they have encountered even when it is fully predictable from the general phonetic rules of the language in question. Her results, however, also indicate that listeners reconstruct and store the full form of the reduced word.

Not all information about reduced forms seems to be stored, as is shown by studies on the recognition of reduced speech. Exemplar-based models like X-Mod (Johnson, 1997) assume that the incoming speech signal maps directly onto exemplar space. If every form a speaker encounters both in production and perception was stored, listeners should have no trouble perceiving reduced forms correctly. Ernestus *et al.* (2002), however, found that heavily reduced forms are not correctly understood without context. For highly reduced forms, not even phonetic context is sufficient to facilitate comprehension, but a larger syntactic context is necessary. This suggests that additional top-down information is necessary in order to correctly decode highly reduced forms.

For abstractionist models like FUL, the failure to perceive reduced forms correctly out of context does not pose a problem. On the contrary, this is what abstractionist models predict: If the input does not give the necessary amount of phonetic features and the context does not provide help either, listeners will be unable to map the incoming signal on the correct underlying representation. With regard to perception, abstractionist models therefore seem to be better suited to explain the behaviour of reduced forms.

The discussion whether or not there is a form of exemplar storage is still ongoing. As will be seen in the next chapter, the analysis of the two factors that will be the focus of this dissertation – token frequency and rhythm – can help provide further insight into this question.

1.2 Factors influencing phonetic reduction

In recent years, a number of factors have been uncovered that influence phonetic reduction. This section will give a short overview of these factors. The focus will be on frequency and predictability measures (ch. 1.2.1) as well as rhythm (ch. 1.2.2). In ch. 1.2.3, other factors are presented that will be taken into account as control factors.

1.2.1 Token frequency and predictability measures

The connection between phonetic reduction and token frequency[5] has long been established in the literature. In recent years, the influence of predictability measures that are grounded in collocational frequencies has also been studied. The influence of token frequency and probabilistic factors is of theoretical interest as, by its very nature, not all words are affected to the same degree. This shows that word-specific knowledge (frequency information and frequency relations between words) affects how words are produced.

One of the most famous proponents of a correlation between token frequency and reduction is George K. Zipf. In his *Psycho-Biology of Language* (1935, 38), he remarks that "the length of a word tends to bear an inverse relationship to its relative frequency". When interpreted diachronically, this statement can be taken to be evidence for a correlation between token frequency and reduction: frequent words are more often realised as phonetically reduced and this phonetic reduction becomes lexicalised over time.

The most extensive examination of the role of predictability factors including frequency of occurrence with regard to phonetic reduction can be found in a series of papers by Jurafsky and colleagues (Jurafsky *et al.* , 1998; Bell *et al.* , 1999;

[5] Token frequency is also called "lexical frequency" (e.g. in Pluymaekers *et al.* , 2005) or "frequency of occurrence" (e.g. in Bybee, 2001). All three terms are considered to be synonymous for the purpose of this dissertation.

Gregory *et al.* , 1999; Jurafsky *et al.* , 2001, 2002; Bell *et al.* , 2003, 2009). In these studies, phonetic reduction is most prominently quantified as durational shortening, but measures of segmental reduction such as t/d-deletion or vowel centralisation are also considered in the majority of the papers (cf. ch. 2).

Conceptually, Jurafsky and colleagues operationalise token frequency as a probability measure ("prior probability"): the lexical frequency of a given word equals its likelihood of occurrence if no context is given. Other probability measures predict the occurrence of a word from its lexico-semantic context. The context from which a word may be predicted most often consists of one or two neighbouring words to the left or to the right. Jurafsky and colleagues propose and test several contextual probabilistic measures (called "collocational probabilities" in Gregory *et al.* (1999)), among them bigram frequency, transitional probability, backward transitional probability.

The results of their investigations (which are summed up in Bell *et al.* (2009)) indicate that backward transitional probability ("following conditional probability") is the most important probabilistic measure for reduction. A word is therefore more likely to be reduced if it is highly predictable given the following word. This shows that reduction to a certain extent correlates with the amount of ease in the lexical planning process.[6] Other probabilistic measures seem to be sensitive as to whether the target is a function word or a content word. Token frequency, for example, only constitutes a significant predictor for content words, while forward transitional probability significantly affects only function words.

Studies by other authors have also found an influence of token frequency and predictability measures on phonetic reduction. According to Bybee & Scheibman (1999), *don't* in American English is reduced more strongly when it is combined with *I* than when it is used with other pronouns or full nouns. This can be interpreted as supporting the impact of predictability on phonetic reduction. The phrase "I don't" has a higher bigram frequency than the phrase "you don't". Therefore, "I don't" behaves more like a unit – i.e. its parts are more predictable from each other – than "you don't".

Pluymaekers *et al.* (2005, 2567) find "strong evidence for the relationship between lexical frequency and acoustic reduction" as lexical frequency influences the reduction patterns of three out of four Dutch affixes analysed in their study. In their view, the interpretation of this result can be twofold: On the one hand, in-

[6] The correlation between reduction and lexical planning is also indicated by the fact that words tend to be less reduced if they are followed by a hesitation that indicates planning problems (Jurafsky *et al.* , 1998).

formation about token frequency could be stored in the lexicon, either as indexed information to one underlying form or directly via the storage of multiple forms or exemplars. On the other hand, frequency effects could also result in processing and articulatory routinisation in that highly frequent elements can be retrieved faster and are thus more prone to be reduced.

Keune *et al.* (2005) examine the reduction behaviour of Dutch adverbs containing the suffix -*lijk* and find that Mutual Information (MI) is one of the best predictors. MI is a predictability measure that takes "both sides" into account, i.e. does not only predict one word from another word, instead measuring the tightness of cohesion between two words. Gahl & Garnsey (2004) and Tily *et al.* (2009) show that not only the probability of words affects reduction but also the probability of a given syntactic construction. Probabilistic knowledge thus extends into the domain of syntax, too. Similarly, Kuperman *et al.* (2007) show that probabilistic morphological knowledge affects reduction as well. In their study, the morphological predictability of two Dutch interfixes affects their duration.

Another factor that can be related to frequency and predictability measures is recency.[7] Fowler & Housum (1987) and Fowler (1988) find that words are shorter, i.e. durationally reduced, when they are uttered for the second time in a conversation than when they are uttered for the first time. Fowler & Husum relate this to the information status of first and second mentions in that the first mention of a given word often carries new information while the second one does not. In a study based on the Edinburgh Map Task Corpus, Trón (2009) establishes that the "latency between consecutive mentions is inversely proportional to the magnitude of repetitional shortening." In other words, second mentions of a word are the more durationally reduced the closer they are to the first mention of the same word in the discourse. Additionally, Trón found that this effect is stronger for self-repetitions than for repetitions of a word previously uttered by another participant.

In sum, frequency of occurrence and predictability measures have been shown to be an important factor in explaining reduction patterns. In addition, frequency of occurrence has been shown to interact with at least the factor word class and possibly with other factors as well. As Bell *et al.* (2009, 1022) remark, "[token frequency] may well interact with other measures, so that the effects found might turn out not to be so strong for less frequent words."

[7] Other terms for the same phenomenon are "priming" Gries (2005) and "persistence" Szmrecsanyi (2005).

1.2.2 Rhythm

Rhythm is the second factor that will be studied in greater detail in the course of this dissertation. Since several different conceptualisations of linguistic rhythm exist, the concept of rhythm first has to be discussed in more detail. Then, its relevance for the study of phonetic reduction will be explained.

In general, the term "rhythm" refers to a succession of a regular pattern of recurring strong and weak elements or beats. As such, rhythm entails two different regularities. On the one hand, the repeated pattern has to consist of identical successions of beats of different strength (isometry). On the other hand, the beats and the pauses between them should be of an identical length (isochrony). While a rhythmic pattern ideally has to be both isometric and isochronous, rhythm is often exclusively understood as isometry in much of linguistic research, especially in the generative tradition,.

In Metrical Phonology (Liberman & Prince, 1977; Selkirk, 1984; Hayes, 1995) and Prosodic Phonology (Nespor & Vogel, 1986), rhythm[8] is defined in purely metrical terms. In both approaches, the alternating strong and weak elements that form a rhythmic pattern are syllables that are either stressed (i.e. strong) or unstressed (i.e. weak). Rhythmically alternating syllables are grouped into feet (cf. Figure 1.1).

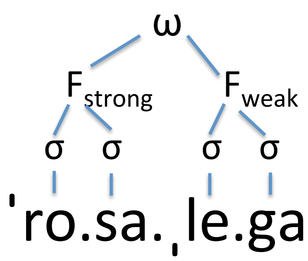

Figure 1.1: Prosodic representation of the word *rosalega* 'very (much)'

Feet then can be classified according to their length (e.g. disyllabic, trisyllabic) and to the ordering of strong and weak syllables within them (e.g. trochaic, iambic, dactylic). Disyllabic feet have been claimed to be universally preferred.[9] Feet of this kind contain two syllables and are either iambic (weak-strong) or trochaic (strong-weak). The most common trisyllabic pattern is dactylic, i.e.

[8] In Prosodic Phonology, the term "eurhythmy" is used instead of "rhythm". This alternative term focuses more on the notion that a rhythmic pattern is composed of identical subparts.

[9] This is evidenced by the very common Optimality Theory constraint FootBin that militates against feet that are other than disyllabic (cf. e.g. Kager, 1999).

strong-weak-weak.

Icelandic words invariably receive main stress on the first syllable (Árnason, 2005, 431).[10] Hence, feet in Icelandic are always head-initial and either trochaic or dactylic (Árnason, 1983).[11] Examples of Icelandic utterances with exclusively trochaic and dactylic feet are given in 1.2 and 1.3, respectively:

(1.2) *(Pé.tur) (haf.ði) (en.gan) (tí.ma)*
Pétur had no time
'Pétur had no time.'

(1.3) *(Jó.han.na) (gaf. hen.ni) (ba.na.na)*
Jóhanna gave her banana
'Jóhanna gave her a banana.'

In the above examples, only feet of the same type co-occur, either trochaic as in 1.2 or dactylic as in 1.3, and form isometrically structured utterances.

Metrical Phonology has been criticised for its narrow perspective on rhythm, both from a phonetic point of view and from the perspective of conversation analysis and interactional linguistics. In their analysis of conversational rhythm in natural speech, Auer *et al.* (1999) argue against a purely isometric notion of rhythm ("abstract rhythm"), which in their view is indicative of a "detemporalization" (p. 3) of language. Rhythm should instead be found and analysed in naturally occurring speech. While Auer et al. are right to point out that much of the early work in Metrical Phonology is not interested in the actual realisation of abstract metrical patterns, of metrical rhythm have (along with phonology in general) become more empirical in recent years studies.[12]

In a recent study on the status of metrical regularity, Tilsen (2011) finds that regular rhythmic alternation of strong and weak syllables increases the speed of utterance production and reduces the occurrence of speech errors when speakers are given the task of repeating a sequence of nonce words. On the basis of his experimental study, Tilsen (p. 213) hypothesises that "gestural reductions and

[10] There are only very few exceptions to this rule in certain prefixed words (Árnason, 1996, 7-8), none of which are relevant for the present study.

[11] This generalisation of course does not extend to monosyllabic words, i.e. words with only one syllable, unless one assumes Icelandic monosyllables are underlyingly disyllabic as Iverson & Kesterson (1989) or Árnason (2005, 193–194) do.

[12] Phonetic research has also investigated other possible instantiations of speech rhythm (e.g. Ramus *et al.* , 1999; Gibbon & Gut, 2001). The operationalisation of rhythm in these studies, however, is very different from the one presented here.

omissions may be biased to occur more frequently in languages that exhibit a statistical tendency for relatively greater degrees of metrical regularity".

According to this hypothesis, it is to be expected that reductive processes that lead to an even rhythm are favoured over ones that don't. It could also be the case that such reduced forms are preferred even over full forms that violate rhythmic requirements. Indeed, several studies have found that the tendency for an even metrical rhythm affects the application of certain reductive processes that involve the deletion of a segment and lead to the loss of a syllable.

Kuijpers & van Donselaar (1998) examine schwa deletion and epenthesis in Dutch and the environments in which they are likely to appear. Their results indicate that rhythm influences the application of both processes, as schwa deletion is more likely if the ensuing loss of a syllable produces a regular trochaic pattern. While "speakers do not have a preference for trochees at the lexical level" Kuijpers & van Donselaar (1998), the trochaic pattern seems to be preferred over the dactylic pattern in connected speech, since there was no effect of a dactylic environment on schwa epenthesis in disyllabic words.

For Icelandic, Dehé (2008b) finds that metrical rhythm influences the application of a reductive phonological process, Final Vowel Deletion. According to the results of her reading study, word final vowels are more likely to be deleted if this deletion results in a metrically regular pattern. Conversely, vowel deletion is disfavoured when this leads to a stress clash. Crucially, unlike what Kuijpers & van Donselaar (1998) found for schwa deletion in Dutch, the rhythmic effect on Final Vowel Deletion holds for both trochaic and dactylic patterns. Essentially, Final Vowel Deletion cannot only found in spontaneous (or in the case of Dehé (2008b): read) speech, but also in poetry or song lyrics, as this extract from an Icelandic pop song in shows.

(1.4)	*Það*	*get(a)*	*ekk(i)*	*allir*	*verið*	*gordjöss*
	it	can.3RDPL	not	everyone.3RDPLNOMMASC	been	gorgeous

'Not everyone can be gorgeous.' [Páll Óskar – Gordjöss]

Thus, a solid body of research exists that demonstrates the influence of metrical regularity on reductive processes which affect a well-defined class of segments. However, so far no study has investigated whether rhythm also affects more far-reaching phonetic reduction, i.e. reduction that involves the application of multiple processes at once. This question is of a broader theoretical interest as it concerns status of reduced forms both in production and perception.

If rhythm affects phonetic reduction proper, the purported difference between phonetic and phonological reduction processes could not be upheld in the same way. Phonetic reduction that is due to articulatory implementation is expected to be gradual in its nature. Metrical rhythm, however, is expected to have a categorical effect: A syllable is either lost or retained in order to achieve or maintain an even rhythm. An effect of metrical rhythm would therefore show that not all "phonetic" reduction is a result of articulatory weakening.

Instead, at least some part of the encountered reduction would have to be present already during phonological computation. Therefore, this would also indicate that reduced forms are represented in some way, providing evidence for an exemplar storage of reduced forms. Recall that in some exemplar-based approaches, pronunciation variants are directly selected for production and not necessarily a product of implementation. If metrical rhythm has an effect on reduction, this could be modelled in a way that the reduced form is stored and can be directly selected in order to satisfy rhythmic constraints.

In conclusion, the study of rhythm in language is a broad field and several different conceptualisations exist. While the concept of isometry has been criticised for being too narrow and atemporal, a solid body of research nevertheless exists that shows how metrical regularity affects language use and language structure. Metrical rhythm has even been shown to affect certain "phonological" alternations. If rhythm also affects broader "phonetic" reduction, this could be interpreted as evidence for a direct exemplar selection in production.

1.2.3 Other factors

In the literature on reduction, a range of additional influencing factors can be found. One of the most prominent and maybe intuitively obvious ones is rate of speech. A high speech rate has been shown to correlate with a high degree of reduction on several scales. Jurafsky *et al.* (2001) find an effect of rate on both durational reduction and on t/d-deletion. Shockey (2003)) shows a similar effect of speech rate for conversational English. Conversely, if a given reduced form also occurs with lower speech rates, this has sometimes been interpreted as an indicator of an ongoing or complete lexicalisation of the reduced form.

Although speech rate seems to have a strong effect on reduction patterns, Ernestus (2014) points out that

> "the question arises whether acoustic reduction indeed *results* from high speech rates or whether the positive correlation is rather due to the fact that both high speech rates and high reduction degrees are indicators of casual speech" [italics in the original].

Casual speech, which has also been assumed to affect reduction, is a certain style of speech and as such rather difficult to define and to operationalise. Attempts have been made to differentiate at least between certain basic styles of speech.

In the H & H theory (Lindblom, 1990), speakers only make the effort that is needed for the communicative situation they are in. Their speech in consequence varies between "hyperspeech" and "hypospeech", depending on how much effort is needed to convey the intended message to the listener. In a more formalised approach, Barry & Andreeva (2001) find a difference between read and spontaneous speech. This difference, however, does not seem to lie "in the type of reductions but in the range of degree of reduction" (Barry & Andreeva, 2001, 64).

Several studies have shown that word class in a broad sense influences reduction (e.g. Jurafsky *et al.* , 2001; van Bergem, 1993).[13] Bell *et al.* (2009) also observe interactions between word class and frequency and predictability. Prior probability, i.e. token frequency, only affects content words, but not function words. On the other hand, forward transitional probability only affects highly frequent function words, probably mostly in collocations like 'kind of'. This interaction between word class and frequency-based measures will have to be kept in mind for the corpus analysis, since the *lega*-adverbs (cf. ch. 2.1) that are the object of study in this dissertation display characteristics of both function and content words.

Related to the variables of word class and speech style is the factor "discourse function". In an analysis combining Discourse Analysis and close phonetic inspection, Plug (2005, 2006) shows that the Dutch adverb *eigenlijk* 'actually' displays different patterns of reduction, depending on its function in the discourse. While the factor "word class" is only able to capture differences between words, there also seems to be a need for an analysis of how *one word* is used in different contexts and how this affects reduction. Of course, the number of tokens that are analysed limits the depth of such an analysis to a certain extent.

Two other intuitively obvious factors are word stress and pitch accent. The placement of word accent in a given language significantly affects the possibilities for reduction. Sounds in lexically unstressed syllables are more prone to reduction than sounds in stressed syllables. In addition to stress as a word level category, several studies show that words which are pitch-accented tend to be less reduced than words that are not. Aylett & Turk (2004) find that "prosodically

[13] The difference between content and function words can also be related to the role of informational status that was found by Fowler & Housum (1987): function words are rarely carriers of new information and can therefore be reduced more easily.

prominent" words are significantly longer than ones that are not. Importantly, while frequency of occurrence and accentedness correlate, there are also unique effects for both variables. Accentedness is also included as a significant control variable in Bell *et al.* (2003).

Another important factor that influences reduction is the presence of disfluencies such as hesitations, repetitions or the use of fillers which can be seen as indicators of planning problems. Elements that are located in utterances containing disfluencies are significantly less likely to be reduced than items in completely fluent utterances. Crucially, the hesitation does not need to be directly adjacent to the target element in order to influence its realisation (Jurafsky *et al.* , 1998; Bell *et al.* , 2009). Positional variables have been found to impact reduction as well. Keune *et al.* (2005) find that sentence-final elements in their corpus are less reduced than non-final items. Similarly, Jurafsky and colleagues show that turn-initial and turn-final elements do not undergo reduction to the same degree as turn-medial items (Jurafsky *et al.* , 1998; Bell *et al.* , 2009).

In addition to these linguistic variables, sociolinguistic factors have been found to influence reduction patterns, too. Gender, for example, seems to play a role in that female speakers reduce less than male ones (Bell *et al.* , 1999; Byrd, 1994). Bell *et al.* (1999) also find evidence for a difference between age groups: Younger speakers reduce more than older speakers. While to a certain extent, age correlates with speech rate, this variable also had an independent effect. There are, however, no longitudinal studies that investigate whether the reduction employed by younger speakers "stays with them" until they are older.

As can be seen from the above overview, a range of variables influences the application of reductive processes. As far as the quality and the range of the corpus data allow for, these variables will be included in the empirical analyses as well.

1.3 Research on phonetic reduction in Icelandic

As mentioned in the introductory remarks of this chapter, research on phonetic reduction in Icelandic has up to now uncovered several reductive processes that are active in the language. To a certain extent, it has also been investigated how pervasive these processes are; the factors influencing their application, however, have not yet been well researched. Most research in this area is based on impressionistic and/or introspective data, and even the studies that use natural spontaneous speech hardly provide any quantitative information. This section is intended to give a brief overview of the studies that have been carried out so far, with an emphasis on those reductive processes that are relevant for the present study.

As Helgason (1993) notes, several studies investigate phonological consonant cluster reduction in Icelandic (e.g. Rögnvaldsson (1993); also cf. Côte (2004) for a later example). Most of them are concerned with the mapping from a purported underlying form to an output or citation form. If e.g. the underlying form of *rigndi* 'rain.3RD.SG.PAST' is taken to be /rɪkntɪ/, the medial cluster in the output form [rɪŋ̊tɪ] is of course reduced with regard to the underlying form. This kind of reduction is morphophonemic and cannot be regarded as phonetic since the citation form is always [rɪŋ̊tɪ] and never *[rɪkntɪ], not even in careful or hypercorrect speech. Instead, forms like [rɪŋ̊tɪ] are examples of lexicalised reduced forms (cf. ch. 1.1.1).

Bergsveinsson (1941) can be considered to be the first scholar to observe connected speech processes in Icelandic. His analysis of Icelandic sentence-level phonetics ("Satzphonetik") focuses on the realisation of vowel and consonant length as well as speech melody. His study is quite advanced for its time as it is based not on introspective or impressionistic observations, but on recordings of actual speech, both read and free. Although, in his dissertation, Bergsveinsson does not explicitly address the phenomenon of phonetic reduction, it is apparent from his phonetic transcription that he notices and records several connected speech processes that can be classified as reductive.

One of the processes to be found quite frequently in his transcription is the deletion of post-vocalic nasals in coda position. This deletion is not complete as it results in the nasalisation of the preceding vowel. The relative pronoun *sem*, e.g., is several times transcribed as [sɛ̃] instead of [sɛm].[14] Another reductive phenomenon that appears in Bergsveinsson's transcription is the reduction of vowels to schwa. This process seems to be confined to lexically unstressed vowels (e.g. [ʏntər] instead of [ʏntɪr] for *undir* 'under') and to vowels in function words (e.g. [ən] instead of [ɛn] for *en* 'and, but').

The first scholar to explicitly study reductive connected speech processes in Icelandic is Árnason (1980). Although all of Árnason's examples are introspective or impressionistic, his observations are quite precise. In his brief overview paper, he identifies three broad types of reductive processes that are active in Icelandic: "consonant assimilations", "loss of consonants" and "loss of vowels". For Árnason,

[14] In his transcription, Bergsveinsson also marks word and sentence accents. These are omitted from the presentation.

nasal place assimilation is most prominent among the consonant assimilations. In the word *inngangur* 'entrance', the alveolar [n] in the first syllable coda often assimilates to the following velar stop, resulting in a realisation such as [ɪŋkaʊŋkʏr] instead of the citation form [ɪnkaʊŋkʏr]. Deletion of nasals with nasalisation of the adjacent vowel or consonant (as already noted by Bergsveinsson (1941)) is included under "manner assimilation". This is exemplified by the realisation [ʏ̃fɛrθ] instead of the standard realisation [ʏmfɛrθ] for *umferð* 'traffic'.

Examples of deletion in Árnason (1980) include both consonant deletion in clusters and vowel deletion. Árnason states that vowel deletion is especially common in trisyllabic words where the second vowel is elided. While the trisyllabic word form *hjólinu* 'bike.DAT.DET.' is pronounced [çouː.lɪ.nʏ] in careful speech, according to Árnason, it is common to delete the word medial [ɪ] and to realise a disyllabic form [çoul.nʏ]. Árnason also touches upon factors he considers to be influencing reduction, among others "sentence stress" (which for him is identical with focus), "syllabic position" and "style and tempo" (p. 212-213). However, he does not go into detail about the precise nature or impact of these factors.

In the 1980s, reductive processes were included in a large-scale dialect survey called RÍN (*Rannsókn á íslensku nútímamáli* 'Research on Icelandic today', (Thráinsson & Árnason, 1992)). Under the heading of *óskýrmæli* 'unclear speech', it was investigated how pervasively six reductive processes apply in the speech of the RÍN informants. The following processes were included in the study:[15]

a)	Deletion of (voiced) fricatives	[θaːɣplaːðið] > [θaːplaːi]
b)	Fricativisation of nasals [sic]	[ʏmfɛrð] > [ʏ̃fɛrð]
c)	Nasal place assimilation	[hantklaiðɪ] > [haŋklaiðɪ]
d)	Syllabic deletion	[aur̥shautɪð] > [aur̥stɪð]
e)	Nasal deletion	[istlɛntɪŋkar] > [istlɛtɪkar]
f)	Monophthongisation of diphthongs	[laiɣð] > [laɣð]

The processes shown above take place on different linguistic levels (segment, syllable) and belong to different reductive classes (lenition, deletion, assimilation). In addition, several processes may co-occur, as the example [haŋklaiðɪ] shows where the cluster medial [t] is deleted and [n] is assimilated to the then following velar stop.

The results of RÍN show no significant[16] differences between the individual re-

[15] Examples of the processes are selected from the presentation of RÍN results in Árnason (2005, 418-424).

[16] No statistical tests were performed in RÍN. Instead, indices were used. Thus, "significant"

gions of Iceland with regard to *óskýrmæli*. The factor "age", however, is significant for a number of processes, most notably for the deletion of fricatives. For other processes, there are only minute age differences or none at all. This is the case for, e.g., the deletion of nasals with nasalisation of the preceding vowel. Crucially, speech rate was not included as a variable in RÍN. More recent research has shown that the variable "speech rate" explains the effect of the variable "age" (Keune *et al.* , 2005) – at least to a certain extent. The results presented in Thráinsson & Árnason (1992) regarding the factor "age" therefore have to be taken with a grain of salt.

Árnason's research on spontaneous speech phenomena is summed up in his two monographs on Icelandic phonology (Árnason, 2005, 2011).[17] In Árnason (2005), the results of the RÍN study are revisited, and other reductive processes are exemplified as well. In this brief overview, the focus will be on cluster reduction. Árnason cites several examples that involve voiceless obstruents which are otherwise quite stable as a sound class. Especially in cluster-medial position, stops can be deleted. In formal speech, *systkin* 'siblings' is pronounced [sɪstcɪn]. Mostly, however, the word-medial obstruent cluster is simplified, resulting in a realisation such as [sɪscɪn]. In clusters of three or more consonants, the medial one is often deleted. Obstruent clusters may also arise due to composition.[18] The citation form of *fótbolti* 'football' is [fou(ː)tpɔl̥tɪ], but a common pronunciation would be [foup(ː)ɔl̥tɪ]. Here, the cluster-initial alveolar obstruent is deleted acoustically due to either gestural overlap or gestural deletion.

Helgason (1993) is a more explicitly empirical example of research on phonetic reduction in Icelandic. In his study, Helgason presents an analysis of a corpus of spontaneous Icelandic and establishes 18 generative "rules of coarticulation and connected speech processes".[19] The rules mostly consist of processes that have already been described in the aforementioned studies. The deletion of weak, voiced fricatives is split into two processes by Helgason. Firstly, he assumes a rule[20] of

in this context does not necessarily entail statistical significance.

[17] Cf. also Hansson (2012)'s review of Árnason (2005). Hansson criticises Árnason for relying too much on the "phonological" notion of deletion, when the actual phonetic-articulatory phenomenon might be one of gestural overlap. Recall that this dilemma was adressed in ch. 1.1.1 by splitting the concept of deletion into "acoustic deletion" and "articulatory deletion".

[18] The example cited above, *systkin*, historically is also a complex word, but hardly transparent in the modern language.

[19] Some of Helgason's results are very briefly repeated in Helgason (1996) where they are also compared to German.

[20] Helgason actually posits three different, context-sensitive rules which are merged into one

approximisation which turns the voiced fricatives [v, ð, ɣ] in most positions into [ʋ, ð̞, ɰ], even in clear speech. According to Helgason, only in "very stressed syllables", this process does not apply. In a second rule, these approximants are deleted completely. This process of approximisation and deletion of voiced fricatives is judged by Helgason (1993, 30) to be "one of the most common in [his] data and [. . .] undoubtedly a major factor in triggering contracted forms in Icelandic."

Among Helgason's rules are also processes that had not appeared in the literature before, most notably several rules of lenition in addition to deletion rules. One of the processes that appear in Helgason (1993) for the first time is the fricativisation of [r], which is often encountered in preconsonantal or word-final position. Helgason also notes several processes specific to function words. Fricatives that are initial to function words can be lenited or deleted completely ([θɛhta] > [hɛhta] > [ɛhta], *þetta* 'this'). This process also appears in Pétursson (1986) and Árnason (2005).

Although Helgason arrives at the rules which he postulates by examining a corpus of spontaneous Icelandic, he does not provide exact quantitative information about the generality of the reductive processes behind his rules. Although he sometimes notes that processes are "rare" (/r/-fricativisation) or "abundant" (approximisation of voiced fricatives), it is not entirely clear how pervasive the effect of his reductive rules in spontaneous Icelandic actually is. Still, Helgason's rules can be compared to the results obtained in the corpus-based analysis of adverb reduction in ch. 3.

In the second part of his study, Helgason provides an analysis of vowel centralisation in unstressed vowels. This part is not based on spontaneous speech as the quality of the recordings he used was not sufficient to carry out a spectrographic analysis. Helgason notes that the centralisation tendencies identified are in accordance with the results of Svavarsdóttir *et al.* (1982).[21]

Pétursson (1986) is the last study to be presented in this chapter and one of the earlier examples of research on phonetic reduction in Icelandic. In this brief article, Pétursson presents a typology of sandhi-phenomena. His data basis is introspective and impressionistic, but like Árnason (1980), his observations are rather precise. Pétursson distinguishes five speech styles ("Sprechstile"). As an exemplification of reduction, he uses the fixed phrase *það er nefnilega það* 'that is namely that; that's how it is; exactly':[22]

The different degrees of reduction shown above exhibit several of the reductive

here for reasons of briefness.

[21] This study did not investigate phonetic reduction in particular, but vowel formants in Ice-

a)	Formal speech	[θaːð e(ː)r nepnɪleːɣa θaː(ð)][23]
b)	Informal speech	[θa eː nepleɣa θaː]
c)	Colloquial speech	[θa neple ðaː]
d)	Excited fast speech	[hamlaha]
e)	Extremely fast speech	[mla]

processes mentioned so far. Voiced fricatives are lenited and deleted already at the second level ([θað] > [θa]), as is preconsonantal /r/ ([eːr] > [eː]). The function-word final fricative [θ] is lenited to [ð] (level 2) or even to [h] (level 3). Post-tonic syllables are deleted, even if they represent an independent word like *er* (level 3).

As can be seen from this brief overview, research on phonetic reduction in Icelandic has mostly focused on establishing which reductive processes appear in spontaneous speech. Most prominent among these processes are nasal place assimilation, deletion of "weak" voiced fricatives/approximants, nasal deletion, deletion of vowels in post-tonic position, various processes affecting smaller function words, and vowel centralisation. Reduction of obstruent clusters is also an important area. The factors that influence the application of these processes, however, have so far been studied only poorly. The corpus analysis in ch. 3 can help shed light on these questions as some of the hitherto identified processes are also at work with regard to adverb reduction.

1.4 Summary

This chapter gave an introduction to the study of phonetic reduction and to the research questions of this dissertation. Firstly, the phenomenon of reduction was subdivided into lenition, deletion and possibly assimilation. Especially for deletion, it is in turn necessary to distinguish between "acoustic" and "articulatory" reduction. Then, theoretical accounts of reduction were presented. Abstractionist models relegate most reduction to phonetic implementation. In exemplar-based models, reduced forms can be stored in the lexicon and cognitively present during speech planning.

landic in general.

[22] The same phrase in varying degrees of reduction is also used by Árnason in several publications, e.g. Árnason (2009, 292). The version given here is taken from Pétursson (1986), since it presents the most degrees of reduction.

Thirdly, a number of factors that have been found to influence reduction were presented and analysed. Among them, especially frequency of occurrence and metrical rhythm will be studied in greater detail. Finally, the study of phonetic reduction since the 1980s has provided insight into which reductive processes are active in Icelandic. The circumstances under which these processes apply, however, have not been investigated. Hence, the focus of this dissertation lies on which factors influence reduction in Icelandic.

2 Methodology

This chapter gives an overview of how the initially formulated research questions will be answered methodologically. First, the "what" of this dissertation, i.e. the object of study, is discussed in ch. 2.1. Then, the "how", i.e. the methodological approach and the sources of data are presented in ch. 2.2. The final part of this chapter discusses how reduction is measured and quantified in this dissertation (cf. ch. 2.3).

2.1 Object of study: *lega*-adverbs

As Zimmerer (2009) notes, acoustic reduction in production can broadly be studied in two different ways. On the one hand, there are studies that concentrate on isolated processes such as t/d-deletion (Raymond *et al.* , 2006), schwa deletion (Buerki *et al.* , 2010) or, more generally, vowel reduction (Kul, 2011). On the other hand, there are studies that examine more general and often more "massive" (Johnson, 2004) reduction phenomena. The former approach has the advantage that the reductive process in focus can be investigated in greater detail, including all the factors that influence its application. Methodologically, these studies often employ both a corpus-based and an experimental approach as it is easier to design experiments that target only a restricted environment. A disadvantage of this type of studies is that the broader picture of reduction in a given language might not be fully described by an individual process.

Studies dealing with more general reduction phenomena that are not limited to the application of an individual process often do so in an overview style. The object of study is mostly not an individual reduction process, but words and the general reduction found in them. This type of research often focuses on a certain group or class of words, such as function words (Jurafsky *et al.* , 1998) or adverbs (Keune *et al.* , 2005).[1] The method of choice in these studies is mostly corpus-

[1] Of course, both approaches are not mutually exclusive. Bell *et al.* (1999), e.g., investigate the general durational reduction of words and the specific process of t/d-deletion in the same words.

based (cf. ibd.). An advantage of this approach is that it can give better insight into general processes of reduction that are active in a given language. However, this might also entail that individual processes are insufficiently described – especially if reduction is quantified on an ordinal scale (cf. ch. 2.3).

This dissertation follows the latter approach of examining a group of words instead of one or two single reductive processes. Since individual processes that are active in Icelandic have already been described by e.g. Árnason (1980, 2005, 2011) and Helgason (1993), it is considered more beneficial to give a broader overview over reduction in Icelandic. As the object of study in the empirical parts of this thesis, Icelandic adverbs containing the suffix -*lega* '-ly' were selected. Examples of *lega*-adverbs are given in (2.1) – (2.3):

(2.1) *náttúrlega* 'of course', *mögulega* 'possibly'

(2.2) *hreinlega* 'just, simply', *líklega* 'probably'

(2.3) *persónulega* 'personally', *ábyggilega* 'surely'

Selecting this class of adverbs as the object of study has a number of advantages, given the research questions formulated in the previous chapter. Most appealing is the fact that *lega*-adverbs represent a rather homogeneous target in several ways. This homogenity makes it possible to control for a number of factors that influence reduction which otherwise would be confounding the results. Additionally, *lega*-adverbs also differ in ways that are relevant for this study, most notably in their frequency of occurrence. In the following, the features of this class of adverbs are elaborated on in greater detail in order to justify their selection as target items for this study.

As mentioned above, *lega*-adverbs form a rather homogeneous group of words. Most importantly, they are quite alike in their morphophonemic makeup. This is, of course, partly due to the fact that all of them share the same suffix, -*lega* [lɛɣa] '-ly'. However, the stems to which this suffix is attached are also structurally similar. Most adverb stems are disyllabic, yielding an overall quadrisyllabic structure (cf. 2.1 above). While there are also trisyllabic (cf. 2.2) and quintosyllabic adverbs (cf. 2.3), their number is much smaller, with regard to both token and type frequency (cf. ch. 3.1.1). The morphophonological uniformity of the adverbs is an important feature as it allows for comparing reductive processes across words, because similar processes can be expected to apply in similar words. In addition, the fact that most of the adverbs are quadrisyllabic is important for the study of rhythm. Metrical rhythm takes the syllable as its basic unit, and syllabic deletion is best studied with items that have the same number of syllables in their citation forms.

Another advantage that *lega*-adverbs display is that they have a large token frequency range in corpora. While the exact distribution of adverbs in the corpus used for this study will be further elaborated in ch. 3.1.1, a brief example is given here in order to illustrate the benefits of choosing this class of adverbs. On the one hand, the most frequent *lega*-adverb, *náttúrlega* 'naturally, of course' could be classified as a high-frequency item. It occurs 965 times in the corpus, almost as often as the lemma *eiga* 'to have (in possession)',[2] which is found 1021 times in the corpus. There are also several mid-frequency adverbs such as *ótrúlega* 'incredibly' (43 tokens) or *algjörlega* 'entirely' (57 tokens). The frequency range stretches down to the bottom, with several hapaxes like *glögglega* 'clearly, distinctly' or *menningarlega* 'culturally'. In total, [89] different adverb types with different token frequencies are found in the corpus (cf. Appendix A).

An additional noteworthy benefit of focusing on *lega*-adverbs is the fact that the reduction patterns of their Dutch cognates have been studied quite extensively (Keune *et al.* , 2005; Pluymaekers *et al.* , 2005). In Dutch, the cognate suffix is -*lijk*, as in *natuurlijk* 'naturally, of course'. The research that has been done on *lijk*-adverbs allows for at least a limited comparison of the results of this dissertation with other studies. With regard to the factors that can influence reduction (cf. ch. 1.2) it is especially noteworthy that the Dutch studies found both frequency effects and effects of contextual predictability, i.e. effects for two variables that are in focus in the empirical chapters of this dissertation. If crosslinguistic comparison is allowed in this line of argumentation, then frequency effects can also be expected in the analysis of reduction in Icelandic *lega*-adverbs.

An important prerequisite for the quantitative study of reduction is the fact that impressionistic observation suggests that Icelandic *lega*-adverbs are prone to undergo acoustic reduction in spontaneous speech, just like their Dutch cognates. The suffix -*lega* seems to reduce especially easily in casual speech. The suffix is canonically realised as [lɛɣa], but reduction to -*la* or similar forms seems to be common. In the adverb stem, reduction is also found frequently. For two adverbs, *náttúrlega* and *nefnilega*, disyllabic reduced forms seem to have been lexicalised: *náttla* and *nefla*. These disyllabic realisations display both reduction in the suffix (from -*lega* to -*la*) and in the stem (from *náttúr*- to *nátt*- and from *nefni*- to *nef*-,

[2] Note that auxiliary HAVE which is used, e.g., to form the perfect is represented by a different lemma in Icelandic: *hafa*.

respectively).[3]

Evidence for the lexicalisation of disyllabic realisations of *náttúrlega* and *nefnilega* can be drawn from two sides. Firstly, native speakers seem to be able to recognise these disyllabic forms out of context. Ernestus *et al.* (2002) have shown that speakers usually do not recognise heavily reduced forms without syntactic embedding. Secondly, the forms *nát(t)la* and *nefla* are found in informal writing, e.g. in text messages or blog posts. Examples 2.4 and 2.5 are taken from the website *blog.is*:

(2.4) *Þetta er náttla bara scary*
this is of.course just scary
'That's just scary, of course.'

(2.5) *kallinn hefði nefla orðið 80 ára*
old.guy-the had.SUBJ namely become.PASTPART 80 years.GEN
í dag
today
'The old man would actually have turned 80 today.'

The corpus-based analysis in ch. 3 will help shed light on the question to what extent stem and suffix reduce for different adverbs and how far the lexicalisation of disyllabic side forms of *náttúrlega* and *nefnilega* has come.

An obvious disadvantage of choosing a fixed class of words for the study of phonetic reduction in Icelandic derives from one of the advantages discussed above: the morphophonological uniformity of the *lega*-adverbs. It might be the case that certain processes that are active in Icelandic are not captured in the analysis due to the trivial fact that certain sounds or combinations of sounds are simply not found in *lega*-adverbs. Vowel nasalation with deletion of the following nasal closure (Árnason, 1980; Helgason, 1993), for example, is not expected to be a process that can be observed very often with *lega*-adverbs, since most of them do not display the appropriate vowel-nasal target structure. In the same vein, processes that are found to be active in the adverbs under study could be argued to apply exclusively to these adverbs.

Given that all *lega*-adverbs belong to the same word class, it might be expected that their syntactic distribution is similar, which again would reduce the amount of variation in the data that has to be controlled. However, this is only partially

[3] The lexicalised reduced forms might actually behave more like discourse or modal particles than "proper" sentence adverbs. More qualitative research on the discourse function of reduced forms is needed in order to fullly characterise the semantics of *náttla* and *nefla*.

the case, since adverbs are notoriously hard to define as a group. In fact, there are two different kinds of *lega*-adverbs that differ both semantically and syntactically: sentence adverbs and intensifier adverbs. In the following, the semantic and syntactic features of these two groups of adverbs are portrayed briefly as far as the differences between them might be relevant for the study of reduction.

Sentence adverbs semantically modifiy the whole proposition of the sentence they are contained in. Syntactically, they typically occur in the position following the inflected verb. In example 2.6[4], the adverb *náttúrlega* directly follows the inflected verb form *er* 'is'. In example 2.7, *örugglega* 'surely' is modified by *alveg* 'in fact'. The two words form a phrase that directly follows the inflected verb *notar* 'use.2ND.SG.PRES.'.

(2.6) *það er náttúrlega bara svo misjafnt hvað fólk finnur*
it is of.course just so uneven what people finds
'Of course, people just feel very differently [about it] [Istal_02_310_03, Speaker B]'

(2.7) *þú notar alveg örugglega fullt af svona*
you use completely surely full of such
'You definitely use a lot of this [= these words] [Vidtal_A2, Speaker A2]'

In the overwhelming majority of cases, intensifier adverbs occur directly in front of an adjective or another adverb. Semantically, intensifier adverbs enhance the meaning of the adjective or adverb with which they form a phrase and sometimes provide an emotional colouring to it. In example 2.8, the intensifier *rosalega* is directly adjacent to the adjective *flott* 'great.NT.SG.', which it modifies semantically:

(2.8) *Þetta er rosalega flott.*
this is INTENS great
'This is really great! [Samtal_4.1, Speaker B7]'

Judging from syntactic distribution and semantic function, intensifiers can also be expected to be pitch-accented more often than sentence adverbs (cf. ch. 3).

In sum, choosing *lega*-adverbs as the object of study has a number of advantages, but also certain disadvantages, often rooted in the same structural characteristic: morphophonological uniformity. On the one hand, a similar structural

[4] These and all further examples are taken from the corpus that is also used for the quantitative corpus-based study. The data are described in greater detail in ch. 3.1.1. Morphological glossing is always kept to a minimum.

makeup is necessary in order to reduce the influence of confounding variables in the analysis, such as variable syntactic placement. On the other hand, similarity might lead to the exclusion of certain processes that could be of interest for a general description of phonetic reduction in Icelandic. In total, the disadvantages morphophonological uniformity entails are considered to be outweighed by the advantages described above, since the focus of this study is not the discovery of reductive processes but the factors that influence this phenomenon. The factor “rhythm” especially calls for entities to be studied that have a similar makeup on the level of word prosody.

2.2 Uniting corpus-based and experimental analysis

The study of reduction is empirical in its very nature. Phonetic reduction is a characteristic of natural spontaneous speech and only to a very limited extent accessible to linguistic intuition. As with a lot of other linguistic phenomena, there are two basic ways of studying reduction empirically: with the help of either a corpus-based or an experimental study.[5] Both methods have been employed extensively, as could already be seen in ch. 1.2 that presented previous research on factors influencing reduction. In the following, advantages and disadvantages of both methodologies will be discussed and evaluated for the purpose of this study. It is argued that both methodologies are necessary to answer the research questions that were posed in the previous chapters conclusively.

Simplifying considerably, one of the main differences between a corpus-based and an experimental analysis lies in the amount of control the researcher has over the variables that are taken into account, as well as whether or not hypotheses can be falsified. In a corpus-based study, a great range of variables can be considered and included in statistical modeling. However, the researcher has only very limited control over those variables. Hence, especially if the data basis is small, confounding effects are prone to arise in such an analysis. Experimental data are ideally carefully controlled for a number of variables so that in the statistical analysis, only a limited set of variables has to be taken into account. Additionally, the “independent variables are manipulated systematically to determine what effect, if any, they have on a (set of) dependent variable(s)” (Gilquin & Gries, 2009). Therefore, corpus-based studies are often considered to be ex-

[5] For a more detailled list of possible types of data in linguistics, cf. Gilquin & Gries (2009).

ploratory or "observational" (ibd.) while experimental studies are considered to be hypothesis-based.

Based on the above comparison, it is clear that both a corpus-based and an experimental study are necessary in order to answer the research questions formulated in ch. 1. Recall that the first research question asks which factors influence reduction in Icelandic. To a certain extent, this question is exploratory in its nature and hence calls for a broad, corpus-based approach. In addition, phonetic reduction is more easily encountered in a natural communicative than in an experimental setting, which might be too formal to allow for heavy reduction to appear. The third research question asks which (if any) conclusions can be drawn from the reduction behaviour of Icelandic *lega*-adverbs about possible cognitive representation of reduced forms; it is therefore better suited for an experimental approach. Thus, a "corpus-based methodology [...] can be paired with traditional controlled laboratory experiments to help provide insight into psychological processes" (Bell *et al.* , 2003, 1022).

Another crucial point that requires the combination of experimental and corpus-based analysis is the fact that certain effects might only appear under certain conditions because other effects are stronger in a different setting. The effect of metrical rhythm that Dehé (2008b) found for Final Vowel Deletion in Icelandic, for example, was based on a reading study. In naturally occurring speech, however, this effect might be too weak and overridden by other factors that are more important to the structuring of spontaneous speech. If therefore a given variable is found to influence reduction in one domain, this does not necessarily entail that it also affects reduction in another domain.

As will be seen in the corpus-based study in ch. 3, control factors like speech rate and accentedness account for a large part of the variation that is found in the corpus. On the one hand, this is a welcome result, as it shows that the same factors are at work in Icelandic and in other languages like English or Dutch. Crucially, a result like this one can only be found in an analysis that incorporates a broad range of variables, i.e. a corpus-based study. The strong effect of control variables, however, can also mean that the effect of the variables that are in focus, i.e. metrical rhythm and frequency of occurrence, is too weak to actually be seen in the natural speech data. This requires an experimental follow-up study. The focus would then be on two selected variables only and interfering variables could be carefully controlled for.

As phonetic reduction is a characteristic of naturally occurring speech, an experimental production study that focuses on reduction has to meet certain obstacles with regard to the naturalness of speech under experimental conditions. The combination of a shadowing and a reading task is considered to be the best solution to this "naturalness problem". The details of the methodology used for the experimental study are described more extensively in ch. 4.2. In sum, two different methodological approaches are considered to be necessary in order to answer the research questions formulated in the previous chapter: a corpus-based analysis of naturally occurring speech (cf. ch. 3) and a controlled experimental analysis (cf. ch. 4).

2.3 Quantifying reduction

The question of what constitutes a reduced pronunciation, which was discussed in ch. 1.1.1, is intricately related to the question of how phonetic reduction should be measured and quantified. Recall that phonetic reduction can be conceptualised in two different ways: on the articulatory and on the acoustic level. If phonetic reduction is primarily thought of as an articulatory phenomenon, it should be measured in terms of weakening and overlapping of articulatory gestures (Browman & Goldstein, 1992). This would require the collection of a corpus of articulatory data, e.g. by way of a palatography study or through other techniques in order to collect articulatory measurements. If phonetic reduction is operationalised as an acoustic phenomenon, high-quality recordings of naturally occuring speech are the preferred source of data.

When comparing the two data sources, it is clear that acoustic measurements are considerably easier to obtain, since no specialised phonetic-experimental equipment is necessary. In addition, acoustic data allow for a broader range of phenomena to be studied, since articulatory data often focus on specific areas of the vocal apparatus. Acoustic operationalisations of phonetic reduction will be used for the purpose of this dissertation. The gestural origin of these measurements, however, has to be kept in mind.

Even if reduction is measured acoustically, there are several ways of quantifying the phenomenon. While most would agree that the reduction from the citation form [l̥joumsveitaraeivɪŋkʏ] (*hljómsveitaræfingu* 'band.practice.ACC.') to [l̥ounstraivɪŋkʏ] in the initial example (1.1) can be considererd to be "massive" in the terminology of Johnson (2004), it is often not directly evident how reduction should be quantified in different words. This question ties in to the problem of how different reduction processes should be compared, e.g. lenition and deletion of different consonantal classes. In example 2.9, the final [ð] of the Icelandic word *augað* 'eye.DEF' is deleted acoustically. In the next example, 2.10, the voiceless stop [c] in the word *ekki* 'not' is lenited and becomes a fricative [ç].

(2.9) [øyɣað] > [øyɣa] *augað* 'eye.DEF'

(2.10) [ɛhcɪ] > [ɛhçɪ] *ekki* 'not'

Should the acoustic deletion of the fricative in the first example be counted as "more" reduction than the lenition of the voiceless stop to a fricative in the second one? In addition to these theoretical considerations, there are also practical questions involved when determining how to best measure reduction. The quality of the recordings that make up a given speech corpus, for example, often sets limits to how fine-grained reduction can be studied.

In a methodological paper on vowel reduction, Kul (2011) identifies two broad trends of how phonetic reduction is operationalised in quantitative studies. Firstly, reduction is often quantified as durational shortening (cf. e.g. Fowler & Housum, 1987; Bell *et al.* , 2009). Here, a realisation of a given word or segment is described as reduced if it is durationally shorter (often measured in ms.) than another realisation of the same element. In this conceptualisation, spectral characteristics such as formant values are not taken into account. These spectral features, secondly, are often approximated in the literature by employing categorical measures, especially in the description of assimilation and deletion processes. Jurafsky *et al.* (1998), for example, operationalise vowel reduction in terms of a nominal variable with three levels: "basic", "other full" and "reduced". Other studies on reduction use binary variables like "present / deleted", e.g. for t/d-deletion (Bell *et al.* , 2003). Recall from ch. 1.1.1 that deletion is often the end result of a gradual lenition process. Categorical variables can therefore only be an approximation of these processes.

After having presented the different ways of how reduction is quantified in the literature, Kul (2011) critically assesses their descriptive adequacy. In a pilot study on vowel reduction, she uses both a temporal, i.e. durational, and a spectral operationalisation of reduction. Kul's results show that durational reduction (in terms of milliseconds) and spectral reduction (in terms of formant centralisation) are only partially correlated. In fact, to a certain degree, both can occur independently of one another, both inter- and intra-speaker-wise. Kul's analysis thus demonstrates that measures of reduction that do not include both the spectral-segmental and durational dimensions are bound to fall short of describing the whole picture of phonetic reduction.[6]

Based on this assessment, Kul develops a new measure for vowel reduction which she calls Combined Parameter Analysis (CPA) by integrating both the spectral and the temporal dimension of reduction. While this measure will surely lead to a significant advancement in the study of phonetic reduction in vowels, it is not fully suitable for the present study. On the one hand, CPA requires several pronunciations of a given word or string for every speaker. Therefore, it is not a priori clear whether CPA can be used for smaller corpora such as the one that is the basis for the corpus study in ch. 3. On the other hand, an implementation of CPA for reduction in consonants is still not fully developed (Kul in prep.), but would be necessary since the present study investigates reduction in both vowels and consonants.

Although the integrated measure CPA can therefore not be used in this dissertation, reduction will be measured at several levels in accordance with Kul (2011) in order to give a broad overview of acoustic reduction in *lega*-adverbs. Firstly, reduction will be quantified as durational reduction at the temporal level. Relatively shorter realisations of a given element will be considered to be more reduced than relatively longer realisations of the same element. Since duration is employed as a reduction measure rather frequently throughout the literature, this will allow for a comparison of the results of this dissertation with those of other studies.

Secondly, reduction will be measured at the level of the syllable, i.e. as syllabic reduction. Of course, this measure is rather coarse-grained in comparison to e.g. quantifying reduction at the segmental level. It is, however, considered appropriate for this study for two reasons. Firstly, the quality of the recordings used for the corpus-based analysis in ch. 3 mostly excludes a fine-grained analysis of consonant and vowel lenition, as Ernestus (2000) provided for spontaneous Dutch. Secondly, recall from ch. 1.2.2 that the syllable is the structural level at which metrical rhythm is thought to be active. Therefore, a measurement has to be made at this level in order to study the possible effect of metrical rhythm on reduction.

[6] Articulatory studies inherently incorporate both dimensions, as they measure both the strength and the duration of particular gestures.

2.4 Summary

This chapter presented the methodological basis for the following empirical parts of this study. It was argued that adverbs ending in the suffix -*lega* represent a good testing ground for the study of phonetic reduction in Icelandic since they are morphophonologically alike and have a known tendency to reduce heavily in casual speech. Next, it was argued that in order to answer the research questions formulated in the initial chapter, both a corpus-based and an experimental approach are necessary. On the one hand, the more exploratory first and second questions can be answered with a corpus-based study. On the other hand, a combination of shadowing and reading task is best suited to answer the more psycholinguistically oriented third question. The last section presented evidence from the literature that reduction has to be quantified at several levels in order to give a full picture. Consequently, this dissertation employs two different measures of reduction: syllabic and durational reduction.

3 Corpus-based study

As was detailed in previous chapters, the corpus-based study of reduction in *lega*-adverbs is intended to fulfil two goals. On the one hand, a corpus-based analysis can provide a broad picture of the factors that influence adverb reduction in Icelandic and allows for comparing these factors to those found in the literature for other languages and reduction measures. On the other hand, the results will be theoretically evaluated with regard to which evidence, if any, they provide for the reduction.

Methodologically, it was argued that reduction should be measured in two ways. First, the number of syllables, albeit a very coarse-grained measure, is necessary in order to evaluate the possible influence of metrical rhythm. Second, the duration of *lega*-adverbs and their morphological parts will be used as a dependent variable. This allows for a comparison of the results of this study with those of previous research.

The next section presents an overview of the methodology of this corpus-based study. First, the corpus is presented, including the adverb distribution. Ch. 3.1.2 details the variables the corpus sample was annotated for. Ch. 3.2 presents a typology of the segmental and syllabic reduction that appears in the sample. The following sections present the results of two multivariate analyses – one for syllabic reduction (ch. 3.3) and one for durational reduction (ch. 3.4) – and discuss these results. Finally, the results obtained in the previous chapters are compared to each others and evaluated in ch. 3.5.

3.1 Corpus and methodology

3.1.1 Corpus description

The data basis for the corpus-based study reported in this chapter consists of three of the four subcorpora that make up the spoken part of the Icelandic national corpus ***Íslenskt textasafn*** ("Icelandic text collection", n = 229,032, Stofnun Árna Magnússonar í íslenskum fræðum (2004)):

- ***Samtöl*** ("Conversations"): conversations among young adults and between young adults and older family members
- ***Viðtöl*** ("Interviews"): sociolinguistic interviews with 30- to 35-year-old adults
- ***Ístal*** ("Ice-talk"): casual conversations among family members and colleagues

The fourth spoken subcorpus, ***Þing***, consists of recordings of parliamentary debates. Unfortunately, audio files for this subcorpus could not be obtained.

In the following, "corpus" refers to the three subcorpora that were used for this study. The corpus is orthographically transcribed and time-aligned for sequences larger than speaker turns. In total, the corpus contains 84 different types of *lega*-adverbs, adding up to 3017 tokens (cf. Table 1).

The by far most frequent adverb in each of the three subcorpora and in the corpus as a whole is *náttúrlega* 'of course' (n=965), followed by *rosalega* 'very (much)' (n=283), *eiginlega* 'actually' (n=216), *örugglega* 'surely' (n=191), and *nefnilega* 'namely' (n=183). While these adverbs rank among the higher-frequency words in general, there are also a number of hapaxes among the *lega*-adverbs in the corpus, e.g. *opinberlega* 'publicly' and *tæknilega* 'technically'. As mentioned in ch. 2.1, tri- and pentasyllabic adverbs have both a lower type and a lower token frequency (cf. Table 3.1). The most frequent trisyllabic adverb type, i.e. an adverb with a monosyllabic stem, is *ferlega* 'tremendously' (n = 13), and the most frequent pentasyllabic adverb type, i.e. one with a trisyllabic stem, is *ábyggilega* 'surely, probably' (n = 36). The exact distribution of adverb types according to their number of syllables is given in Table 1.

The overview table on the following pages also shows differences in relative adverb frequency between the three subcorpora – i.e. the number of adverb tokens in relation to the overall number of words varies between subcorpora. Taking into

	trisyllabic	quadrisyllabic	pentasyllabic
Types	16	59	9
Tokens	98	2838	81

Table 3.1: Distribution of adverbs of different length (based on citation forms)

account only the 10 most frequent adverb types, the differences in distribution are significant, according to a chi-square test ($\chi^2 = 84.5939$, $p < 0.001$). These differences are due to the *Samtöl* corpus containing relatively more *lega*-adverbs than the other two subcorpora. Two reasons could be hypothesised to be responsible for this difference. Either *Samtöl* could contain more tokens of every adverb in equal proportion, or there could be a significant overrepresentation of one or more individual adverb types.

The latter possibility is the case, as shown by a chi-square test over the distribution of the ten most frequent adverb types in the three subcorpora ($\chi^2 = 161.0379$, $p < 0.001$). One reason for these differences could be the fact that the adverb *náttúrlega* 'naturally, of course' is relatively more frequent in the *Samtöl* subcorpus than in the other two parts. *Náttúrlega*, although a high-frequency item in all subcorpora, thus seems to be especially typical for young adult speech, a fact that will be taken up again in the discussion section (cf. ch. 3.5).

The basis of the following analysis is a sample of 900 quadrisyllabic adverbs. This sample was obtained by randomly selecting 300 *lega*-adverbs from each subcorpus. The sample was limited to quadrisyllabic adverbs for two reasons. First, in order to study the effect of rhythm, target items need to metrically uniform in order to make them comparable in a multivariate analysis. Rhythm might influence pentasyllabic adverbs that have a trisyllabic stem with more "expendable material" differently than adverbs that have a disyllabic or monosyllabic stem. Second, as detailed above, quadrisyllabic adverbs represent the largest group of *lega*-adverbs, both with regard to type and token frequency.

As the three subcorpora contain different number of adverbs, both relatively and absolutely, the overall sample is not balanced in comparison to the corpus as a whole. This was done in order to include more younger speakers in the sample, since their is mostly found in the smallest subcorpus, *Samtöl*. This subcorpus is therefore overrepresented in the sample. The distribution of adverb types in the three subsamples is in each case representative for the respective subcorpus.

Adverb	Translation	Total	Ístal	Samtöl	Viðtöl
náttúr(u)lega	of course	965	444	235	286
rosalega	very (much); incredibly	283	161	52	70
eiginlega	actually	216	132	35	49
örugglega	surely	191	106	26	59
nefnilega	namely	183	122	20	41
nákvæmlega	exactly	100	24	15	61
ofsalega	really; very (much)	88	42	36	10
endilega	absolutely; sure	82	35	7	40
sérstaklega	especially	77	34	7	36
voðalega	very (much)	64	32	10	22
algjörlega	totally	57	15	9	33
greinilega	obviously	47	17	3	27
ofboðslega	very (much)	45	33	1	11
ótrúlega	incredibly	43	17	17	9
ógeðslega	very (much)	39	25	10	4
aðallega	mainly	38	19	5	14
ábyggilega	surely; probably	36	26	9	1
virkilega	really	32	14	6	12
sennilega	probably	31	16	6	9
gjörsamlega	totally; entirely	27	24	0	3
svakalega	very (much)	27	17	4	6
ágætlega	nicely; okay	23	17	2	4
mögulega	possibly	17	1	15	1

Adverb	Translation	Total	Ístal	Samtöl	Viðtöl
almennilega	properly	16	7	0	9
ferlega	tremendously	13	8	0	5
líklega	probably	13	7	1	5
ægilega	very (much)	12	10	0	2
ákaflega	very (much)	11	4	0	7
hreinlega	just; simply	11	5	0	6
óskaplega	very (much)	11	3	8	0
persónulega	personally	11	1	1	9
hugsanlega	possibly	10	5	1	4
skemmtilega	nice; in a fun way	10	2	1	7
væntanlega	presumably	10	1	5	4
daglega	daily	9	1	0	8
nýlega	recently	9	4	3	2
reglulega	reglularly	9	7	0	2
tiltölulega	relatively	9	3	2	4
hryllilega	terribly; very (much)	8	7	0	1
klárlega	clearly	8	0	4	4
rúmlega	circa	8	6	1	1
þokkalega	fairly	8	6	0	2
fljótlega	soon	7	4	1	2
hrikalega	terribly; very (much)	6	5	0	1
ógurlega	remendously; very (much	6	3	3	0
tæplega	barely; scarcely	6	4	0	2

Adverb	Translation	Total	Ístal	Samtöl	Viðtöl
upphaflega	originally; initially	6	3	0	3
innilega	profoundly	5	0	0	5
sérlega	particularly	5	2	2	1
vissulega	certainly	5	1	1	3
eðlilega	naturally	5	2	0	3
gifurlega	immensely; very (much)	4	3	0	1
hræðilega	terribly; painfully	4	3	0	1
peningalega	moneywise	4	3	1	0
rólega	casually; tranquilly	4	1	1	2
afskaplega	remendously; very (much	3	1	0	2
fullkomlega	perfectly; wholly	3	1	0	2
gríðarlega	vastly; very (much)	3	1	1	1
aftarlega	at the back; rearwards	3	1	1	1
alvarlega	seriously	2	1	0	1
augljóslega	plainly; evidently	2	0	0	2
iðulega	frequently	2	1	0	1
menningarlega	culturally	2	1	0	1
merkilega	interestingly	2	1	0	1
norðarlega	northwards	2	1	0	1
óttalega	dreadfully	2	1	0	1
sannarlega	indeed; really	2	0	1	1
brjálæðislega	screamingly; madly	1	0	0	1
fáránlega	utterly; very (much)	1	0	1	0

Adverb	Translation	Total	Ístal	Samtöl	Viðtöl
fjálglega	unctuously; eloquently	1	0	0	1
glögglega	clearly; distinctly	1	0	1	0
hættulega	desperately	1	0	0	1
harkalega	harshly; rough	1	0	1	0
kærlega	cordially; very (much)	1	0	0	1
konunglega	royally	1	1	0	0
lauslega	vaguely; loosely	1	0	0	1
óendanlega	interminably; infinitely	1	0	1	0
opinberlega	publicly	1	0	0	1
praktíklega	almost	1	0	0	1
skiljanlega	understandably	1	0	0	1
sorglega	tragically; sadly	1	0	0	1
tæknilega	technically	1	0	0	1
temmilega	quite; pretty	1	0	1	0
undarlega	strangely	1	0	0	1
Adverbs total		**3017**	**1505**	**573**	**939**
Words total		472952	233910	46485	192557

3.1.2 Variables and annotation

The sample of 900 *lega*-adverbs (and the utterances they were embedded in) that was extracted from the corpus was annotated for a range of variables. The choice of variables was firstly based on the discussion in ch. 1.2, presenting factors that are known to influence reduction. Secondly, variables like metrical rhythm, whose influence on phonetic reduction has not been investigated, were selected for their theoretical relevance. The annotation was done in Praat (Boersma, 2001), measurements were subsequently fed for statistical analysis into the R statistical platform (R Core Team, 2013). In this section, an overview is given over the variables used in the annotation and the hypotheses derived from them. This includes an overview of how the variables were operationalised and how the annotation proceeded.

Since the selection of variables that was used in the corpus-based study is mostly drawn from the literature, a first, general hypothesis about reduction in *lega*-adverbs can be formulated on the basis of the results found in previous studies:

1. Adverb reduction in Icelandic is influenced by the same factors as acoustic reduction in other languages.

This general hypothesis will be made more explicit during the following discussion in which more specific hypotheses about the individual variables will be formulated. On the one hand, these hypotheses will be based on how the variables in question were found to influence reduction in the literature. On the other hand, for variables that have not been discussed in previous studies, a brief explanation will be provided for why a given variable is expected to behave in a certain way.

Duration and number of syllables In a first step, the target adverbs were annotated for the two dependent variables with which reduction was measured and quantified. The first dependent variable was the total length, i.e. the duration of the adverb. Duration was measured in milliseconds. In addition to the duration of the adverb as a whole, the duration of adverb stem and adverb suffix, respectively, and their ratio was also annotated for. The second dependent variable was the number of syllables with which the adverbs were realised. The number of syllables a given element has in spontaneous speech can be rather difficult to determine. This applies especially to the adverb sufix -*lega*. The suffix is canonically realised as [lɛɣa], but the velar fricative is most often reduced heavily (cf. ch. 3.2) giving rise to a stretch of sound that is not easily divided into individual segments. In the annotation process, the following guidelines were therefore used in order to determine the number of syllables in the suffix.

First, the spectrogram was inspected. If there were signs of a velar fricative or a "velar pinch" between the two vowels of the *lega*-suffix, the velar element was taken to be a reflex of the velar fricative [ɣ] that appears in the citation form. The velar stretch was therefore classified as the onset of the second suffix syllable and the suffix was classified as disyllabic.

As this was only the case for very few items, additional features had to be checked when there was no sign of a velar. In a second step, the intensity curve on the suffix was inspected as to whether it contained one or two peaks. When the curve displayed two peaks, these were interpreted as belonging each to separate syllable nuclei and the suffix was therefore classified as disyllabic.

When there was only one intensity peak visible, formant transitions were inspected as to whether there was a visible change in formant structure that could indicate a bivocalic structure, e.g. [ɛa]. If this was the case, the two vowels in the suffix were interpreted as belonging to different syllables each and the suffix was classified as disyllabic, too. When there were no clear changes in formants, the suffix was classified as monosyllabic.

A bivocalic structure could of course not only be interpreted as a hiatus (which is the approach taken here), but also as a diphthong – which would make the suffix monosyllabic. However, there were three reasons for classifying bivocalic structures as a hiatus. Firstly, interpreting sequences like [ɛa] as two syllables confirms with native speaker intuition. Native speakers, among them the second annotator (cf. below), consistently judge the sequence [lɛa] to be disyllabic. Secondly, the diphthong [ɛa] does not occur in the lexical phonology of Icelandic (Árnason, 2005, 142-151). It is therefore consistent with Icelandic phonology to classify this sequence as a hiatus. Thirdly, this procedure is supported by the literature Pluymaekers *et al.* (2005) who annotate a sample of words from a corpus of spontaneous Dutch also set segment and syllable boundaries when there are clear changes in formant structure.

In addition to the two dependent variables detailed in the previous paragraphs, the adverb sample was annotated for a number of predictor and control variables. Some of these variables related to the adverb itself while others represented features of the environment the adverb was embedded in or of the utterance as a whole.

Token frequency Adverb token frequency was calculated from the corpus as a whole as presented in the previous section. For the statistical analysis, token frequency values were log-transformed as log-frequency values have been shown to be a better predictor than raw or relative frequencies. The hypothesis below is based on the well-attested relation between frequency of occurrence and reduction (Zipf, 1935; Jurafsky *et al.* , 2001; Bell *et al.* , 2009; Pluymaekers *et al.* , 2005).

2. High-frequency adverbs reduce more than low-frequency adverbs.

Accentedness Target adverbs themselves were annotated for whether they received a pitch accent or not. The following hypothesis about the relation between reduction and pitch-accentedness is based on Aylett & Turk (2004).

3. Adverbs that are not pitch-accented reduce more than adverbs that receive a pitch-accent.

Adverb function Bell *et al.* (2009) and others have shown that differences in semantic or syntactic function can have an effect on reduction behaviour. As was detailed in ch. 2.1, *lega*-adverbs can be divided into two groups according to their syntactic and semantic function. One group is constituted by sentence adverbs like *eiginlega* 'actually, in fact' that refer to the proposition as a whole. The other group of *lega*-adverbs consists of intensifiers like *rosalega* 'very (much)' that are adjuncts to an adjective or an adverb. The following hypothesis is based on the impressionistic observation reported in ch. 2.1 that sentence adverbs like *náttúrlega* or *nefnilega* tend to reduce more heavily than intensifier adverbs.

4. Sentence adverbs reduce more than intensifier adverbs.

Phonological-structural variables Three variables were included that related to the phonological structure of the adverb stem (cf. ch. 2.1). Firstly, the sample adverbs were classified as to whether there was an obstruent in the coda of the second syllable or whether there was an sonorant in same position or no coda at all. An example for the first type is the adverb *ofboðslega* where the coda of the second syllable is made up of the obstruent cluster [ðs]. The second type is exemplified by the adverb *náttúrlega* which has the liquid [r] in coda position in the second syllable. While sonorants in the coda are easily deleted and therefore give way to both syllabic and durational reduction, obstruents such as [s] or [t] resist reduction to a greater extent (cf. also ch. 3.2).

5. Adverbs with a sonorant in the coda of the first syllable or no coda at all reduce more than adverbs with an obstruent in the same position.

The other two structural-phonological variables refer to the nature of the onset of the adverbs' second syllable. This onset is important especially for syllabic reduction in two ways. Firstly, the manner of articulation of the onset consonant is important, i.e. whether the consonant is a sonorant or an obstruent, and was consequently annotated for. Again, sonorants are "weaker" and more readily deleted in conversational speech, while obstruents are not (cf. again ch. 3.2). When the onset of the second syllable is deleted, this gives way to a hiatus or diphthong which could in turn lead to the deletion of a syllable.

Take the adverb *mögulega* as an example. This item is realised canonically as [møːɣ̞ʏlɛɣa]. As Helgason (1993, 31-32) and Árnason (2005, 166) detail, voiced fricatives, among them the intervocalic <g> in the onset of the second syllable are mostly realised as an approximant, i.e. [ɣ̞]. Approximants are usually classified as sonorants. When this very weak consonant is deleted, this gives rise to a hiatus in the stem: [øːʏ]. Reduction can go further from this to [øː]. If however the onset of the second syllable is an obstruent that resists deletion (as the [s] in *rosalega*), this way of reduction is not given in the same way.

6. Adverbs with a sonorant in the second syllable onset reduce more than adverbs with an obstruent in the same position.

The second aspect of the second syllable onset that was annotated for is its place of articulation. Some adverbs have a coronal consonant in this position like the alveolar [t] in *náttúrlega*. Other adverb types such as *virkilega* have a dorsal consonant in the same position, in this case a velar [k]. As the suffix *lega* that immediately follows the stem starts with a coronal consonant, the alveolar approximant [l], it would be expected that the nucleus of the second syllable is more readily deleted when the onset of the second syllable is a coronal consonant as the transition from e.g. coronal [t] to coronal [l] would be easier than the transition from dorsal [k] to coronal [l].

7. Adverbs with a coronal consonant in the second syllable onset reduce more than adverbs with an dorsal consonant in the same position.

Transitional probabilities Other variables referred to the immediate surroundings of the adverb. Transitional probabilities from the surrounding words have been shown to be an important predictor of acoustic reduction and where therefore annotated for in the sample as well. For the present study, two probability measures were chosen, first the likelihood of occurrence of a particular word given the previous word in the utterance ("forward transitional probability") and second the probability of a particular word given the next word in the utterance ("backward transitional probability"). Other probability measures like Mutual Information (MI) were not annotated for since these could either not be calculated due to corpus limitations or had been shown not to influence reduction (Jurafsky *et al.* , 2001; Bell *et al.* , 2009).

Forward transitional probability is calculated by dividing the frequency of the bigram "previous word + target word" (w_{i-1} w_i) by the frequency of the previous word (w_{i-1}). In the same vein, backward transitional probabilities are calculated by dividing the frequency of the bigram "target word + following word" (w_i w_{i+1}) by the frequency of the following word (w_{i+1}). The formulae for the calculation of forward and backward transitional probability, respectively, taken from Jurafsky *et al.* (2001), are given in the following:

$$P(w_{\text{i}}|w_{\text{i-1}}) = \frac{freq(w_{\text{i-1}}w_{\text{i}})}{freq(w_{\text{i-1}})} \qquad P(w_{\text{i}}|w_{\text{i+1}}) = \frac{freq(w_{\text{i}}w_{\text{i+1}})}{freq(w_{\text{i+1}})} \tag{3.1}$$

Forward and backward transitional probabilities were based on the lemmatised version of the corpus. This was necessary due to the structure of Icelandic morphology and due to corpus size limitations. Icelandic is a highly inflecting language that inflects verbs (which often precede the target adverbs) for tense, number, person and mood. If transitional probabilities were calculated from a non-lemmatised corpus, i.e. based on word forms, *var náttúrlega* "be.1ST/3RD P.SG.PAST.INDICATIVE naturally" would be a different bigram from *varst náttúrlega* "be.2ND P.SG.PAST.INDICATIVE naturally". Even if this were deemed desirable, the relatively small size of the corpus would not allow for meaningful numbers to emerge from this calculation as the number of hapaxes and hapax-bigram would simply be too high. Therefore, transitional probabilities were calculated based on lemma frequencies. For the statistical analyses, log-transformed probabilities were used.

8. High backward transitional probability from the word following the adverb to the adverb itself leads to more reduction.

9. High forward transitional probability from the word preceding the adverb to the adverb itself leads to more reduction.

Speech rate The rate of speech of an utterance is standardly measured by the ratio of the number of syllables produced in a given stretch of speech divided by the total duration of this stretch. Accordingly, in order to determine the rate of speech of the utterance the adverb was embedded in, the total number of syllables of the longest stretch of speech without pauses or hesitations was counted.

This number was based on the number of syllables in the citation forms of words, except for the adverb itself where the phonetic number of syllables was used (cf. Pluymaekers *et al.* (2005) for this methodology). This sum was then divided by the total duration of the utterance stretch. Speech rates ranged from 3.44 to 12.99 syllables per second with the mean speech rate at 7.38. For the statistical analyses described in the following chapters, speech rate values were log-transformed in order to achieve a more normal distribution. The following hypothesis about the relation between speech rate and reduction is based on a broad consensus in the literature (Jurafsky *et al.* , 2001; Shockey, 2003):

10. High speech rate leads to more reduction than low speech rate.

Disfluencies Disfluencies in informants' speech such as hesitations or repetitions have been shown to influence reduction behaviour and were therefore also noted. Following Goldman-Eisler (1968), pauses in the speech signal were interpreted as hesitations if they exceeded a length of 0.2 seconds. An example of an utterance containing disfluencies is given in 3.2:[1]

(3.2) *Þeir vita eiginlega ekki hverju þeir eiga að (.) svara*
they know actually not what.DAT they shall to HES answer
'They don't actually know what they should answer. [Viðtöl_AA, Speaker 3]'

The presence of disfluencies in an utterance, even if they are no directly adjacent to the target word, has been shown to have a very strong influence on reduction (Jurafsky *et al.* , 1998; Bell *et al.* , 2009). Based on the results from the literature, the following hypothesis was formulated

11. Adverbs that are located in an utterance containing disfluencies are less reduced than adverbs in an utterance without disfluencies.

[1] As in previous chapters, morphological glossing is kept to a minimum as morpho-syntactic structure is not of prime importance in this context.

Positional variables Two variables were annotated for that relate to the position of the adverb within the utterance it is embedded in. Firstly, the adverb was classified as to whether it was utterance-initial or not. Secondly, it was noted whether the target adverb was in prepausal position or not. Items in prepausal position have been shown to be longer ("final lengthening") than items within the utterance. Similarly, utterance-initial items have been reported to be less reduced than items within an utterance.

12. Adverbs that are located at the beginning of an utterance are less reduced than adverbs in non-initial position.

13. Adverbs that are located in prepausal position are less reduced than adverbs in non-initial position.

Metrical rhythm The variable metrical rhythm also relates to larger stretches of the utterance that target adverbs are embedded in. Rhythmic environment was measured by inspecting the phonological feet immediately preceding and following the target adverb. If the surrounding feet had an identical rhythmic structure, the environment was classified as rhythmically even, either trochaic or dactylic. If the surrounding feet displayed different rhythmic structures or their rhythmic structure was not clear, the adverb was classified as having no regularly rhythmic embedding. An example of a trochaic and a dactylic environment is shown 3.3 and 3.4, respectively:

(3.3)	*ˈÞað*	*var*	*ˈvoðalega*	*ˈbragðgott.*
	that	was	very	tastegood

‘That was really tasty! [Ístal_01_112_02, Speaker A]’

(3.4)	*Ég*	*reyndar*	*ˈman*	*ekkert*	*ˈsérstaklega*	*ˈeftir*	*því*
	I	actually	remember	nothing	particularly	after	that.DAT

‘I actually don’t remember it that much. [Viðtöl_AA, Speaker 2]’

In 3.3 both (ˈ*það var*) and (ˈ*bragðgott*) form disyllabic feet with a trochaic structure. Therefore the rhythmic environment was classified as trochaic. In 3.4, (ˈ*man ekkert*) and (ˈ*eftir því*) both constitute trisyllabic dactylic feet which makes the rhythmic environment dactylic. Of the 900 adverbs in the sample, 238 adverbs were situated in an environment that was classified as rhythmically even, i.e. either trochaic or dactylic. In order to evaluate whether potential rhythmic effects are only due to the structure of the preceding or following foot alone, surrounding feet were also individually classified for their rhythmic makeup. Based on the results of Dehé (2008b) and Kuijpers & van Donselaar (1998), the following hypotheses are formulated:

14. a) Reduced adverbs that appear in a trochaic environment are preferably realised as disyllabic.
    b) Reduced adverbs that appear in a dactylic environment are preferably realised as trisyllabic.

Sociolinguistic variables As sociolinguistic variables, speaker gender and speaker age were included. The factor "age" was operationalised as having three distinct levels, "young" ($<$ 20 years), "middle" (20-50 years) and "old" ($>$ 50 years). This division is rather coarse and it could be argued that the cutoff-point for the young group should be put somewhat later. However, as there are only very few subjects in the sample that are between 20 and 25 years old, this question is not of prime importance for the statistical analyses. In addition, the results presented in the following sections show that this system of age classification is justified for the present study. Based on the results in the literature (Bell *et al.* , 1999; Byrd, 1994), the following hypotheses are formulated:

15. Younger speakers reduce more than older speakers.

16. Male speakers reduce more than female speakers.

Since information about education and current employment was not available for all speakers, these variables were not included in the analysis. In addition, for every token it was recorded from which of the three *subcorpora* (*Samtöl*, *Ístal* or *Viðtöl*) they were extracted, to which *recording* they belonged and the ID of the *speaker*. The variable "recording" can also be seen as a coarse approximation of the social status or the education of speakers as it can be expected from the corpus descriptions that subjects in each recording belong to roughly the same social class. No hypotheses were put forward for these three variables. Instead, they were included as random effect variables in the statistical analysis (cf. the next chapters).

Final Vowel Deletion As a control variable, adverbs were classified as to whether they displayed Final Vowel Deletion or not. Final Vowel Deletion (FVD) is a categorical reduction process that targets word final vowels that are followed by a vowel-initial word, i.e. word final vowels in a hiatus context (Dehé, 2008b). As *lega*-adverbs end in an [a], they represent targets for this kind of process if the following words starts with a vowel. An example of Final Vowel Deletion from the Samtöl-subcorpus where the adverb *náttúrlega* is pronounced as [nat.l] is given in 3.21. In this case, the [l] is resyllabified to the onset of the initial syllable fo the following word.

(3.5)

Sögurnar	*náttúrlega*	[nat.l]	*eru*	*bara*	*til að*	*hafa*	*gaman*	*af*
stories.the	of.course		are	just	to	have	fun	of

‘The stories of course exist to be enjoyed. [Samtal_1_1, Speaker A1]’

No hypothesis was put forward for this control variable, since the deletion of the word-final vowel automatically leads to the deletion of a syllable. Hence, the dependent variables were residualised for the effect of FVD before statistical models were calculated (cf. below).

3.2 Reduction typology

The main focus of this dissertation is to find the factors that influence the reduction of *lega*-adverbs in Icelandic (cf. the research questions proposed in ch. 1). However, it is necessary to give a brief overview of the segmental and syllabic reduction processes that are active in these words. Therefore, in the following, a short “reduction typology” is developed that describes how and where syllabic and non-syllabic reduction successively appears.

Syllabic reduction (ch. 3.2.1) describes what kind of reduction happens from quadri- to trisyllabic, from tri- to disyllabic and from disyllabic to monosyllabic adverbs. Reduction that does not involve the loss of syllabic material is described in ch. 3.2.2. Explanations for the order of syllabic reduction will be sought in the word prosodic structure of *lega*-adverbs. Non-syllabic reduction will be explained in terms of syllable structure and sonority or articulatory strength. Both types of reduction can be compared to the processes identified by Árnason (1980, 2005, 2011) and Helgason (1993).

Importantly, the succession of reductive phenomena presented in the following sections is taken to be a *logical* order and not a *temporal* one. Hence, it is not implied that the different reductive processes happen successively in the speech production process. Instead, the ordering of processes presented below represents generalisations over the data found in the corpus in an implicational scale.

3.2.1 Syllabic reduction

Broadly speaking, the loss of a syllable involves the loss of the syllable bearing segment. In Icelandic, this always is a vowel as lexically syllabic consonants do not exist in this language(Árnason, 2005, 68-69). The *lega*-adverbs that were selected for the present study are all lexically quadrisyllabic. Hence, four possible "locations of deletion" can be identified. Since the ordering of syllabic reduction in Icelandic *lega*-adverbs will be explained by the prosodic structure of the adverbs, it is first necessary to recapitulate the prosodic makeup of quadrisyllabic *lega*-adverbs. Consider the following figure:

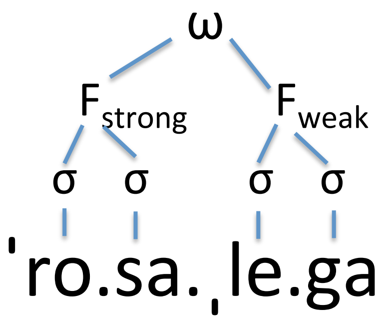

Figure 3.1: Prosodic structure of *lega*-adverbs

In the above example, the general prosodic structure is exemplified by the adverb *rosalega*. Recall that main stress on *lega*-adverbs, as in nearly every other word in Icelandic, falls on the first syllable which in this case is *ro*-. Secondary stress is located on the first syllable of the adverb suffix. According to traditional classification, -*lega* is a "strong" or class II-suffix which invariably receives secondary stress (Indriðason, 1994, 76-77). Based on these stress assignment patterns, it can be stated that quadrisyllabic *lega*-adverbs consist of two metrical feet, a strong one and a weak one. The first syllable of the stem is the head of the strong foot while the first syllable of the suffix is the head of the weak foot. The prosodically weakest syllable is the second syllable of the suffix. A general prediction made from word-prosodic structure locates the first syllable to be lost in the adverb suffix. More specifically, it could be anticipated based on word prosodic structure that the last adverb syllable which is prosodically weakest is deleted first.

In quadrisyllabic adverb realisations, all four syllable-bearing vowel segments are present. In 3.6, the adverb *ofsalega* is realised with both the stem vowels and the suffix vowels are realised quantitatively unreduced.

(3.6) *Það* *er* *ofsalega* [ɔf.sa.lɛ.ɣ̞a] *spennandi*
it is massively interesting
'It's incredibly interesting [Istal_01_112_02, Speaker A]'

The first syllable that is lost in almost all cases is situated in the adverb suffix[2] -*lega* which, as shown above, represents the prosodically weaker foot of the adverbs. The general prediction about the location of deletion is thus borne out by the corpus evidence. The reduction in the suffix accounts for the difference between quadrisyllabic and trisyllabic adverbs. While quadrisyllabic adverb realisations have a (syllabically) unreduced suffix, trisyllabic adverb realisation display a suffix that is reduced by one syllable. In citation forms, the suffix is realised disyllabic as [lɛɣa]. The suffix-medial fricative is realised as an approximant even in citation forms (cf. rule no. 1 in Helgason (1993)) and very often fully deleted in casual speech (cf. rule no. 12 in (Helgason, 1993)).

When the suffix is reduced to a monosyllable, it is thus mostly realised as [la] (cf. also below). An example of this kind of reduction taken from the corpus is shown in 3.7. Here, the adverb *örugglega* is realised as trisyllabic [œ.rək.lɐ]. While there is some qualitative reduction in the adverb stem, none of it leads to the loss of a syllable.[3] The suffix, however, is reduced from two syllables to one, leading to an overall trisyllabic adverb realisation.

(3.7) *Sumir* *gætu* *það* *örugglega* [œː.rək.lɐ] *mjög* *vel*
some could that surely very well
'Some would be very well able to do that [Vidtal_AA, Speaker AA3]'

In the following example, the suffix of the adverb *örugglega* is pronounced as monosyllabic [lɐ] and the stem as disyllabic, leading to an overall trisyllabic realisation.

[2] Impressionistic observation suggests that reduction from four to three syllables can also involve the loss of a syllable in the adverb stem, especially for the adverb *nefnilega*. Both the author of this study and Kristján Árnason (p.c.) have come across realisations like [nɛp.lɛ.a] instead of lexically [nɛp.nɪ.lɛ.ɣa]. Here, the suffix remains disyllabic, but one syllable is deleted in the adverb stem. The conclusion that all reduction in the corpus from four to three syllables confirms with predictions from word prosody therefore has to be taken with a grain of salt. However, no example of the kind of reduction exemplified by the form [nɛplɛa] was found in the corpus. Hence, while word prosody might not *categorically* predict reduction in this case, it at least predicts a very strong statistical tendency.

[3] Stem reduction that does not entail the loss of a syllable is adressed in more detail further below.

(3.8) *Sumir*	*gœtu*	*það*	*örugglega* [œːː.rək.lɐ]	*mjög*	*vel*	
some	could	that	surely	very	well	

‘Some would be very well able to do that [Vidtal_AA, Speaker AA3]’

Another example of a trisyllabic adverb realisation which involves reduction in the adverb suffix is given in 3.9. Here, the adverb *rosalega* is realised as [rɔː.sɐ.lɛ]. Note that the suffix vowel in this case is more [ɛ]-like than [a]-like. This realisation is trisyllabic due to the reduction of the adverb suffix from two to one syllable. However, as in the two examples above, the number of syllables in the stem are not reduced quantitatively.

(3.9) *nei*	*ég*	*hef*	*rosalega* [rɔː.sɐ.lɛ]	*litla*	*samúð*	*með*	*þér*
no	I	have	very	small	compassion	with	you

‘No. I have very littla sympathy for you. [Istal_01_112_04, Speaker A]’

The fact that syllabic reduction happens first in the suffix can be accounted for by word prosodic structure and the segmental structure of the suffix. As detailed above, the suffix represents the prosodically weaker foot of the adverb. Recall in addition that the suffix is canonically produced as [lɛɣa], i.e. with a voiced velar fricative as the onset of the second syllable. This consonant is structurally “weak” in itself as voiced non-sibilant fricatives are prone to undergo reduction rather easily (Árnason, 2005; Rögnvaldsson, 1990), although it is situated in a syllabically strong position, the syllable onset. The deletion of this fricative leads to the clash of the two suffix vowels [ɛ] and [a], i.e. a hiatus. This vowel-vowel-sequence can then be pronounced with varying vowel qualities. In many cases, however, one of the vowels, mostly [ɛ], is deleted which then results in a monosyllabic suffix -*la*.

When the reduced suffix is realised with an [a]-like vowel as in 3.7 and most other trisyllabic examples, the syllabic nucleus that is lost is strictly speaking not located in the last, i.e. prosodically weakest syllable. Instead, the nucleus of the first suffix syllable, namely [ɛ], is lost. This could be interpreted as a case of vowel deletion in hiatus context, similar to Final Vowel Deletion (FVD). In FVD, it is also the first vowel in a hiatus that is deleted. The contraction from *lega* to *la* thus confirms with the general prediction that the first syllabic nucleus to be lost is situated in the adverb suffix. The more concrete prediction that the reduction is located in the last adverb syllable, however, is not borne out.

While the reduction from quadri- to trisyllabic adverb forms happens in the adverb suffix, the reduction from tri- to disyllabic forms takes place in the adverb stem. Examples for this kind of reduction are given in 3.10 and 3.11. In the first example, the adverb *náttúrlega* is pronounced as [nɐt.l̥ə]. This realisation is disyllabic with syllabic reduction occurring in both in the adverb stem and in the adverb suffix.[4] In addition, the remaining two vowels are also heavily reduced qualitatively.

(3.10)

Þær	*verða*	*náttúrlega* [nɐt.l̥ə]	*alltaf*	*á*	*(.)*	*ensku*
they.FEM	become	of.course	always	on	HES	English

‘They [= the commercials] are of course always in English then. [Vidtal_A2, Speaker S1]’

(3.11)

Það	*er*	*nefnilega* [nɛb̥.la̰]	*það*
that	is	namely	that

‘Exactly. [Samtal_1.2, Speaker B2]’

In the second example above, *nefnilega* is realised as disyllabic as well. As with the first example, one syllable is deleted from the adverb stem and one from the adverb suffix.[5]

While there is some evidence that disyllabic side forms of *náttúrlega* (and *nefnilega*) have become lexicalised (cf. ch. 2.1 and the discussion further below), disyllabic realisations do not exclusively occur with these two adverb types. In 3.12, the adverb *örugglega* is produced with two syllables as [œkː.la]. Both the stem and the suffix are contracted to one syllable each.

(3.12)

sem	*ég*	*hef*	*ekki*	*séð*	*örugglega* [œkː.la]
that	I	have	not	seen	surely

‘which I probably have’t seen (yet) [Istal_06_107_01, Speaker A]’

In the following example, the adverb *væntanlega* is realised as disyllabic [vaiṋ.tɛ.l]. While the stem is quantitatively unreduced, the suffix has almost disappeared due to the application of Final Vowel Deletion. Recall that in Final Vowel Deletion, word final vowels are deleted in a hiatus context, i.e. if the following word starts with a vowel. The word final vowel that is omitted also constitutes the nucleus of the word final syllable. When the final nucleus vowel is deleted, this automatically

[4] Note the realisation of the suffix-initial [l]. The preceding voiceless stop is released laterally which leads to the almost complete devoicing of the following lateral consonant. This “fusion” phenomenon could be interpreted as an indicator of the fact that lexicalised disyllabic side forms of *náttúrlega* are monomorphemic and do not represent concatenation of stem and suffix.

[5] Recall from ch. 1.3 that the fixed phrase *Það er nefnilega það* is used to exemplify different stages of reduction in Árnason (1980, 2009) and Pétursson (1986).

leads to the loss of a syllable. In the case of *lega*-adverbs, the word final vowel is [a] and as shown in the above table is readily deleted in hiatus contexts. In the example below, Final Vowel Deletion can apply since the following word starts with a vowel, thus creating a hiatus context. The first vowel in this hiatus, the suffix-vowel of *væntanlega*, is then deleted. The suffix-initial [l] now forms a syllable with the first sounds of the following word, [eiht].

(3.13)	*Jú*	*þetta*	*er*	*væntanlega* [vain̥.tɛ.l]	*eitthvað*	*skipulögð*	*(.)*
	yeah	this	is	presumably	something	organised	HES

hópferð
group.tour
'Yeah, it's probably some organised group tour. [Samtal_2_1, Speaker A2]'

Examples like 3.13 above represent exceptions in that most disyllabic forms display reduction in both stem and suffix. In most disyllabic forms, it is not the suffix that is deleted completely, leaving only the stem. Instead, disyllabic adverbs mostly consist of the first syllable of the stem (with maybe the coda of the second syllable) and one syllable belonging to the suffix. This pattern of reduction can be explained by word-prosodic structure: The weakest syllable prosodically is the second syllable of the suffix, i.e. the unstressed syllable in the weak foot. The next-weakest syllable then is the unstressed syllable in the strong foot, i.e. the second syllable in the stem. And this is exactly where syllabic reduction from tri- to disyllabic forms happens.

The monosyllabic forms in the sample mostly involve the application of Final Vowel Deletion. In example 3.14, the adverb *nefnilega* which is followed by the vowel-initial word *ekkert* 'nothing' is realised as [nɛb.l]. The stem is reduced from *nefni-* to *nef-* and the remaining suffix vowel is deleted in the hiatus context.

(3.14)	*hann*	*lítur*	*nefnilega* [nɛb.l]	*ekkert*	*illa*	*út*	*sko*
	he	looks	namely	nothing	bad	out	PART

'Well, he doesn't actually look bad [Istal_06_220_02, Speaker A]'

In a similar vein, in example 3.15 the adverb *eiginlega* is radically reduced to [ei.l]. The stem is reduced from [eiːjɪn] to [ei] and the suffix vowel is deleted in the hiatus created by the following vowel-initial word *ekki* 'not'.[6]

[6] Interestingly, in the same example, another case of Final Vowel deletion is found involving the adverb *eiginlega*. Since this lexeme is vowel-initial, it creates a hiatus with the word-final [a] of the preceding word *vita* 'know' which is then realised as [vɪːt]. The sequence *vita eiginlega ekki* 'know actually not' is thus pronounced as something like [vɪː.tei.lɛ.çə].

(3.15) *(Þeir) vita eiginlega* [ei:.l] *ekki hverju þeir eiga að (.)*
(they) know actually not what they have to HES
svara
answer
'In fact, they don't know what they should answer [Vidtal_AA, Speaker AA3]'

The strong relation between monosyllabicity in reduced forms and Final Vowel Deletion is shown in Table 3.2.[7]

With FVD	Without FVD
38	6

Table 3.2: Monosyllabic forms and Final Vowel Deletion in the corpus

The overwhelming majority of monosyllabic forms found in the corpus involves the application of Final Vowel Deletion. The correlation of monosyllabic forms and Final Vowel Deletion points to an interesting fact about the reduction pattern of *lega*-adverbs. The disyllabic form seems to be some kind of "reduction baseline" that can only be further reduced by involving a very specific and context sensitive process.

This generalisation does not entail, however, that disyllabic forms are always "clearly pronounced". On the contrary, disyllabic forms can be very heavily reduced in both their consonant structure and their vowel structure as shown in e.g. 3.10 above. The following example below displays a very heavily reduced disyllabic realisation of *náttúrlega*:

(3.16) *(það er) náttúrlega* [n̩.tl̩] *hægt að gera svo ótrúlega mik-*
(it is) of.course possible to do so incredibly mu-
margt.
much
'Of course you can so incredibly many things [with that money]. [Samtal_1_1, Speaker A1]'

Both adverb stem and adverb suffix are reduced to the point of being unrecognisable. Only the initial nasal and the plosive remain of the stem and the suffix is represented by the initial [l]. The sonorants [n] and [l] form the nuclei of the two phonetic syllables. The example above therefore represents an exception insofar

[7] Final Vowel Deletion of course also applies to fuller, i.e. quadri- or trisyllabic forms as shown above.

as syllabic consonants which do not exist in the lexical phonology of Icelandic (Árnason, 2005, 58-59) are only very rarely found in the data. The pronunciation [ntl] is therefore actually much more heavily reduced than many monosyllabic realisations that have undergone Final Vowel Deletion.

3.2.2 Non-syllabic reduction

The previous paragraphs mainly dealt with reduction that leads to the loss of one or more syllables, i.e. deletion of vowels that represent syllabic nuclei. Syllabic reduction in the suffix happens when the suffix-medial [ɣ] plus a suffix vowel is deleted. In the stem, syllabic reduction involves the deletion of the second syllable nucleus vowel. As the example in the previous section already showed, segments that are not syllable-bearing, i.e. the loss of which does not entail the deletion of a syllable, can also be lenited or completely deleted. The classification of reduction in terms of lost syllables presented in the previous paragraphs can therefore only partially represent the pattern of reduction found in *lega*-adverbs.[8]

In order to partially make up for the shortcoming of this classification, in the following a short overview is given over segmental reduction in the data that does not entail syllabic reduction, i.e. consonantal reduction. Reduction in the suffix -*lega* has already been covered in the previous section. Hence the following overview will focus on consonantal reduction in the adverb stem. A detailed segmental phonetic analysis was not possible in all cases due to limitations in the acoustic quality of the recordings the corpus is based on. Therefore, only (acoustic)[9] deletions will be considered, although sporadic reference to lenition will be made as well.

While the order of syllabic reduction was explained by word-prosodic structure, more parameters have to be taken into account in order to explain the order of non-syllabic consonantal deletions. Consonantal segmental reduction in the stem can broadly be analysed with the help of three variables: Firstly the syllabic position the deleted segment occupies (onset vs. coda)[10] and secondly natural classes of segments that are affected. A third variable concerns the question whether a

[8] Recall from ch. 2.3 that the syllabic reduction was chosen as a measure of reduction for two reasons. On the one hand, the syllable is the phonological level at which potential rhythmic effects are visible. On the other hand, the quality of the corpus recordings does not allow in all cases for a detailed segmental phonetic analysis.

[9] Cf. the discussion about the possible difference between acoustic and articulatory deletion in ch. 1.1.1.

[10] Recall that there are no lexically syllabic consonants, i.e. consonants occupying the nucleus position, in Icelandic.

given syllabic position is occupied by more than one segment, i.e. whether the reduced segment forms a consonant cluster together with other segments.

With regard to syllabic position, segments that occupy the coda position of a syllable can be considered to be more prone to undergo reduction than segments in the syllable onset. With regard to segmental types or natural classes of segments, sonorants are expected to reduce before obstruents. In addition, reduction is expected to happen more easily in segment clusters than in non-clusters. All three hypotheses are backed up both by phonological research especially in the framework of Optimality Theory (Prince & Smolensky, 1993/2002; Kager, 1999) and by phonetic research on naturalness (Dressler, 1985; Vennemann, 1988) and on reduction (Ernestus, 2000).[11]

On of the most common structuring or explanatory devices for differences in behaviour between segment types is the sonority hierarchy that orders classes of segments according to their inherent "sonority". One instantiation of the sonority hierarchy is shown in the following figure:

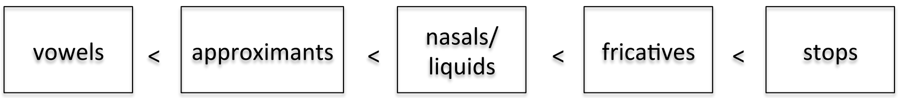

Figure 3.2: Simplified sonority hierarchy

The sonority hierarchy has been used amongst other things to explain syllabification processes. The Sonority Sequencing Principle states that the level of sonority rises towards the nucleus of the syllable. Therefore, the nucleus is typically occupied by a vowel and the "outer regions" of the syllable by obstruents, i.e. stops and fricatives. The sonority hierarchy can also be used to predict the reduction behaviour of different classes of segments. Segment classes that display the least amount of sonority should also have the least inclination to reduce in spontaneous speech. More sonorous segments such as approximants and nasals, on the other hand, should be more likely to reduce. The case of vowels, the most sonorous segments, is slightly different as vowels typically (and in Icelandic always) occupy the nucleus position of the syllable and are therefore necessary ingredients of the syllable structure.

[11] It could be argued that the statements made above lend themselves well to a formalisation in the framework of Optimality Theory. However, following Ohala (2005), an explanation in terms of grammatical competence need not be invoked when an explanation in terms of phonetics is sufficient.

While the sonority hierarchy has been claimed to be universal in nature, there are minor differences between how different languages order and cluster sound classes. The hierarchy displayed above largely can be used in its current form to predict the reduction behaviour of different segment types in Icelandic, with the status of [s] being the only exception. As Árnason (2005) observes, [s] behaves in many ways like the fortis stops /p, t, k/, e.g. with regard to vowel length in simple words and compounds. In stressed syllables in Icelandic, vowels are short preceding consonant clusters, except clusters consisting of <p, t, k, s> and [r, j] with [s] patterning with the "hard" stops (Árnason, 2005, 185-186). Similarly, if the monosyllabic first part of a compound ends in a single /p, t, k/ or /s/, the nucleus vowel is long, regardless of the number and identity of the following segments (Árnason, 2005, 199-200). The clustering of [s] with /p, t, k/ will be shown to be important for explaining reduction patterns as detailed below.

It was stated above that sonorants should reduce more easily than obstruents and that elements in coda position reduce more easily than elements in onset position (cf. also Árnason (2005, 229-231)). Combining these hypotheses, the first segments to be lenited or deleted in the stem should be sonorants in the coda of the second syllable, which is indeed what is found in the corpus data. This kind of reduction is often accompanied by reduction in the suffix. Example 3.17 shows a realisation of *náttúrlega*:

(3.17)	*og*	*óþægilegt*	*fyrir*	*náttúrlega*	[nauh.tə.lɛ.a]	*hina*	*makana*
	and	uncomfortable	for	of.course		other	spouses.the

'And of course uncomfortable for the other spouses. [Istal_01_112_04, Speaker A]'

In this example, *náttúrlega* is realised as [nauh.tə.lɛ.a] without the trill/tap [r] in the second syllable coda, but otherwise there are no further deletions in the adverb stem. Since [r] is a sonorant consonant, this pattern fits well with the predictions made above. Helgason (1993) sums up the deletion of [r] under the rules of approximant deletion (9–11) since in his computationally oriented model he assumes voiced fricatives and [r] to be lenited to approximants first and then deleted secondly. The above example also shows that the nucleus of the second syllable is of course also qualitatively reduced before it is deleted entirely, in this case from a full vowel [u] to a reduced vowel [ə].

Example 3.18 below shows a realisation of *eiginlega* which in its citation form is pronounced [ei.jɪn.lɛ.ɣɐ]. Here, the nasal consonant [n] in the second syllable coda is deleted, but all other consonants in the stem are present.[12] This is equivalent to rule no. 14 in Helgason (1993) ("Nasal deletion preceding consonants following a vowel").

(3.18) *maður* *er* *eiginlega* [ei.jə.lɛ.ɐ] *guðslifandi* *feginn* *á meðan* *þeir*
one is actually god.living relieved while they
þegja
are.quiet
'One is actually infinitely relieved when they don't say anything. [Vidtal_AA, Speaker AA3]'

The only segment class that is traditionally classified as an obstruent and that is deleted at an early stage of reduction in the coda of the second syllable are voiced fricatives like [ð] in the adverbs *ofboðslega* and *ógeðslega* (cf. rules 1 and 11 in Helgason (1993)).

(3.19) *Ég* *kom* *ógeðslega* [ouː.cɛs.lɛ.a] *hress* *á morgnana* *(.)*
I came insanely in.good.spirits in.the.morning HES
upp *úr* *lauginni*
upp out pool.the
'I came incredibly incredibly fit out of the pool in the morning [istal_01_112_02, Speaker A]'

In the above example, the adverb *ógeðslega* is realised relatively unreduced. The only segments that are deleted acoustically in the realisation [ouː.cɛs.lɛ.a] are the voiced fricatives/approximants [ð] in the second syllable coda cluster and the suffix-medial [ɣ].

According to the predictions derived from the hypotheses presented above, the next consonants to be deleted should be consonants in the first syllable coda or in consonant clusters between the first and second syllable. Consonant clusters between the the nuclei of the first two syllables, i.e. at the transition from the first to the second syllable, can be syllabified in different ways in Icelandic. The syllabification in these cases depends on the place of the types of segments that are involved on the sonority hierarchy and the Sonority Sequencing Principle (cf. above). In cases like *virkilega*, a sonorant precedes an obstruent and is therefore syllabified as belonging to the first syllable (˜textitvir.ki.le.ga) since an onset cluster like *[rk] is illicit. In cases like *nákvæmlega* where a voiced, i.e. "weak"

[12] In the case of [n], deletion can of course also apply to the oral closure part of the consonant only, leaving the nasality behind on the vowel.

fricative follows a voiceless, i.e. "strong" obstruent, the two segments together form the onset of the second syllable: *ná.kvæm.le.ga*.

This difference in syllabification also entails differences in the reduction behaviour of the two cluster types. As with the examples above, sonorants like [r] that are found in the first syllable coda, especially when followed by an [s], are the easiest target for reduction. "Weak" voiced fricatives, however, like [f] or [v] are also reduced at an early stage. Example 3.20 shows a realisation of the adverb *ofboðslega* which is pronounced as [ɔv.pɔðs.lɛ.ɣa] in citation form.

(3.20) *þetta* *er* *ofboðslega* [ɔː.pɔs.la] *mikið* *af* *fólki* *sem* *hefur* *búið*
this is massively much of people that has lived
(.) *hérna*
HES uh
'There are so incredibly many people that have lived, uh, [somewhere] [Istal_02_310_03, Speaker B]'

In the example above, the voiced fricative/approximant [v] that occupies the second syllable coda is deleted acoustically. The vowel of the first syllable which is lexically short is lengthened instead. This compensatory lengthening of the nucleus vowel satisfies a very important syllable structure constraint of Icelandic: Stressed syllables are always bimoraic, i.e. vowels in closed stressed syllables are short and vowels in open stressed syllables are long. Therefore, when [v] is deleted, either the vowel has to be lengthened or the following stop has to become a geminate. The former possibility is shown above, the latter possibility, however, also occurs frequently, leading to pronunciations like [ɔpːɔs.la].

If the sonorant or voiced fricative that is deleted is part of the onset of the second syllable as in *ná.kvæm.le.ga* or *ó.trú.le.ga*, no compensatory lengthening takes place as the structure of the first (open) syllable remains unaffected. Consider the following realisation of the adverb *nákvæmlega* which is realised as [nauː.kvaim.lɛ.ɣa] in citation form:

(3.21) *ég* *veit* *ekki* *nákvæmlega* [nauː.kɛ.la] *hvernig* *þetta* *er* *en* *(.)*
I know not exactly how that is but HES
'I don't know exactly how that works, but (.) [Samtal_4_1, Speaker B7]'

In the pronunciation [nauːkɛ.la], the [v] in the onset cluster of the second syllable is deleted. Unlike with *ofboðslega* where the deletion of [v] results in a length restructuring of one of the surrounding consonants, in the above example the neighbouring consonants remain unaffected. Note also that the sonorant [m] in the second syllable coda is deleted as well.

Weak fricatives like [ð] or [ɣ] can also be deleted in the second syllable onset if they are not part of a consonant cluster. Consider the following example of the adverb *mögulega* which is realised as [mœ.ɣʏ.lɛ.ɣa] in citation form.

(3.22) *sem* *vildu* *veiða* *eins* *mikið* *af* *fiski* *eins og* *við*
who wanted hunt as much of fish as we
mögulega [mœ.ə.lɛ.ɐ] *gátum*
possibly could
'who wanted to fish as much fish as we possibly could [Vidtal_A2, Speaker A2]'

Here, the voiced fricative/approximant [ɣ] in the second syllable onset is deleted although it does not form part of a cluster. Similar examples are found for the adverb voðalega that has the voiced fricative/approximant [ð] in the onset of the second syllable:

(3.23) *hann* *hefur* *(.)* *er* *ekkert* *voðalega* [vɔː.ə.la] *áberandi*
he has HES is nothing terribly noticeable
'he hasn't (.) isn't terribly noticeable [Istal_06_107_01, Speaker D]'

In the above example, the adverb *voðalega* is realised without the intervocalic [ð]. As mentioned in ch. 1.3, Helgason (1993, 30) describes this rule of intervocalic voiced fricative/approximant deletion as "one of the most common in [his] data and [. . .] undoubtedly a major factor in triggering contracted forms in Icelandic."

All of the examples in the previous paragraphs consisted of sonorants and voiced fricatives in the coda of the first and second syllable and in the onset of the second syllable. The segments that appear in the onset of the first syllable, regardless of their natural class and stops and voiceless fricative are hardly affected by reduction in the corpus. Stops and the sibilant [s] remain mostly unaffected until the very late stages of reduction. [s] in particular is very stable in Icelandic, unlike in languages such as Spanish where the reduction from [s] to [h] has been phonologised in many varieties (Quilis, 1999, 276). The stability of stops and [s] is shown in examples 3.24 and 3.25:

(3.24) *það* *er* *svo* *ógeðslega* [oəːcs.la] *lengi* *alltaf* *í* *svona* *rannsóknum.*
it is so disgustingly long always in such studies
'Studies like that always take such incredibly long time. [Samtal_1_1, Speaker B1]'

(3.25) *í* *gamla* *daga* *man* *ég* *sérstaklega* [səstɐkl] *eftir* *því* *að*
in old days remember I especially after that that
á *ríkisútvarpinu* *(.)*
on national.radio.the HES
'I remember especially that in the old days on National Radio (.)'

The above examples from the corpus sample are quite heavily reduced. Nonetheless, stops and [s] remain relatively intact. The adverb *ógeðslega* which is featured in example 3.24 is realised as [ouː.cɛðs.lɛ.ɣa] in citation form. In the example featured above, however, the second syllable in particular is heavily reduced and the adverb is pronounced [oːcs.la].[13]

Naturally, stops and [s] are affected by some kind of gradual lenition and durational shortening. This kind of reduction, however, mostly does not lead to full deletion in the examples in the corpus. As Árnason (2005, 229-230) shows on the basis of introspective and impressionistic examples, stops are not "immune" to deletion in Icelandic, but they are only deleted in complex clusters that involve several obstruents like [sps] or [tns]. Since no such clusters occur in the stem of *lega*-adverbs, no stop deletion could be observed.

The fact that [s] patterns with stops with regard to reduction mirrors the status of [s] in the "lexical" phonology of Icelandic that was discussed above. An additional example that is taken from the IceTask-corpus, a small map-task corpus of Icelandic (Schäfer, 2011) shows how [s] is especially resistent to deletion.[14] Note the realisation of the phrase *sem sagt* which literally translates to "as said", but is commonly used as a hesitation.

(3.26) *vinstra* *megin* *við* *(.)* *sem sagt* [sə̃st] *(.)* *hundrað og áttatíu*
left side at HES as.said HES 180
gráður *(.)*
degrees
'to the left of, like, 180 degrees (.)'

In citation form, *sem sagt* is realised as [sɛ(ː)msaxt]. In the above example, however, only the two s-segments, one heavily reduced vowel and the word final

[13] Informal impressionistic evidence by the author and others (Kristján Árnason p.c.) suggests that heavy reduction is very common for the intensifier adverb *ógeðslega*. A disyllabic side form *ógsla* may indeed have been lexicalised for certain younger, especially female speakers. However, the adverb occurs too infrequently in the corpus, especially among younger speakers, to confirm this hypothesis. In fact, in most cases the adverb is realised as significantly less reduced than in the example above.

[14] The corpus unfortunately is too small to be included in the data basis for the main subject of the present study as it hardly contains any *lega*-adverbs.

plosive remain which again shows that [s] is one of the most stable or "strong" consonants in Icelandic.[15]

Summing up, this section has given a short overview of segmental reduction in *lega*-adverbs that. First, it was shown that the course of syllabic reduction is mostly predicted by word prosodic structure. The first syllable to be deleted is located in the prosodically weak suffix. It was then shown that with regard to segment deletion, sonorants in the coda of the second syllable are easily lenited and deleted as well as sonorants in consonant clusters between the first and second syllable of the adverb. Single segments that occupy the onset of the second syllable are only lenited if they are "weak" voiced fricatives like [ð] or [ɣ]. The most stable consonants are stops and [s] and consonants occupying the onset of the first, i.e. stressed syllable.

3.3 Syllabic reduction

3.3.1 Results

The first part of this section gives a descriptive overview over the syllabic reduction in the sample. Then, a multivariate analysis is conducted in order to evaluate the influence of the different predictor variables that were detailed in ch. 3.1.2.

3.3.1.1 General overview

The mean number of syllables with which the adverbs in the sample were realised was 2.77. Table 3.3 shows the frequencies of forms with different number of syllables in the adverb sample that was extracted from the corpus:

monosyllabic	disyllabic	trisyllabic	quadrisyllabic	pentasyllabic
44	327	315	212	2

Table 3.3: Frequency of different syllabic types in the sample

As was described in ch. 2, the *lega*-adverbs selected for this study are all quadrisyllabic in their citation form. Adverb tokens in the sample that were classified

[15] Observations from the same MapTask corpus show that the sibilant fricatives can be realised as a voiced [z] which might be counted as a case of reduction. However, no such voicing is found in the corpus that is the basis for the present study.

as quadrisyllabic in the sample thus display a pronunciation that is near citation-form-level. There were of course still differences in duration even between quadrisyllabic adverbs. Those differences and the relation of the number of syllables and adverb duration will be detailed in ch. 3.4. The two tokens that were pronounced with five syllables are hypercorrect tokens of the adverb *náttúrlega* which has a pentasyllabic side form in writing, *náttúrulega*.

Interestingly, the lexeme *náttúrlega* was not only responsible for the tokens with the highest number of syllables, but also for a large part of the reduced and heavily reduced forms. The following table contrasts the frequencies of adverb forms with different number of syllables for *náttúrlega* and for the rest of the sample.

	monosyllabic	disyllabic	trisyllabic	quadrisyllabic	pentasyllabic
náttúrlega	25	178	72	6	2
other	19	149	243	206	–

Table 3.4: Distribution of syllabic types for *náttúrlega* and the rest of the sample

As the comparison shows, *náttúrlega* in the absolute majority of cases was pronounced as disyllabic while for the rest of the adverb sample, tri- and quadrisyllabic forms were more frequent than disyllabic forms. As was mentioned in ch. 3.1.1, *náttúrlega* also is by far the most frequent adverb in the corpus. The exact nature of this suggestive correlation of very high frequency and inclination for reduction will be further studied in the second part of this section with the help of a multivariate analysis.

Final Vowel Deletion (FVD) occurred in 69 tokens. Recall that with the application of FVD, one syllable is lost, since the nucleus vowels of the last adverb syllable is deleted in these cases. Especially for the multivariate analysis (cf. the next section), the effect of Final Vowel Deletion was not of primary interest. Therefore, the number of syllables were residualised for this variable, using a simple linear regression model with "number of syllables" as dependent variable and the binary factor "occurrence of Final Vowel Deletion" as predictor variable. The residuals of this model where then used as dependent variable for the multivariate analysis. According to the simple linear model, the occurrence of Final Vowel Deletion explained 8% of the variation found in the data.

As it is notoriously difficult to determine the number of syllables in a stretch of actual spoken language, despite the guidelines that were described in ch. 3.1.2, an additional rater annotated a subsample of 120 tokens for their number of syllables in order to test the reliability of the annotation. The second annotator was a female native speaker of Icelandic who had received basic linguistic training and who had worked as a student assistant in a dialectological project. She had, however, no specific training in phonetics. A comparison of results shows that the annotations made by the second annotator for the variable "number of syllables" are similar to those obtained by the author of this study. As a measure of interrater reliability, Krippendorff's Alpha was calculated from the combined sample resulting in a value of 0.72 indicating "some reliability" in the coding of the number of syllables.[16]

Since the difference between the annotation strategies can possibly be illuminating for the study of adverb reduction, in the following the annotation of the author of this dissertation and those of the second annotator will be compared briefly. The following table shows how many syllables both annotators assigned to the adverbs in the sample of 120 adverbs:

		First annotator			
		1	**2**	**3**	**4**
Second ann.	**1**	4	3	0	0
	2	1	31	4	0
	3	0	7	28	9
	4	0	0	13	18
	5	0	0	0	1

Table 3.5: Comparison of first and second annotator syllable assignments

The table shows that both annotators agree on the phonetic number of syllables in most cases. The agreement is largest for disyllabic forms and lowest between tri- and quadrisyllabic forms. Recall that reduction from four syllables to three syllables typically involves reduction in the adverb suffix -*lega*. As detailed in ch. 3.1.2, the phonetic number of syllables in the adverb suffix can be difficult to determine since the spectrogram sometimes does not provide clear segment boundaries. This relative indeterminacy of the speech signal indeed seems to have caused problems or disagreements between the annotators.

In order to shed more light on the disagreements between the first and second

[16] Values between 0.6 and 0.8 indicate average reliability while values above 0.8 indicate strong reliability (Krippendorff, 2004).

annotator, the tri- or quadrisyllabic tokens where the annotators had assigned a different number of phonetic syllables were inspected manually. This inspection showed that the relevant tokens often displayed a relatively poor quality of sound. Recall that tokens with very poor sound quality had been discarded already in the adverb sampling process. There was, however, still some variation in sound quality, especially with regard to the amount of background noise present.

Unlike for tri- and quadrisyllabic adverb realisations, there was relatively stable agreement about the difference between disyllabic and trisyllabic items. Only in few cases, the second annotator judged an adverb to have three syllables while the first annotator assigned it two syllables, or vice versa. Recall that reduction from trisyllabic to disyllabic takes place in the adverb stem. Stem structure is rather diverse across the different adverb types, apart from the fact that all adverb stems in the sample were "lexically" disyllabic. Still, syllabic reduction in the stem seems to have been clearer than reduction in the adverb suffix.

3.3.1.2 Multivariate analysis

In order to evaluate the effect that the variables described in ch. 3.1.2 have on syllabic reduction in *lega*-adverbs, a multivariate analysis was conducted using a linear mixed-effects model (Pinheiro & Bates, 2000). The dependent variable was the number of syllables the adverbs in the sample were realised with (residualised for the effect of Final Vowel Deletion, cf. previous section). As fixed effects predictors, log-transformed adverb frequency, log-transformed speech rate, rhythmic environment, accentedness, syntactic function, participant gender, participant age, initial position, prepausal position, presence of disfluencies and three variables relating to the phonological structure of the adverb were included. In addition, two way-interaction between these variables were calculated.

As random effect predictors, speaker-ID, the subcorpus and the recording from which the adverbs were extracted were included. The final model ($R^2 = 0.54$) presented in Figure 3.3 was obtained using the standard simplification procedures by eliminating insignificant factors in a step-wise evaluation process (Baayen, 2008). Also in accordance with Baayen (2008), predictor variables were considered to have a significant effect on the dependent variable when their absolute t-value was larger than two.

The inclusion of backward and forward transitional probabilities in the statistical model proved to be difficult as this reduced the number of available data points greatly. This loss of data is due to the fact that forward and backward transitional probabilities cannot be calculated in prepausal and initial position,

```
  AIC  BIC logLik deviance REMLdev
 1188 1274 -574.9     1090    1150
Random effects:
 Groups    Name        Variance  Std.Dev.
 speaker   (Intercept) 0.0090486 0.095124
 subcorpus (Intercept) 0.0022398 0.047327
 Residual              0.2823848 0.531399
 groups: speaker, 68; subcorpus, 3

Fixed effects:
                      Estimate Std. Error t value
(Intercept)            0.23153    0.46647   0.496
prepausal              0.12499    0.09502   1.315
token frequency       -0.05785    0.03244  -1.783
age (mid)              0.13669    0.08660   1.578
age (high)             0.25392    0.10330   2.458
speechrate            -0.51690    0.19172  -2.696
pitch accent (yes)     0.53899    0.06481   8.316
function (sentence)   -2.16467    0.54870  -3.945
manner of art. (son)  -0.91067    0.27755  -3.281
cody type (obs)        1.86794    0.42918   4.352
frequency:manner      -0.08047    0.03253  -2.473
frequency:function    -0.10735    0.03352  -3.202
frequency:coda         0.14184    0.05086   2.789
rate:function          0.60745    0.23155   2.623
prepausal:accent       0.33143    0.13004   2.549
accent:coda           -0.38531    0.15027  -2.564
```

Figure 3.3: Final model for the dependent variable “number of syllables”

respectively. Hence, two separate models were fitted to the data. First, a model was fitted that excluded transitional probabilities as predictor variables. This model was then compared to a second one that included backward and forward transitional probabilities and their interaction. In the following, the effect or non-effect of the individual variables in the first model is presented briefly. Then, the role of transitional probabilities and possible differences between the two models are discussed.

Of the three random effect variables that related to the structure of the corpus, only “subject ID” and “subcorpus” were retained in the final model. The variable “recording” did not improve model fit and was therefore dropped during the model fitting process. The differences that exist between the different recordings in the subcorpora thus seem to be largely due to differences on the individual level or to social differences (cf. below).

Rhythmic environment The fixed effect predictor "rhythmic environment" did not have a significant effect on syllabic reduction and was therefore dropped during the model fitting process. The rhythmic environment that adverbs were embedded in thus did not influence the number of syllables with which an adverb was realised. Figure 3.4 shows the distribution of different syllable types across rhythmic environments.

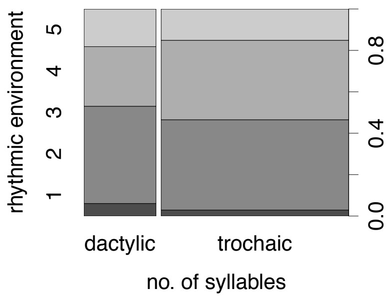

Figure 3.4: Rhythmic environment and no. of syllables

If there were rhythmic effect on syllabic reduction, a larger number of quadri- and disyllabic adverb realisation would be expected in the trochaic environment than in the dactylic environment. However, as the above figure shows, the distribution of adverbs with different number of syllables hardly differed across trochaic and dactylic structures. While in the trochaic environment 46% of adverbs were realised as disyllabic, almost the same percentage of adverbs (47%) in the dactylic structure were produced as disyllabic.

In studies that investigate the effect of metrical rhythm on a given item, the target item is usually surrounded by identical rhythmic structures, i.e. only trochees or only dactyls (Dehé, 2008b; Kuijpers & van Donselaar, 1998). This was also the approach taken in the above calculation. It could, however, also be the case that the target item does not need to be set in a "pure" rhythmic environment in order for rhythmic effects to appear. Instead, rhythmic effects could be due to the structure of the preceding or following foot alone, regardless of the structure of the other surrounding foot. Therefore, a second linear mixed-effects model was fitted to the data that included the number of syllables in the foot preceding the adverb and the number of syllables in the foot following the adverb and their interaction as fixed-effects predictors.

If there were rhythmic effects on adverb reduction that are only due to some sort of "rhythmic priming" (i.e. the preceding foot) or "rhythmic anticipation" effect (i.e. the following foot), these variables would be expected to have a significant effect on adverb reduction. However, neither of the two rhythmic variables turned out to be significant in this second model, either.

Figure 3.5 shows how the number of syllables in the adverb sample were distributed according to the structure of the preceding and following foot. The figure on the left shows that there are indeed more disyllabic adverb realisations following a disyllabic foot than trisyllabic realisations as would be expected under the Rhythm Hypothesis. However, as mentioned above, this difference did not turn out to be significant in the statistical model.

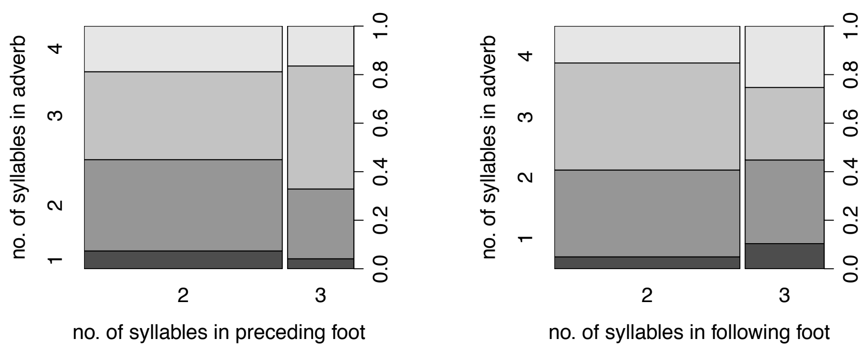

Figure 3.5: Preceding (left) and following (right) foot and no. of syllables

Adverb function The first significant main effect to be presented is that of adverb function (t = −3.945). According to the statistical model, sentence adverbs such as *náttúrlega* or *örugglega* were more often realised as reduced than intensifier adverbs such as *rosalega* or *ofsalega*. The effect is displayed in Figure 3.6. Sentence adverbs were realised with a mean number of 2.58 syllables whereas the realisations of intensifier adverbs displayed a mean of 3.27 syllables which shows that there were more reduced realisations for sentence adverbs than for intensifier adverbs.

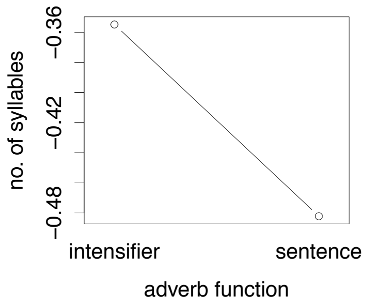

Figure 3.6: Effect of adverb function on reduction

The question could be raised of whether the effect for adverb function is only due to the behaviour of one or two (high-frequency) sentence adverbs. As the general overview in the previous subsection showed, the adverb *náttúrlega* is by far the most frequent adverb in the corpus and also displays the largest number of heavily reduced forms. In order to exclude the possibility of skewing, a dataset was created that excluded all instances of *náttúrlega* and a model with the same predictors discussed above was fitted to this dataset. When *náttúrlega* was excluded from the data basis the mean number of syllables for sentence adverbs rose to 2.85. In the statistical model for this reduced dataset, the variable "adverb function" was still a significant factor ($t = -3.514$), which shows that the effect of adverb function in the main model was not based on the behaviour of *náttúrlega* alone.

Frequency of occurrence Adverb token frequencies were included in the model as (log-transformed) relative frequencies. Token frequency on its own was only marginally significant ($t = -1.783$), but displayed significant interactions with two structural-phonological variables: presence of a coda obstruent ($t = 2.789$) and manner of articulation of the second syllable onset ($t = -2.473$) (cf. below). In addition, a significant interaction of token frequency and adverb function was found ($t = -3.202$).

Figure 3.7 presents the relation of token frequency and syllabic reduction according to the statistical model. The more frequent an adverb was, the less syllables it tended to be realised with, i.e. higher token-frequency was associated with a larger degree of syllabic reduction. As mentioned above, however, this trend was only marginally significant.

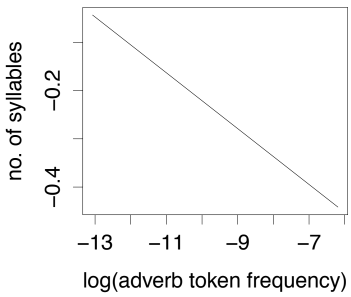

Figure 3.7: Effect of token frequency on syllabic reduction

The significant interaction of adverb function and token frequency shows that the role of token frequency was greater for sentence adverbs than for intensifiers. While sentence adverbs in general displayed a greater tendency to reduce in the corpus, high-frequency sentence adverbs were realised with even fewer syllables than low-frequency sentence adverbs. The same tendency was found for intensifier adverbs as well, i.e. high-frequency intensifier adverbs reduced more often than low-frequency intensifier adverbs. For this second group of adverbs, however, the tendency was not significant.

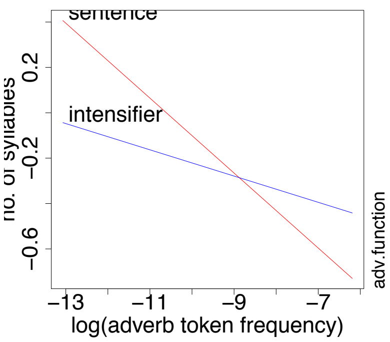

Figure 3.8: Interaction of token frequency and adverb function

As with the main effect for adverb function, the data have to be reinspected in order to ensure that the effect is not only due to the behaviour of the high-frequency adverb *náttúrlega*. In the model fitted to the dataset excluding *náttúrlega*, the interaction of adverb function and token frequency was still significant ($t = -2.629$). In conclusion, the frequency effect for sentence adverbs cannot be reduced to the behaviour of the high-frequency adverb *náttúrlega*. Instead, it applied to the group of sentence adverbs as a whole.

In addition to the interaction with adverb function, token frequency displayed significant interactions with two structural phonological variables. The first interaction to be discussed is with the factor "coda obstruent" (cf. Figure 3.9).

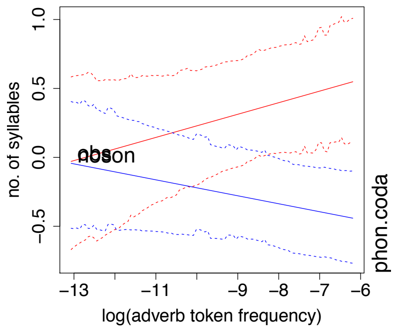

Figure 3.9: Interaction of token frequency and type of second syllable coda

As the above figure shows, for adverbs that have a sonorant in the coda of the second syllable such as *nát.túr.le.ga* or no coda consonant such as *ro.sa.le.ga*, there was an effect of frequency in the expected direction: high-frequency adverbs in this group reduced more than low frequency adverbs. For adverbs that have an obstruent in the coda of the second syllable such as *of.boðs.le.ga*, the frequency effect went in the opposite direction.

Frequency of occurrence also displayed an interaction with a second structural-phonological variable, "manner of articulation of the second syllable onset":

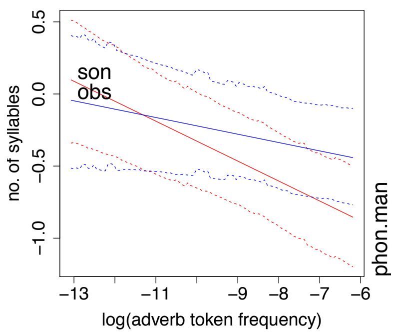

Figure 3.10: Interaction of token frequency and manner of articulation of the second syllable onset

Both for adverbs such as *mögulega* that have a sonorant in the onset of the second syllable (in this case [ɣ]) and for adverbs that have an obstruent in this position such as *rosalega*, there was a tendency to be reduced more if the adverb in question is highly frequent. However, as the lack of a main effect for token frequency and the interaction of frequency and manner of articulation show, this tendency was only significant for those adverbs that have a sonorant as second syllable onset.

Accentedness The factor "pitch accent" turned out to be significant both on its own ($t = 8.316$) and in interaction with two other factors, prepausal position ($t = 2.549$) and presence of a coda obstruent in the second adverb syllable ($t = -2.564$). The main effect of accentedness is shown in the following figure:

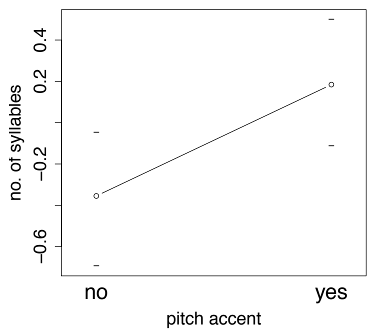

Figure 3.11: Effect of accentedness on the no. of syllables

Adverbs that received a pitch accent were realised with significantly more syllables than adverbs that were not pitch-accented.

The interaction of the variables "prepausal position" and "accentedness" shows that the effect of accentedness on adverb reduction was even more pronounced in prepausal position. The interaction is displayed in Figure 3.12:

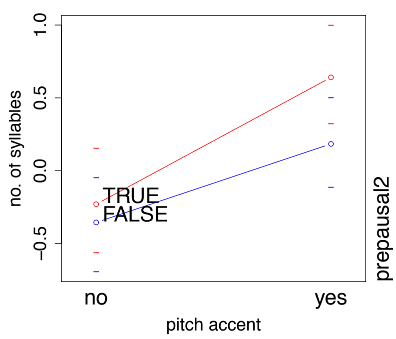

Figure 3.12: Interaction of accentedness and prepausal position

The above figure shows again that pitch-accented adverbs in general were realised with more syllables than adverbs that did not receive a pitch-accent. In addition, pitch-accented adverbs in prepausal position were pronounced with even more syllables.

The factor "prepausal position" was not a significant factor on its own (t = 1.315). Given the results from the literature (e.g. Bell *et al.* , 2009), the accentedness-variable would have been expected to also display a significant main effect in the present data. However, most of the studies that investigated this factor used duration as a measure of reduction while the dependent variable in this section is the number of syllables of the target words. It could therefore be the case that a pitch accent in Icelandic leads to durational lengthening but not necessarily to the retention of syllabic material. A comparison with the results for the dependent variable "adverb duration" in ch. 3.4 will have to reveal whether the non-effect or partial effect of the variable "accentedness" in the above model in fact constitutes a difference to previous studies.

Speech rate Another variable that displayed both a significant main effect and a significant interaction is the factor "speech rate". In the model, speech rate was significant on its own (t = −2.696) and in interaction with adverb function (t = 2.623). The main effect for speech rate is displayed in the following figure:

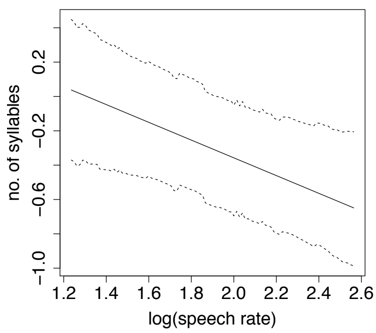

Figure 3.13: Effect of speech rate on syllabic reduction

As the above figure shows, adverbs that occurred with higher speech rates were realised with significantly less syllables than adverbs that occurred with lower speech rates. Higher speech rates thus facilitated syllabic reduction. However, the interaction of speech rate and adverb function shows that the effect of speech rate was not the same for different types of adverbs. Figure 3.14 displays this interaction of speech rate and adverb function:

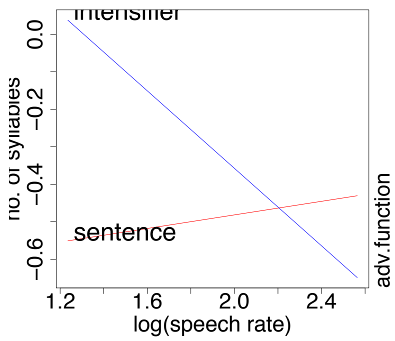

Figure 3.14: Interaction of speech rate and adverb function

Intensifier adverbs were significantly more affected by higher speech rates than sentence adverbs. While higher speech rate thus correlated with a higher degree of reduction for intensifier adverbs, this correlation was weaker for sentence adverbs. Importantly, however, sentence adverbs reduced more often than intensifier adverbs also for lower speech rates. This means that the real difference between sentence and intensifier adverbs with regard to the effect of rate of speech is found for lower speech rates: While sentence adverbs were often realised as reduced both with higher and with lower speech rates, heavy reduction in intensifier adverbs seemed to be confined to environments with higher speech rates.

Phonological-structural variables According to the statistical model, the phonological structure of the adverbs in the sample influenced syllabic reduction behaviour significantly. Of the three structural-phonological variables that were included in the model, two displayed significant main effects and significant interactions. Firstly, the nature of the coda of the second adverb syllable was a significant factor ($t = 4.352$):

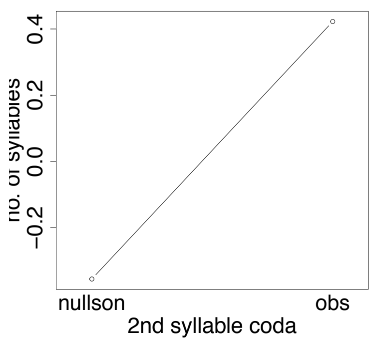

Figure 3.15: Effect of type of second syllable coda

Adverbs that have an obstruent in the coda of the second syllable such as *ofboðslega* or *sérstaklega* reduced to a significantly higher degree than adverbs that have sonorant in the same position such as *náttúrlega* or no coda at all such as *rosalega*. Coda sonorants are easily deleted, obstruents in the same position, however, are not, which may block the deletion of syllabic material.

The model also revealed a significant interaction of the variable "presence of a coda obstruent in the second syllable" ($t = -2.564$) with the factor "accentedness":

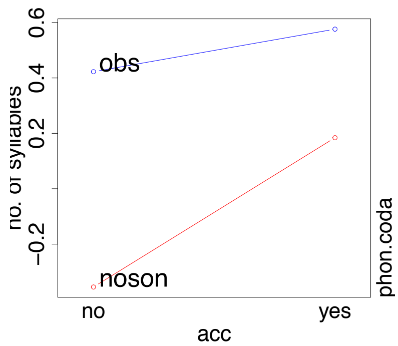

Figure 3.16: Interaction of accentedness and presence of a coda obstruent

As the graph shows, the main difference between adverbs that have an obstruent in the second syllable and those that do not, was in unaccented realisations. When adverbs were unaccented, adverbs with a coda obstruent in the second syllable were realised with more syllables than the other group. For accented realisations this difference was reduced, i.e. adverbs with and without coda obstruents hardly differed in the number of syllables with which they were pronounced.

The second significant structural-phonological variable was the manner of articulation of the onset of the second syllable of the adverb ($t = 3.692$).

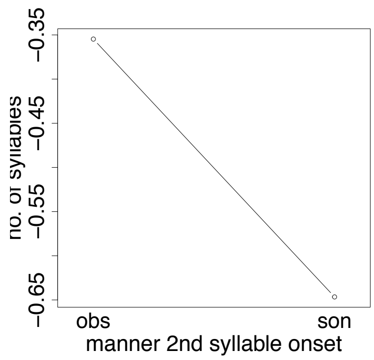

Figure 3.17: Effect of manner of articulation of the second syllable onset

Adverbs that have a sonorant in the onset of the second syllable reduced significantly more often in the corpus than adverbs such as *rosalega* that have an obstruent in the onset of the second syllable. Recall that the former group also includes adverbs like *mögulega* or *eiginlega* where the onset of the second syllable in citation form pronunciations is a voiced fricative, [ɣ] and [j], respectively. Fricatives are generally classified as obstruents. Voiced fricatives in Icelandic, however, are realised as approximants, i.e. as sonorants, even in formal speech. These sonorant onsets are easily reduced further to zero, leading to an empty onset in the second syllables. This in turn can lead to a coalescence of the first two syllables as in [mœːla] instead of [mœːɣʏlɛɣa] for *mögulega* which would explain the effect of this structural factor on syllabic reduction.

Disfluencies The presence of disfluencies turned out not to have a significant effect on syllabic reduction according to the statistical model. The variable was therefore dropped during the model fitting process. Figure 3.18 contrasts environments with and without disfluencies with regard to syllabic reduction:

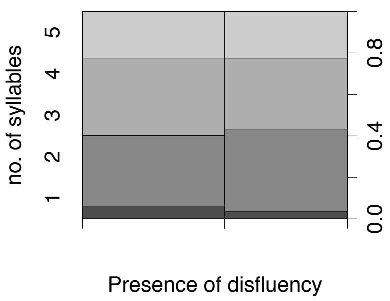

Figure 3.18: Effect of the presence of disfluencies on syllabic reduction

As the above figure shows, there was no difference between utterances with disfluencies and those without disfluencies. The mean number of syllables for adverbs in both environments containing disfluencies and in environments that do not contain disfluencies was 2.77. This result is surprising given the results in the literature that show an effect of disfluencies on reduction. However, as with the role of the factor "prepausal position" (cf. above), only a comparison with the results for durational reduction will show whether this result really constitutes a difference to previous studies.

Age and gender Of the two sociolinguistic variables, only the factor “age” had a significant effect on syllabic reduction while the speakers’ gender did not influence reduction significantly. Recall that the variable “age” had three levels, the first comprising speakers under the age of 20 years, the second one speakers aged 20 to 45 and the third one speakers above 45 years of age. The statistical model showed a significant difference between the third group, the oldest speakers, and the other two groups.

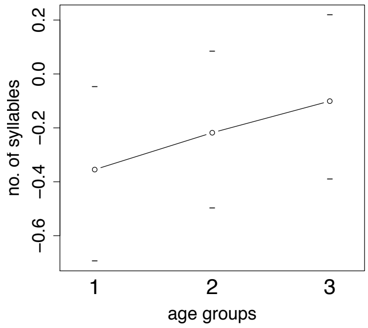

Figure 3.19: Effect of age on syllabic reduction

The oldest speakers reduced significantly less than speakers in the other two groups. There was, however, no difference between speakers in the other two groups, i.e. the youngest speakers did not significantly differ from middle-aged speakers. Interestingly, the significant effect for age was not present in the model fitted to the dataset that excluded realisations of *náttúrlega*. This indicates that the difference between the oldest speakers and the other two groups lies mostly in how they pronounce *náttúrlega*.

Transitional probabilities As was mentioned in the beginning of this section, two linear mixed-effects models were fitted to the data that differed from each other as to whether forward and backward transitional probabilities were included or not. The results discussed above were taken from the first model that did not include transitional probabilities as predictor variables. In the following, the differences between the first and the second model and the role of transitional probabilities in the second model will be presented briefly.[17]

[17] Recall that transitional probabilities were calculated from the lemmatised version of the corpus as the number of different word forms in a highly inflecting language like Icelandic is too big to calculate reliable probabilities from such a small corpus based on word forms only.

Although the data set that the model that included transitional probabilities was fitted to consisted of less data points, the model revealed largely the same significant effects. This points to the overall stability of the results obtained in the first model. Only one interaction that was significant in the first model turned out not to be significant in the second one, namely that of prepausal position and accentedness. This difference is easily explained by the fact that the number of available data points for the variable "prepausal position" was greatly reduced by including forward transitional probabilities which cannot be calculated in utterance-final position.

Neither forward nor backward transitional probabilities, nor their interaction turned out to be significant predictors of syllabic reduction in the second model:

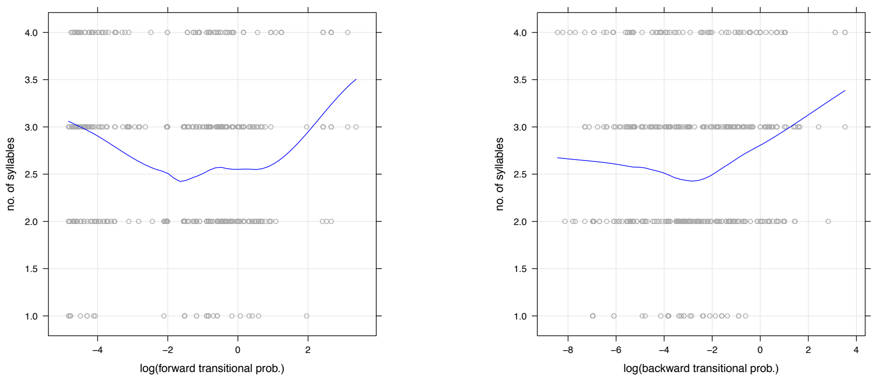

Figure 3.20: Forward (left) and backward (right) transitional probabilities and syllabic reduction

As the above figures show, there was hardly any correlation of transitional probabilities and syllabic reduction.

Summing up, the statistical model revealed a number of significant main effects and interactions. The rhythmic environment the corpus adverbs were embedded in did not have a significant effect on syllabic reduction. The model showed that the role of frequency in syllabic reduction is rather intricate: there was no significant main effect for frequency, but three significant interactions of token frequency with other variables. It was shown that frequency of occurrence was only a significant factor for sentence adverbs, but not for intensifier adverbs and that this interaction was not only due to the high-frequency adverb *náttúrlega*. In addition, high token frequency facilitated reduction for those adverbs whose phonological structure makes them prone to undergo reduction.

Pitch-accented adverbs reduced significantly less than adverbs that did not receive a pitch-accent. This effect was even more pronounced in prepausal position. Higher speech rates correlated with a greater degree of reduction. Sentence adverbs, however, displayed a tendency to reduce even with lower speech rates. The phonological makeup of the adverbs' stem played a role as well, with certain structures facilitating reduction. The results presented here will be analysed and discussed in the following section.

3.3.2 Discussion

The first measure by which phonetic reduction of Icelandic *lega*-adverbs in the corpus was quantified was the number of syllables with which they were realised. As was discussed in ch. 3.1.2, measuring the number of phonetically realised syllables is both difficult and a very coarse-grained quantification of acoustic reduction. However, two reasons were mentioned for including the number of phonetic syllables in the study. Firstly, the quality of the recordings in the corpus did not always allow for a fine-grained spectral analysis of the segmental material and the number of syllables was therefore deemed a more reliable though also more coarse-grained measure. Secondly, metrical rhythm, one of the factors investigated with regard to its effect on adverb reduction, operates at the level of the syllable, which makes employing the dependent variable "number of realised syllables" necessary. In the following, the significance or non-significance of the variables in the statistical model will be discussed and evaluated, both with regard to the results found in the literature and, as far as possible, with regard to theoretical-phonological questions of storage and computation in reduction. Comparisons with the literature, however, have to be made carefully, as this study stands alone in employing the number of syllables as the dependent variable.

The multivariate analysis presented in the previous chapter revealed that a number of factors affect the reduction behaviour of *lega*-adverbs in the sample. Effects that had the expected direction and are supported by the literature were found for speech rate, accentedness and Final Vowel Deletion. Adverbs were realised with fewer syllables when speech rates were high rather than low. However, as the interaction of speech rate and adverb function showed, this correlation applied to intensifier adverbs only – a point which will be further discussed below. Similarly, pitch-accented adverbs were longer than adverbs without a pitch accent. Finally, the application of Final Vowel Deletion lead to the loss of one syllable; consequently, adverbs that underwent FVD were shorter than ones that did not.

Interestingly, there was only limited evidence for prepausal lengthening. The variable "prepausal position" was only significant in interaction with the variable "accentedness". Adverbs thus lengthened prepausally only when they were accented, but not otherwise. Prepausal lengthening is usually taken to be a very strong predictor of reduction (e.g Bell *et al.* , 1999; Pluymaekers *et al.* , 2005; Bell *et al.* , 2009). However, all studies cited use dependent variables that are different from the presently discussed one. A direct comparison with the literature will thus be made in the chapter on durational reduction (cf. ch. 3.4).

Metrical rhythm was not a significant predictor of reduction since no significant effect for the variable "rhythmic environment" was found. If there had been an effect of rhythm on syllabic reduction, the distribution of syllabic types would have been expected to differ between trochaic and dactylic environments. More disyllabic than trisyllabic realisations would have been expected to appear in trochaic than in dactylic structures and vice versa. The syllabic distribution, however, was largely identical across trochaic and dactylic environments. Splitting the variable in two by including the variables "preceding" and "following rhythmic structure" did not make a difference in the statistical model. The factor "rhythm" was therefore dropped from the final model as presented in Figure 3.3. The lack of a rhythmic effect warrants a closer inspection due to its theoretical value with regard to the roles of storage, computation and implementation in adverb reduction.

In the discussion of metrical rhythm in ch. 1.2, it was assumed that this variable could serve as a testing ground for exemplar storage and retrieval in production. As mentioned above, metrical rhythm takes the syllable as its basic unit. The regular succession of strong and weak syllables that are grouped into metrical feet is what constitutes a rhythmical pattern in Metrical Phonology (Liberman & Prince, 1977). For Icelandic, metrical feet are always trochaic or dactylic in nature, as main or secondary stress invariably falls on the initial syllable of a foot. In actual speech, not every utterance displays a regular rhythmic pattern. However, it has been shown that certain reductive alternations are affected by rhythm. Both schwa deletion in Dutch (Kuijpers & van Donselaar, 1998) and Final Vowel Deletion in Icelandic (Dehé, 2008b) are more likely to apply if this leads to the creation of an even trochaic or dactylic rhythm. Examples for utterances with regular trochaic and dactylic metrical patterns involving reduced *lega*-adverbs from the corpus are given in 3.27 and 3.28, respectively:

(3.27)	*en*	*ˈmaður*	*ˈmyndi*	*ˈnáttúrlega* [nahtla]	*ˈkannski*	*ˈreyna*
	but	one	would	of.course	maybe	try

'but of course you'd want to try it'

(3.28)	*það*	*ˈværi*	*nú*	*ˈofsalega* [ɔfsala]	*ˈgaman*	*að*	*(.)*
	it	would	PART	hugely	fun	to	(.)

'of course it would be a ton of fun to ... '

In example 3.27, the lexically quadrisyllabic adverb *náttúrlega* is surrounded by disyllabic, trochaic feet, (ˈ*myn.di*) and (ˈ*kanns.ki*). In this case, the target adverb is realised as disyllabic [nahtla], thus fitting into the trochaic surroundings. In the same vein, *ofsalega* in example 3.28 – which is quadrisyllabic in citation form as well – is embedded in a dactylic structure with the trisyllabic feet (ˈ*væ.ri. nú*) and (ˈ*ga.ma.n að*) to its left and right, respectively. In the example, the adverb is produced as trisyllabic, thus giving rise to an even dactylic structure.

Crucially, when rhythm affects reduction, this has to be a categorical and not a gradient process. A syllable is deleted (or not) in order to create a regular rhythmic pattern, but it cannot be lost "partially" as this would not alter its rhythmic structure. In formal phonology, categorical sound-structure changing processes are usually situated at the level of phonological processing and computation while gradient processes, i.e. the weakening or lenition of the closure phase of a stop, are relegated to phonetic implementation.[18] Reduction of the kind found in *lega*-adverbs is usually classified as phonetic-implementational, i.e. post-phonological. If metrical rhythm were to influence this kind of acoustic reduction (that is not connected to a well-defined process like e.g. Final Vowel Deletion), the reduction would have to be present at some stage in phonological computation and could not solely be the product of gradual implementation. This in turn could be seen as evidence for the direct retrieval and, consequently, the storage of reduced forms (also cf. ch. 1.2.2).

On the basis of the theoretical background discussed above (and in spite of the singular examples given in 3.27 and 3.28), the fact that metrical rhythm did not influence the syllabic reduction of *lega*-adverbs in the sample can be interpreted in several ways. The possible explanations differ across two lines: Firstly, they differ as to whether one accepts the non-effect of metrical rhythm on adverb reduction

[18] The location of gradient processes is a topic of great discussion. In "classical" generative phonology, gradience is exclusively found in the phonetic-implementational module (Ernestus, 2014). However, several processes believed to be categorical-phonological have been shown to be subject to statistical generalisations and gradual implementation, e.g. Regressive Voice Assimilation in Dutch (Ernestus *et al.* , 2006).

as a fact or whether the lack of a rhythmic effect is explained with intervening factors. Secondly, even if the rhythmic non-effect is taken as a given, explanations can differ as to whether this represents a refutation of exemplar-based theories or whether the results are interpreted as being inconclusive with regard to examplar storage and retrieval.

A first strain of interpreting the data would take for a fact that metrical rhythm does not influence the reduction observed in the adverb sample. This lack of an effect would then rebuke the hypothesis that reduced forms are stored as exemplars and directly retrieved in production. According to this interpretation, the reduction observed in the corpus is purely phonetic-implementational in nature.[19] This kind of explanation fits in well with generative-abstractionist models of the phonetics-phonology relation and "division of work" between them. In this view, metrical rhythm does not affect adverb reduction because the two happen in different modules or, to put it more theory-neutral, in different domains. On the one hand, metrical rhythm calls for categorical effects on reduction and is hence situated, broadly speaking, in the phonological part of the grammar. On the other hand, gradient acoustic reduction is part of phonetic implementation which occurs after phonological computation and can therefore not be targeted by categorical phonological processes.

It could still be asked why rhythm targets the application of reductive processes like schwa deletion, but is not able to induce broader reductive processes in phonological computation. Why is metrical rhythm in a generative-abstractionist model not "strong enough" to induce categorical processes that lead to an improvement in terms of metrical regularity of the rhythmic structure at hand? Considering that the reduction found in the corpus can be quite extensive and that rhythm does target other reductive processes, this question is legitimate to ask.

In an abstractionist model of phonology, segments and syllables cannot be deleted in computation at will (or at the will of a process like metrical rhythm), but the possibility of categorical deletion before implementation is very limited. Under the abstractionist view of phonology, this limitation is due to formal constraints on computation, either generally formulated or more specific, like in Optimality Theory (OT). In this theory, the constraint type or family Dep-Input-Output militates against the deletion of any segmental material present in the input of phonological computation. Dep can only be overriden by other

[19] Of course, generative-abstractionist accounts, especially dual-route models like Bermúdez-Otero (2012), also readily incorporate the morpho-lexical reduction found for *náttúrlega* and *nefnilega*, cf. the discussion below.

specific constraints, making it necessary to delete phonological material. Therefore, if a general Dep constraint is ranked higher than one that would enforce an even metrical structure, segmental material cannot be omitted at will in the phonological derivation only to construct an even rhythm.

A second interpretation of the data also accepts as given the non-effect of metrical rhythm, but does not take this lack as counterevidence for exemplar storage and retrieval in production. In a rich-memory exemplar-based model, reduced forms are stored just like other pronunciation variants. In a radically exemplar-based model of production – as represented by Johnson (1997, 2005) –, the production of a reduced form involves the direct selection of a reduced variant. The latter is then produced almost in the way it is stored. Acoustic reduction in a radically exemplar-based model is therefore already present when selecting a variant for production with very little room left for reduction in phonetic implementation. In the same vein, if a reduced variant is directly selected, there is very little room left for altering the segmental string during phonological computation. If both the effect of rhythm on segmentally limited processes like Final Vowel Deletion and the lack of a rhythmic effect on broader acoustic reduction are accepted, an exemplar-based model cannot be maintained in the radical form described in this paragraph.

In a modified exemplar model, a larger role has to be allowed for phonetic implementation to affect reductive variation. While representations are still formed by clouds of exemplars, the selection of variants for production is biased against the canonical form, and processes like Final Vowel Deletion or metrical rhythm are only able to influence this selection to a certain degree. The present data thus suggest that broad-scale acoustic reduction occurs in the phonetic-implementational part of speech production. However, the corpus-based data are not able to answer the question of whether heavy reduction is already present at an earlier stage of production. In such a scenario, a reduced form could be selected directly for production, but then be even further reduced in phonetic implementation. While the lack of a rhythmic effect suggests that broader acoustic reduction mostly happens in implementation and is not present when selecting a variant, this possibility cannot be completely discarded. The development of a modified exemplar model of storage and production will be taken up again in the general discussion in ch. 5.

A third way to interpret the non-effect of rhythm on acoustic reduction in the data is to question the data themselves, with regard to both acoustic quality and comparability. Previous studies on the role of metrical rhythm in the application of reductive processes have all relied on experimental setups. While Kuijpers & van Donselaar (1998, 90) claim that "[i]t has been shown that in connected speech, the rhythmic structure of words is influenced by the rhythmic context", the rhythmic effect on reduction has in fact only been demonstrated for carefully controlled data that were read by participants in an experiment – which can be called "connected speech" but definitely not "spontaneous speech".

The data used for the corpus-based study presented above, however, are "messy" both with regard to the acoustic quality of the recordings and to the many factors that affect adverb reduction in spontaneous speech. It could therefore be the case that the effect of rhythm on adverb reduction is so weak that it does not appear in conversational speech but only in carefully controlled environments.[20] Table 3.6 shows how the present corpus-based study only provides limited opportunity for comparison to previous studies on rhythm and reduction.

		Type of study	
		experimental	corpus-based
Type of process	"phonological"	✓	?
	"phonetic"	?	✓

Table 3.6: Types of studies investigating the effect of metrical rhythm on different kinds of reductive processes

In order to achieve full comparability, it is necessary to conduct an experimental study that investigates the relation of metrical rhythm and adverb reduction in a more controlled environment. This experimental study – that consists of a shadowing task with an accompanying reading task – is presented in ch. 4.2.[21]

Frequency of occurrence was found not to be a significant factor on its own according to the statistical model. While there was a tendency for high-frequency adverbs to be realised with fewer syllables rather than low-frequency ones, this trend was not significant, i.e. there was no significant main effect for the variable "log(adverb token frequency)" in the final model. Token frequency, however, had a moderating effect on several other factors, as evidenced by three significant

[20] If this were the case, the difference in "effect size" between studies of spontaneous speech and studies that use controlled speech would still be interesting.

[21] Another possibility to explain the non-effect of metrical rhythm in this corpus-based study is to question the validity of the studies employing the factor metrical rhythm itself. In this view, effects ascribed to *metrical* rhythm are really due to other rhythmic properties which also involve the dimension of time.

interactions of token frequency with other variables. Interactions of token frequency with other factors were in line with the expectations formulated by Bell *et al.* (2009, 1022): "[Token frequency] may well interact with other measures, so that the effects found [in their study] might turn out not to be so strong for less frequent words". This is exactly the case in the present study: the effect of some variables is mediated by frequency of occurrence, i.e. it is stronger or sometimes weaker for high- than for low-frequency words.

The lack of a main effect for token frequency is surprising, conisdering the results from the literature that very consistently ascribe frequency of occurrence an important role in explaining acoustic reductions. However, since other studies on acoustic reduction usually take different measures of reduction as their dependent variable (such as duration or reduction of single segments), a comparison of the non-effect for token frequency in this study with previous results is difficult. The results obtained for the dependent variable "adverb duration" are easier to compare. Therefore, a comparison with the literature will be made when discussing durational reduction (cf. ch. 3.4.2). Likewise, the lack of an effect for forward and backward transitional probabilities will be discussed in ch. 3.4.2.

As mentioned above, the statistical model revealed significant interactions of token frequency with other variables, among them adverb function. The model also displayed a main effect for the variable "adverb function", i.e. a difference between sentence adverbs like *eiginlega* 'actually' and intensifier adverbs like *rosalega* 'very (much)'. Sentence adverbs were generally realised with fewer syllables than intensifier adverbs. This effect was also found in the model that was fitted to the dataset that excluded realisations of the high-frequency sentence adverb *náttúrlega* which showed the largest number of disyllabic, i.e. heavily reduced forms (cf. also below). The difference between sentence and intensifier adverbs was even more pronounced for high-frequency adverbs, as the interaction of the variables "log(adverb token frequency)" and "adverb function" revealed. Only sentence adverbs displayed a frequency effect, while intensifier adverbs didn't.

A first explanation for the difference between the two types of adverbs would be to assume that adverb function itself, i.e. semantic and syntactic features, is not the real cause of the effect. Instead, prosodic features that are associated with the different functions could be made responsible for the difference in syllabic reduction. A prime candidate for a prosodic feature that correlates with adverb function is accentedness. Intensifier adverbs were accented considerably more often in the corpus than sentence adverbs. While 93% of intensifier adverbs in the sample received a pitch accent, this was the case for only 53% of sentence adverbs. This percentage rises to 61% if the high-frequency adverb *náttúrlega* is excluded, but the difference between the two adverb types remained and was in fact significant according to a chi-square test (chi-squared = 172.8329, df = 1, $p < 0.0001$). The difference in accentedness, however, cannot be made solely responsible for the difference in syllabic reduction since the factor "accentedness" was included in the model as well and was significant on its own as well.

A second explanation for the difference between sentence and intensifier adverbs relies more directly on the semantic features of the two groups. Intensifier adverbs do not have much semantic value on their own, but instead are semantically dependent on the adjective or adverb following them. However, they form a rather tight semantic unit with the item they refer to. On the other hand sentence adverbs refer to the clause as a whole and provide a modal or epistemic "colouring" for its proposition. Crucially and in contrast to intensifier adverbs, sentence adverbs are not used to highlight (or intensify) the meaning of the clause.

This explanation – based on semantic lightness – is supported by the interactions of adverb function with frequency of occurrence and speech rate. The first interaction showed that the difference between intensifier and sentence adverbs was even larger for high-frequency adverbs. This can be taken as evidence that high-frequency sentence adverbs have the tendency to behave like discourse markers or modal particles (also cf. Keune *et al.* (2005) for Dutch sentence adverbs). Discourse items can be more easily reduced both because they are mostly unaccented and because they do not carry a lot of propositional weight (which is correlated of course). In turn, the lack of a frequency effect for intensifier adverbs shows that the difference in functional load between high- and low-frequency intensifiers is not as big as for sentence adverbs. While native speaker intuition suggests that low-frequency intensifiers such as *svakalega* are "stronger" than intensifiers with a higher token frequency such as *rosalega*, this perception is not mirrored in the data for syllabic reduction.

Similarly, the interaction of adverb function with speech rate showed that the latter only affected intensifier, but not sentence adverbs which thus reduced also with lower speech rates. Intensifier adverbs, however, reduced only with higher speech rates. In principle such an interaction can be taken as evidence for the lexicalisation of reduced forms: if they are produced under lower speech rates, they could be selected directly for production and therefore be called "lexicalised". However, the interaction between adverb function and speech rate was also found in the model excluding *náttúrlega*. While there is good evidence that disyllabic forms of *náttúrlega* have been lexicalised (cf. below), it is rather unlikely that *all* sentence adverbs have lexicalised reduced side forms. Instead, the rate-function interaction could be taken as evidence for the semantic lightness hypothesis. Since sentence adverbs are semantically and prosodically light, they can be realised as reduced without losing too much of the proposition.

Adverb semantics discussed in the previous paragraphs are only one part of the explanation for the syllabic reduction found for *lega*-adverbs in the sample. According to the statistical mixed-effects model, the phonological-structural makeup of the adverbs also played an important role in explaining syllabic reduction. Two of the three phonological variables that referred to the structure of the adverb stem turned out to be significant in the model. In addition, both variables that displayed a significant main effect interacted with frequency of occurrence, i.e. their effect was stronger for high- than for low-frequency adverbs. One structural-phonological factor also interacted with the variable "accentedness".

The manner of articulation of the second syllable onset played a significant role in explaining syllabic reduction according to the statistical model. If the onset was a sonorant as in *mögulega* (<g> as [ɣ̞]), more syllabic reduction was found than for adverbs that had an obstruent in the same position like the [s] in *rosalega*. The status of the second syllable coda played a significant role as well. If the coda consonant was an obstruent such as [s] in *ofboðslega*, less reduction was found in the sample than if it was a sonorant such as [r] in *náttúrlega* or empty.

Interestingly, the place of articulation of the second syllable onset did have a significant effect on syllabic reduction. It did thus not matter whether the onset was a coronal consonant such as [t] or a dorsal consonant such as [k]. The lack of an effect for "place of articulation" can be explained by the difference between this variable and the other two structural ones. The factors "manner of articulation" and "type of coda" both refer to how easily the respective consonant is lenited and deleted, i.e. its "reducibility". The variable "place of articulation", however, was expected to predict syllabic reduction based on the consonantal clusters found in the adverbs *after* deletion, i.e. the output of deletion. Recall that in the onset of the second syllable, a coronal consonant such as [t] was expected to allow for a greater rate of reduction since [tl] (the cluster that emerged from the deletion of the second syllable) would be easier to produce than a cluster like [kl] with a dorsal consonant.

The split between the phonological-structural variables with regard to their significance in the statistical model therefore shows that only one out of two aspects of the phonological structure seems to matter. The phonetic acceptability of the “output” of reduction is not of prime importance to syllabic reduction, although it has to be noted that most of the structures observed in the corpus are permissible in Icelandic phonology. Instead of reduction output, the likelihood of syllabic reduction is rather governed by the structure of the “input” which lends itself to deletion and reduction in varying degrees.

The data for syllabic reduction contained several indications that *náttúrlega* (and to a certain extent also *nefnilega*) behaved differently from other adverb types. Recall from ch. 2.1 that native speaker intuition and occurrence of disyllabic forms in informal writing suggest that disyllabic side forms of *náttúrlega* and *nefnilega* (*náttla* and *nefla*) have been “lexicalised”, i.e. stored independently from the original form. The data support this hypothesis to a certain extent. First, on quantitative grounds, *náttúrlega* reduced of all adverbs most often and most heavily. In fact, *náttúrlega* was realised as disyllabic in 63% of all cases in the sample. *Nefnilega* was realised as reduced even more often, displaying a quota of 79% disyllabic realisations. The rest of the adverb sample displayed disyllabic realisations in only 17% of all cases. This huge quantitative difference can be taken as a first indicator that the disyllabic forms of *náttúrlega* and *nefnilega* have a different status than other disyllabic realisations.

The data also provide qualitative evidence for the lexicalisation hypothesis, as shown by the role of the variable “age”. The statistical model based on the full dataset showed a significant difference between the oldest and the younger two age groups. However, this effect disappeared in the model fitted to the dataset that excluded realisations of *náttúrlega*. The effect for age therefore seems to have been due to a difference between age groups with regard to the realisation of *náttúrlega*. Indeed, the younger two groups displayed a much higher proportion of disyllabic realisations of *náttúrlega* (66%) than the oldest age group (44%). The fact that the age effect was not found for other adverb types suggests that there is a qualitative difference between how older and younger speakers realise *náttúrlega*.

If one accepts the lexicalisation of disyllabic sideforms of at least *náttúrlega* and maybe also *nefnilega*, the reduction found for these adverb types is different from the one found for the other lexemes in the sample. While the lack of a rhythmic effect suggests that the reduction in the data is phonetic-implementational in nature, the reduction of *náttúrlega* and *nefnilega* to disyllabic forms is morpholexical. Disyllabic forms of these two adverbs thus have a related but distinct representation from the original quadrisyllabic adverbs and are directly selected for production. These morpholexcially disyllabic forms can then in turn be subject to additional phonetic-implementational reduction, which explains the variation among the disyllabic forms.

Summing up, the discussion of the results for syllabic reduction revealed several aspects that are important for characterising the reduction found in *lega*-adverbs in the sample. Both adverb function (i.e. semantics) and the phonological structure of *lega*-adverbs are at play with regard to syllabic reduction. The likelihood that certain sounds in the stem can be deleted is a structural-phonological influence. The status of token frequency was interesting insofar as it only seemed to influence acoustic reduction for one half of the adverb sample, namely sentence adverbs. Metrical rhythm did not influence syllabic reduction, which can be easily explained by abstractionist, but also by modified exemplar models of storage and production.

3.4 Durational reduction

3.4.1 Results

The first part of this section will present a descriptive overview over the reduction patterns in the adverb sample with regard to durational reduction. Then, several multivariate analyses are presented that analyse durational reduction in the adverb as a whole, in the adverb stem and the adverb suffix.

3.4.1.1 General overview

The mean adverb duration in the corpus was 366ms with a median of 337ms and a standard deviation of 156ms. The highest duration value found in the corpus was 1305ms while the shortest adverb realisation was only 93ms long. A histogram of the duration values is given in Figure 3.21. For the multivariate analysis in the next chapter, the durational data were log-transformed in order to achieve a more normal distribution. After the transformation, no data point exceeded the mean by more than 1.5 standard deviations.

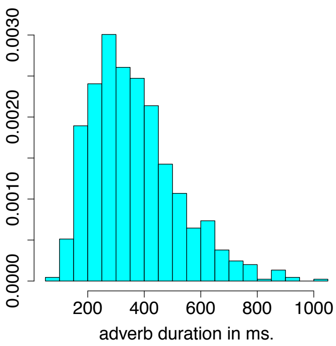

Figure 3.21: Histogram of adverb duration values in the sample

Adverb stems were generally longer than adverb suffixes, with the mean duration of stems at 240ms (standard deviation = 123ms, median = 217ms) and the mean duration of suffixes at 133ms (standard deviation = 62ms, median = 120ms). Comparative histograms of stem and suffix duration values, respectively are given in Figure 3.22:

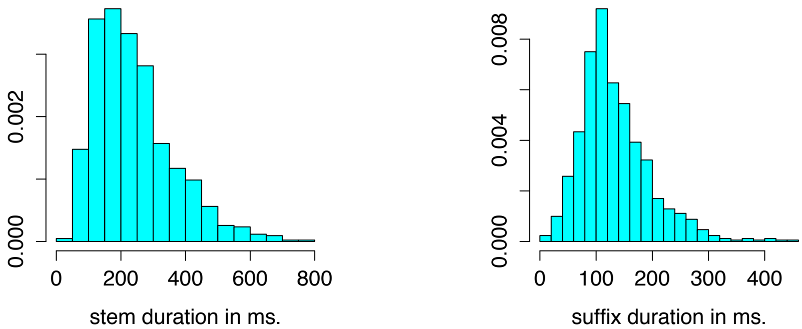

Figure 3.22: Histograms of stem (left) and suffix (right) duration values in the sample

The difference between stem and suffix duration is unsurprising given the fact that as mentioned in previous chapters, main stress in Icelandic categorically falls on the first syllable of a word. In the case of *lega*-adverbs, stress therefore always falls on the stem. As increased length is a correlate of stress in Icelandic, adverb stems are naturally longer than the suffix *lega*. The effect of stress and accent also explains the rather low correlation of stem and suffix duration of 0.33 ($p < 0.0001$): When the adverb as a whole lengthens, lengthening happens mostly in the stem. Stem duration values were log-transformed for the multivariate analysis, suffix duration values were not as this operation did not lead to an improved distribution.

Generalising over all adverb types and all different syllabic realisations, the correlation of adverb duration and the number of phonetic syllables was 0.72 ($p < 0.0001$). This rather high correlation shows that the more syllables an adverb realisation contained, the longer durationally it typically was:

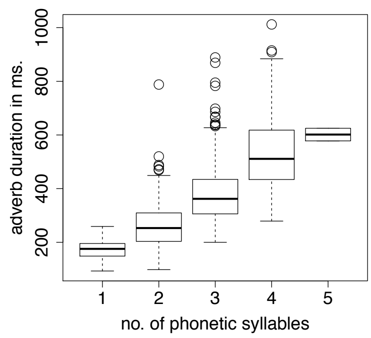

Figure 3.23: Boxplots of adverb duration by number of syllables

Rather large differences in mean duration were found between the different adverb types. While e.g. realisations of the adverb type *náttúrlega* had a mean duration of 280ms, the adverb *ofsalega* was realised with a mean duration of 483ms. Figure 3.24 shows boxplots of the duration of all adverb types with more than 20 tokens in the corpus:

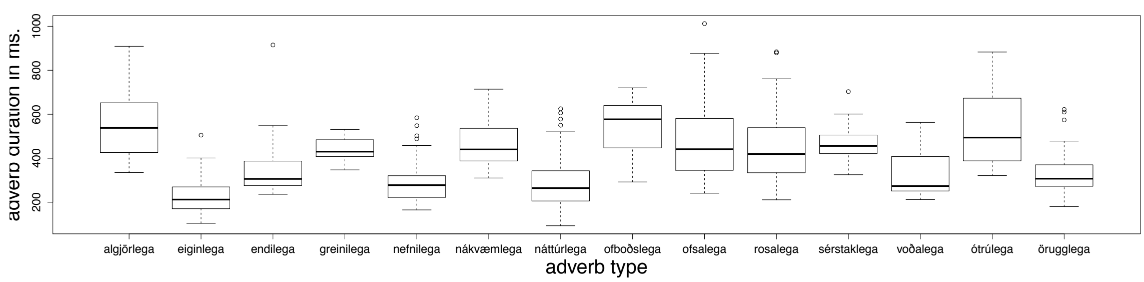

Figure 3.24: Boxplots of adverb duration by adverb type

Crucially, the durational differences cannot be reduced to differences in the number of syllables, i.e. there still remained significant differences between adverb types even when only adverb realisations with the same number of syllables were compared. While, for example, quadrisyllabic realisations of *náttúrlega* had a mean duration of 443ms, quadrisyllabic realisations of *ofsalega* had a mean duration of 658ms.

3.4.1.2 Multivariate analysis

As for the the dependent variable "number of syllables", a linear mixed-effects model was fitted to the data in order to evaluate which factors influence durational reduction for *lega*-adverbs in the corpus. As basis for the dependent variable, the log-transformed adverb duration in ms. was used. Duration values were residualised for the effect of Final Vowel Deletion using a simple linear regression model. The residuals of this model were then used as dependent variable in the mixed-effects model predicting adverb duration. The occurrence of Final Vowel Deletion explained 9% of the variation found in the durational data.

In addition to the main model, two linear mixed-effects models were calculated predicting the log-transformed duration of the adverb stem and the duration of the suffix, respectively. These values where residualised for effects of Final Vowel Deletion, as well. In the first part of this section, the main model that refers to the adverb as whole will be presented. Then, the results from the other two models will be compared to those of the first model.

For all three models, random-effect predictors were the subcorpus and the recording, respectively, from which the adverbs were sampled and the ID of the speaker which had uttered the adverb. Fixed-effect predictor variables were the same as for the model predicting syllabic reduction, i.e. log-transformed adverb frequencies, log-transformed speech rate, rhythmic environment, accentedness, syntactic function, participant gender, participant age, initial position, prepausal position, presence of disfluencies and three variables relating to the phonological structure of the adverb. The final model for adverb duration that emerged from the model fitting process with an R^2 of 0.68 is given in Figure 3.25.

In addition, two separate models were fitted to the duration data that differed slightly from the above model. Firstly, a model was fitted to a dataset that excluded realisations of the high-frequency adverb *náttúrlega*. As this model revealed more differences to the model given in Figure 3.25 than the comparable model for syllabic reduction, it will be discussed in greater detail below. Secondly, a model was fitted to the data that included forward and backward transitional probabilities. This led to some loss of data since adverbs in initial and final position could not be included in the dataset (cf. the discussion in the previous chapter).

However, the model that included transitional probabilities did not differ from

```
  AIC   BIC logLik deviance REMLdev
 82.61 168.8 -22.31   -48.71   44.61
Random effects:
 Groups   Name        Variance Std.Dev.
 speaker  (Intercept) 0.003863 0.062153
 Residual             0.053238 0.230733
groups: speaker, 68

Fixed effects:
                         Estimate Std. Error t value
(Intercept)               0.59633    0.28861   2.066
prepausal                 0.18404    0.02863   6.429
token frequency          -0.10541    0.02821  -3.737
age (mid)                 0.04417    0.03516   1.256
age (high)                0.12110    0.04664   2.597
speechrate               -0.79973    0.08749  -9.141
accentedness (yes)        0.53834    0.15562   3.459
function (sentence)      -0.74883    0.24475  -3.060
manner of art. (son)     -0.50055    0.15115  -3.312
place of art. (front)     0.44927    0.17472   2.571
type of coda (obs)       -0.43131    0.24450  -1.764
frequency:manner         -0.04245    0.01689  -2.514
frequency:place           0.04709    0.01938   2.430
frequency:accent          0.03602    0.02040   1.766
frequency:function       -0.03135    0.01611  -1.946
speechrate:function       0.20102    0.10148   1.981
speechrate:coda           0.26962    0.12429   2.169
```

Figure 3.25: Final model for the dependent variable “log(adverb duration)”

the model without transitional probabilities that was given in 3.25. The same significant main effects and interactions emerged while neither forward nor backward transitional probabilities influenced durational reduction significantly. In the following, first the results from the model based on the full dataset including *náttúrlega* will be presented, with the effects mostly ordered according to their effect size. Then, differences between the first model and the one fitted to the data excluding *náttúrlega* will be discussed.

Of the three random effects only the one for speaker-ID was retained in the final model. The random effects for recording and subcorpus did not significantly improve the model and were consequently dropped during the model fitting process. Recall that the variable “subcorpus” did improve the model for syllabic reduction (cf. ch. 3.3.1). The differences in adverb duration between the three different subcorpora were thus not as large as the differences in the number of syllables, while the differences in adverb duration on the individual level were significantly large enough to warrant the inclusion of the random effect variable.

Rhythmic environment The metrical environment adverbs were embedded in was expected to influence adverb duration only via syllabic reduction since the syllable is the basic unit that makes up metrical rhythm. As the number of syllables with which adverbs were realised was not affected by the rhythmic environment, adverb duration was not expected to be influenced by rhythm either. This prediction was confirmed in the model, as the rhythmic environment did not have a significant effect on adverb duration and was dropped during the model fitting process.

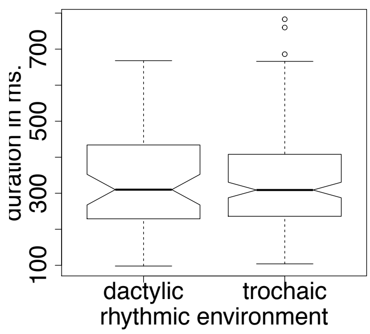

Figure 3.26: Adverb duration across rhythmic environments

The mean duration for adverbs situated in the two different rhythmic structures was nearly identical, with a mean of 339ms for dactylic environments and a mean of 340ms for trochaic environments. As was the case for syllabic reduction, a second model was fitted to the data that did not include "pure" rhythmic environments, but the metric structure of the preceding and following foot, respectively, as individual variables. However, this did not make a difference.

Speech rate Of all the variables in the model, log-transformed speech rate had the largest effect on durational reduction ($t = -9.141$). Figure 3.27 displays this effect graphically:

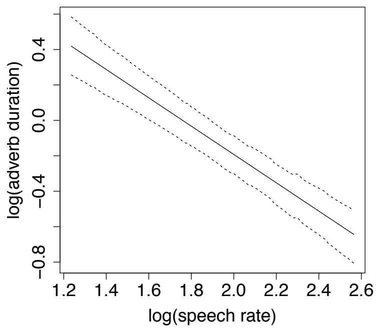

Figure 3.27: Effect of speech rate on adverb duration

The plot shows that adverbs were significantly shorter the higher the rate of speech was, i.e. the faster subjects speak. The model also showed a significant interaction of speech rate with a structural-phonological factor, the presence of a coda obstruent in the second adverb syllable (t = 2.169). The interaction is given in Figure 3.28:

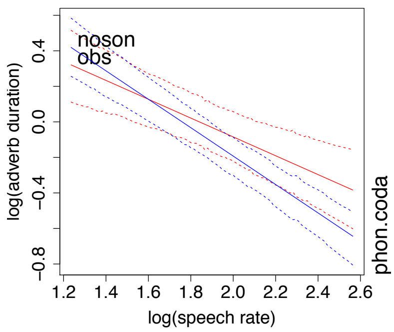

Figure 3.28: Interactions of speech rate and presence of a coda obstruent in the second syllable

For both adverbs that have an obstruent in the coda of the second syllable like *ofboðslega* and for those that have a sonorant in the second syllable coda like *náttúrlega* or no coda at all like *nefnilega*, higher speech rates correlated with reduced adverb duration. As the interaction displayed in Figure 3.28 shows, however, this correlation was significantly less strong for adverbs with a coda obstruent in the second syllable. Note that there was no significant main effect for the factor "type of second syllable coda". Adverbs with different coda types thus only differed in duration with higher speech rates, i.e. there was no durational difference between the two groups for lower speech rates.

Prepausal position The second largest effect in the model was found for the factor “prepausal position” (t = 6.429). No significant interactions were found for this variable. The main effect is represented graphically in Figure 3.29. As the graph shows, adverbs that were located in prepausal position were significantly longer than adverbs that are situated in a different position. The models for stem and suffix duration, respectively, will reveal whether this prepausal lengthening effect applied to the adverb as whole or only to the suffix part (cf. below). The second positional variable, “utterance-initial position”, did not affect adverb duration significantly and was dropped during the model fitting process.

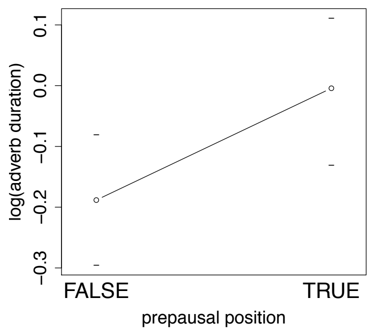

Figure 3.29: Effect of prepausal position on adverb duration

Accentedness The presence or absence of a pitch-accent on the adverb also had a rather large effect on adverb duration (t = 3.459):

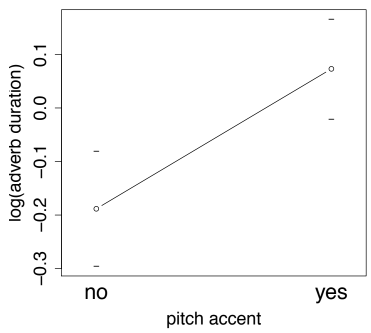

Figure 3.30: Effect of accentedness on adverb duration

Adverbs that were pitch-accented were significantly longer than adverb that did not receive a pitch-accent. The variable “accentedness” also displayed a significant interaction with two structural-phonological factors that will be discussed below.

Adverb function Adverb function was a significant factor in explaining durational reduction as well (t = −3.060). The differences between intensifier adverbs and sentence adverbs according to the statistical model are displayed in the following figure:

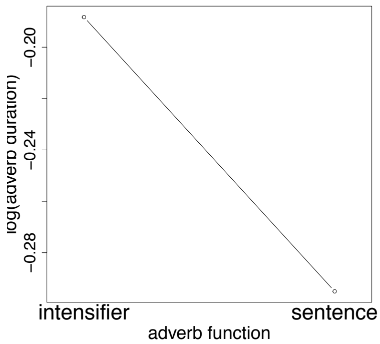

Figure 3.31: Effect of adverb function on adverb duration

As can be seen in the graph, sentence adverbs like *náttúrlega* or *mögulega* had on average significantly shorter realisations than intensifier adverbs like *ofsalega* or *svakalega*. Intensifier adverbs were often realised as pitch-accented, which could be thought to explain the effect of adverb function. The significant main effect of pitch-accentedness that was presented above, however, shows that the influence of the variable "adverb function" cannot be reduced to the role of pitch-accentedness alone.

Adverb function interacted significantly with the variable "speech rate" (t = 1.981). A graph of the interaction is given in Figure 3.32:

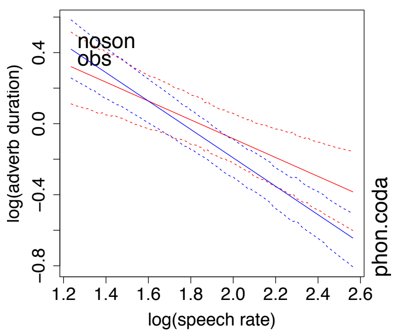

Figure 3.32: Interactions of speech rate and presence of a coda obstruent in the second syllable

Intensifier adverbs typically were longer durationally than sentence adverbs (cf. above). However, intensifier adverbs were affected more strongly by variation in speech rate than sentence adverbs. With higher speech rates, intensifier adverbs reduced relatively more than sentence adverbs. Hence, the difference in duration between sentence adverbs and intensifier adverbs is equalised for high speech rates.

Frequency of occurrence In contrast to the model for syllabic reduction, the model for durational reduction showed a significant main effect of frequency of occurrence (t = −3.737). Frequency of occurrence also displayed significant interactions with four other variables that are discussed below. The main effect for frequency is displayed in Figure 3.33:

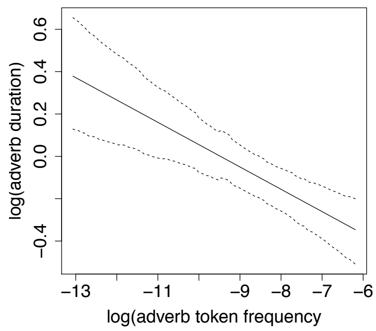

Figure 3.33: Effect of token frequency on adverb duration

The effect shows that adverbs that have a higher token frequency were significantly shorter than adverbs that have a lower token frequency. While for example the mean duration for the high frequency adverb *náttúrlega* (n = 965) in the sample was 280ms, the mean duration for the low-frequency adverb *greinilega* (n = 31) in the sample was 444ms.

As mentioned above, the main effect for frequency was moderated by several other factors. Firstly, a significant interaction of frequency of occurrence with adverb function was found in the model (t = −1.946) which is given in Figure 3.34:

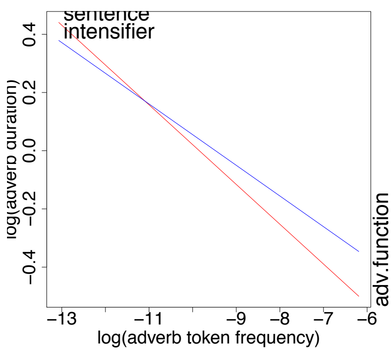

Figure 3.34: Interaction of token frequency and adverb function

It has already been noted above that adverb function played a significant role in explaining duration reduction. Sentence adverbs were significantly shorter in the corpus than intensifier adverbs (cf. above). The interaction of token frequency and adverb function now shows that sentence adverbs were even shorter when they have a high token frequency. Since both the main effect of frequency and the interaction of frequency and adverb function have the same direction, the model shows that the frequency effect exists for both sentence adverbs and intensifier adverbs, but that it is stronger for sentence adverbs.

Phonological-structural variables The other three significant interactions that included frequency of occurrence as a factor are discussed in the following in combination with the main effect for the other variables that take part in the interaction. The main effect for the variable "manner of articulation of the onset of the second adverb syllable" ($t = -3.312$) is displayed in the following figure:

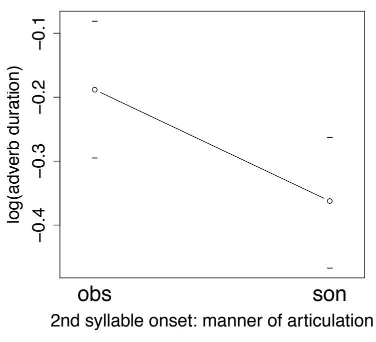

Figure 3.35: Effect of manner of articulation of the second syllable onset on adverb duration

Adverbs that have a sonorant in the onset of the second syllable like *eiginlega* – recall that the first <g> is realised [j] – were significantly shorter than adverbs that have on obstruent in the same position like *rosalega*. The interaction of the manner-variable with frequency of occurrence ($t = -2.514$), however, shows that this was not the case equally across the whole frequency range (cf. Figure 3.36). The frequency effect was stronger for adverbs that have a sonorant in the onset of the second syllable. Or to put it in a different way: "Sonorant"-adverbs were shorter than "obstruent"-adverbs in general and the difference was even larger for high-frequency items.

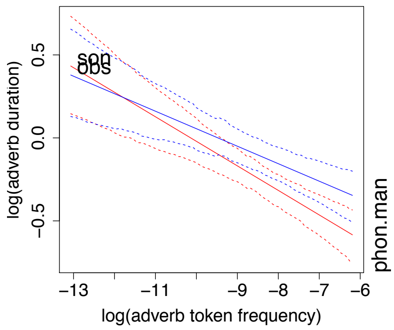

Figure 3.36: Interaction of manner of articulation of the second syllable onset with frequency of occurrence

The place of articulation of the onset of the second syllable mattered as well, as evidenced by the significant main effect ($t = 2.571$) and the interaction with frequency of occurrence. The main effect is displayed in Figure 3.37

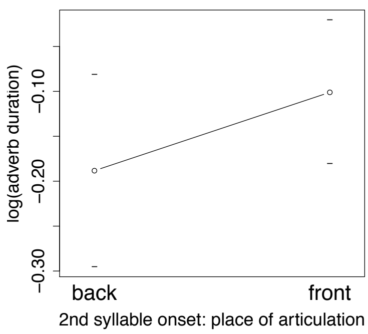

Figure 3.37: Effect of place of articulation of the second syllable onset on adverb duration

Adverbs that have a coronal consonant in the onset of the second syllable like *náttúrlega* or *rosalega* had significantly longer realisations in the corpus than adverbs with a dorsal consonant in the same position like *virkilega*. The interaction of this second structural-phonological variable with frequency of occurrence is displayed in 3.38. While "back"-adverbs were generally shorter than "front" adverbs, "back"-adverbs reduced even more heavily when they have a high token frequency.

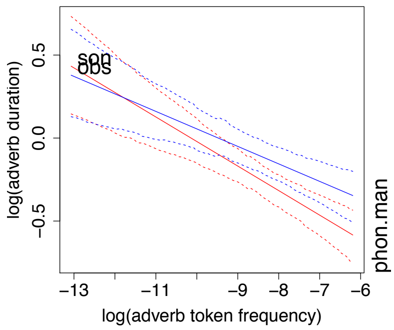

Figure 3.38: Interaction of place of articulation of the second syllable onset and frequency of occurrence

Age and gender Of the two sociolinguistic variables, in analogy to the model for syllabic reduction, only the factor "age" influenced durational reduction while the variable "gender" did not. The effect of age is given in Figure 3.39:

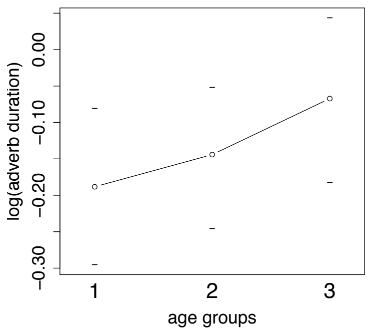

Figure 3.39: Effect of age on adverb duration

The oldest age group, i.e. those speakers aged 45 and older, produced adverbs that were on average significantly longer (mean = 436ms) than the adverbs of the middle group (mean = 358ms) and the youngest group (mean = 332ms). The two other groups did not differ significantly from one another as factor relevelling showed.

Model without *náttúrlega* Recall that the results presented above were based on the full dataset that also included realisations of the high-frequency adverb *náttúrlega* that makes up a large portion of the data. Recall also that in order to exclude possible skewing effects, an additional model was fitted to a reduced dataset that did not contain any realisations of *náttúrlega*. The reduced model itself is given in Figure 3.40:

```
    AIC   BIC logLik deviance REMLdev
 -15.35 38.64  20.67   -102.8  -41.35
Random effects:
 Groups   Name        Variance  Std.Dev.
 speaker  (Intercept) 0.0055732 0.074654
 Residual             0.0444168 0.210753
groups: speaker, 66

Fixed effects:
                         Estimate Std. Error t value
(Intercept)               0.75037    0.20890   3.592
prepausal                 0.16769    0.03051   5.496
token frequency          -0.07540    0.01772  -4.256
speechrate               -0.74127    0.06264 -11.835
pitch accent (yes)        0.25366    0.02792   9.087
manner of art. (son)     -0.82940    0.15524  -5.343
place of art. (front)     0.52703    0.16462   3.201
type of conda (obs)      -0.38494    0.23401  -1.645
frequency:manner         -0.07336    0.01714  -4.281
frequency:place           0.05620    0.01822   3.085
speechrate:coda           0.24636    0.11910   2.068
```

Figure 3.40: Linear mixed-effects model predicting log(adverb duration) based on a dataset excluding realisations of *náttúrlega*

At first glance, the reduced model is indeed "reduced", i.e. simpler, as there were fewer significant main effects and interactions than in the full model shown in Figure 3.25. In the following, the model based on the full dataset and the model based on the smaller dataset are compared and differences between the models are presented.

With regard to significant main effects, the two models were largely similar. The reduced model also showed significant effects for accentedness ($t = 9.087$), prepausal position ($t = 5.496$), speech rate ($t = -11.835$) and two structural-phonological variables. Crucially, the reduced model also showed a significant main effect for frequency of occurrence (t = −4.256) that was even stronger than in the full model (t = −3.737). The frequency effect in the full dataset can therefore not be reduced to the reducing behaviour of the high-frequency adverb *náttúrlega*. In addition the reduced model displayed significant interactions of token frequency with all three structural-phonological variables, just like the full model did.

There were, however, also several differences between the full and the reduced model, both with regard to main effects and with regard to interactions. In total, there were two main effects that were found in the full model, but not in the reduced model. Firstly, unlike in the full model, there was no significant main effect for "adverb function" in the reduced model. Recall that according to the full model, sentence adverbs were significantly shorter in duration that intensifier adverbs. The absence of this effect in the reduced model shows that this effect was largely due to realisations of the high-frequency sentence adverb *náttúrlega* which often displayed very short realisations (cf. the previous subsection). Also absent from the reduced model were the interaction of frequency of occurrence and adverb function and the interaction of adverb function with speech rate. The lack of significance for these two interactions again points to the special status of high-frequency *náttúrlega*.

The variable "age" was the second variable that was significant in the full, but not in the reduced model. The full model showed that the speakers in the third, i.e. oldest age groups produce adverbs that are significantly longer than the adverbs realised by speakers of the other two age groups. The model comparision, however, provides evidence that the difference in adverb duration between the age groups was largely confined to realisations of *náttúrlega*.

Stem and suffix duration All of the results presented above, referred to the duration of the adverb as a whole. In the following, the results from the two statistical models relating to the duration of the adverbs' stem and suffix, respectively, will be presented and compared. The initial model for both dependent variables included the same random and fixed-effect predictor variables as the model for the duration of the adverb as a whole. The final model for the dependent variable "log(adverb stem duration)" with an R^2 0.86 of is given in Figure 3.41. The model for the dependent variable "adverb suffix duration" with an R^2 of 0.61 is displayed in Figure 3.42. As can be seen from a comparison between the two models, there were a number fo variables that affected both stem duration and suffix duration significantly. However, there were also differences in significant main effects and interactions and also in the strength of shared main effects.

```
   AIC BIC logLik deviance REMLdev
 370.4 478 -161.2      205   322.4
Random effects:
 Groups   Name        Variance  Std.Dev.
 speaker  (Intercept) 0.0067774 0.082325
 Residual             0.0783421 0.279897
groups: speaker, 68

Fixed effects:
                         Estimate Std. Error t value
(Intercept)              -1.77291    0.71199  -2.490
prepausal                 0.04379    0.03638   1.204
token frequency          -0.35459    0.08724  -4.064
speechrate                0.03181    0.30722   0.104
disfluency                0.26373    0.12002   2.197
pitch accent              0.53727    0.07953   6.756
function (sentence)      -0.70687    0.17279  -4.091
manner of art. (son)     -0.74895    0.18798  -3.984
place of art. (front)     0.71424    0.22535   3.169
type of coda (obs)        0.96144    0.25618   3.753
age (mid)                 0.75665    0.17363   4.358
age (high)                1.37136    0.22970   5.970
frequency:manner         -0.07797    0.02302  -3.387
frequency:place           0.05963    0.02689   2.218
frequency:rate            0.09093    0.03765   2.415
frequency:disfluency      0.03776    0.01485   2.544
frequency:function       -0.06818    0.01971  -3.459
frequency:coda            0.08730    0.02861   3.051
frequency:age(mid)        0.08904    0.02196   4.055
frequency:age(high)       0.15566    0.02829   5.502
accent:manner            -0.20060    0.06601  -3.039
accent:place             -0.17728    0.07553  -2.347
```

Figure 3.41: Linear mixed-effects model predicting log(adverb stem duration)

Both stem duration and suffix duration were significantly affected by whether the adverb was accented or not (stem $t = 6.756$, suffix $t = 1.992$). Accentual lengthening thus applies not only to the stem, which is the main locus of the pitch accent, but also to the suffix. The token frequency of the adverb as a whole also affected both stem ($t = -4.064$) and suffix duration ($t = -3.893$). The frequency effect was equally strong for stems and for suffixes. Crucially, the significant main effect for frequency of occurrence remained in the model even when realisations of the high-frequency adverb *náttúrlega* were excluded from the sample.

```
   AIC   BIC logLik deviance REMLdev
 343.2 396.9 -159.6      269   319.2
Random effects:
 Groups   Name        Variance  Std.Dev.
 speaker  (Intercept) 0.0021639 0.046518
 Residual             0.0881422 0.296887
groups: speaker, 68

Fixed effects:
                      Estimate Std. Error t value
(Intercept)            1.059069   0.221116   4.790
prepausal              0.404741   0.037044  10.926
token frequency       -0.036778   0.009446  -3.893
speechrate            -0.723170   0.106695  -6.778
pitch accent (yes)     0.073730   0.037004   1.992
function (sentence)   -0.437014   0.259130  -1.686
manner of art. (son)  -0.104811   0.039866  -2.629
type of coda (obs)    -0.098440   0.033958  -2.899
rate:function          0.233041   0.130863   1.781
accent:manner          0.139924   0.053481   2.616
```

Figure 3.42: Linear mixed-effects model predicting adverb suffix duration

Adverb function (t = −4.091) and age were only significant factors in the model for stem duration. Stems of sentence adverbs were thus generally longer than stems of intensifier adverbs. This effect was even more pronounced for high-frequency adverbs as the interaction of token frequency and adverb function shows (t = −3.459). In addition, older speakers realised stems that were significantly longer than the stems realised by younger speakers. The suffix *lega* on the other hand was reduced equally by all age groups. The effects for function and age, however, disappear in a model that excludes realisations of *náttúrlega*. Generational differences in stem duration therefore seem to be confined to *náttúrlega*.

The location of an adverb in prepausal position led to durational lengthening in the suffix (t = 10.926), but not in the stem (t = 1.204). Interestingly, only the model for suffix duration displayed a significant main effect for speech rate (t = −6.778). Adverb suffixes were shorter with higher speech rates than with lower speech rates. This was, however, not the case for the duration of adverb stems. In the model for stem duration, speech rate proved to be only significant in interaction with frequency of occurrence (t = 2.415). This interactions shows that the large frequency effect that was found for stem duration is reduced with higher speech rate. While the stems of high-frequency adverbs were generally shorter than the stems of low-frequency adverbs, this difference was much less pronounced when speech rates were higher. With higher speech rates, both high- and low-frequency adverb stems reduce equally strongly.

Structural-phonological variables mostly influenced the duration of the adverb stem, but less so the duration of the adverb suffix. Since all three structural factors refer to the phonological makeup of the stem, this difference is hardly surprising. Both adverb stems and adverb suffixes were significantly affected by the variable "manner of articulation of the second syllable onset" (stem $t = -3.984$, suffix $t = -2.629$). Both parts of the adverb were significantly shorter when the onset of the second syllable was a sonorant than when it was an obstruent. This correlation was even more pronounced for stems of higher-frequency as the interaction of frequency of occurrence and manner of articulations showed ($t = -3.387$).

The other two structural variables only affected stem duration. Adverb stems were longer when the second syllable had an obstruent in the coda than when it had a sonorant in the same place or no coda at all ($t = 3.753$). This correlation was even stronger for high-frequency adverbs ($t = 3.051$). When the onset of the second syllable was a coronal consonant, adverb stems had a significantly higher duration than when adverbs had a dorsal consonant in the same position ($t = 3.169$). Place and manner of articulation of the onset of the second syllable also moderated the effect for accentedness on stem duration. When the the second syllable onset was a sonorant ($t = -3.039$) and when it was a coronal consonant ($t = -2.347$), the lengthening effect that a pitch accent had on stem duration was significantly less pronounced.

The presence of disfluencies affected only stem duration. Adverb stems were generally longer when there were disfluencies in the utterance ($t = 2.197$) and this effect was stronger for high-frequency adverbs as the interaction of the variables "disfluencies" and "frequency of occurrence" shows ($t = 2.544$). For suffix durations, the factor "disfluencies" was not a significant factor.

In sum, the statistical model for the dependent variable "log(adverb duration)" revealed a number of significant main effects and interactions. The comparison of this model with a model based on the same data sample excluding realisations of *náttúrlega* also showed that some of these effects are only due to the behaviour of the high-frequency adverb *náttúrlega* which often appears as segmentally and durationally reduced in the corpus. Both models displayed significant effects for speech rate, accentedness, prepausal position, Final Vowel Deletion and two structural-phonological factors. Effects of adverb function, the presence of disfluencies and age were only found in the first model and therefore can be attributed to high-frequency *náttúrlega*. Importantly, the main effect for frequency of occurrence itself was found in both models.

The models for stem and suffix duration revealed that the realisations of both stems and suffixes were influenced by accentedness, adverb token frequency and prepausal position, albeit to different degrees. A general shortening effect for higher speech rates was only observed for suffix duration. Speech rate had, however, also a levelling effect on the role of token frequency in relation to stem duration, with the frequency effect on stems being less pronounced for higher spechrates. The effect of adverb function and speaker age was confined to the duration of stems for the adverb type *náttúrlega*. Structural-phonological factors mostly influenced the duration of the stem, but not the duration of the suffix. The role of the effects on adverb duration, stem and suffix duration will be discussed in the next section.

3.4.2 Discussion

In the following, the results presented for durational reduction in the previous section will be discussed. The dependent variable "adverb duration" was included in this study as a measure of reduction for two reasons. Firstly, the duration of a word is comparatively easier to measure than its spectral features, even with reduced corpus quality. Secondly, duration is used to quantify reduction in a majority of the studies that investigate acoustic phonetic reduction, often in addition to other dependent variables.[22] Thererfore, the main focus of this discussion is the comparison between the results given above and the ones obtained by other studies. The goal is to establish which factors affect acoustic reduction crosslinguistically and which ones are active only in Icelandic. In addition, theoretical considerations with regard to storage and retrieval of reduced forms are made where possible. For the main part, the discussion will be based on the dataset that included the full sample. Where necessary, the model for the reduced dataset (excluding realisations of *náttúrlega* and the models for stem and suffix duration) will be included in the discussion.

A number of variables had a significant effect on durational reduction that were expected to do so on the basis of the results presented in the literature. Speech rate had the largest effect on duration, with higher speech rates correlating with

[22] Word duration is used by e.g. Fowler & Housum (1987); Jurafsky *et al.* (1998, 2001); Bell *et al.* (2009). Aylett & Turk (2004, 2006) use syllable duration and Kuperman *et al.* (2007) the duration of the interfix they study.

reduced duration. This correlation of speech rate and duration is found in all studies on durational reduction that include rate of speech as a variable (e.g. cf. Jurafsky *et al.* , 1998; Fosler-Lussier & Morgan, 1999; Pluymaekers *et al.* , 2005; Kuperman *et al.* , 2007; Bell *et al.* , 2009). In a similar vein, the significant effect for accentedness revealed by the model is completely expected. Adverbs that receive a pitch-accent are longer than others. This effect is also supported by the results from the literature that ascribe a dominant role to prosodic prominence in accounting for durational reduction (Aylett & Turk, 2004, 2006; Raymond *et al.* , 2006). The variable "prepausal position" also had a large effect on adverb duration. Adverbs were longer if preceding a pause than otherwise. This prepausal lengthening effect is also well documented in similar studies (e.g. cf. Bell *et al.* , 1999; Pluymaekers *et al.* , 2005; Bell *et al.* , 2009).

Both accentedness and prepausal position could be expected to influence stem and suffix duration to different degrees, since the loci for lengthening are different in both cases. On the one hand, prepausal lengthening would be expected to occur predominantly in the last part of a word, in this case the suffix -*lega*. The variable "prepausal position" indeed affected suffix duration to a much larger degree than stem duration, although the prepausal lengthening effect was also significant for the latter. A lack of this effect for stem duration would not have been completely surprising given the results of Kuperman *et al.* (2007) who did not find a lengthening effect in prepausal position for the Dutch interfixes -*s*- and -*(e)n*-. While the main locus of prepausal lengthening therefore seems to be the adverb suffix, pitch accents and the lengthening effect associated with them would be expected to affect mostly the adverb stem.[23] The variable "accentedness", however, was significant for both stem and suffix duration, and the difference in t-values was by far not as large as for the variable "prepausal position". Lengthening induced by a pitch accent therefore seems to spread across the main locus of the pitch movement[24] and into the farther parts of a word.

Metrical rhythm did not influence durational reduction, as the statistical model presented in the previous section did not show a significant effect of rhythm on the dependent variable. A significant effect of metrical rhythm on durational reduction would in fact have been rather surprising, considering that rhythm did not influence syllabic reduction (cf. ch. 3.3.1). As rhythm takes the syllable as its basic unit, a rhythmic effect on adverb duration would have to be mediated by

[23] Recall again that *lega*-adverbs are lexically stressed on the first syllable, which is therefore also the natural site for a pitch accent.
[24] Dehé (2008a) locates the end of pitch movement in a pitch accent on the second syllable.

way of the number of syllables with which the adverbs are realised. The non-effect of rhythm on adverb duration is therefore completely expected and will not be further discussed in this section. The reader is instead referred to the theoretical discussion in ch. 3.3.2.

As probability-based factors, log-transformed adverb token frequency ("prior probability") and forward and backward transitional probability were included in the linear-mixed effects model. Frequency of occurrence was a significant factor in explaining durational reduction according to the final model. This token frequency effect in fact appeared in all the different models presented in the previous section: the one based on the full dataset, the one based on the dataset excluding *náttúrlega* and the models for stem and suffix duration. The frequency effect in the main model (predicting adverb duration based on the whole data set) shows that high-frequency adverbs had shorter realisations than low-frequency adverbs in general. The model for adverb duration that did not include realisations of the high-frequency adverb *náttúrlega* (which features some of the shortest realisations found in the sample) still displayed a significant token frequency effect. Therefore, the correlation of high token frequency and durational reduction cannot be accounted for by the behaviour of high-frequency *náttúrlega* alone.

The results for the variable "token frequency" as given above are in principle in line with those of previous studies of acoustic phonetic reduction that use "word duration" as their dependent variable. Bell *et al.* (2009), who sum up more than a decade of corpus-based research on reduction by Jurafsky and colleagues, show that frequency of occurrence is an important predictor of durational reduction for both content and (albeit to a lesser extent) function words. They show that frequency of occurrence separates high- from mid- and low-frequency function words, but has no effect within these two groups. Since the status of *lega*-adverbs oscillates between content and function words (cf. ch. 2.1), it is especially important to note that the frequency effect was also found in the model that excluded the high-frequency function word *náttúrlega*. The effect of frequency of occurrence thus does not merely separate high- from low-frequency adverbs, but runs through the whole dataset. With regard to frequency effects on reduction, *lega*-adverbs therefore behave more like content than function words.

As mentioned above, the effect of frequency is not confined to the duration of the adverb as a whole, but is also found in the models for stem and suffix duration, respectively. Both the adverb stem and suffix were shorter for high-frequency than for low-frequency adverbs. Importantly, the effect of token frequency was much larger for stem than for suffix duration. Similar to the model for word duration, the effects of token frequency were still significant if realisations of *náttúrlega* were excluded from the dataset. Similar to this study, Pluymaekers *et al.* (2005) investigated the reduction of suffixed and prefixed words and measured duration of both the word as a whole and affix and stem duration. Among their objects of study were Dutch adverbs with the suffix -*lijk* which is the cognate suffix to -*lega*. Pluymaekers and colleagues also found frequency effects for stem, suffix and word duration. The results of the present study therefore present a validation of the results of Pluymaekers *et al.* (2005) that is as close as possible, considering that the two studies investigate different languages.

The larger size of the frequency effect for stem than for suffix duration shows that the differences between high- and low-frequency words with regard to suffix reduction are smaller than the ones in stem reduction. While the suffix can be more easily reduced for lower-frequency adverbs as well, heavy stem reduction is only found for mid- and high-frequency adverbs. This distribution shows that to a certain extent, the suffix can be reduced independently of the stem. Another piece of evidence supporting this assumption is that the effect of the variable "age" was only found for stem but not for suffix duration. While younger speakers generally display shorter realisations of adverb stems, this difference is not found for adverb suffixes. This shows again that to a certain degree, stem and suffix reduction proceed independently of each other.

It has been noted above that the frequency effect for adverb duration suggests that *lega*-adverbs behave more like content than function words if the results of Bell *et al.* (2009) are taken as a measure of comparison. Interestingly, with regard to the effect of the other two predictability factors (backward and forward transitional probability), *lega*-adverbs were more akin to function than to content words. In all models on durational reduction, neither forward nor backward transitional probability affected duration significantly. Since collocational probabilities have been shown to be a very important predictor of durational reduction (e.g. Jurafsky *et al.* , 2001; Raymond *et al.* , 2006; Bell *et al.* , 2009), this result might seem surprising. However, Bell *et al.* (2009) show that effects of contextual predictability on durational reduction are mostly found for content words and only to a lesser extent for function words. Backward transitional probability is the most important predictor of reduction for content words as well as mid- and low-frequency function words. High-frequency function words, however, are only affected by forward transitional probability, which Bell *et al.* (2009) attribute to high-frequency collocations like *because of* having become lexicalised.

One explanation for this lack of a significant probability effect for *lega*-adverbs would be to locate their status between function and content words. Disregarding semantic considerations, content and function words differ in their syntactic distribution. On the one hand, function words such as prepositions are often bound in their distribution, i.e. as to which classes of words they appear next to. On the other hand, the actual lexemes function words can occur with are rather diverse, and a collocational analysis (like collexeme analysis (Stefanowitsch & Gries, 2005)) would not work for a lot of them. Intensifier adverbs behave like "classic" function words in that they are almost invariably followed by either an adjective or another adverb.[25]

(3.29) *Hann er svo rosalega langur sko þessi fjörður*
he is so terribly long PART this fjord
'It's so terribly long, this fjord. [Istal_06_220_02, Speaker C]'

(3.30) *Þetta er rosalega vel skrifað, maður*
this is terribly well written man
'Man, that's terribly well written! [Viðtöl_A2, Speaker 2]'

Sentence adverbs most often appear directly preceding the finite verb, as shown in 3.31:

(3.31) *Þeir vita eiginlega ekki hverju þeir eiga að (.) svara*
they know actually not what.DAT they shall to HES answer
'They don't actually know what they should answer. [Viðtöl_AA, Speaker 3]'

This kind of distribution lends itself even less to predictability effects from context, especially as sentence adverbs semantically refer to the proposition as a whole and not to individual items. In addition, high-frequency *náttúrlega* (and to a certain extent also *nefnilega*) has become more similar to a modal particle with a rather free distribution that is hardly bound to either syntactic or semantic contexts.

If cross-linguistic argumentation is permitted, however, the results of Keune *et al.* (2005) can be used as an argument against the syntactic explanation of the lack of contextual predictability effects. Keune *et al.* (2005, 210) found an effect of contextual predictability on Dutch adverbs containing the suffix -*lijk*,

[25] Also recall from ch. 2.1 that intensifiers can also be situated utterance-initially, i.e. apart from the item they form a phrase with ("Rosalega er hann góður!" - 'He's incredibly good!' (lit. 'incredibly is he good')). However, this usage is not too frequent and not found in the corpus data at all.

which are the direct cognates of Icelandic *lega*-adverbs. They even remark that "reduced high-frequency words in -*lijk* [...] are becoming more similar to the most common words", i.e. high-frequency function words that are not subject to contextual effects (cf. again Bell *et al.* , 2009). Still, the effect of context on reduction was pervasive in their study. Two differences, however, might limit the comparability of the study of Keune et al. to the present one. On the one hand, Keune *et al.* (2005) used an ordinal measure of "no/medium/high reduction" as their dependent variable. On the other hand, they used Mutual Information (MI) as a measure of contextual predictability while this study employed backward and forward transitional probabilities.

MI was discarded as a possible measure of contextual predictability, among other reasons due to limitations in corpus size – which might be a second, more "mundane" explanation for the lack of contextual effects in the data. The corpus used to calculate forward and backward transitional probabilities only encompasses about 230,000 words. As was mentioned in ch. 3.1.2, in order to arrive at meaningful probability values, the lemmatised version of the corpus was used for the calculation, since lemmatisation amounts to a reduction of the number of different word types. However, the corpus could still have been too small. The corpora used by other studies on reduction were in fact much larger. Keune *et al.* (2005), e.g., used a subsample of the Corpus of Spoken Dutch with 4.7 million words, while Bell *et al.* (2009) used the Switchboard corpus with a size of over a million words. Unfortunately, no other corpora of spoken Icelandic were available in order to increase the corpus, and the inclusion of written corpora would have distorted the results since *lega*-adverbs are mostly found in oral speech. Of course, the two explanations for the lack of contextual predictability effects given above are not fully mutually exclusive. It is possible that for the distributional reasons outlined, *lega*-adverb are subject to weaker contextual effects than other elements. These weak contextual influences could in turn only be found in a sufficiently large corpus.

Adverb function, i.e. the difference between sentence and intensifier adverbs, was significant in the main model, both on its own and in interaction with frequency of occurrence. These effects showed that sentence adverbs are generally shorter than intensifier adverbs and that this tendency is even more pronounced for high-frequency words. While in the sample, sentence adverbs had a mean length of 325ms, intensifier adverbs were realised with a mean length of 469ms. However, both the main effect and the interaction were not present in the model based on the reduced dataset excluding realisations of *náttúrlega*. As was mentioned previously, *náttúrlega* is a high-frequency sentence adverb that displays some of the shortest realisations found in the sample (with regard to both duration and the number of syllables). The mismatch in effects for adverb function between the full model and the one excluding *náttúrlega* is therefore again an indicator of the special status *náttúrlega* enjoys.

One reason for including phonological-structural variables was to filter out the variation in syllabic and durational reduction that was simply caused by the different phonological mark-up of the adverb stem. This is especially important when it comes to evaluating the effect of frequency of occurrence: "Since words generally differ not only in frequency, but also in at least one of their speech sounds, they are bound to differ in duration as well" (Pluymaekers *et al.* , 2005). As the analysis of syllabic reduction in ch. 3.3 showed, the phonological structure of adverb stems influences reduction significantly indeed. Structural variables could be expected to influence duration mostly via segment and syllable reduction. The deletion of a segment or a syllable should lead to a shorter duration of the adverb stem. The effect of structural variables on durational reduction would therefore be expected to mirror the effect structural factors had on syllabic reduction. Interestingly, this was only partially the case.

Recall that structural-phonological variables firstly referred to the manner and place of articulation of the second syllable onset. Secondly, the type of coda of the second syllable was included as a variable. The manner of articulation of the second syllable onset influenced adverb duration significantly. Adverbs were shorter if the onset was a sonorant than if it was an obstruent. This effect was even more pronounced for high-frequency adverbs, as the interaction of manner of articulation and token frequency showed. These results mirror the one obtained for syllabic reduction. Therefore, durational reduction can be assumed in this case to proceed via segmental and syllabic reduction. Sonorants are more easily reduced than obstruents, and when a sonorant is deleted, this leads to an overall shorter duration of the adverb (also cf. ch. 3.3.2.

The variable "type of second syllable coda" did not reach significance in the model for durational reduction, contrary to the results obtained for syllabic reduction, although the tendency was the same: adverbs that had a sonorant in the coda or no coda at all tended to be shorter than adverbs with an obstruent in the second syllable coda. The partial mismatch – if not in effect direction then at least in significance – shows that segment deletion does not necessarily lead to a shortened duration. This mismatch is in line with expectations formulated by Kul (2011), who shows that different measures of reduction are necessary in order to get a full picture of acoustic reduction. The comparison between the effect of phonological-structural variables for durational and syllabic reduction will be taken up again in the general discussion in ch. 3.5.

The role of disfluencies is interesting both in comparison with the results from the literature and as additional evidence for the lexicalisation of disyllabic forms of *náttúrlega*. The variable "presence of disfluencies" was a significant factor, both as a main effect and in interaction with frequency of occurrence – only in the model that included realisations of *náttúrlega* and not in the model based on the reduced dataset. The literature, however, shows that the presence of disfluencies is usually a very important and powerful predictor of durational reduction. In fact, Jurafsky *et al.* (1998) find that disfluencies are the most important predictor of reduction (or in this case non-reduction), both for durational reduction and for the segmental variables that were also included in their study. Two different explanations for the seeming lack of an effect of disfluencies can be thought of: one relying on a closer inspection of the adverb type "náttúrlega", the other one on a comparison of the variables that were included in other studies.

Firstly, as mentioned above, disfluencies only seemed to affect the adverb type *náttúrlega*. It is possible that *náttúrlega* simply occurs in the vicinity of disfluencies more often than other adverbs, which would reduce the number of data points with disfluencies in relative terms for the rest of the sample – if *náttúrlega* is taken out. This can indeed be found in the data. *Náttúrlega* occurs in utterances with disfluencies in 51% of all cases, while in the rest of the sample, only 44% of all utterances contain disfluencies.

Secondly, the difference between the present study and the literature could be thought to lie in the operationalisation of the factor "presence of disfluencies" itself and the inclusion of additional factors in the present study. This methodological difference might take away some of the explanatory power of the variable. The present study e.g. included the variable "speech rate" which was not taken into account by the study by Jurafsky *et al.* (1998). The presence of disfluencies in the vicinity could lead to a slowed down speech rate which in turn would account for the durational lengthening found for items that occur in the vicinity of a disfluency. However, the data do not support this second hypothesis as speech rates did not differ significantly between utterances with or without disfluencies.[26]

As was the case for syllabic reduction, the variable "age" corroborates the hy-

[26] Since speech rates were measured across the largest utterance stretch that included the adverb between pauses, it could still be the case that local speech rates – i.e.in the immediate vicinity of the disfluency – were different between the two conditions.

pothesis of a lexicalised disyllabic form of *náttúrlega*. Again, age was only significant in the model that included realisations of *náttúrlega*, showing that the oldest age group behaves differently from the other two groups only with regard to the adverb type *náttúrlega*. When looking at the data more closely, it was revealed that the differences between age groups only apply to stem duration, but not to the duration of the adverb suffix -*lega*, since the variable only affected stem duration in the statistical model, but not in the model for suffix duration. Recall that the adverb stem is the locus of the reduction from trisyllabic to disyllabic forms, in the case of *náttúrlega* from a form such as [nauhtula] to a realisation like [nauhtla]. The age difference in the stem shows that young and middle-aged speakers reduce the stem more often, i.e. they produce more disyllabic realisations, than older speakers.

The variable "gender" did not influence durational reduction significantly. The results for this factors are contradictory in the literature. While some studies find that men reduce more than women (Byrd, 1994; Keune *et al.* , 2005), others did not find a significant difference in reduction behaviour between genders (Strik *et al.* , 2008; Raymond *et al.* , 2006). The studies that found gender differences mostly did not incorporate speech rate as a variable, which may be the reason for gender to appear as a significant factor since men tend to speak faster than women. The present study does include speech rate as a variable, which turned out to be a significant predictor of reduction (cf. above). The sample utterances produced by male speakers had a mean speech rate of 7.22 syllables per second, while the ones produced by females had a mean speech rate of 7.59 syllables per second. Although these gender-based differences in speech rate are not very large, they are significant according to a t-test ($t = -3.5752$, $df = 669.856$, $p < 0.001$). Thus, it cannot be ruled out that the lack of gender effects in the sample is due to differences in speech rate between males and females.

Summing up, the discussion has revealed that with regard to adverb duration, several factors are at play that influence how and if *lega*-adverbs are realised as reduced or not. Implementational factors like speech rate and accentedness played a great role in explaining durational reduction or lengthening – which is in accordance with the results in the literature. Frequency of occurrence was an important factor, too, but transitional probabilities were not. These conflicting results were taken as indicative of the intermediate status *lega*-adverbs have between function and content words. Phonological structure was more important for durational reduction than semantics, as seen in the lack of an effect for adverb function (if *náttúrlega* is excluded from the dataset), while two phonological-structural factors were significant in the model. The limited significance of the variable "age" was again taken to support the hypothesis that disyllabic sideforms of *náttúrlega* have been lexicalised.

3.5 General discussion and summary

The aim of the corpus-based study presented in this chapter was twofold. Firstly, factors that influence the reduction of *lega*-adverbs in Icelandic were to be identified and compared with studies of acoustic reduction for other languages. Additionally, theoretical considerations on the effect or non-effect of certain variables should be made with regard to the role of storage, computation and implementation in reduction. The data basis for this chapter was a sample of 900 adverbs with the suffix -*lega* from a corpus of spontaneous Icelandic. This sample was annotated for a range of variables, including two predictor variables, the number of phonetic syllables and the total adverb duration. Multivariate analyses were conducted in order to evaluate the contribution of the different predictor variables.

This general discussion is intended to compare and evaluate the empirical results and to recapitulate and elaborate the theoretical discussion of the previous sections. Table 3.7 gives an overview of how the variables included in this corpus-based study performed in the statistical models for syllabic and durational reduction, respectively.[27] A variable in brackets indicates that it was only significant in the model based on the full dataset, but not in the one excluding realisations of *náttúrlega*. An asterisk indicates that this variable took part in one or several significant interactions.

As the comparison of effects shows, there were a number of variables that affected both syllabic and durational reduction (or neither) as well as a number of variables that only had an effect on one of the two dependent variables used in this study. Recall that the general hypothesis formulated in ch. 3.1.2 stated that adverb reduction in Icelandic is influenced by the same factors as in other languages. Indeed, several factors that are well known to influence reduction also turned out to be significant in the statistical models. Prosodic prominence, i.e. accentedness, and rate of speech affected both durational and syllabic reduction. Prepausal lengthening was only observed with regard to duration but not with regard to the number of phonetic syllables.

[27] Cf. ch. 3.1.2 for a description of the individual variables.

Predictor	No. of syllables	Adverb dur.	Stem dur.	Suffix dur.
rhythm	–	–	–	–
token frequency	–*	✓*	✓	✓
trans. probabilities	–	–	–	–
accentedness	✓*	✓*	✓	✓
speech rate	✓*	✓*	–*	✓
adverb function	✓*	(✓*)	(✓)	–
prepausal pos.	–*	✓	✓	✓
initial pos.	–	–	–	–
disfluencies	–	(✓*)	(✓)	–
onset manner	✓*	✓*	✓	✓
onset place	–	✓	✓	–
coda	✓*	– *	✓	–
age	(✓)	(✓)	(✓)	–
gender	–	–	–	–

Table 3.7: Comparison of factor performance in different statistical models

Metrical rhythm affected neither the number of syllables with which *lega*-adverbs were realised in the sample nor their duration. Several different explanations for this non-effect were offered in ch. 3.3.2. First, the lack of a rhythmic effect fits well with abstractionist models that posit a strict division of labour between phonetics and phonology. Influences of metrical rhythm on reduction are categorical in nature and therefore have to be situated in the phonological module. Since the reduction observed in the sample is phonetic-implementational, metrical rhythm cannot influence this reduction, according to the generative-abstractionist account.

While metrical rhythm failed to provide evidence for exemplar storage and direct retrieval of reduced forms in production, there are still possible explanations of the data that allow for exemplars to play a role. A radical exemplar-based account that situates reduction almost exclusively in storage and leaves no room for reduction in implementation was discarded. Instead, at least some of the reduction encountered in *lega*-adverbs has to happen phonetically if the difference in rhythmic effects between controlled-size reductive processes and broader acoustic reduction is taken as fact.

Lastly, is was noted that the present corpus-based study fails to provide an adequate comparison to studies which investigate the effect of metrical rhythm on controlled-size processes like metrical rhythm and schwa deletion. Since previous studies employed mostly read or otherwise controlled speech, they are not fully comparable with the present study which relies on spontaneous speech. In order to exclude the possibility that the effect of rhythm on reduction in *lega*-adverbs is simply masked by other factors, it was proposed that an experimental follow-up study needs to be conducted which will be the topic of ch. 4.2.

The picture for token frequency was slightly more complicated. This variable influenced adverb duration significantly for all items. A higher token frequency was generally associated with shorter duration. With regard to syllabic reduction, however, token frequency influenced only sentence, but not intensifier adverbs. In addition, the variable interacted with a number of other variables so that the effect of e.g. structural-phonological variables was stronger for high-frequency than for low-frequency words. However, there were also frequency interactions that were exclusively due to the influence of high-frequency *náttúrlega*, as the comparison with models excluding realisations of this adverb showed.

The locus of frequency effects is difficult to determine from the present data. It i that frequency affects speech production already in the planning phase. A second possibility is that frequency effects are part of implementation. Pluymaekers *et al.* (2005) note that corpus-based data "do not allow us to distinguish between these two hypotheses [with regard to where the effect of frequency takes place], as the words under investigation were produced after both conceptual and articulatory preparation had taken place". They go on to suggest that experimental setups like shadowing could be more useful since they liberate speakers partly from the need of conceptual planning. This could allow for a better investigation into the stage of production where frequency effects are located. Accordingly, the experimental task presented in the following chapter – that also investigates the role of rhythm further – will be a shadowing task.

Contextual predictability affected neither duration nor the number of syllables, although especially backward conditional probability has been shown in the literature to be a strong predictor of reduction. An explanation in terms of adverb distribution was given in ch. 3.4.2 which is grounded in the intermediate status that *lega*-adverbs have between function words and content words. However, it was deemed more likely that the corpus material used for the calculation of transitional probabilities was simply too small to produce reliable results. If a larger corpus of spontaneous Icelandic had been available, significant results for contextual predictability variables might have been observed.

Adverb semantics or function played a significant role for syllabic, but hardly any for durational reduction. While sentence adverbs were generally realised with fewer syllables than intensifier adverbs, sentence adverbs were not necessarily shorter in absolute duration than the second type of adverbs, at least when the high-frequency adverb *náttúrlega* was excluded from the dataset. In ch. 3.3.2, explanations for the split between sentence and intensifier adverbs were proposed in terms of both semantic lightness and prosody. Sentence adverbs are far less frequently realised as accented, and their semantics lend themselves better to reduction than those of intensifier adverbs.

In addition to adverb semantics phonological structure was also important for explaining adverb reduction. Out of the three phonological-structural variables that were included as predictors, only the manner of articulation of the second syllable onset turned out to be a significant factor in the models for both syllabic and for durational reduction. Where this onset was a sonorant that could easily be deleted, adverbs were both shorter in duration and were realised with fewer syllables than when the onset was an obstruent. The structure of the second syllable coda only played a role for syllabic reduction. Where this coda position was filled with an obstruent, adverbs were realised with more syllables than where the same position was filled with a sonorant or not filled at all. However, adverbs with a coda obstruent in the second syllable were not necessarily longer.

Thus, both the aforementioned variables were significant predictors of syllabic reduction. However, the place of articulation of the second syllable onset was not. This difference was interpreted in ch. 3.3.2 that the "reducibility" of a segment is more important for reduction in the stem *lega*-adverbs than the acceptance of the structure that emerges from reduction. In addition, the mismatch between the models for syllabic and durational reduction with regard to the significance of the variable "presence of a coda obstruent in the second syllable" underscores the importance of measuring reduction by way of more than one dependent variable (Kul, 2011).

Summing up, this chapter has provided an overview of factors which influence acoustic reduction in Icelandic *lega*-adverbs and has offered possible theoretical explanations for these effects where possible. The data justify the selection of more than one dependent variable for the study of reduction, as several discongruencies between syllabic and durational reduction were observed. In order to explain acoustic reduction for *lega*-adverbs in the corpus, both phonological-structural and semantic-functional variables have to be taken into account, as the analysis showed. Frequency of occurrence was an important factor, both on its own and in interaction with other variables – which confirms the expectation formulated by Bell *et al.* (2009) that the effect of certain variables may be stronger or weaker for high-frequency items.

Theoretical questions about the role of storage and computation were raised especially with regard to the lack of a rhythmic effect on syllabic reduction. On the one hand, reduction seems to be genuinely phonetic-implementational. On the other hand, there were indications that disyllabic reduced forms of *náttúrlega* and (to a certain extent) also *nefnilega* are stored independently and that reduction was therefore morpho-lexical in these cases. Abstractionist models are able to easily account for the data, but the same applies to modified exemplar models. In order to rule out that the rhythmic non-effect is due to the choice of spontaneous speech and in order to better situate token frequency effects in the production process, an experimental follow-up study was deemed necessary. This experimental study will be the topic of the next chapter.

4 Experimental analysis

4.1 From corpus to experiment

It was argued in ch. 2.2 that the results of the corpus-based analysis need additional verification via an experimental analysis. In such an analysis, one or two factors can be studied more closely and under more controlled conditions than is possible when using a corpus of natural speech as data source. Additionally, "a corpus-based methodology [...] can be paired with traditional controlled laboratory experiments to help provide insight into psychological processes like lexical production" (Bell *et al.* , 2003, 1022). The experiments that are the subject of this chapter focus on the role of two selected variables and their role in acoustic reduction of Icelandic *lega*-adverbs: metrical rhythm and frequency of occurrence.

The corpus-based study presented in the previous chapter showed that many of the same factors that influence reduction in other languages such as English or Dutch also affect the reduction of *lega*-adverbs in Icelandic. Among those factors was frequency of occurrence, which has been demonstrated to correlate with phonetic reduction for other languages as well (cf. e.g. Bell *et al.* , 2009). However, it could not be determined on the grounds of corpus-based production data alone, where the locus of frequency effects in production is. On the one hand, frequency could "pass information about redundancy on to the articulator, where it could influence the amount of effort put into articulation" (Pluymaekers *et al.* , 2005). On the other hand, it could be the case that "effects of frequency arise during phonological processing" (ib.). Pluymaekers *et al.* (2005) suggest experimental methods such as a shadowing task where no conceptual planning is required in order to determine where frequency effects are located in the production process.

In addition to the open questions about frequency of occurrence, the theoretically interesting factor "metrical rhythm" will be looked at closer in the exeperimental study. This variable did not turn out to have a significant impact on adverb reduction in the corpus-based analysis, but has been shown in other studies to influence "phonological" alternations such as schwa deletion and epenthesis in Dutch (Kuijpers & van Donselaar, 1998) and Final Vowel Deletion in Icelandic

(Dehé, 2008b). These studies, however, base their analysis on controlled experimental data. A rhythmic effect on reductive alternations in natural speech has not been demonstrated yet.

It could therefore be the case that the influence of rhythm on reduction in the corpus is simply overridden by other factors that are more important in natural speech. In this event, the non-effect of rhythm would be due to modality and could possibly be found in a more controlled experimental setting. Only if rhythm does not turn out to be a significant factor in an experimental study either, the present study would be comparable to the aforementioned studies that demonstrate rhythmic effects for other alternations. If rhythm, however, does show an effect on reduction, this could be taken as evidence for exemplar-based storage and direct retrieval of reduced forms for production as argued in previous chapters.

Given the introduction above, a shadowing task was deemed to be the appropriate experimental method for three reasons. Firstly, in a shadowing task – the details of which will be explained in the next section – participants are given a fixed structure that they have to repeat. This allows for control over the rhythmic structure of the utterances that experiment participants produce. Secondly, participants receive the stimulus auditorily. This reduces the influence of written language on their production.

Thirdly, participants in a shadowing task are under a certain time pressure since they have to repeat the stimulus as fast as possible. On the one hand, this time pressure might increase the likelihood that participants produce reduced forms. This likelihood might be even more increased by the inclusion of reduced forms in the stimulus material. On the other hand, repetition with very short delays is important for the analysis of the factor frequency of occurrence since it partially eliminates the need for conceptual planning (cf. the next section). If frequency effects arise under these conditions, too, frequency effects are not to be situated in the planning process, but rather in the actual implementation.

As a shadowing task represents a rather artificial environment for speech production, it was deemed necessary to obtain additional, more natural data from the same speakers that had participated in the shadowing experiment. Hence, a second experiment, a reading task, was designed in order to elicit formal, yet relatively natural sounding adverb realisations from experiment participants. This task could also help verify possible frequency effects that are found in the shadowing task.

The following chapter describes these two experiments, the shadowing task and the reading task. It is structured as follows: In the next section, previous research that employed shadowing tasks as experimental methods and their relevance for this study will be presented (ch. 4.2.1). Then, in ch. 4.2.2, the methodology of the present shadowing task will be detailed, followed by the results of the experiment in ch. 4.2.3 and a discussion of the results. The design of this second experiment, the reading task, is detailed in ch. 4.3.1 and its results in ch. 4.3.2. The results of the reading experiment are then discussed in ch. 4.3.3. A general discussion and comparison of both experiments and a conclusion follows in ch. 4.4.

4.2 Shadowing experiment

4.2.1 Shadowing: an overview

In a shadowing task, participants receive an auditory stimulus and are asked to repeat ('shadow') the stimulus as soon as they hear it, i.e. without any delay and without waiting for the offset of the stimulus. In other words, a subject "is said to be shadowing an auditory message when he repeats it aloud word for word as he hears it" (Carey, 1971). Shadowing experiments have successfully been employed since the 1950s in the study of speech perception and the interaction between speech perception and speech production, "looking at the way the system analysed the incoming speech signal in real time" (Marslen-Wilson, 1985, 56).

Generalising the results from the literature, shadowing-based research on the production-perception-interface has focused on two areas: first, the speed of shadowing, i.e. the reaction latencies, and second, the role and extent of imitation of the stimulus in the shadowing process. In the following, the main results of these experiments and their relevance for the present study are discussed briefly before detailing the design of the shadowing experiment for *lega*-adverbs.

Chistovich and colleagues were among the first to employ shadowing tasks in phonetic-phonological research (Chistovich, 1960; Chistovich *et al.* , 1960, 1998). As stimuli, Chistovich used VCV-syllables in her studies. With regard to the speed of shadowing, her results showed that subjects were able to shadow the stimulus syllables at remarkably short response delays, sometimes at under 150ms. In fact, Chistovich found that there were two distinct groups of shadowers, "close" shadowers that displayed a response delay of about 150-200ms and "distant" shadowers whose response latencies ranged between 500ms and 1500ms. The difference between close and distant shadowers, according to Chistovich, also correlated with a difference in intelligibility. While there was nothing unusual in the speech of distant shadowers, the speech of close shadowers was slurred almost to the degree of incomprehensibility.

Porter & Castellanos (1980) replicated Chistovich's results, but did not find any difference with regard to clearness of speech among close and distant shadowers. In addition, they contrasted the shadowing of different VCV-syllables with a simple choice task where participants always had to produce the same VCV-structure when they heard the stimulus material no matter what the nature of the stimulus was. In general, participants were faster in the simple choice task than in the shadowing task, but only by about 30-80ms.

In a second experiment, Porter & Lubker (1980) found that subjects were able to shadow a given vowel-vowel-sequence at almost the same speed as when they had to produce the same structure in the simple choice task as a reaction to an identical stimulus. In other words, subjects were almost equally fast at shadowing e.g. an [ao]-sequence as at producing the same structure when it was a predefined response to a varying stimulus. Thus, it made hardly any difference, whether participants knew what they were going to produce before the onset of the stimulus or whether they had to analyse the incoming material first to a certain degree. Porter & Lubker (1980) therefore concluded that these short reaction latencies "strongly suggest[] overlapping of analysis and execution processes during shadowing."

It could be argued that the short reaction latencies that were obtained by the researchers cited in the previous paragraph are due to the nature of their stimuli, i.e. simple VCV-syllables, that are not particularly difficult to analyse, especially if experiment participants know beforehand what kind of structures they are going to hear. Marslen-Wilson (1985) therefore used connected prose as stimulus material and expected shadowers to perform at considerably higher response latencies. In his studies, he found the same two groups of "close" and "distant" shadowers among his subjects. Of his 65 subjects, eight were close shadowers, all of them women.[1] While even close shadowers were slower in reacting to the prose stimuli than to the simple VCV-structures employed by Porter & Castellanos (1980); Porter & Lubker (1980) and Chistovich (1960), they were still able to shadow the connected prose material at a delay of about 300ms.

Marslen-Wilson (1973) (reported in Marslen-Wilson 1985) showed via a post-experiment memory test that both "close and distant shadowers can recall information which could only have come from full comprehension of the shadowed

[1] Marslen-Wilson (1985) notes that he has no way of showing with his data whether this reflects a true sex difference.

material." Higher-level cognitive processes are therefore also active in close shadowers, but these subjects additionally seem to be able to "shortcut" their way from perception to production: They begin (re)production before they have fully analysed the incoming material, but an analysis nevertheless takes place afterwards, as evidenced by the results of the memory tasks.

Given the results from the literature discussed above, a divide between close shadowers and distant shadowers can be expected to emerge in the present study, too. Close shadowers will be especially of interest for the analysis of frequency of occurrence. Recall that the role of conceptual planning is taken to be reduced during production for close shadowers (Pluymaekers *et al.* , 2005). If close shadowers display effects of token frequency in their production, this could be interpreted as evidence that the locus of frequency effects is not in the process of conceptual planning and lexical selection, but rather in the later stages of speech production, e.g. in phonetic implementation. Crucially, since a shadowing task represents a rather unnatural form of production, a comparison of the results of close shadowers with the results of the same participants in the reading task is necessary in order to establish whether frequency effects are also found in other types of speech for these speakers.

The second area of research that has been explored in shadowing-based studies is the role and extent of imitation of the stimulus in the shadowing output. Here, the question is asked to what degree subjects reproduce the auditory stimulus exactly as it is sent out and what aspects of the stimulus are more readily shadowed than others. The fact that imitation of an incoming signal takes place at all is well known from accommodation theory and studies in interactional linguistics. Imitation in conversation (or "convergence") extends to different linguistic and non-linguistic features, such as speech rate, information density, pausing frequencies and length, gesture and posture (Giles *et al.* , 1991; Pickering & Garrod, 2004). The socio-interactional benefits of imitation have been hypothesised to be that "relative similarity in [different linguistic features] is viewed more positively than relative dissimilarity on the dimensions of social attractiveness" (Giles *et al.* , 1991, 19).

Goldinger (1998), however, showed that imitation also takes place in a shadowing task, i.e. in a laboratory setting where there is no socio-interactional gain from imitation. For his study, he combined a shadowing experiment with an AXB-task. In an AXB-paradigm, subjects have to compare the shadowing stimulus (X) with both a shadowed version of it (A) and a version that was repeated with several seconds time delay (B). Experiment participants then have to judge which version, A or B, resembles the original (X) the most. In Goldinger's study, subjects significantly more often judged the shadowed version to be a better imitation of the shadowing stimulus than the second version that was produced with time delay. Imitation therefore seems to be stronger in shadowing than in simple repetition (or "delayed shadowing" in Goldinger's terms).

According to Goldinger (1998), this difference in imitative behaviour between shadowing and simple repetition is evidence for an episodic, i.e. exemplar-based theory of memory and the lexicon. When subjects hear a word, this word leaves a trace in their memory. If subjects have to repeat the word back as soon as they hear it, the trace left by the word is still highly activated and therefore prone to be the model for the repeated version that subjects produce. If, however, there is a certain delay between the stimulus and the repetition, the memory trace the stimulus has left fades and the exemplar that is activated for production is likely to come from previously stored experience, but not directly from the shadowing stimulus.

Several studies have attempted to replicate Goldinger's results with varying degrees of success. On the one hand, Kappes *et al.* (2009) were unable to replicate the difference in imitative behaviour between shadowing and simple repetition. On the other hand, Shockley *et al.* (2004) replicated Goldinger's results concerning imitation from the combination of a shadowing task and an AXB-test. However, they did not compare these results to a simple repetition task.[2] Additionally, Shockley *et al.* (2004) investigated which aspects of the stimulus material were imitated and whether imitation was limited to phonologically relevant information or also extended to subphonemic, i.e. "phonologically irrelevant" aspects of the stimulus.

In one experiment, Shockley and colleagues artificially lengthened the Voice Onset Time (VOT) of the stimulus-initial stops. This lengthened VOT was deemed phonologically irrelevant as only the difference between aspiration and non-aspiration is contrastive in English, but not the degree of aspiration itself. Shockley *et al.* (2004) found that the artificially created overlong VOTs were indeed imitated by their experiment participants. However, participants only displayed a tendency to shadow overlong VOTs, but did not reproduce the full

[2] The main goal of the research by Fowler and colleagues cited in this and the following paragraph (Fowler *et al.* , 2003; Shockley *et al.* , 2004; Honorof *et al.* , 2011) is to show that phonological representations are gestural in nature. As this aspect of the shadowing-based literature is not of prime importance for the present study, it will not be dealt with further in this context.

amount of aspiration, i.e. even although subjects' VOTs for material based on stimuli with overlong VOTs were longer than those based on unaltered stimuli, their VOTs were never as long as they were in the stimulus material.

In another study by the same research group, Honorof *et al.* (2011) analysed the imitation of a different feature. In their study, participants had to shadow syllables containing "light" and "dark" l's, i.e. [l] and [ɫ], in unpredictable positions. In varieties of English that have a "dark l", this l-type only occurs in the syllable coda, but never in the syllable onset. Honorof *et al.* (2011) placed dark l's also in the onset of the syllables that made up their stimulus material. Subjects indeed displayed a significant tendency to shadow the different l-types correctly. However, participants did not produce categorically distinct l-versions or what could be called different allophones. Instead, they "darkened" their l's to a certain degree when the stimulus contained a dark l. As was the case with the shadowing of overlong VOTs in the study by Shockley *et al.* (2004), imitation was not complete, but only constituted a tendency.

Suprasegmental aspects of the stimulus have also been found to be imitated by listeners. In a comparison of natural and synthetic shadowing stimuli, Bailly (2003) showed that the F0-contour of the stimulus utterance was partially imitated by participants. Both Peschke *et al.* (2009) and Kappes *et al.* (2009) replicated this finding and reported significant imitation of F0-contours, too. Another variable in the study by Kappes *et al.* (2009) was the imitation of reduced and un-reduced schwa-syllables in several different experimental set-ups, among them a shadowing task and a simple repetition task. Subjects displayed a significant tendency to imitate the schwa-syllable as it was pronounced in the stimulus utterance. This tendency, however, was smaller in the shadowing task than in the simple response task where subjects repeated an auditory stimulus without the time pressure inherent in the shadowing task. Peschke *et al.* (2009) also showed that "subjects apparently 'copied' the speaking rate of the acoustic stimuli", i.e. imitated the speech rate of the speaker who had produced the stimulus material.

While Kappes *et al.* (2009) had included reduced schwa-syllables in their stimulus material, Brouwer *et al.* (2010) were the first to explicitly study the shadowing of reduced speech. They were also the first to use natural spontaneous speech as stimulus material. In their study, both word duration and the nature of individual segments (full vs. reduced) were used as measures of reduction. Their results show that imitation also happens when reduced speech is shadowed. The majority of both reduced and unreduced segments were shadowed as unreduced. Crucially, however, 32% of reduced segments were shadowed as reduced, in contrast to only

12% of unreduced segments. Participants thus produced more reduced segments when shadowing reduced speech than when shadowing unreduced speech. The results of Brouwer *et al.* (2010) therefore show that the shadowing of reduced speech is possible in principle. However, the limited percentage of "correctly" shadowed reduced segments shows (in accordance with the results of Shockley *et al.* (2004) and Honorof *et al.* (2011)) that imitation of reduced structures represents only a tendency and is never complete.

Brouwer *et al.* (2010) also found differences between the shadowing of reduced and unreduced speech with regard to error rates. For reduced stimulus items, error rates were significantly higher than for unreduced stimulus items. It thus seemed to be the case that participants had trouble recognising or parsing reduced forms. Additionally, the analysis of durational differences between stimulus and response elements showed that participants seemed to reconstruct the original form to a certain extent. In general, the words that participants produced tended to be longer than the corresponding words in the stimulus. However, this effect was larger for reduced stimulus items than for unreduced items, i.e. the relative difference between stimulus form and shadowed form was larger for reduced stimuli than for canonical stimuli. In sum, Brouwer *et al.* (2010) conclude that on the one hand "listeners align their productions when listening to reduced speech", but on the other hand "participants' productions [also] show a bias toward the canonical forms".

Summing up, the research cited in the previous paragraphs has shown that participants imitate certain aspects of the stimulus material that they shadow. This imitative behaviour also extends to the shadowing of reduced forms which is a prerequisite for the present study. The imitation, however, is not complete but only represents a tendency. Interestingly, the factors that influence the degree of imitation have hardly been investigated to a greater extent. While it is known, as mentioned above, that the type of stimulus influences the speed of shadowing, i.e. reaction latency, shadowing studies that have the degree of imitation as dependent variable rarely deal with what influences this imitation.

Goldinger (1998), in his combination of shadowing task and AXB-test, showed that word frequency has an effect on the degree of imitation: High-frequency words are imitated to a lesser degree than low-frequency words.[3] The interpretation that Goldinger (1998) offers again relies on an episodic model of memory.

[3] This results remains true even with an artificially created non-word lexicon where high- and low-frequency stimuli are unlikely to contain "traces" of their frequency that subjects could make use of (Goldinger, 1998, 258-260)

High-frequency words have a stronger representation in episodic memory than low-frequency words. Therefore, the trace left by the incoming high-frequency stimulus will not determine the shape of the response token to a great extent. Instead, for high-frequency words, the exemplars that had already been stored in memory before the stimulus left its trace will be activated for production. For low-frequency words that do not have as strong a memory representation the trace left by the incoming stimulus plays a much higher role in selecting the exemplar for production which in turn leads to a greater degree of imitation. Based on Goldinger's results, frequency of occurrence can be expected to play a role in the present study as well.

Nye & Fowler (2003) studied the role that knowledge of language structure in general plays in shadowing and imitation. In their study, they used non-word sentences as stimuli. These sentences differed in the degree to which they were an approximation of actual English words. The criterion by which this approximation was measured was the phonotactic validity of sound sequences in the stimulus words. The results of this study showed that subjects were faster in shadowing material that was closer to English than material that was more unlike English. Nye & Fowler (2003) therefore concluded that the availability of knowledge of language speeds up the shadowing process. With regard to imitation, a different result emerged from the task. Subjects shadowed the utterances that were further away from actual English more precisely: "shadowers who hear phonetic sequences that diverge from normal English phonotactics tend to mimic such utterances more precisely than utterances that structurally conform to English" (Nye & Fowler, 2003, 76).

Mitterer & Ernestus (2008) studied the role of phonological relevance for the degree of imitation. In their shadowing study, they employed Dutch nonwords as stimuli items that contained stops with different amount of prevoicing. While the difference between no versus some prevoicing is phonologically relevant in Dutch, differences in the actual amount of prevoicing are not. Mitterer & Ernestus (2008) found that participants indeed imitated the difference between no prevoicing vs. some prevoicing, but not the exact amount. They therefore concluded that the phonological relevance of a given feature has an effect on whether it is shadowed or not.[4] Phonologically relevant information is shadowed, phonologically irrelevant

[4] Mitterer & Ernestus (2008) also investigated the shadowing of two different Dutch /r/-allophones. They showed that participants mostly stuck to the variant they preferred in their actual speech, but were not slowed down in their shadowing when they heard a different variant.

information, however, only to a lesser degree.

Summing up, the shadowing-based research presented in this section has provided the basis for the present experiment on two levels. Firstly, there is a division between slow or "distant" shadowers and fast or "close" shadowers. Close shadowers are especially of interest for the study of frequency of occurrence since the role of conceptual planning in their speech production process can be assumed to be diminished which in turn can help locate the effect of frequency in speech production.

Secondly, shadowers imitate certain properties of the stimulus, albeit to varying degrees and never completely. Brouwer *et al.* (2010) show that this imitation extends to the shadowing of reduced forms. However, they do not investigate which factors influence the "correct" shadowing of reduction since their study was only intended to show *whether* reduction is imitated at all. Nevertheless, hypotheses about the shadowing of reduction can be deduced from the research on imitation in shadowing in general which showed that e.g. frequency of occurrence played an important role. These hypotheses and the general set-up of the experiment are the content of the following section.

4.2.2 Methodology

4.2.2.1 Experimental design

Based on the studies discussed in the previous section, the question arises: Which factors influence whether a reduced form is reproduced, i.e. shadowed "correctly" as reduced or whether it is reconstructed and produced as a full form?

Research question 1 Which factors influence the degree to which a reduced form is shadowed or not?

The hypotheses for the present study are on the one hand based on the literature, on the other hand on the corpus-based study in ch. 3. It is assumed that both the rhythmic environment a target adverb is embedded in and the frequency of occurrence of the target adverb influence whether a reduced adverb form is shadowed or not.

Hypothesis 1.1 A reduced form of a target adverb is more likely to be shadowed correctly if it fits the rhythmic context it is embedded in.

Hypothesis 1.2 A reduced form of a high frequency target adverb is less likely to be shadowed correctly than a reduced form of a low-frequency target adverb.

According to the first hypothesis, participants should be more likely to reproduce, i.e. correctly shadow a disyllabic reduced form when it is embedded in a trochaic context than when it is embedded in a dactylic context. The basis for this hypothesis is the assumption that reduced forms that match their rhythmic context are perceived as more natural and therefore reproduced more easily. The second hypothesis predicts a negative correlation of adverb token frequency and the likelihood of shadowing a reduced form: the more frequent an adverb is, the less likely it is that its reduced forms will be shadowed correctly. This hypothesis is based on Goldinger's (1998) results that show that high-frequency words are imitated to a lesser degree than low-frequency words.

The research questions formulated above only refer to the "correct" shadowing of reduced form. One might also change the perspective slightly and ask the question: Which factors influence the production of reduced forms in a shadowing task in general – independently of whether the stimulus item is already reduced or not?

Research question 2 Which factors influence the production of reduced forms in a shadowing task?

While this question of course allows for the degree of reduction in the stimulus to play a role, its scope is broader than that of the first research question formulated above as it also allows for the analysis of reduced forms that are not based on a reduced stimulus. The hypotheses for the second research question are analogous to those for the first question:

Hypothesis 2.1 The rhythmic context a target adverb is embedded in influences whether it is produced as reduced in the shadowing task.

Hypothesis 2.2 The token frequency of a target adverb influences whether it is produced as reduced in the shadowing task.

Framing the research question and hypotheses in this way broadens the focus of the study and allows for a more open statistical analysis.

In order to test the hypotheses formulated above, the experimental stimuli employed in this study have to be carefully constructed and selected. The stimuli that are commonly used for shadowing tasks differ along two dimensions: in their naturalness and in the linguistic level that they maximally constitute. In the majority of shadowing experiments, three types of stimuli are used that differ in the basic linguistic unit that is to be shadowed (cf. also the previous section).

Firstly, participants in several experiments had to shadow isolated sequences of sounds that typically formed a VCV-disyllable (e.g. Chistovich, 1960; Porter & Castellanos, 1980; Fowler *et al.* , 2003). Another kind of stimulus is constituted by isolated words (Goldinger, 1998; Radeau & Morais, 1990) or non-words (Kappes *et al.* , 2009; Mitterer & Ernestus, 2008). Finally, some studies like Davis *et al.* (1961) or Marslen-Wilson (1985) used connected prose as stimulus material. As the present study seeks to investigate among other things the influence rhythm on the shadowing of reduction, stimulus items have to reach at least sentence level length while isolated words or syllables are not an option.

With regard to the dimension of naturalness, most shadowing studies employ non-natural speech as stimuli. These kinds of stimuli are specifically constructed for the experiment and are then read by an experienced speaker or sometimes spoken freely after an amount of practice time. As mentioned above, Brouwer *et al.* (2010) were the first to use natural spontaneous speech in a shadowing task. By using natural speech, however, Brouwer *et al.* (2010) were not able to control the stimuli for linguistic factors such as speech rate or accentedness that might influence the shadowing process in general or the shadowing of reduction in particular.

Since the present study seeks to investigate the effect of frequency of occurrence and the rhythmic environment on the shadowing of reduction, the stimuli have to be specifically constructed for the experiment in order to be able to control for the predictors and other variables that might influence the shadowing of reduction. Such a high level of control would not be possible with stimuli selected from a corpus of spontaneous speech. The stimuli, however, have to be as natural-sounding as possible since heavy acoustic reduction is mainly a feature of natural spontaneous speech. Stimulus items, while constructed specifically for the experiment, therefore have to be practised by a native speaker of Icelandic and recorded in a colloquial or casual style.

The structure of the stimulus items is determined by the general object of study of this dissertation – Icelandic *lega*-adverbs – and by the two variables that the experiment seeks to explore – metrical rhythm and frequency of occurrence.

The critical stimuli that participants listen to and subsequently shadow therefore have to contain *lega*-adverbs of different token frequencies in different rhythmic embeddings and with different levels of reduction. The target items consist of a sample of the *lega*-adverbs that were studied in the corpus analysis in ch. 3 and that represent a broad range of token frequency values. A list of all adverb types that were selected for the shadowing task and their token frequency values in the corpus is given in Table 4.1:

Adverb type	**Token frequency**	**Frequency range**
náttúrlega	965	high
rosalega	283	
nefnilega	183	
ofsalega	88	mid
voðalega	64	
greinilega	47	
virkilega	32	low
sennilega	31	
svakalega	27	

Table 4.1: Adverb types with token frequencies

In order to reduce the number of control variables that had to be taken into account for the multivariate analysis, only adverb types that have a sonorant in the second syllable coda or no coda at all were taken into account. In the construction of the stimulus items, the target adverbs were then embedded in sentences with two different rhythmic structures. Each adverb was on the one hand placed in a trochaic environment, on the other hand in a dactylic environment. Each sentence then was to be recorded three times with the adverbs in varying degree of reduction, once as quadrisyllabic, once as trisyllabic and once as disyllabic. Importantly, "degree of reduction" was conceptualised as an inter-subject variable, i.e. participants heard every sentence only once in one degree of reduction.

Based on the exposition above, the main predictor variables for the experiment are "rhythmic environment" (trochaic / dactylic) and "adverb token frequency" along with "degree of reduction in the stimulus" (quadri-, tri-, disyllabic). The possible combinations of these factors are shown in Table 4.2. In total, 18 sentences were constructed that served as the basis for the critical stimuli, one for every of the nine adverb types in each of the two rhythmic conditions (see Ap-

		Degree of reduction		
Frequency	**Rhythm**	4syll	3syll	2syll
high	trochaic	3	3	3
	dactylic	3	3	3
mid	trochaic	3	3	3
	dactylic	3	3	3
low	trochaic	3	3	3
	dactylic	3	3	3

Table 4.2: Factor combinations

pendix 1 for a full list of stimulus items). Every critical stimulus was then recorded in three different versions: once with the adverb in a quadrisyllabic, once in a trisyllabic and once in a disyllabic form. Two examples of critical stimuli are given in (4.1) and (4.2). In the first example, the high-frequency adverb *nefnilega* is situated in a trochaic environment. In the second example the same adverb type is surrounded by dactyls.

(4.1) *ˈInga ˈRósa ˈvildi ˈnefnilega ˈekki ˈgera ˈþetta.*
Inga Rósa wanted NEFNILEGA not do that
'Inga Rósa actually didn't want to do that.'

(4.2) *ˈJóhanna ˈskrifaði ˈnefnilega ˈmikið um ˈpólitík.*
Jóhanna wrote NEFNILEGA much about politics
'Jóhanna actually wrote a lot about politics.'

In addition to the critical stimuli, 38 filler items were constructed (36 for the main part of the experiment, 2 for the familiarisation phase).

In the critical stimuli, the number of syllables preceding and following the adverb, respectively, was held constant at six. For the dactylic condition, this amounted to two dactyls following and preceding the target adverb whereas in the trochaic condition, the adverb was preceded and followed by three trochees. In total, target items contained 12 syllables plus the number of syllables with which the *lega*-adverb was realised in each case. The number of syllables that filler items consisted of ranged from 9 to 22. The mean number of syllables in filler items was 16, which equals the number of syllables of the target items that contained a quadrisyllabic adverb realisation.

In addition to the rhythmic structure surrounding the target adverb, several other factors were controlled for in the construction of critical stimuli. Firstly, it was attempted to hold backward transitional probability from the word following the target adverb to the target adverb constant. As mentioned in ch. 1.2 backward transitional probability has been established as the most important probabilistic factor for explaining phonetic reduction (Bell *et al.* , 2009). Although the results of the corpus-based analysis in ch. 3 did not fully corroborate the findings reported in the literature, it was nevertheless deemed important to limit the range of backward transitional probabilities for the bigrams in question.

For the calculation of the relevant probabilities, Google search results were used. Calculating transitional probabilities from Google counts could be considered problematic since Google counts are based on the number of pages a given item appears in, but not on the actual number of tokens of the item. Alternatively, the corpus that was the basis for the analysis in ch. 3 might have been used. This was, however, not an option since not every combination of target adverb and following word that was used for the experimental stimuli was found in the corpus. In the final critical stimuli, the logged backward transitional probabilities from the word following the target adverb to the target adverb ranged from -2.82 to -3.93 with a mean of -3.67.

Another factor that has been shown to influence acoustic reduction and that was partially controlled for in the design of the critical stimuli was the identity of the following segment. As shown by e.g. Jurafsky *et al.* (1998), words are more reduced when the onset of the following word is a consonant than when it is a vowel. For Icelandic, Final Vowel Deletion, which could apply to the final [a] of the suffix if the following sound is a vowel, had to be ruled out as a factor. Therefore the onset of the word that followed the target adverb was always a consonant. The exact identity of the consonant, however, could not be kept constant since this would have led to larger differences in backward transitional probabilities.

4.2.2.2 Stimulus preparation

Stimulus items for the shadowing task were recorded in a sound proof booth located in the experimental laboratory of the Department of Psychology at the University of Iceland. The speaker was a female native speaker of Icelandic. Stimuli were recorded digitally with a AKG HSD 171 headset over the course of several days. After each session, recordings were inspected by the experimenter and where necessary additional recordings were made. Stimuli should sound as naturally as possible and be of roughly the same speech rate.

Since the corpus-based study in ch. 3 has shown that reduced adverb variants preferably in higher speech rate, it could be argued that a constant speech rate across different versions of target items makes the sentences that contain reduced adverb forms more unnatural. However, recording different versions of a target item in different speech rates would have introduced an additional variable that would have been difficult to control for in the statistical analysis. The mean speech rate of the stimuli was ca. 4.54 syllables per second, which is somewhat lower than the rate of speech in a colloquial conversation.

4.2.2.3 Participants and Procedure

36 native speakers of Icelandic participated in the experiment. Most of the participants were undergraduate students at the University of Iceland in Reykjavik. Subjects took part voluntarily in the experiment and were paid ISK 1000 (ca. €6.60) for their participation. The experiment took place in September 2012 in the sound-proof booth at the psychological laboratory at the University of Iceland.

The experiment participants were seated in front of a computer where they received instructions on screen as to what their task was. Participants were informed that they were about to hear a number of sentences which they then had to reproduce. They were told that they had to start repeating the sentences as soon as they started hearing them, i.e. without waiting for the end of the utterance. The introduction explicitly did not contain the instruction to shadow the utterances exactly as they were heard. Stimulus items were presented through a AKG HSD 171 headset and recorded digitally via a M-Audio Fast Track Pro interface with the same headset.

The experiment started with a training block of two filler items that were repeated three times each. The actual experiment proceeded in three blocks of 18 items each (12 filler items and 6 target items). Target items were spread equally across blocks so that no adverb type occurred twice in one block and that each block contained the same number of rhythmic and reduction conditions. Each item was introduced by a auditory signal. After each item there was a pause of two seconds. Blocks were separated by a pause of 60 seconds.

After they had performed both the shadowing and the reading task which directly followed the first experiment (cf. ch. 4.3.1.1), participants were asked about whether they could identify the goal of the experiment or whether they had noticed anything special during the course of the tasks. Most participants did not seem to have noticed what the experiment had been about. Two subjects reported they had noticed the speaker from the recording sometimes shortened adverbs. As the results from these participants did not differ significantly from those of other subjects they were nevertheless retained in the analysis. One participant reported after the experiment that she was familiar with the researcher's subject, having attended a talk on the topic half a year earlier. This subject was therefore excluded from the statistical analysis.

4.2.2.4 Annotation

All items produced by participants during the experiment were cut with Audacity 1.3.13 software and subsequently annotated for a variety of factors in Praat. Several parameters were annotated for in both target items and filler items, others only in target items.

Errors Errors could be of several different kinds. For the most part it was counted as an error when participants deviated in a major way from the target utterance, i.e. left out a part of the sentence or did not finish it. Similarly, self-repetitions were counted as an error. Smaller deviations, however, that were only due to the substitution of one or two sounds, were not included in the error list. This was the case, for example, when participants realised the word *alltof* 'all too (much)' instead of the word *alltaf* 'always'.

Hesitations The second parameter that was applied to both target and filler items was whether hesitations occurred in the utterance and if so how long they were. Following Goldman-Eisler (1968), pauses in the speech signal were counted as hesitations when they exceeded 0.2 seconds in length. For target items, hesitations were additionally classified as to their position with regard to the target adverb. Hesitations could occur before the adverb, directly before the adverb, directly after the adverb or further behind the adverb.

Reaction latency and speech rate Participants' reaction latency was measured from the onset of the target item to the onset of participants' utterance. Then, the total length of the utterance was measured in order to determine participants' rate of speech. speech rate was calculated by dividing total utterance duration by the number of phonological syllables in the sentence, except for the adverb itself where the phonetic number of syllables was used.

Adverb duration and number of syllables In addition to these four measures, several parameters that concerned participants' realisations of target adverbs were noted for target items only. Firstly the adverb's duration was measured as were the duration of the adverb's stem and suffix, respectively. Secondly, the number of syllables with which the adverb was realised was noted. As has already been discussed in ch. 3.1.2, it can be difficult to determine from the acoustic signal how many syllables a given realisation of the suffix -*lega* contains. The reader is referred to that chapter for the guidelines that were used in the annotation process.

Token frequency and rhythmic environment For every token, the rhythmic environment the target adverb was embedded in (trochaic or dactylic) was noted as well as the frequency of occurrence of the target adverb in the corpus that was used in ch. 3.

The measurements detailed in this section were subsequently fed into the R statistical software where the statisticial analyses presented in the next sections were calculated. Several participants had to be excluded from the statistical analysis for various reasons. As mentioned above, one participant was familiar with the experimenter's previous work. In two cases, technical failures in the experimental software occurred. A fourth participant was unable to perform the shadowing task correctly. Another participant reported a hearing impairment in one ear. A sixth participant had to be excluded since she had not lived in Iceland for most of her teenage years.

The last two participants were excluded because they differed greatly from other participants in their shadowing behaviour. Subject no. 22 in almost all cases started shadowing the target utterance after the stimulus utterance was completed. Subject no. 31 showed a very high number of errors, both in filler and in target items and was therefore excluded as well. After this filtering-out process, 28 participants remained that were included in the statistical analyses, yielding 1486 tokens of shadowed utterances. 478 of these tokens were realisations of critical stimuli.

4.2.3 Results

4.2.3.1 Reaction latency and speech rate

Generalising over all 28 participants that were included in the final analysis, the mean **reaction latency** was 1.41 seconds. This places the mean onset of participants' utterance at about half of the stimulus utterance. (Recall that one participant was excluded from the analysis because she consistently began her production after the stimulus utterance was finished (cf. ch. 4.2.2.4).) A number of participants in single instances started shadowing after the end of the stimulus utterance. In most of these cases, it had taken participants too long to finish the previous utterance, e.g. because of an error. These items were kept in the analysis. No difference was found between target and filler items with regard to reaction latency according to a t-test ($t = 0.8255$, $df = 842$, $p = 0.41$). Participants thus started shadowing target and filler items with roughly the same speed. For the multivariate analysis presentsed in the following sections, the centralised log values of reaction latencies were used.

The mean **speech rate** for the 28 participants included in the analysis was 5.12 syllables per second. This is a rather low value, but somewhat faster than the average speech rate of the stimulus items which was 4.55 syllables per second. As with reaction latencies, no difference in speech rate was found between target items and filler items according to a t-test ($t = -0.1053$, $df = 571$, $p = 0.92$). Recall again that speech rate was only measured for those utterances that did not contain any hesitations or errors. Based on the results of the corpus-based study and the reports in the literature (cf. e.g. Ernestus, 2014; Jurafsky *et al.* , 1998), speech rate could be expected to influence adverb reduction with higher speech rates correlating with a higher degree of reduction. Participants' speech rate in turn could be influenced by features of the experiment, especially the speech rate of the stimulus. Therefore, it was necessary to study which factors affected participants' speech rate.

Trial and trial round did not correlate with participants' rate of speech. Experiment participants thus neither slowed down nor sped up in the course of the experiment. speech rate, however, correlated positively with reaction latency ($r = 0.51$, $t = 16.2458$, $df = 747$, $p < 0.001$). The longer it took participants to begin shadowing the stimulus, i.e. the higher their reactions latency was, the faster they spoke on average. This correlation is probably due to the time pressure inherent in the task. Participants might have felt they had to complete their production quickly before they heard the next stimulus item. Therefore, they spoke faster when they felt they had only little time left before the onset of the next stimulus item.

Participants' speech rate also correlated positively with the speech rate of the stimulus (r = 0.57 for filler items, r = 0.34 for critical stimuli). While it had been attempted to hold the speech rate of stimulus items constant, there was still some variation in stimulus speech rate and participants seemed to be sensitive to this variation. This correlation fits well with both findings from research on accommodation and with results from previous shadowing studies like Peschke *et al.* (2009) which found that "subjects apparently 'copied' the speaking rate of the acoustic stimuli."

In order to reduce correlations between variables in the multi-variate analyses presented in the following chapters, the log values of participants' speech rate were residualised both for reaction latency and for stimulus speech rate using simple linear regression models in both cases. Following this procedure, the values for speech rate were centralised.

4.2.3.2 Error and hesitation rate

Both the rate of errors and the rate of hesitations participants displayed in their utterances can be taken as a sign of difficulties with parsing the stimulus items (Brouwer *et al.* , 2010). Therefore, these measures can be used as indicators of whether participants had trouble shadowing items that contained reduced forms. Out of 1486 items, participants produced an **error** in 185 cases.[5] Table 4.3 shows the distribution of errors across item types:

	With error	**Without error**
Target items	79	399
Filler items	106	902

Table 4.3: Errors by item type

Of the 79 errors participants produced while shadowing target items, 35 related to the target adverb, i.e. participants made an error while producing the adverb or did not produce an adverb at all.

The likelihood of an error was modelled with a logistic mixed-effects model with "subject" as random effect. The model included three fixed effect predictors: first, whether a given utterance contained a hesitation and second, whether the

[5] For the definition of what counted as a production error cf. ch. 4.2.2.4.

utterance represented a filler or a target item as fixed effect predictors. Since error rates seemed to be higher both for short reaction latencies (< 500ms) and for long latencies (> 1500ms), the square of reaction latencies was included as a third predictor in the model. The effect of speech rate on error production could not be modelled as speech rate was only measured for utterances that did not contain errors or hesitations.

According to the final model, all three predictors emerged as significant. The likelihood of an error thus correlated significantly with the occurrence of a hesitation in the utterance ($t = 9.841$, $p < 0.001$), whether the utterance was a target or a filler item ($t = 3.514$, $p < 0.001$) and with the square of reaction latencies ($t = 3.718$, $p < 0.001$). Figure 4.1 shows the relation between hesitations and errors:

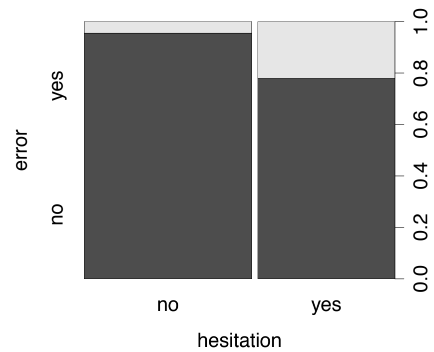

Figure 4.1: Relation of items with errors and items with hesitations

Utterances with an error contain significantly more hesitations than utterances where participants did not make an error. Error production is thus correlated positively with hesitation rate.

According to the statistical model, target items contained significantly more errors than filler items. This difference can be accounted for by to those stimulus items that contained reduced, i.e. tri- and disyllabic adverb forms. When the data set is limited to filler items and target items containing quadrisyllabic, unreduced adverb forms only, the effect of "target vs. filler" disappears.[6] The problems participants seemed to have with target items thus did not stem from the makeup of the target items per se, but from the reduction present in some of them. However, for the target sentence that contained the adverb type *svakalega*

[6] For the differences between stimulus items with varying degrees of reduction cf. ch. 4.2.3.3.

in a trochaic environment, error rates were high also for unreduced adverb realisations. This points to a general problem participants had in parsing the stimulus utterance. Therefore, realisations of the item were excluded from the multivariate analyses conducted in the following chapters.

In 17 utterances, participants did not produce an adverb at all. Five of those non-realisations occurred with the stimulus item discussed in the previous paragraph that contained the adverb *svakalega* in a trochaic rhythmic embedding. In ten of the remaining twelve cases of non-realisations, the adverb in the stimulus was disyllabic which is indicative of the special status of disyllabic stimulus adverbs discussed in greater detail in the next sections. This finding corroborates the results of Brouwer *et al.* (2010) who find a higher error rate for reduced target items than for unreduced target items. The cases where participants did not produce an adverb at all in the present experiment can be explained by the assumption that participants did not seem to recognise the adverb in question. Interestingly, in two cases, participants produced the word *mjög* 'very' instead of a disyllabic intensifier adverb in the stimulus. Participants thus were able to predict from the context that the word they did not understand correctly must have been an intensifier modifying the following word.

Out of 1486 utterances, 669 contained one or more **hesitations**. Taking into account that some utterances contained up to three hesitations, this amounts to a total of 810 hesitations. The rate of sentences with hesitations in them correlated significantly with error rate as shown in the previous paragraphs. The number of hesitations, however, varied greatly between subjects. Subject 8 produced only 10 hesitations over the course of their shadowing. The utterances of subjects 20 and 36, in comparison, contained 51 hesitations each. Interestingly, in contrast to error rate, there was no difference between filler and target items with regard to the number of hesitations as shown in Table 4.4:

	With hesitation(s)	**Without hesitation(s)**
Target items	271	207
Filler items	546	462

Table 4.4: Items with hesitations by item type

A logistic mixed-effects model predicting the likelihood of a hesitation was fitted to the data with “subject” as random factor. As fixed-effects predictors, type of item (target or filler), the log of reaction latency, presence of an error and length of stimulus utterance in syllables. No significant effect for the variable item type was found.

The model thus confirmed that the likelihood of a hesitation was not greater for target items than for filler items. Significant effects emerged for the log of reaction latency ($t = -8.223$, $p < 0.001$) and for whether the utterance contained an error ($t = 2.542$, $p < 0.01$). Both effects were also present for the model predicting error rate (cf. above). Additionally, a significant effect was found for the length of the stimulus utterance measured in no. of syllables ($t = 7.063$, $p < 0.001$).

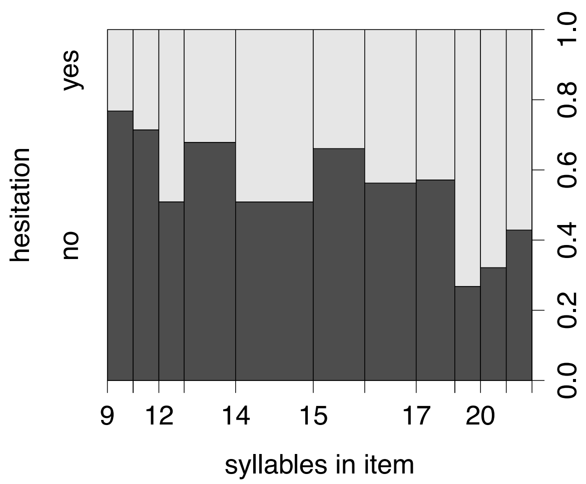

Figure 4.2: Relation of likelihood of a hesitation and length of stimulus utterance

As the above figure shows, the longer the stimulus utterance was, the greater the likelihood was of a hesitation occurring. Since only filler items exceeded a length of 16 syllables, the effect for “length of stimulus” probably explains the lack of an effect for item type.

4.2.3.3 Number of syllables

The phonetic number of syllables constituted the first operationalisation of reduction in the shadowing task. Figure 4.3 gives an overview over how often target adverbs were realised with a given number of syllables.[7] As the figure shows, participants were rather conservative in their adverb production. If they had simply shadowed the target adverb as it was in the stimulus, an equal number of di-, tri- and quadrisyllabic adverb realisations would have been expected to occur in the data.

Instead, the majority of the adverbs participants realised were quadrisyllabic. Trisyllabic adverb realisations occurred much less often and disyllabic adverb forms were even more rare in the data. In a few instances, participants produced hypercorrect pentasyllabic realisations of the adverb *náttúrlega* which has a sideform *náttúrulega* that contains five syllables.

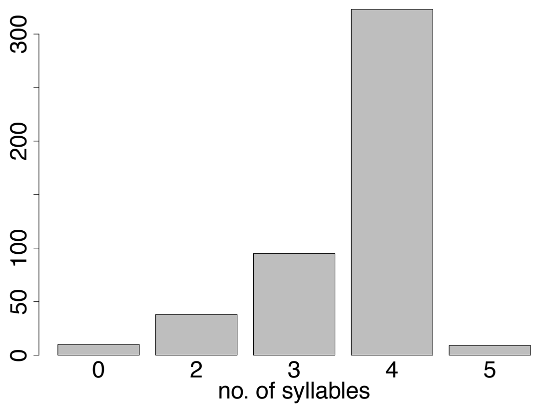

Figure 4.3: Distribution of syllabic types in participants' productions

In order to determine which factors influenced participants' adverb realisations, the data were modelled with a linear mixed-effects model. The dependent variable was the phonetic number of syllables target adverbs were produced with. As fixed-effect predictor variables, the number of syllables in the stimulus adverb (degree of stimulus reduction), the rhythmic environment, the residualised log of speech rate, the log of adverb token frequencies, the log of reaction latency and two-way interactions between these factors were included in the model.[8] Participant-ID and adverb type were included as random-effect predictors.

[7] "Zero syllables" denotes instances where participants did not produce an adverb at all (cf. the previous section).

[8] As speech rate was considered to be an important predictor, only those item were taken into the analysis, that did not contain errors or hesitations.

As the random variable "adverb type" did not improve the model, it was dropped during the model fitting process. Insignificant predictors were eliminated in a step-wise evaluation process. The final model with an R^2 of 0.51 is displayed in Figure 4.4. As the model shows, several variables and interactions between variables had a significant effect on the number of syllables in participants adverb realisations.[9] In the following, the effect or non-effect of the different predictor variables is discussed in more detail.

```
 AIC   BIC logLik deviance REMLdev
 352 403.5   -161    285.4     322
Random effects:
 Groups   Name        Variance Std.Dev.
 subj     (Intercept) 0.037644 0.19402
 Residual             0.193528 0.43992
 groups: subj, 28

Fixed effects:
                             Estimate Std. Error t value
(Intercept)                   4.94198    0.52562   9.402
reaction latency             -0.50979    0.27931  -1.825
speechrate                    1.64759    0.42362   3.889
speechrate stimulus          -0.29201    0.09345  -3.125
no. of syll in stim (two)    -0.98096    0.13135  -7.468
token frequency              -0.14672    0.05518  -2.659
accentedness (yes)           -0.80726    0.36000  -2.242
adverb function (sentence)   -0.05470    0.06691  -0.818
reaction latency:speechrate  -2.09710    0.87671  -2.392
reaction latency:frequency    0.12392    0.06004   2.064
reaction latency:function    -0.48941    0.12565  -3.895
syll stim (two):acc (yes)     0.54395    0.15333   3.548
frequency:acc                 0.16336    0.06755   2.418
```

Figure 4.4: Final model for the dependent variable "no. of syllables"

Metrical rhythm The rhythmic environment that target adverbs were embedded in did not have a significant effect on syllabic reduction in the shadowing task. This variable was therefore dropped during the model fitting process. Figure 4.5 shows how adverbs were realised in trochaic and dactylic environments, respectively. If there had been an effect of metrical rhythm on the phonetic number of syllables in the shadowing task, more disyllabic than trisyllabic adverbs would have been expected in the trochaic environment and more trisyllabic than disyllabic adverbs in the dactylic condition. However, as the above figure shows, the distribution of different syllabic types is largely identical across the two rhythmic conditions.

[9] Recall that factors were considered to be significant in the statistical model if their absolute t-value exceeded 2 (Baayen, 2008).

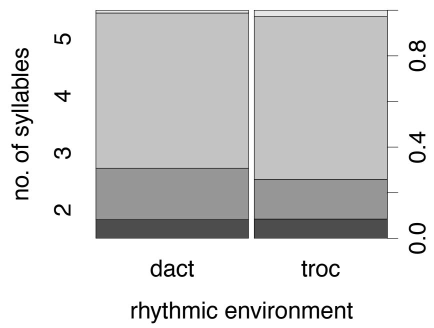

Figure 4.5: Relation of rhythmic environment and no. of syllables

Token frequency Log-transformed token frequency was a significant factor in the statistical model both on its own (t = −2.659) and in interaction with reaction latency and accentedness. Figure 4.6 shows the effect of frequency on syllabic reduction:

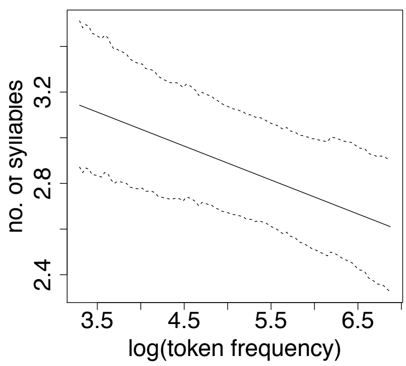

Figure 4.6: Effect of token frequency on syllabic reduction

The higher the token frequency of the stimulus adverb, the more disyllabic realisations were found. Token frequency therefore correlated positively with the degree of reduction. The two interactions of frequency of occurrence with other factors, however, showed that the frequency effect was not equally strong for all environments.

Firstly, frequency of occurrence interacted significantly with the variable accentedness (t = 2.418). The interaction is displayed graphically in Figure 4.7:

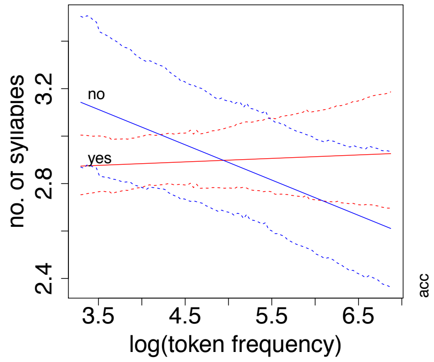

Figure 4.7: Interaction of token frequency and accentedness

As the above figure shows, the correlation of frequency of occurrence and reduction was only true for unaccented adverbs. When adverbs were realised with a pitch accent, higher adverb frequency of occurrence did not lead to a greater degree of reduction.

Secondly, token frequency displayed a significant interaction with log of reaction latency (t = 2.064). This interaction shows that token frequency only affected the degree of syllabic reduction for shorter reaction latencies. When experiment participants started shadowing early, frequency of occurrence played a significant role. However, when participants were slow in their reaction to the stimulus, high token frequency did not correlate with a greater degree of syllabic reduction.

No. of syllables in the stimulus The degree of stimulus reduction, i.e. the number of syllables in the stimulus adverb, had a significant effect on syllabic reduction in participants' adverb realisations. Recall that stimulus adverbs were either disyllabic, trisyllabic or quadrisyllabic. In the model fitting process, however, no difference emerged between quadrisyllabic stimulus adverbs on the one hand and trisyllabic stimulus adverbs on the other hand.

The number of tri- and quadrisyllabic adverbs, respectively, produced by participants was approximately even across the two conditions while there were hardly any disyllabic realisations. Figure 4.8 shows how different syllabic types were distributed in participants' adverb realisations across different degrees of reduction in the stimulus.

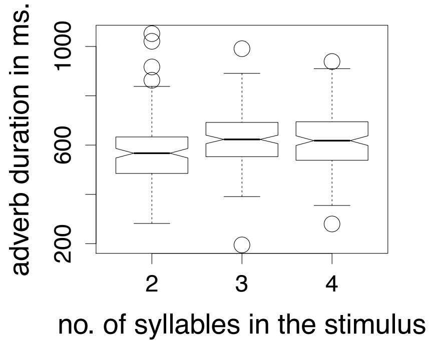

Figure 4.8: Relation of no. of syllables in the stimulus adverb and no. of syllables in the shadowed adverb

In order to simplify the statistical model, the variable "no. of syllables in the stimulus adverb" was releveled so that it only contained two levels: "disyllabic stimulus" and "tri- or quadrisyllabic stimulus". This releveling did not alter the fit of the model significantly and was therefore kept in the final model.

The transformed variable had a rather large effect on syllabic reduction ($t = -7.468$). Figure 4.9 displays this effect graphically:

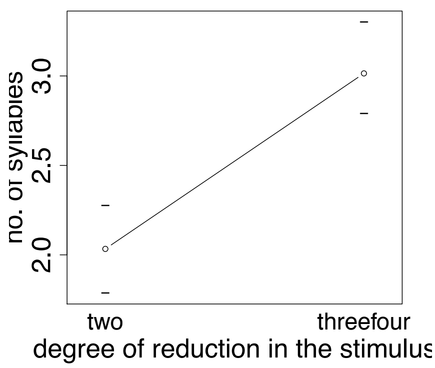

Figure 4.9: Effect of degree of stimulus reduction on syllabic reduction

As was already evident from Figure 4.8, participants produced significantly more disyllabic forms when the stimulus was disyllabic than when the stimulus was tri- or quadrisyllabic. In fact, over 70% of disyllabic realisations were found for disyllabic stimulus adverbs. Participants thus hardly ever produced disyllabic forms when the stimulus adverb contained more than two syllables.

Speech rate Participants' speech rate was a significant factor both on its own and in interaction with reaction latency. Recall that the variable "speech rate" was residualised for both reaction latency and the speech rate of the stimulus utterance. The main effect for speech rate (t = 3.889) is displayed in Figure 4.10. Higher speech rates seemed to correlate with a lower degree of reduction. The faster participants spoke, the less reduced forms they produced. Reduced forms therefore seemed to only occur with slower speech rates.

The interaction of speech rate and reaction latency (t = −2.392), however, shows that this was only partially the case. For larger reaction latencies, higher speech rates did in fact facilitate reduction. When participants were slow to react to the stimulus and spoke fast, they produced more reduced forms. When they reacted fast, reduced forms only appeared with slower speech rates.

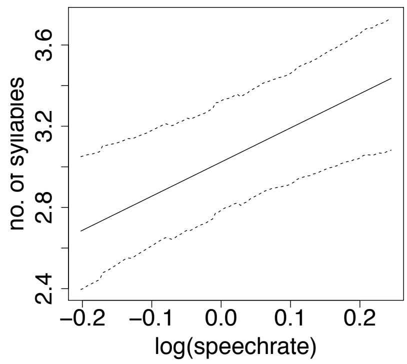

Figure 4.10: Effect of speech rate on syllabic reduction

Reaction latency The factor "reaction latency" was only marginally significant on its own (t = −1.825), but participated in several significant interactions. Apart from the two interactions that have already been presented above, the variable reaction latency displayed a third significant interaction with adverb function. Figure 4.11 shows the tendency found for reaction latency graphically.

The interaction of reaction latency and adverb function pictured in 4.12 shows that reaction latency mattered only for sentence adverbs, but not for intensifier adverbs. Sentence adverbs reduced more with higher reaction latencies than when participants started their response early. No such difference, however, was found for intensifier adverbs.

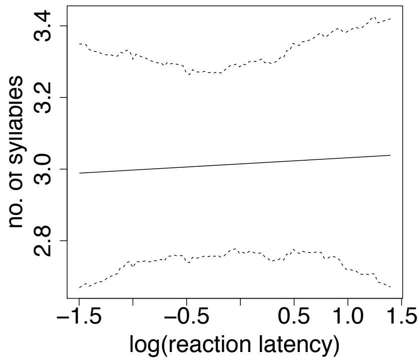

Figure 4.11: Relation of reaction latency and no. of phonetic syllables

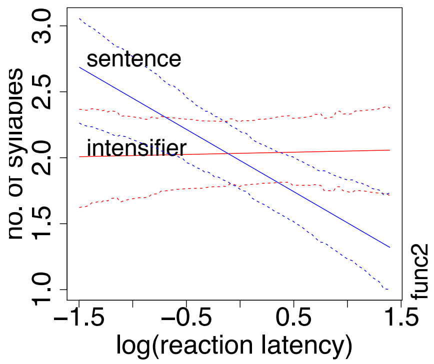

Figure 4.12: Interaction of reaction latency and adverb function

Stimulus speech rate The speech rate of the stimulus utterance had a significant effect on syllabic reduction, independently of participants' own speech rate (t = −3.125). Recall again that participants speech rate was residualised for stimulus speech rate before the model fitting process.

The effect of stimulus speech rate is displayed in Figure 4.13. As the figure shows, a higher speech rate in the stimulus correlated with a higher degree of syllabic reduction. The faster the stimulus utterance was, the more reduced forms participants produced.

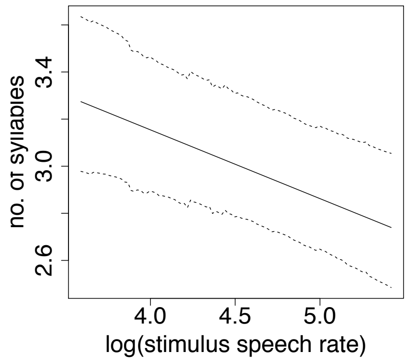

Figure 4.13: Effect of stimulus speech rate on syllabic reduction

Accentedness The variable "accentedness" was significant both on its own ($t = -2.242$) and in interaction with frequency of occurrence (cf. above) and the degree of reduction in the stimulus ($t = 3.548$). The main effect for accentedness is displayed in the following figure:

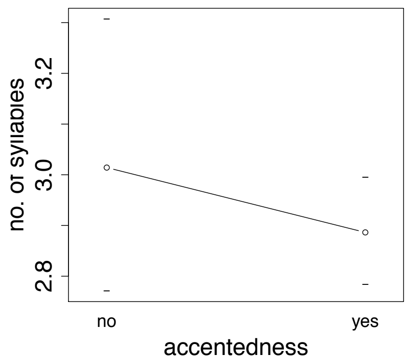

Figure 4.14: Effect of accentedness on syllabic reduction

The effect suggests that accented adverbs were realised with fewer syllables than adverbs that did not receive a pitch accent. The interaction of accentedness and the number of syllables in the stimulus (cf. Fig. 4.15), however, shows that this rather counterintuitive correlation is only partially true: There was no significant difference between accented and unaccented adverbs when the stimulus was tri- or quadrisyllabic. However, when the stimulus was disyllabic, accented adverbs were realised with significantly more syllables than unaccented adverbs. The variable "accentedness" therefore only plays a role for disyllabic stimulus adverbs.

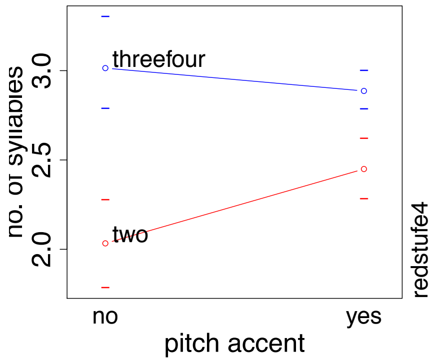

Figure 4.15: Interaction of accentedness and degree of reduction in the stimulus

Phonological-structural variables Two variables that referred to the phonological structure of the adverb stem were included in the initial model, the manner of articulation of the second syllable onset and the place of articulation of the same segment. Neither of these variables, however, affected syllabic reduction in the shadowing task significantly and they were therefore dropped from the final model. Neither the manner of articulation of the second syllable onset nor its place of articulation thus influenced with how many syllables target adverbs were produced by participants.

Summing up, participants in general were rather conservative in their adverb realisations. In the majority of cases, they produced quadrisyllabic adverb forms, independently of the degree of reduction of the stimulus adverb. In the statistical analysis, several variables emerged as significant predictors of syllabic reduction in the shadowing task. The degree of reduction in the stimulus adverb influenced adverb production heavily. Participants produced disyllabic realisations almost exclusively when the adverb in the stimulus was also disyllabic. The statistical model also showed an effect for the variable frequency of occurrence. Speech rate affected participants' adverb realisations in such a way that reduced forms occurred mostly with lower speech rates. Phonological-structural variables did not influence syllabic reduction in the shadowing task.

4.2.3.4 Duration

The second dependent variable analysed is the duration of the target adverbs that participants produced. After the removal of two outlier values that had a duration of more than 1500 ms,[10] adverb durations ranged from 195 to 1052 milliseconds with a mean of 601 milliseconds (cf. Figure 4.16). In general, the more syllables an adverb was produced with, the longer it was durationally. The correlation of the two variables "number of syllables" and "duration" was quite strong ($r = 0.48$) and highly significant ($p < 0.001$).

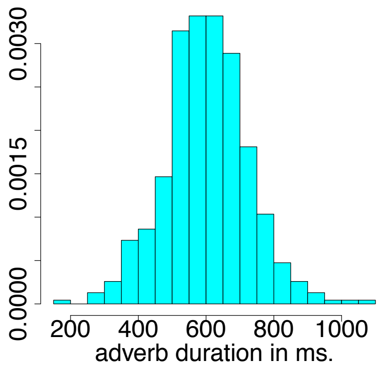

Figure 4.16: Histogram of adverb durations

Adverb duration also correlated significantly with the duration of the corresponding stimulus adverb ($r = 0.33$, $p < 0.001$). In general, however, the adverbs that participants produced were significantly shorter than the adverbs in the stimulus according to a t-test ($t = 4.25$, $df = 909$, $p < 0.001$, cf. Figure 4.17). While stimulus adverbs had a mean duration of 641ms, the adverbs that participants produced in the task had a mean duration of 609ms.

This difference may seem surprising given that it was shown in ch. 4.2.3.3 that the adverbs that participants shadowed generally contained more syllables than the stimulus adverbs. In order to rule out confounding effects of speech rate, adverb durations were residualised for participant speech rate and stimulus speech rate, respectively. After the residualisation, the length difference between stimulus adverbs and participants' adverb realisations still persisted.

[10] Outliers were removed in accordance with Baayen (2008, 266) who advises against the removal of extreme values without inspecting the distribution for individual subjects or items first. Durations of more than 1500 ms turned out to be both extreme values when generalising over all participants and for the individual participants that produced them.

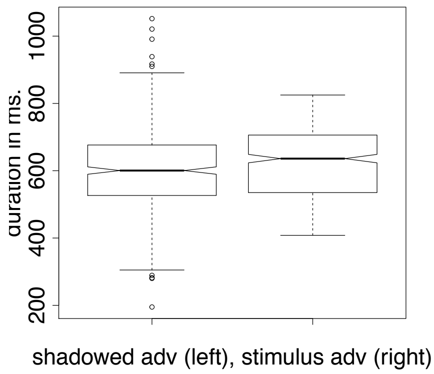

Figure 4.17: Duration of stimulus adverbs and shadowed adverbs

In the next step, the durational values of shadowed adverbs were compared to each other on the basis of how many syllables the stimulus adverb contained. Figure 4.18 displays this comparison graphically. Adverb realisations that were based on tri- and quadrisyllabic stimuli were significantly shorter than the adverb in the stimulus. Adverb realisations that were based on a disyllabic stimulus, however, were significantly longer in duration than the stimulus adverb. Since disyllabic adverbs were mostly shadowed as tri- or quadrisyllabic, this difference is not surprising.

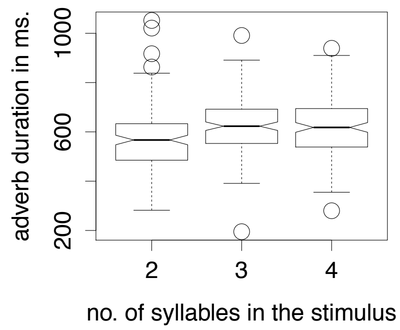

Figure 4.18: Adverb duration based on the number of syllables of the stimulus adverb

Shadowed adverbs that had the same number of syllables did not differ in length depending on how many syllables the stimulus adverb contained. The duration of, e.g., quadrisyllabic realisations, thus, did not vary significantly according to whether they were shadowed from a quadri-, tri- or disyllabic stimulus, as shown in Figure 4.19:

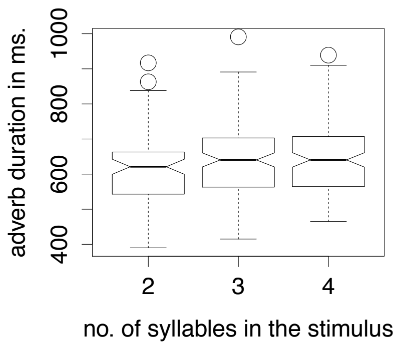

Figure 4.19: Duration of quadrisyllabic adverbs by the number of syllables of the stimulus adverb

For the multivariate analysis, a linear mixed-effects model was fitted to the data predicting the duration of shadowed adverbs. The initial model contained the variables "subject" and "adverb type" as random effects. The rhythmic environment, log values of the residualised speech rate, log values of reaction latency, the speech rate of the stimulus utterance, the number of syllables in the stimulus adverb, adverb token frequencies and two structural-phonological variables (place and manner of articulation of the onset of the second syllable) were included as fixed-effect predictors. The final model ($R^2 = 0.66$) is shown in Figure 4.20.

Metrical rhythm The rhythmic environment did not significantly affect adverb duration. While the mean duration for adverbs in trochaic structures was 617 ms, mean adverb duration was 601 ms in dactylic environments.

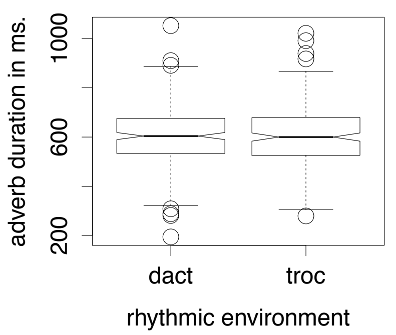

Figure 4.21: Rhythmic environment and adverb duration

```
 AIC  BIC logLik deviance REMLdev
 2442 2504  -1203     2527    2406
Random effects:
 Groups   Name        Variance Std.Dev.
 subj     (Intercept)  453.51  21.296
 Residual             4425.34  66.523
groups: subj, 28

Fixed effects:
                             Estimate Std. Error t value
(Intercept)                  1128.198    145.646   7.746
reaction latency              -92.909     13.364  -6.952
speechrate                   -368.158     63.961  -5.756
speechrate stimulus           -62.379     14.983  -4.163
rhythm                          2.180      9.937   0.219
no. of syll in stim (two)    -107.971     20.023  -5.392
manner of art.                417.605     96.010   4.350
place of art.               -1519.180    511.048  -2.973
token frequency               -66.754     33.588  -1.987
accentedness (yes)             17.755     16.121   1.101
adverb function (sentence)    -97.836     30.234  -3.236
reaction latency:function     -40.274     18.696  -2.154
speechrate:manner             245.388    115.799   2.119
syll stim:acc                  71.287     23.395   3.047
manner:frequency              -71.901     16.473  -4.365
place:frequency               419.676    149.723   2.803
```

Figure 4.20: Final model for the dependent variable "adverb duration"

Token frequency The adverbs' frequency of occurrence was a marginally significant factor both on its own (t = -1.987, cf. Figure 4.22) and in interaction with two structural-phonological factors (cf. below).

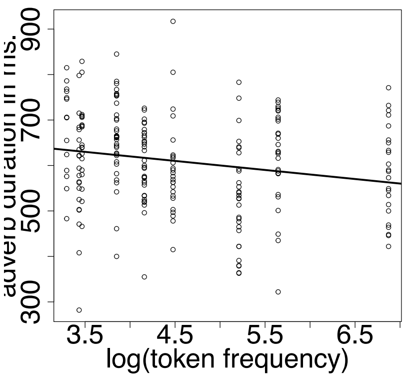

Figure 4.22: Effect of frequency of occurrence on adverb duration

The higher the adverb token frequency was, the shorter participants' adverb realisations in general were. Token frequency thus correlated negatively with adverb duration.

No. of syllables in the stimulus The degree of reduction in the stimulus adverb influenced adverb duration significantly ($t = -5.392$) as shown in Figure 4.23. Recall that this variable was releveled so that it contained only the two levels "disyllabic stimulus" and "tri- or quadrisyllabic stimulus".

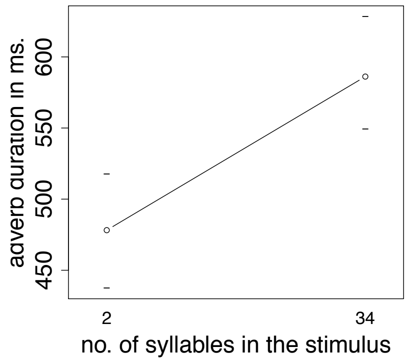

Figure 4.23: Effect of degree of stimulus reduction on adverb duration

When the stimulus adverb was disyllabic, participants' adverb realisations were shorter durationally than when the stimulus adverb was tri- or quadrisyllabic. A larger degree of stimulus reduction correlated therefore with a larger degree of durational reduction in participants' production.

Accentedness There was no significant main effect for the variable "accentedness" in the statistical model. Generalising over the whole data set, adverbs were thus neither shorter nor longer when they were accented. The model contained, however, a significant interaction of accentedness and degree of reduction in the stimulus. Figure 4.24 displays this interaction graphically.

Accentedness played a role for those adverbs that were based on disyllabic stimulus items. When stimulus adverbs were tri- or quadrisyllabic, no difference between accented and unaccented realisations was found. However, for those adverbs that were based on disyllabic stimuli, accented realisations were longer durationally than unaccented adverbs.

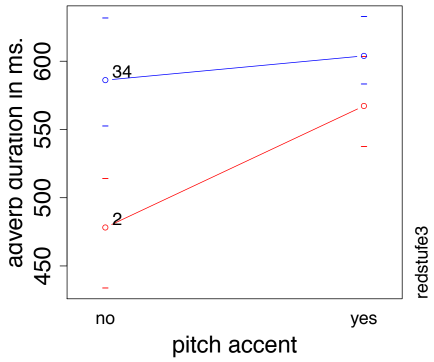

Figure 4.24: Interaction of accentedness and degree of reduction in the stimulus

Reaction latency Participants' reaction latency, i.e. the time it took participants to start shadowing after the onset of the stimulus, affected adverb duration significantly (t $= -6.952$) as shown in the following figure:

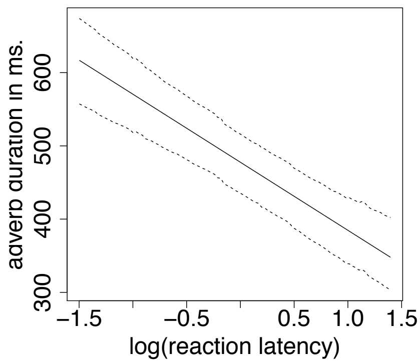

Figure 4.25: Effect of reaction latency on adverb duration

High reaction latency correlated with a high degree of durational reduction. The longer it took participants to react to the stimulus, the shorter their adverb realisations generally were.

Adverb function Adverb function played a significant role in explaining durational reduction as well (t $= -3.236$). Figure 4.26 displays this effect graphically.

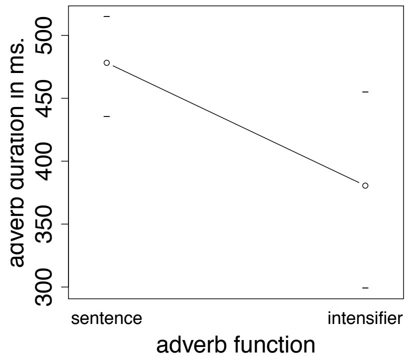

Figure 4.26: Effect of adverb function on adverb duration

Sentence adverbs like *náttúrlega* or *sennilega* were realised as shorter durationally than intensifier adverbs like *rosalega* or *ofsalega*. In addition to the significant main effect, the variable "adverb function" participated in a significant interaction with the variable "reaction latency". This interaction is shown in Figure 4.27:

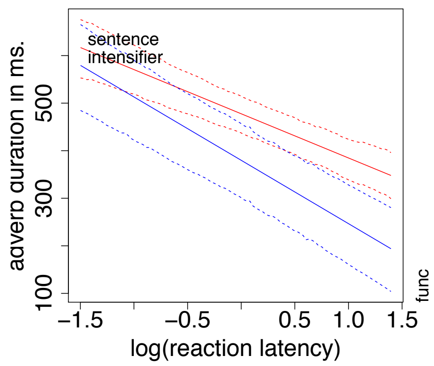

Figure 4.27: Interaction of adverb function and reaction latency

As was noted in the previous paragraph, reaction latency correlated negatively with adverb duration. The interaction of reaction latency and adverb function shows that this reducing effect of reaction latency was even more pronounced for sentence adverbs. While all adverb types reduced more when it took participants longer to react, sentence adverbs were more affected by higher reaction latencies than intensifier adverbs.

Speech rate Participants rate of speech affected adverb duration significantly ($t = -5.756$). The variable "speech rate" also displayed a significant interaction with a structural-phonological factor (cf. below). Recall again that the variable speech rate was residualised for both reaction latency and stimulus speech rate before being entered into the statistical model. The following figure displays the main effect for speech rate:

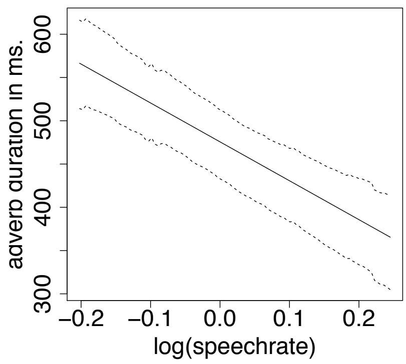

Figure 4.28: Effect of speech rate on adverb duration

High speech rate correlated with a high degree of durational reduction. The faster participants spoke, the shorter their adverb realisations were.

The interaction of speech rate with the manner of articulation of the second syllable onset (t = 2.119) is shown in the figure below:

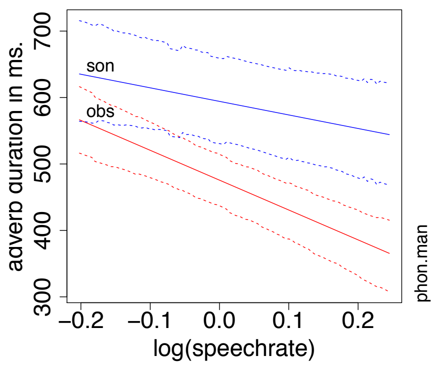

Figure 4.29: Interaction of speech rate and manner of articulation of the second syllable onset

All adverbs were realised shorter with higher speech rates. However, this correlation was stronger for adverbs that have an obstruent in the second syllable onset than for those that have a sonorant in the same position.

Speech rate stimulus The speech rate of the stimulus had a significant impact on durational reduction in the shadowing task (t = −4.163). This effect is shown in Figure 4.30:

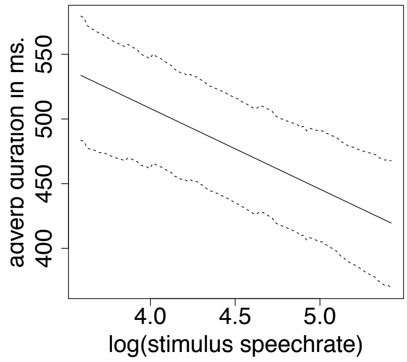

Figure 4.30: Effect of stimulus speech rate on adverb duration

The faster the stimulus utterance was realised, the shorter participants' adverb realisations were.

Phonological-structural variables Both variables that referred to the phonological makeup of the adverb stem were significant factors in the statistical model on their own and in interaction with frequency of occurrence. The main effect for manner of articulation of the second syllable onset (t = 4.350) is displayed in the following figure:

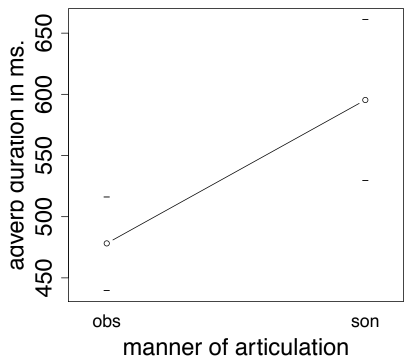

Figure 4.31: Effect of manner of articulation of the second syllable onset on adverb duration

Adverbs with a sonorant in the onset of the second syllable seemed to have been longer than adverbs with an obstruent in the same position. The interaction of this variable with frequency of occurrence ($t = -4.365$) shows that this difference was even more pronounced for high-frequency items:

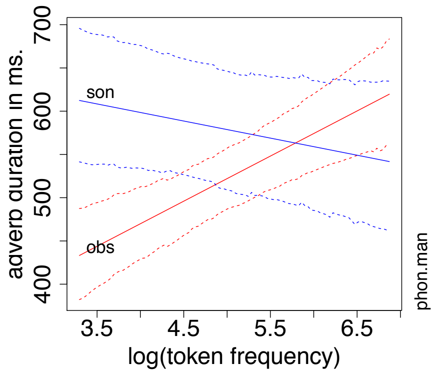

Figure 4.32: Interaction of manner of articulation of the second syllable onset and token frequency

Adverbs with an obstruent in the second syllable onset were inversely affected by frequency than those with a sonorant in the same position. Only high-frequency manner adverbs were shorter than their low-frequency counterparts. High-frequency obstruent adverbs were in fact longer than low-frequency equivalents.

The place of articulation of the second syllable onset influenced adverb duration as well ($t = -2.973$) as shown in the following figure:

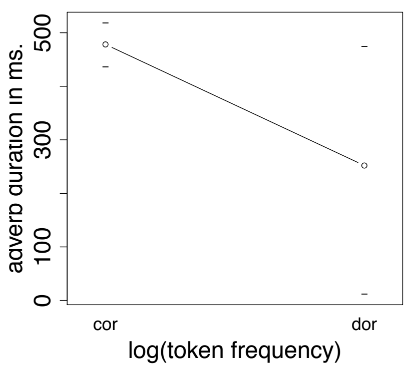

Figure 4.33: Effect of place of articulation of the second syllable onset on adverb duration

Adverbs with a dorsal consonant in the second syllable onset were generally shorter than adverbs with a coronal consonant. However, the interaction of place of articulation with frequency of occurrence (t = 2.803) demonstrates that this correlation applied only to a subset of the data:

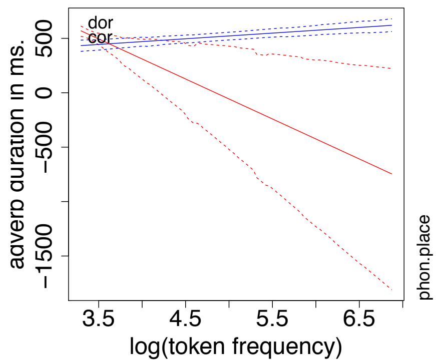

Figure 4.34: Interaction of place of articulation of the second syllable onset and token frequency

Only high-frequency items with a dorsal consonant in the second syllable onset were shorter than their coronal counterparts while there was no difference between low-frequency items with different consonant types in the onset of the second syllable.

Summing up, participants's adverb realisations were generally slightly shorter than the stimulus adverbs. The multivariate analysis revealed a number of factors that influenced adverb duration significantly. The rhythmic environment did not have any effect on adverb duration. Frequency of occurrence, on the other hand, affected adverb duration significantly. High-frequency adverbs were generally realised as shorter than low-frequency adverbs. Reaction latency, speech rate and stimulus speech rate correlated negatively with adverb duration. In addition, significant effects were found for adverb function and structural-phonological variables.

4.2.4 Discussion

The shadowing experiment that was presented in the previous sections was designed in order to evaluate the role of two variables more closely: metrical rhythm and frequency of occurrence. In the experiment, participants had to repeat as quickly as possible a number of stimulus sentences. Some of these stimuli contained adverbs with the suffix -*lega* in two rhythmic environments (trochaic and dactylic). The adverbs were presented in three different degrees of reduction (quadri-, tri- and disyllabic). Adverb token frequency and the rhythmic environment were expected to influence the shadowing and production of reduced forms. Based on the results from the literature, a divide between close, i.e. fast shadowers and distant, i.e. slow shadowers was expected to emerge. This difference was considered especially important for the study of the variable token frequency since more insight could be gained into the place of pronunciation frequency effects in production.

The same two dependent variables as in the corpus-based study in ch. 3 were used as measures of reduction: the phonetic number of syllables and the total adverb duration. The rhythmic environment was expected to influence the number of syllables with which adverbs were realised and in consequence also adverb duration. Adverb token frequency was expected to influence both dependent variables as well. The discussion of the shadowing results is structured as follows: First, the participants' general shadowing behaviour is discussed. Then, the results of the multivariate analyses are discussed, especially with regard to the two variables in focus, frequency of occurrence and metrical rhythm.

Looking at the general shadowing behaviour, participants were rather conservative in their adverb realisations. While the data contained many quadri- and trisyllabic forms, heavily reduced forms occurred only rarely in participants' speech. In fact, only 8% of adverb realisations were disyllabic while nearly two thirds of the data were quadrisyllabic realisations. If participants had simply shadowed exactly what they had heard in the stimulus, an equal number of di-, tri- and quadrisyllabic adverbs would have been expected to occur. Participants thus often produced realisations that were close to the citation form of the adverbs, but hardly any heavily reduced forms.

This skewed distribution of adverb realisations is in principle in line with the results of Brouwer *et al.* (2010). In their study, Brouwer *et al.* (2010) also investigated the shadowing of reduced forms and found that "participants' productions show a bias toward the canonical forms." Their tentative explanation for this tendency was that "listeners reconstruct canonical forms from their reduced forms." In principle, this explanation can also be applied to the present study. There are, however, certain variables that are specific to this study that might also help explain the conservative shadowing behaviour.

First, the bias might have been induced by the task itself in combination with the type of speakers that participated in the experiment. Shadowing is a rather complicated and difficult task that requires participants to concentrate intensively. In contrast to the shadowing study by Brouwer *et al.* (2010) who used participants from the Max Planck subject pool, most of the participants of the present study had never taken part in an linguistic experiment and might therefore have reverted to a more formal register in order to fulfill expectations that they projected on the experiment

In addition, this adaptive behaviour might have been enhanced by the general attitude of Icelanders toward their language. Iceland has a very strong prescriptivist tradition (Ottósson, 2002; Árnason, 2003), made famous by the introduction of neologisms for many common internationalisms (cf. e.g. *tölva* 'computer'). While the purist movement these days is not as strong as it was until the end of the 20th century, Icelanders are still very much aware of their language and the normative pressure to "speak correctly". In fact, one of the participants that was excluded form the analysis for technical reasons displayed patterns that could be classified as hyperspeech and remarked after the experiment that he "tries to speak clearly". The perception of the experiment as a formal setting therefore might have led other participants toward a speech style that exhibited signs of hyperarticulation.

A second explanation for the bias toward careful pronunciation which is not mutually exclusive with the one given above might be found in the nature of the stimuli used in the shadowing task. In contrast to Brouwer *et al.* (2010), the stimuli were not taken from a corpus of spontaneous speech, but rather specifically constructed and recorded for the experiment (cf. ch. 4.2.2). This makes them by definition more unnatural than spontaneous discourse. Participants might have unconsciously detected that the stimulus material was based on constructed speech and aligned their production more to the variety of careful speech than to spontaneous speech.

In addition, the speech rate of the stimuli was rather slow. In principle, this might be considered beneficial for shadowing as it makes the stimuli easier to follow and to reproduce. However, the slow speech rate introduced yet another form of unnaturalness. As the corpus-based analysis in ch. 3 (in accordance with the literature) showed, reduced forms typically occur with higher speech rates. The reduced forms in the experimental stimuli thus occurred in an unnatural environment. Recall that this conflict had been considered when constructing and recording the stimuli, but was deemed less important than introducing a larger amount of variation in stimuli speech rate.

Since there was still a small amount of variation in speech rate in the experimental items, the stimulus speech rate was taken up as a variable in the statistical models predicting the phonetic number of syllables and adverb duration (cf. below). The model showed that a higher stimulus speech rate correlated with a higher degree of syllabic and durational reduction. Slightly faster speech rates in the stimulus therefore did not lead to parsing difficulties as evidenced by e.g. higher error rates.[11] On the contrary, participants seemed to be more ready to (re)produce reduced adverb forms under these circumstances.

As Rácz (2012) shows in the context of the evolution of segmental sociolinguistic markers, linguistic items that are in principal familiar to a hearer are perceived as salient when they occur in an unfamiliar or unexpected environment. While the experiment participants can be assumed to be familiar with reduced adverb forms, they were seemingly not used to reduced forms occurring in these particular contexts. Reduced target adverbs that were embedded in a target utterance with low speech rate might therefore have "stuck out" and have been perceived as unnatural in this context.[12] One indication that this was indeed the case in the present experiment can be drawn from the analysis of error patterns. The distribution of errors showed that target items per se were not perceived as more unnatural than filler items. Participants did not produce more errors with target utterances that contained quadri- or trisyllabic adverb realisations than with filler items. Only the target items that contained heavily reduced forms exhibited an error pattern that was different from filler items.

While error patterns could also be taken as a general indicator of parsing difficulties for reduced forms, the distribution of hesitations in the data shows even more clearly that reduced forms in the stimuli were perceived as unnatural. Recall that hesitations were classified as to their position in relation to the target adverb. Hesitations could either occur before the adverb, directly before the adverb, directly following the adverb or at some later point following the adverb. Hesitations that directly preceded a target adverb were found significantly more often when the stimulus adverb was disyllabic than when it was tri- or quadrisyllabic. Crucially, adverb realisations that were directly preceded by a hesitation were not necessarily more often disyllabic. On the contrary, most adverbs that were directly preceded by a pause were quadrisyllabic.

In sum, participants' tendency to produce adverb realisations that were close to

[11] Recall that even "faster" stimulus items were rather slow-paced in comparison to naturally occurring speech.

[12] Recall, however, that only two participants reported that they had noticed different realisations of *lega*-adverbs in the stimuli.

citation form pronunciations can be interpreted in several ways. On the one hand, in accordance with Brouwer *et al.* (2010), participants might have unconsciously reconstructed full forms when shadowing reduced forms. On the other hand, conservative realisations might have been the result of a general bias toward careful speech that was rooted in the structure of the experiment itself and the attitude of Icelanders toward their language.

In spite of the conservative tendencies, the data still contained enough variation to warrant a closer inspection. Hence, for both the phonetic number of syllables and the total duration, multivariate analyses were conducted in order to evaluate which factors influenced the production of reduced forms in the shadowing task. Table 4.8 presents the results of these analyses for the two variables. As the table shows, the number of phonetic syllables and the adverb duration were largely influenced by the same factors with some differences in the role of structural-phonological factors. In the following, the results given below will be discussed especially with regard to the hypotheses put forward in ch. 4.2.2.1.

Predictor	No. of syllables	Adverb dur.
rhythm	–	–
token frequency	✓*	–
no. of syllables in stim.	✓*	✓*
reaction latency	– *	✓*
accentedness	✓*	– *
speech rate	✓*	✓*
speech rate stim.	✓	✓
adverb function	– *	✓*
onset manner	–	✓*
onset place	–	✓*

Table 4.5: Comparison of factor performance in different statistical models

Participants produced more reduced forms when they reacted slow to the stimulus utterance, i.e. when reaction latency was high (cf. also Table 4.8). When participants started shadowing late, the computational load during production was smaller since there was less time where perception and production overlapped. In order to verify whether this effect was only due to the overlap of stimulus and adverb production, a variable was included in the statistical model that measured whether the targe adverb was produced before the offset of the stimulus utterance, i.e. before the stimulus was finished. This variable, however, did not reach significance.

The first hypothesis presented in ch. 4.2.2 stated that the rhythmic environment target adverbs were embedded in would influence if and how reduced forms were (re)produced in the shadowing task. This hypothesis was not confirmed by the data: the variable "metrical rhythm" neither had a significant effect on the phonetic number of syllables nor on adverb duration. Recall that the shadowing experiment was in part designed to achieve comparability of the present study with previous studies investigating the role of metrical rhythm on reductive alternations since these all made use of experimental data. The following table is reproduced from ch. 3.3.2 with the cell for "experimental analysis of (the role of rhythm in) phonetic reduction" now filled in:

		Type of study	
		experimental	corpus-based
Type of process	"phonological"	✓	?
	"phonetic"	X	X

Table 4.6: Types of studies investigating the effect of metrical rhythm on different kinds of reductive processes

As the table shows, rhythmic effects have been found for "phonological" alternations such as schwa deletion in Dutch (Kuijpers & van Donselaar, 1998). Rhythm, however, did not influence the "phonetic" reduction investigated in the corpus-based part of this dissertation. The results of the shadowing task confirm that the lack of a rhythmic effect in the corpus data was not due to the "messiness" of this kind of data. Instead, there indeed seems to be a categorical difference with regard to rhythmic effects between the reduction investigated by Kuijpers & van Donselaar (1998) or Dehé (2008a) and the reduction that is the topic of this dissertation.

The discussion in ch. 3.3.2 has already established that this categorical difference between different kinds of reduction is easily explained by generative-abstractionist models. These models rely on a modular division of labour between phonetics and phonology. On the one hand, reductive processes like Final Vowel Deletion are then, broadly speaking, part of the phonological module. On the other hand, the reduction investigated in this dissertation is generally phonetic-implementational in nature. Also in ch. 3.3.2, possible modifications of [classic] exemplar-based models of production were discussed that could accommodate the same facts as the abstractionist model. The discussion of how different theoretical models can account for the present reduction data and the role of metrical rhythm will be taken up again in the general discussion in ch. 5.

The second hypothesis that was put forward in ch. 4.2.2 concerned the role of frequency of occurrence. Adverb token frequency was expected to influence the production of reduced forms in the shadowing task. The role of frequency was deemed especially important for close shadowers that started their repetition of the stimulus with only a minimal delay. As previous studies have suggested, close shadowers start repeating the stimulus before they have fully analysed the incoming material (Marslen-Wilson, 1985). If frequency effects were found for these fast shadowers, this could give important clues as to where frequency effects are located in the production process.

The data, however, revealed that there was hardly any shadowing behaviour that could be classified as "close". Only three of the original 36 participants displayed a mean reaction latency of under 500ms – which is still higher than the 300ms that Marslen-Wilson (1985) found for close shadowers that had to repeat connected prose.[13] In addition, one of these three "marginally close" shadowers had to be excluded from the analysis because he produced too many errors and seemed distracted from the experiment. Hence, no conclusion about the location of possible frequency effects in the speech production process can be drawn from the present data.

Table 4.8 suggests that the frequency-based hypothesis was confirmed by the data. According to the statistical models, frequency of occurrence influenced the phonetic number of syllables with which adverbs were realised and the total adverb duration. Since the number of different adverb types in the shadowing task (and therefore also the variation in frequency values) was naturally smaller in the shadowing task than in the corpus-based study, it is important to take a closer look at the role that individual adverb types played in the frequency effect found for the phonetic number of syllables.

Disyllabic adverb realisations were almost exclusively found for two adverb types: *náttúrlega* and *nefnilega*. Both of these types are high frequency adverbs which might explain the significant effect for token frequency in the statistical model. However, for both *náttúrlega* and *nefnilega*, there is evidence that disyllabic side forms like *náttla* and *nefla* have been lexicalised (cf. ch. 2.1 and

[13] The relative number of close shadowers in the study by Marslen-Wilson (1985) was, however, not much higher. In his study, only eight out of 64 participants, or one eighth, could be classified as fast shadowers. Interestingly, while Marslen-Wilson's close shadowers were all female, two out of the three "marginally close" shadowers in the present study were male.

3). Three pieces of evidence suggest that participants reproduced these reduced forms because they had stored them independently or, to put it differently, these forms had acquired a strong enough representation of their own.

Firstly, as the discussion of error and hesitations rates above has shown, participants had problems recognizing and parsing disyllabic, i.e. heavily reduced forms in the stimulus. With utterances containing *náttla* and *nefla*, however, participants produced fewer errors and fewer hesitations than with other target utterances that contained disyllabic reduced forms. This pattern suggests that disyllabic realisations of *náttúrlega* and *nefnilega* were more easily recognised and parsed with less difficulties than other disyllabic forms. As Ernestus *et al.* (2002) have shown, heavily reduced forms are hardly ever recognised and identified as the correct lexical item out of context. While the target utterance in the present shadowing task of course provided a syntactic and semantic context, it was argued above that disyllabic forms nevertheless "stuck out" because they were not put in the exactly right prosodic and stylistic context. However, disyllabic *náttla* and *nefla* did not confuse experiment participants as much as other disyllabic reduced forms because these lexicalised forms can also occur with lower speech rate and even in isolation.

While the argument in the previous paragraph was based on perception and lexeme recognition, a second argument for lexicalisation of *náttla* and *nefla* can be drawn from the production of disyllabic reduced forms. The statistical model predicting the phonetic number of syllables revealed a surprising effect for speech rate. (Recall that this variables was residualised for both reaction latency and stimulus speech rate as participants rate of speech correlated with both variables.) Contrary to the results in the literature and the results in ch. 3, reduced forms occurred with *lower* speech rates instead of with higher speech rates. Only with higher reaction latencies, i.e. when participants started shadowing late in the stimulus utterance, high speech rate had a facilitating effect on syllabic reduction.

This pattern of effects suggests again that disyllabic forms such as *náttla* and *nefla* are in fact lexicalised and produced consciously when they are shadowed directly. However, when participants start their production later during the stimulus and have more freedom and do not have to compute as much of the signal or no signal at all, disyllabic forms occur more often and under different circumstances, i.e. higher speech rates. Summing up, the significant effect for frequency of occurrence in the model for the phonetic number of syllables has been explained by the status of two high-frequency adverbs *náttúrlega* and *nefnilega*. Both of these adverbs have lexicalised disyllabic side forms which participants recognised more easily than other heavily reduced forms and therefore also reproduced more often.

As the above discussion has already suggested, disyllabic reduced forms occurred almost exclusively when there was a disyllabic adverb in the stimulus. This correlation was evidenced by the significant effect for the variable "number of syllables in the stimulus adverb". This variable provided another interesting aspect for the explanation of reduction in the shadowing task. The statistical model showed that there was no significant difference in participants' productions between when there was a trisyllabic adverb in the stimulus or when there was a quadrisyllabic adverb in the stimulus.

Experiment participants thus did not react significantly differently to trisyllabic stimulus adverbs than to quadrisyllabic stimulus adverbs. Recall that the reduction from quadri- to trisyllabic happens in the adverb suffix -*lega*. In quadrisyllabic adverb this suffix is realised as [lɛ.ɣa] or [lɛ.a], while in trisyllabic adverbs the suffix is contracted to [la].[14] This lack of a difference suggests that participants did not notice suffix reduction and accordingly did not reproduce it systematically, either. In ch. 3.3.2 it was argued that suffix reduction in production can occur to a certain degree independently of reduction in the stem.

In summary, the shadowing experiment was not successful in verifying the initial hypotheses. Participants displayed a rather conservative speech style and produced only few reduced forms. This behaviour was attributed to both features in the experimental makeup and to Icelanders' attitude toward their language. As in the corpus-based analysis, no rhythmic effect was found in the data. While the statistical model displayed a significant effect for frequency of occurrence, this effect was reduced to the disyllabic lexicalised side forms of *náttúrlega* and *nefnilega*.

4.3 Reading experiment

4.3.1 Methodology

4.3.1.1 Experimental design

In addition to the shadowing task that was discussed in the previous sections, a second experiment was designed. There, participants read a number of sentences containing *lega*-adverbs. The reading task served two related functions. First, the

[14] The suffix vowel can of course also be reduced qualitatively even more.

reading experiment was designed to confirm possible frequency effects found in the shadowing task. Second, via the reading data, relatively natural speech data could be obtained from the same speakers that had participated in the shadowing experiment. Recall that one of the purposes of the shadowing task was to locate the effect of frequency in the speech production process (cf. ch. 4.2.2.1). However, as was detailed in the previous chapter, the setting and general structure of the shadowing task placed certain limits on participants' behaviour.

The results of the shadowing task showed, for example, that participants' speech rate was influenced by the speech rate of the stimulus utterance. In the reading task, participants could determine their speech rate independently of a pre-recorded stimulus and thus more freely. The same participants that had taken part in the shadowing experiment were thus expected to be able to produce relatively formal, yet naturally sounding adverb realisations. These realisations were then to be compared with those in the shadowing task in order to evaluate the role of task structure on the effects of frequency of occurrence and other variables.

For every adverb type that was used in the shadowing task, one sentence was constructed for participants to read. The items for the reading task had a similar structure as the critical stimuli in the shadowing experiment. Target adverbs were placed in the middle of the sentence and were surrounded by six or seven syllables on both sides. The rhythmic structure of the sentences, however, was not controlled for. The feet preceding and following the adverb thus were not regular trochees or dactyls, but rather a mixture of both.

Every sentence in the reading experiment was cued by a question so that focus in the target sentence would be on the element directly following the adverb. Participants only had to read the answer, i.e. the target sentence. An example of a question and answer pair is given in 4.3:

(4.3) *Verður líka sól í Reykjavík á morgun? – Í Reykjavík*
Becomes too sun in Reykjavik tomorrow? – In Reykjavik
verður sennilega skýjað allan daginn.
becomes probably clouded all day
'Is it going to be sunny in Reykjavik tomorrow, too? – In Reykjavik, it's probably going to be cloudy all day.'

The target sentence and its cues were additionally preceded by another pair of questions and answers. This double cueing ensured that the structure of the critical stimuli matched the structure of the distractors which all consisted of two question-answer-pairs (cf. Appendix 2 for a list of all critical stimuli).

Hypotheses about participants' behaviour in the reading task were derived from the results of both the shadowing task and the corpus-based study presented in ch. 3. Firstly, adverb token frequencies were expected to influence the realisation of target adverbs, both with regard to duration and the number of phonetic syllables. High-frequency adverbs were expected to reduce more than low-frequency adverbs syllabically and durationally. Secondly, speech rate and adverb accentedness were hypothesised to impact adverb realisations as well. Both variables were expected to show effects on reduction that are more in accord with the corpus based study than with the shadowing task since the reading task represented a more natural setting than the shadowing experiment. The number of iterations, i.e. how many times participants had already read a given sentence, was also expected to influence adverb realisations since the literature shows that the degree of reduction increases the more often a given item is repeated (Fowler, 1988; Kul, 2011).

4.3.1.2 Participants and procedure

The same 36 subjects that had taken part in the shadowing task also performed the reading task. The reading experiment directly followed the shadowing experiment after a short break.

In this second task, participants were asked to read aloud a number of sentences. Each sentence was preceded by a question in order to elicit focus on a given element of the sentence. The items were presented to the participants via Apple Keynote. Each slide contained two semantically related question-answer pairs. Nine items contained the target adverbs that were also used in the shadowing experiment. In these items, the question framed the target sentence in such a way that focus would be put on the element directly following the target adverb. Additionally, the reading part contained a number of sentences that were either filler items or material for a different study. Participants were asked to read every answer three times. Items were recorded in the same way that was described in ch. 4.2.2.3. The data from the same 28 participants that were taken into account for the shadowing task were also formed the basis for the analysis of adverb reduction in the reading task. These participants produced in total 747 items that contained target adverbs.

The reading data were then annotated for the same variables as the shadowing data (cf. ch. 4.2.2.4): utterance duration, number of syllables in the adverb, adverb duration, stem and suffix duration, the number of errors and hesitations, speech rate, accentedness and phonological structural variables. In addition, the number of iterations were noted. For obvious reasons, variables that were specific to the structure of the shadowing task such as reaction latency and stimulus speech rate were not taken down for the reading data.

4.3.2 Results

4.3.2.1 Number of syllables

The reading task, as detailed in ch. 4.3.1, was designed to elicit formal, yet relatively natural sounding adverb realisations from participants. A first comparison of syllable counts in the shadowing and the reading task (cf. Figure 4.35) shows that participant's speech seemed to have been less formal in the reading task than in the shadowing task:

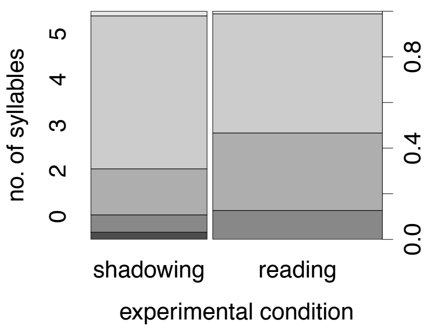

Figure 4.35: Comparison of no. of syllables across experimental conditions

As can be seen in the above figure, participants in the reading task produced adverbs that contained on average less syllables than the adverbs in the shadowing task. In fact, participants produced relatively more disyllabic adverb forms in the reading than in the shadowing task. While the mean number of syllables in the shadowing task was 3.57, it was 3.43 in the reading task. This difference is significant according to a t-test ($p = 0.002$, $t = 3.14$, $df = 902$).

Experiment participants differed in the speech style they employed in the reading task. This is evidenced by the large differences in speech rate that participants displayed as shown in the following figure:

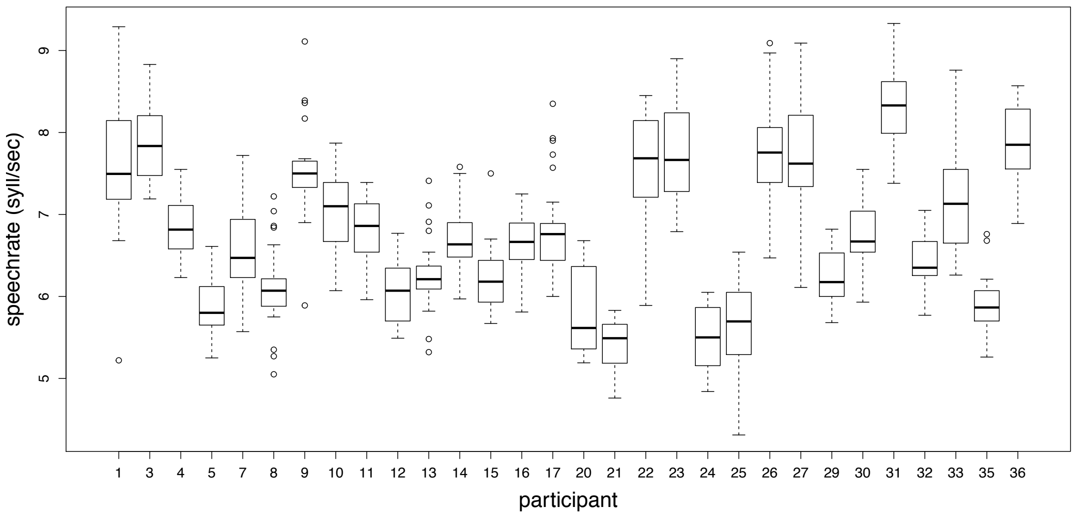

Figure 4.36: Speech rate by subject

While, e.g., participant no. 3 produced on average 7.89 syllables per second, participant no. 21 averaged at 5.41 syllables per second. Even the latter number, however, is still higher than the mean rate in the shadowing task.

In order to evaluate the effect of speech rate and other factors on syllabic reduction in the reading task, a linear mixed-effects model was fitted to the data. The initial model contained "subject" and "adverb type" as random factors. Log-transformed speech rate, log-transformed token frequency, number of iterations and the structural-phonological variables place of articulation and manner of articulation of the onset of the second syllable were included as fixed effects predictors.[15] Additionally, two-way interaction between all fixed-effects predictors were included in the initial model.

As with the previous statistical analyses, the final model was obtained using the standard simplification procedures by eliminating insignificant factors in a step-wise evaluation process. The model that emerged from the model-fitting process ($R^2 = 0.31$) is shown in Figure 4.37:

[15] These are essentially the same factors as in the shadowing task. Only the rhythmic environment that was not controlled for in the reading task and variables that were specific to the procedure of the shadowing task such as reaction latency and stimulus speech rate were not included for obvious reasons.

```
  AIC  BIC logLik deviance REMLdev
 1237 1281 -608.3     1197    1217
Random effects:
 Groups   Name        Variance Std.Dev.
 subj     (Intercept) 0.073896 0.27184
 Residual             0.356524 0.59710
 groups: subj, 28

Fixed effects:
                              Estimate Std. Error t value
(Intercept)                    3.41433    0.07871   43.38
speechrate                    -2.12868    0.40132   -5.30
manner of articulation (son)  -0.08436    0.12527   -0.67
token frequency               -0.14500    0.03210   -4.52
adverb function (sentence)    -0.08048    0.12893   -0.62
speechrate:manner             -2.66081    0.64642   -4.12
speechrate:function            1.86210    0.59681    3.12
manner:frequency              -0.22747    0.06957   -3.27
```

Figure 4.37: Linear mixed-effects model for the dependent variable "no. of syllables" in the reading task

Adverb type The random variable "adverb type" did not improve the statistical model and was therefore dropped during the model fitting process. Figure 4.38 gives an overview over how different adverb types were realised in the reading task:

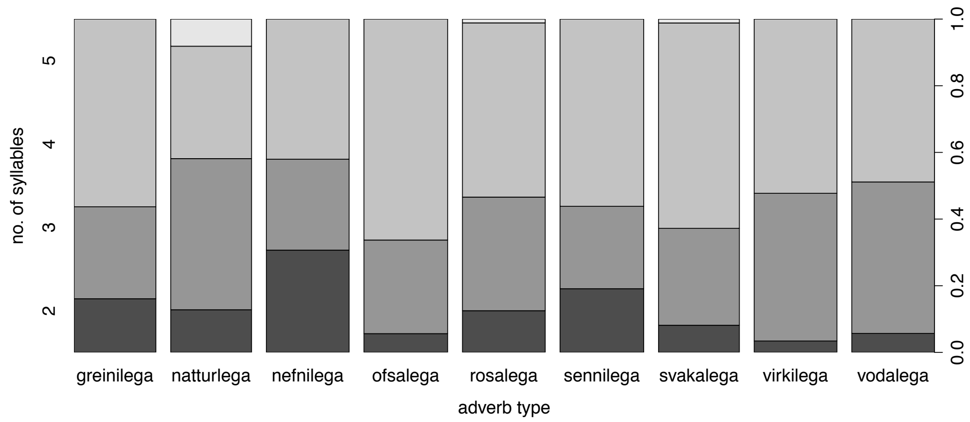

Figure 4.38: Number of syllables across adverb types

The above figure shows that the adverb *nefnilega* had the most disyllabic realisations of all adverb types and also the lowest mean number of syllables at 3.11. The adverb types *náttúrlega*, *rosalega*, *greinilega* and *sennilega* had roughly the same number of disyllabic realisations, although *náttúrlega* displayed a lower mean than the other three types. *Virkilega* was produced as disyllabic in only three cases and also had the highest mean at 3.49 syllables.

Iteration The variable "iteration" did not have a significant effect on the phonetic number of syllables and was therefore dropped from the final model. Figure 4.39 shows the relation of the realised number of syllables and the number of iterations:

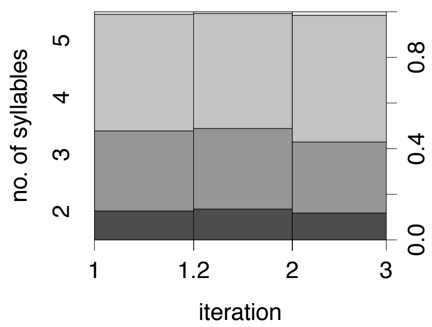

Figure 4.39: Number of syllables across iterations

The mean number of phonetic syllables in the first reading was 3.41, 3.38 in the second reading and 3.45 in the third.

Speech rate Participants' speech rate had a significant effect on the number of syllables with which target adverbs were realised (t = −5.30). The following figure shows this effect graphically:

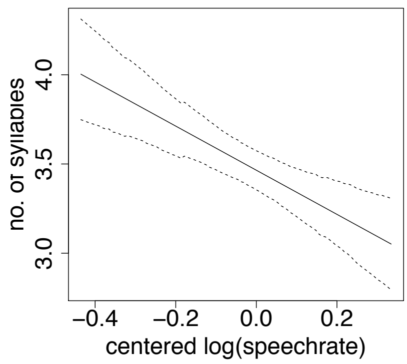

Figure 4.40: Effect of speech rate on syllabic reduction

The faster participants spoke, the less phonetic syllables they produced. This general effect, however, was moderated by two interactions. First, the interaction of speech rate with the variable "adverb function" (t = 3.12) is displayed in Figure 4.41:

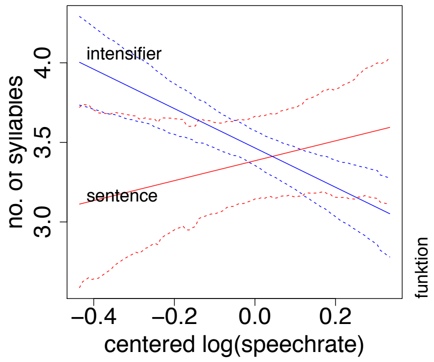

Figure 4.41: Interaction of speech rate and adverb function

The above figure shows that the reducing effect of speech rate only applied to intensifier adverbs. This type of adverbs reduced more heavily when participants spoke fast. Sentence adverbs, however, did not reduce more often with higher speech rate since they already underwent syllabic reduction with lower speech rates.

The factor speech rate also interacted significantly with the variable "manner of articulation of the second syllable onset" (t = −3.27) as shown in the following figure:

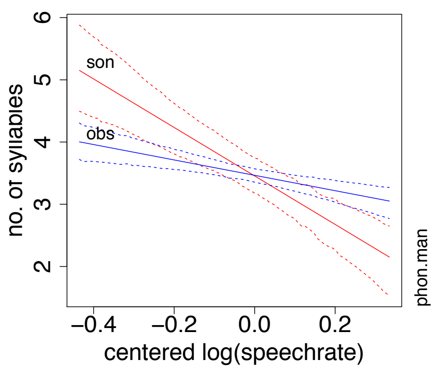

Figure 4.42: Interaction of speech rate and manner of articulation

Both adverbs with a sonorant in the onset of the second syllable such as *sennilega* and adverbs with an obstruent in the same position such as *rosalega* were affected by speech rate and were realised with fewer syllables when participants spoke fast. For sonorant-adverbs, however, this effect was stronger than for obstruent adverbs.

Token frequency Adverb token frequency was a significant predictor of syllabic reduction both on its own and in interaction with a phonological structural variable (cf. below). The main effect for frequency (t = −4.52) is displayed in Figure 4.43:

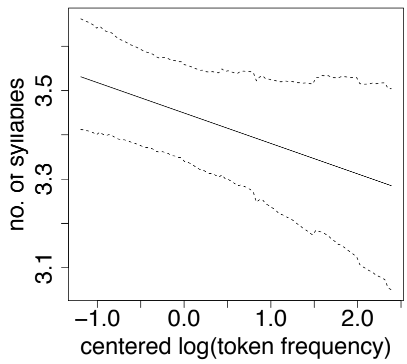

Figure 4.43: Effect of token frequency on syllabic reduction

Adverbs with higher token frequency were realised with significantly less syllables than adverbs with lower frequencies of occurrence. This effect, however, is moderated by an interaction of frequency with the variable “manner of articulation of the second syllable onset” (t = −3.27).

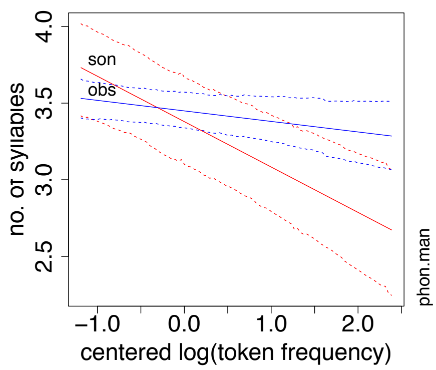

Figure 4.44: Interaction of token frequency and manner of articulation

For both adverbs with a sonorant in the second syllable onset and for those with an obstruent in the same position, an effect of token frequency was found. This frequency effect, however, was stronger for sonorant-adverbs than for obstruent-adverbs. High frequency adverbs with a sonorant as second syllable onset reduced even more than the comparable high-frequency adverbs with an obstruent in the same position.

Accentedness According to the statistical model, it did not make a difference for the phonetic number of syllables whether target adverbs were realised as pitch-accented or not. The majority of adverbs in the data (>75%) were realised as accented. Accented adverbs in general were realised with more syllables than unaccented adverbs, but this difference did not prove to be significant.

Adverb function The statistical model did not display a main effect for adverb function. In general, sentence adverbs were thus neither longer nor shorter (measured in phonetic syllables) than intensifier adverbs. The interaction of speech rate and adverb function (cf. above), however, showed that intensifier adverbs reduced relatively more for higher speech rates than sentence adverbs while sentence adverbs were also realised as reduced with lower speech rates.

Phonological-structural variables Neither of the two variables that referred to the phonological structure of the adverb stem was significant on its own in the statistical model. The variable "place of articulation of the second syllable onset" did not make a difference at all and was therefore dropped during the model fitting process. The variable that referred to the manner of articulation of the second syllable onset took part in two significant interactions, the results of which have been shown above.

The results presented in this section have demonstrated that the number of syllables with which *lega*-adverbs were realised in the reading task was influenced by several factors. Both high speech rates and high token frequencies facilitated syllabic reduction. For both variables, the effect was stronger for "sonorant adverbs" than for "obstruent adverbs". Accentedness, number of iterations and the second structural-phonological variable did not improve the statistical model and were therefore dropped from the final model.

4.3.2.2 Duration

A comparison of adverb duration in the shadowing task and in the reading task reveals that adverbs in the reading task were generally shorter durationally than those in the shadowing task.

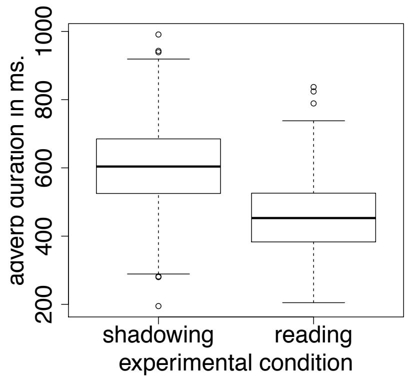

Figure 4.45: Comparison of adverb durations across experimental conditions

While adverbs in the reading study had a mean duration of 457 milliseconds, adverbs were on average 607 milliseconds long in the shadowing task. This difference is highly significant according to a two-sample t-test ($t = 19.47$, $df = 776$, $p < 0.001$). Since adverbs in the reading task contained on average less syllables than the adverb in the shadowing task, adverb duration was adjusted for the phonetic number of syllables. In this comparison, the durational difference between the two tasks remained significant: Even the syllabically adjusted adverb durations in the reading task were shorter than the adverb durations in the shadowing experiment. The correlation between adverb duration and the number of syllables was somewhat lower in the reading task ($r = 0.39$, $p < 0.001$) than in the shadowing task ($r = 0.43$, $p < 0.001$).

For the statistical analysis of durational reduction, a linear mixed-effects model was fitted to the data. The initial model included the same fixed-effects and random-effects predictors as the model for syllabic reduction. The final model that was obtained by the standard simplification processes is shown in Figure 4.46. This model displayed the best fit of all statistical models discussed in this chapter ($R^2 = 0.77$).

```
  AIC  BIC logLik deviance REMLdev
 6891 6945  -3434     6943    6867
Random effects:
 Groups   Name        Variance Std.Dev.
 subj     (Intercept)  479.47  21.897
 adverb   (Intercept) 1260.49  35.503
 Residual             2718.39  52.138
 groups: subj, 28; adverb, 9

Fixed effects:
                              Estimate Std. Error t value
(Intercept)                    242.918     75.419   3.221
speechrate                    -368.947     29.051 -12.700
place of articulation          676.585    332.798   2.033
token frequency               -162.309     66.737  -2.432
pitch accent (yes)              63.064      7.396   8.526
adverb function (sentence)       7.280     27.790   0.262
speechrate:place               121.422     42.806   2.837
speechrate:funktion            -71.154     36.576  -1.945
place:token frequency          664.019    299.988   2.213
```

Figure 4.46: Final model for durational reduction in the reading task

Adverb type Both the random effects for "subject" and for "adverb type" or lexeme significantly improved the model and were therefore retained in the final model. Figure 4.47 shows how the individual adverb types in the reading task differed in duration:

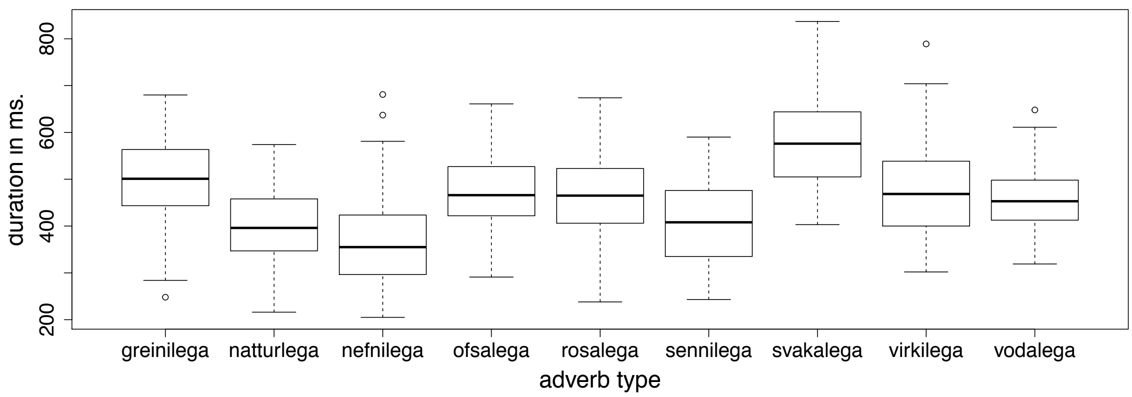

Figure 4.47: Adverb duration by adverb type

The adverb types *náttúrlega* and *nefnilega* had the shortest mean durations at 359ms and 391ms, respectively. The adverb *svakalega* had the longest realisations with a mean of 583ms. This difference between adverb types remained when only adverbs with the same number of phonetic syllables were considered:

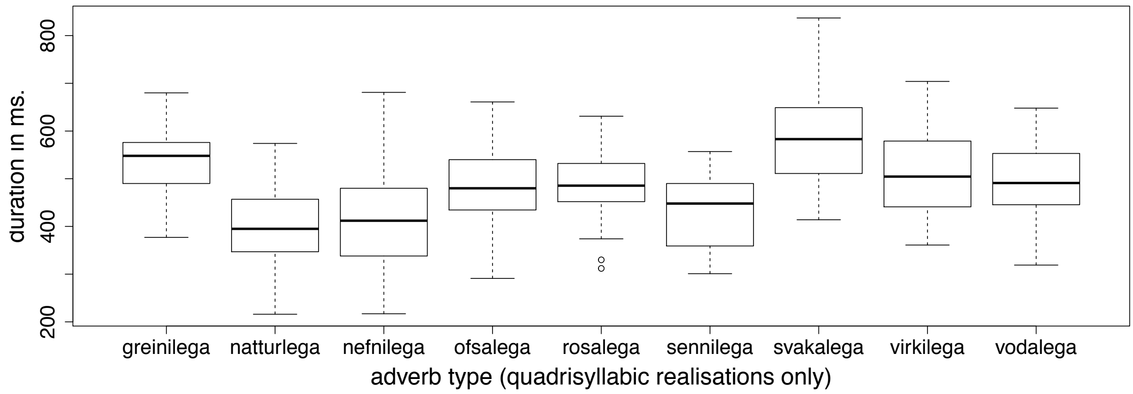

Figure 4.48: Adverb duration by adverb type for quadrisyllabic realisations

The above figure shows that even when only quadrisyllabic realisations were taken into account, *nefnilega* and *náttúrlega* had the shortest mean duration while *svakalega* had the longest.

Iteration According to the statistical model, adverb durations did not differ significantly between the first, second or third repetition:

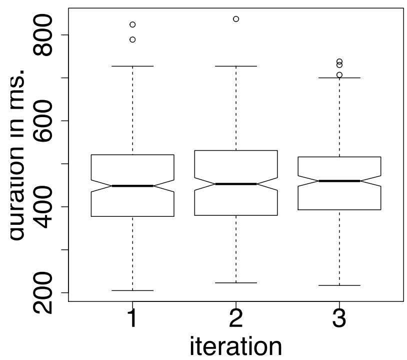

Figure 4.49: Iteration and adverb duration

As can be seen in the above figure, there was no difference in adverb duration across iterations since the mean duration hardly differed.

Speech rate Speech rate was a highly significant predictor of durational reduction in the statistical model (t = −12.7). The following figure displays the effect of rate of speech graphically:

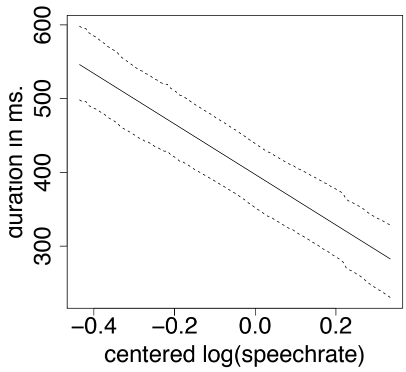

Figure 4.50: Effect of speech rate on adverb duration

The faster participants spoke, the shorter their adverb realisations generally were. The marginally significant interaction of speech rate and adverb function ($t = -1.945$) shows that intensifier and sentence adverbs differed slightly with regard to the effect of speech rate:

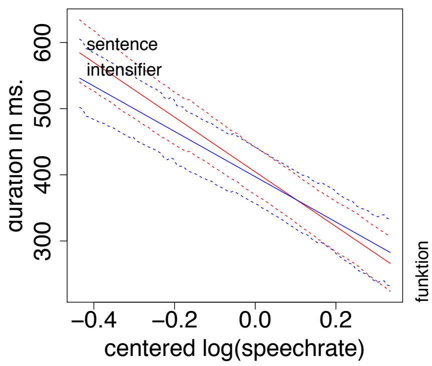

Figure 4.51: Interaction of speech rate and adverb function

Both the duration of intensifier adverbs and that of sentence adverbs was heavily affected by speech rate. The effect of speech rate, however, was even stronger for sentence adverbs than for intensifier adverbs.

The statistical model showed that the effect of rate of speech was moderated by a second variable. The interaction of speech rate and the place of articulation of the second syllable onset ($t = 2.837$) is given in Figure 4.52:

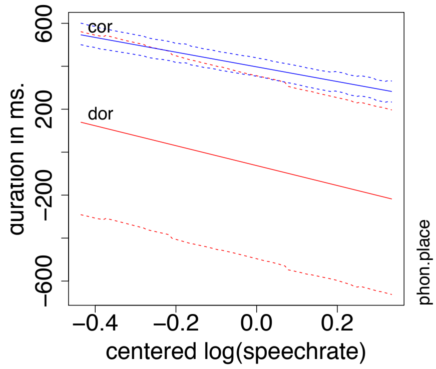

Figure 4.52: Interaction of speech rate and place of articulation

Adverbs with a dorsal consonant in the second syllable onset were affected by speech rate slightly stronger than adverbs that had coronal consonant in the same position.

Token frequency Adverb token frequency played a significant role in predicting adverb duration according to the statistical model. The main effect for frequency of occurrence ($t = 2.432$) is given in Figure 4.53:

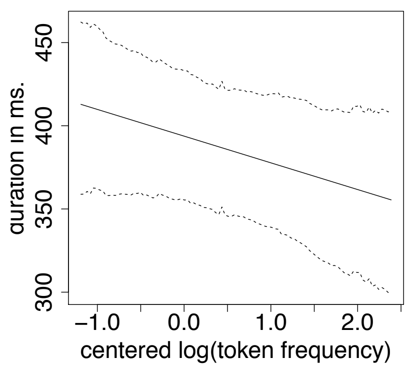

Figure 4.53: Effect of token frequency on adverb duration

Adverbs with a high token frequency were generally realised as shorter than adverbs with a low token frequency. The frequency effect for duration was moderated by an interaction of token frequency with the place of articulation of the second syllable onset ($t = 2.213$):

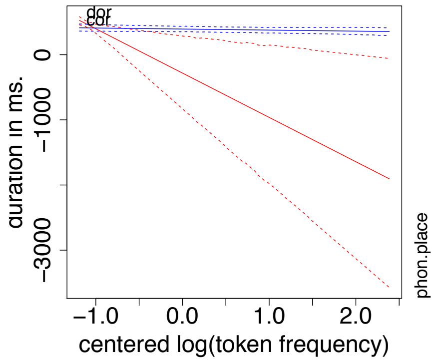

Figure 4.54: Interaction of frequency of occurrence and place of articulation

The above figure shows that the frequency effect only applied to adverbs with an dorsal consonant in the second syllable onset, but not to adverbs with a coronal consonant in the same position.

Accentedness According to the statistical model, the variable "accentedness" had a highly significant effect on adverb duration (t = 8.526). The effect of pitch accentedness is shown in the following figure:

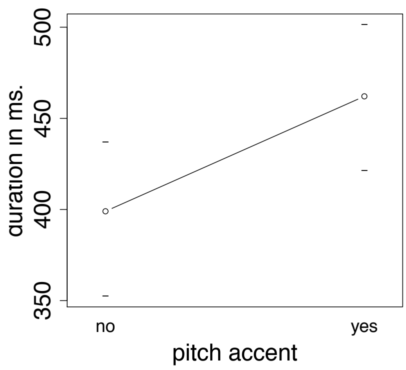

Figure 4.55: Effect of accentedness on adverb duration

Adverbs that received a pitch accent were generally longer durationally than adverbs that were not pitch-accented.

Adverb function The semantic and syntactic function of the target adverbs was not significant on its own in the linear mixed-effects model, but displayed a marginally significant interaction with rate of speech (cf. above). Sentence adverbs were generally affected more by higher speech rates than intensifier adverbs.

Phonological-structural variables Of the two phonological-structural variables, only the place of articulation of the second syllable onset was retained in the final model while the manner of articulation was dropped during model fitting process. In addition to the two significant interactions presented above, place of articulation also displayed a significant main effect as shown in Figure 4.56:

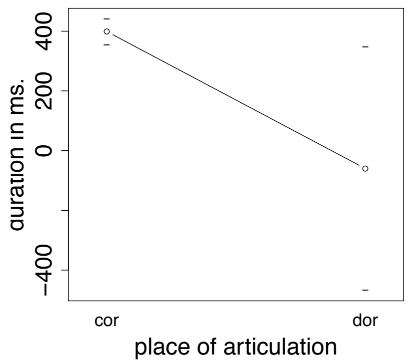

Figure 4.56: Effect of accentedness on adverb duration

Adverbs with a dorsal consonant in the second syllable onset were shorter according to the statistical model than adverbs with a sonorant in the onset of the second syllable.

Summing up, adverb duration in the reading task was significantly affected by a number of variables. The differences between individual adverb lexemes were large enough to warrant the inclusion of "adverb type" as a random effect variable. High speech rates and a high frequency of occurrence both facilitated durational reduction. Both variables interacted with the place of articulation of the second syllable onset. Adverbs that were accented were significantly longer durationally than adverbs that were not.

4.3.3 Discussion

The reading task was constructed as a comparison to the shadowing task. The same participants that had taken part in the shadowing experiment read a number of sentences that contained the same adverb types as in the shadowing experiment. For every adverb type, one sentence was constructed. Since one of the goals of the shadowing task was to locate the role of frequency effects in speech production, the reading task was intended to verify that participants exhibited frequency effects also under more natural circumstances. Apart from frequency of occurrence, adverb realisations were expected to be influenced by variables known from the literature and the corpus-based study in ch. 3 such as speech rate, accentedness and phonological-structural factors. Task-specific variables like the number of iterations were also assumed to influence reduction.

The same two dependent variables that had already been employed in the shadowing and the corpus-based study were used for the reading task as well: the phonetic number of syllables and adverb duration. In addition, the adverbs were annotated for a number of predictor variables. These independent variables were a subset of those variables that had been used in the shadowing task, excluding task-specific variables. In this section, the results of the reading task are analysed with regard to the hypotheses outlined in ch. 4.3.1 and compared to the results of the corpus-based study (cf. ch. 3) where necessary. A comparison of the reading experiment with the shadowing task is made afterwards in the general discussion in ch. 4.4.

In general, the syllabic data showed an unexpectedly high number of heavily reduced forms: Disyllabic forms made up 12% of the data. The durational data mirrored this tendency in that many very short ($<$ 200ms) forms were found in the corpus. However, the durational data also showed a number of very long realisations that exceeded 1000ms. Participants thus showed a large amount of variability in their adverb realisations and made use of the greater freedom that the reading task offered them in comparison to the shadowing task (cf. also ch. 4.4).

Adverb types differed in their preference for reduction. Most disyllabic forms were found for the adverb type *nefnilega*. *Náttúrlega*, *sennilega* and *greinilega* also displayed a high number of disyllabic realisations. The intensifier adverb *svakalega* had the highest number of quadrisyllabic realisations and also the longest adverb realisations durationally. Differences were not only found between adverb types, but also between experiment participants. While some participants maintained a rather formal style in their reading, others read the target sentences in a more casual manner. This was evidenced by both the differences in participants' amount of adverb reduction and differences in mean speech rate.

Linear mixed-effects models were fitted to both the syllabic data and to the durational data in order to test the hypotheses outlined above and in order to evaluate in general which factors influenced the variation in the reading task. The following table gives an overview of which variables had a significant impact on the reading data:

Predictor	No. of syllables	Adverb dur.
iteration	–	–
token frequency	✓*	✓*
accentedness	–	✓
speech rate	✓*	✓*
adverb function	– *	– *
onset manner	– *	–
onset place	–	✓*

Table 4.7: Comparison of factor performance in different statistical models

In the following, the effects of individual variables will be discussed and evaluated.

The variable "iteration" was neither significant in the model predicting the phonetic number of syllables nor in the model predicting adverb duration. This is somewhat surprising given the results from the literature that suggest that repetition leads to more reduction (Fowler, 1988; Kul, 2011). The non-effect of iteration could be explained in two ways. Firstly, three iterations might simply not be enough to allow for a reducing effect to appear in a reading study. Kul (2011), for example, employs seven iterations of a text that itself contains the target word four times. A second interpretation is related to the succession of tasks. As the reading task directly followed the shadowing task, participants had probably become used to the experimental setting and therefore did not vary much across iterations. The latter explanation would point to a ceiling effect in participants' productions which can also help explain the unexpectedly high amount of reduced forms that were found in the data.

Based on the results from the corpus-based analysis in ch. 3, the variables speech rate, accentedness and frequency of occurrence were all expected to influence syllabic and durational reduction in the reading task. These expectations were mostly confirmed. Participants' speech rate emerged as the strongest predictor of reduction in both statistical models. Participants reduced more when they spoke faster. This result is fully in line with that of the corpus-based analysis and with the literature. For both dependent variables, speech rate also interacted with adverb function, albeit in opposing directions.

The interaction of speech rate and adverb function in the model predicting the phonetic number of syllables indicated that sentence adverbs can also reduce syllabically with lower speech rates, while intensifier adverbs only reduce with higher speech rates. This interaction can be taken as evidence for the lexicalisation of disyllabic side forms of the sentence adverbs *náttúrlega* and *nefnilega* (cf. also the previous chapters). If disyllabic reduced forms can appear with lower speech rates, they cannot be classified as an allegro-phenomenon and are most likely not (solely) the product of phonetic implementation. Hence, the interaction of speech rate and adverb function in the syllabic data shows that the reduction in adverbs like *nefnilega* is at least partly lexical since participants deliberately produced disyllabic forms also with lower speech rates.

The variable "accentedness" only had a significant impact on adverb duration but not on the phonetic number of syllables. While the former is expected and in line with the results of the corpus-based study, the latter is not. In order to explain the disassociation between syllabic and durational reduction with regard to the effect of accentedness, one might look at the rate by which adverbs in the reading task were accented. In general, the adverbs in the reading task displayed a higher rate of pitch accentedness than the adverbs in the corpus-based study. While in the corpus-based study, less than 50% of all tokens were pitch-accented, in the reading task 77% of the target adverbs received a pitch-accent. The main difference between the two data types is in the accentedness of sentence adverbs. While in the corpus data, only a third of sentence adverbs were accented, in the reading task 53% of sentence adverbs were accented.

For the syllabic data, a quadrisyllabic realisation represents the ceiling, i.e. adverbs cannot not be realised with more than four syllables. For the durational data, however, there is in principle no limit to lengthening. In addition, there were also a number of quadrisyllabic realisations that were unaccented. These were, however, still shorter than accented quadrisyllabic productions. While the greater degree of accentedness in the reading data could therefore hardly influence the phonetic number of syllables, since these were already "at the limit", pitch accents could still lead to durational lengthening even when adverb realisations with the same number of phonetic syllables are compared.

The token frequency of target adverbs was a significant predictor in both the model for the phonetic number of syllables and the model for adverb duration. This effect persisted when high-frequency *nefnilega* which showed the largest number of reduced disyllabic forms was excluded from the data base. The token-frequency-effect can therefore not be reduced to the behaviour of one ore two high-frequency items alone, but runs through the whole data set. With regard to impact of token frequency, the results of the reading study are comparable with those of the corpus-based study which also showed an effect of frequency of occurrence for both the durational data and the syllabic data.

Phonological-structural variables emerged as significant predictors of adverb reduction in the reading task as well. There was, however, a split between the two dependent variables with regard to the role of phonological factors. The number of syllables with which *lega*-adverbs were realised was only influenced by the *manner* of articulation of the second syllable onset (in certain interactions, cf. below). In contrast, adverb duration was significantly influenced only by the *place* of articulation of the onset of the second adverb syllable.

The variable "manner of articulation" participated in two significant interactions in the model predicting the phonetic number of syllables. Adverbs were realised with fewer syllables when they had a sonorant in the second syllable onset and either speech rate was high or the adverb in question had a high frequency of occurrence. The latter interaction can be reduced to the behaviour of the adverb *nefnilega* which has the sonorant [n] in the second syllable onset. *Nefnilega* is a high-frequency adverb that displayed the highest number of disyllabic, i.e. heavily syllabically reduced realisations in the reading task. When *nefnilega* was excluded from the data set, the interaction of frequency of occurrence and manner of articulation was no longer significant.

The second interaction, manner-speech rate, remained significant even in the data set excluding realisations of *nefnilega*. This interaction states that when speech rates were high, adverbs with a sonorant in the onset of the second syllable were realised with fewer syllables than adverbs with an obstruent in the same position. The reduction of the nucleus of the second syllable and the accompanying syllable loss is therefore facilitated when the onset of the second syllable is a sonorant (which in all cases is homorganic with the following lateral) and participants spoke fast. This phenomenon is exemplified by the reduction of the adverb *sennilega* from trisyllabic [sɛnːɪla] to disyllabic [sɛnla].

In these cases, the phonological structure of the adverbs in question lends itself very well to syllabic reduction. Since this kind of reduction happens only with high speech rates, it can be classified as an allegro phenomenon. This allegro reduction applies mostly to the adverbs *sennilega* and *greinilega* which both exhibit the necessary phonological structure. For these two adverbs, the reduction in the stem has not been lexicalised like in the adverbs *nefnilega* and *náttúrlega*. While the "reducibility" of the phonological structure therefore is a prerequisite for acoustic reduction in (fast) spontaneous speech, for the lexicalisation of these reduced forms a high-token frequency is necessary as well.

Interestingly, the interaction of manner and speech rate was not found for the dependent variable adverb duration. This entails that syllabic reduction from e.g. [sɛnːɪla] to [sɛnla] does not necessarily lead to durational reduction. Instead of "manner of articulation", for adverb duration, the variable "place of articulation of the second syllable onset" was significant in the statistical model. Adverbs with a dorsal consonant in the second syllable onset were significantly longer durationally than adverbs with a coronal consonant in the same position. Intensifier adverbs like *virkilega* and *svakalega* that belong to the former group displayed the longest realisations in the data which might explain the significant effect for this variable. Since, as was mentioned above, quadrisyllabic realisations in general are rather frequent in the data, the "place"-effect was not found for the second dependent variable, the phonetic number of syllables.

Summing up, participants in the reading task displayed a high amount of variability and produced both many highly reduced disyllabic forms and a number of durationally long realisations. The multivariate analyses showed that adverb realisations were influenced by much the same variables as in the corpus-based study presented in ch. 3. Token frequency had a significant effect on both adverb duration and the phonetic number of syllables. speech rate and accentedness influenced adverb realisations as well. Evidence for lexicalisation of disyllabic side forms of *náttúrlega* and *nefnilega* could be drawn from the interaction of speech rate and adverb function.

4.4 General discussion and summary

This chapter has presented two experimental follow-up studies to the corpus-based analysis presented in ch. 3: a shadowing and a reading task. In this section, the set-up and the results of these tasks are summed up. Subsequently the results of both tasks are compared with regard to the effect that the difference in task structure had on adverb realisations.

The goal of the shadowing task was twofold. Firstly, the experiment was intended to verify the (non-)effect of metrical rhythm in an experimental setting. This was deemed necessary in order to achieve comparability with other studies that had demonstrated a rhythmic effect on reductive alternations. The second goal of the shadowing task was to locate the effect of frequency of occurrence in the speech production process. Close shadowers, i.e. participants that displayed very short response latencies, were of particular interest in this case since for those participants the role of conceptual planning in production can be seen as diminished. The reading task was intended to verify whether possible frequency effects that were established in the shadowing experiment could also be found in a different, slightly more natural setting. As the shadowing task produced a number of spurious results (see below), the reading task in addition served as a measure of comparison in order to establish whether the effects found in the shadowing task were only due to factors in the experimental setting.

In the shadowing task, participants had to repeat as quickly as possible, i.e. "shadow" a number of sentences some of which contained adverbs ending in -*lega*. The adverbs were embedded in two different rhythmic surroundings (trochaic and dactylic). In addition, *lega*-adverbs in the stimulus were presented in three different degrees of reduction (quadrisyllabic, trisyllabic and disyllabic).[16] With regard to the influence of rhythm, participants were expected to (re)produce reduced adverb forms when they matched the rhythmic structure surrounding them. According to this hypothesis, disyllabic forms would be reproduced more often when they were embedded in a trochaic structure while trisyllabic adverb forms would be expected to be produced more often in a dactylic surrounding. Participants were also expected to shadow reduced forms of high-frequency adverbs more often than reduced forms of low-frequency adverbs.

The results of the shadowing task showed that participants in general were very conservative in their adverb realisations. Only in very few instances, they produced heavily reduced, i.e. disyllabic forms. Disyllabic forms almost exclusively occurred when the stimulus was also disyllabic. Conversely, participants did not seem to make a difference between quadrisyllabic and trisyllabic stimulus items. The statistical model thus showed a difference in participants' productions between disyllabic stimulus items on the one hand and tri- and quadrisyllabic stimulus items on the other hand.[17] Recall that reduction from quadrisyllabic to trisyllabic takes place in the adverb suffix -*lega*. The experiment therefore comfirmed the results of the corpus-based analysis in ch. 3 that speakers do not notice suffix reduction. Reduction that appears in the adverb suffix can therefore be classified as phonetic-implementational.

The two hypotheses formulated above were not confirmed in the shadowing task. The first hypothesis stated that the rhythmic environment target adverbs

[16] Recall that "degree of reduction" was an inter-subject variable, i.e. every participant heard every sentence only once with the adverb in a certain degree of reduction.

[17] In this respect, the results of the shadowing task mirror those obtained by Ernestus *et al.* (2002). Although the experimental set-up was a wholly different one in Ernestus et al.'s case, their results also show no significant difference in participants' reaction between items with mid-reduction and items with no reduction at all.

were embedded in would influence participants' adverb realisations. However, as the statistical analysis showed, this was not the case. It thus made no difference whether adverbs were surrounded by trochaic feet only or by dactylic feet only. In this respect, the shadowing task confirmed the results of the corpus-based analysis in ch. 3. Since almost all participants were classified as “distant” shadowers, no conclusions could be drawn about the place of possible token frequency effects in the speech production process.

The second hypothesis stated that the shadowing of reduced forms would be influenced by the frequency of occurrence of the target adverbs. The variable “token frequency” indeed had an effect on adverb production according to the statistical model. Closer inspection of the data, however, revealed that this effect was due to the behaviour of only two high-frequency adverb types: *náttúrlega* and *nefnilega*. Most of the disyllabic forms that participants reproduced were realisations of these two adverbs. Recall from the previous chapters that the disyllabic forms *náttla* and *nefla* have acquired a status that is relatively independent of their original lexemes. Participants therefore almost exclusively shadowed disyllabic adverbs realisations when the disyllables in the stimulus can be classified as “lexicalised”.

Evidence for lexicalisation was also drawn from the fact that disyllabic realisations were mostly produced with *lower* speech rates than items that were not as heavily reduced. This results contrasts with general expectations of speech rate effects on reduction. As the literature and the corpus-based analysis in ch. 3 have shown, higher speech rates usually correlate with a greater degree of reduction. A second surprising result was the behaviour of the variable accentedness. According to the statistical models, the presence of a pitch accent did not have an effect on durational reduction and the adverse effect on syllabic reduction. Since the results for the variables frequency, speech rate and accentedness were contradictory to previous results, the question was raised whether the set-up of the experiment itself led to the surprising behaviour of participants in the shadowing task.

Therefore, the reading task, as detailed above, was constructed to be a “companion experiment” to the shadowing task. In this second experiment, participants had to read a number of sentences that contained *lega*-adverbs. The structure of the sentences was similar to those in the shadowing task. However, adverbs were not embedded in a regularly rhythmic setting. The stimulus sentences were cued by questions in order to make them more natural sounding and shift sentence stress from the adverbs to the item directly following them. The same subjects that had taken part in the shadowing task also participated in the reading task. Participants were expected to behave more naturally than in the shadowing task. It was therefore hypothesised that the variables that influenced speakers' adverb realisations in the corpus-based analysis in ch. 3, but that did not influence adverb realisations in the shadowing task, would display a significant effect in the reading task. Specifically, the variables speech rate, accentedness and frequency of occurrence were expected to influence adverb production in the reading task in the way they did in the corpus-based analysis.

The results of the reading task mostly confirmed the expectations formulated above. Large differences between participants' reading styles were found in the data. Some participants spoke in a relatively fast, colloquial style. Others spoke relatively slow and displayed a rather formal speaking style. For both groups, most of the expected significant effects were found in the statistical models that were fitted to the syllabic and durational data. Rate of speech emerged as the most significant predictor of both syllabic and durational reduction. Adverbs were thus generally shorter when participants spoke faster. Adverb accentedness also affected reduction, most prominently adverb duration.[18]. Frequency of occurrence was a significant factor in explaining both syllabic and durational reduction. High-frequency adverbs were realised as shorter than low-frequency adverbs, both with regard to duration and with regard to the phonetic number of syllables. Crucially, it could be ruled out in the analysis that the frequency effect was only caused by one or two high-frequency items. Adverb realisations in the reading task thus resembled those found in the corpus-based study in ch. 3.

In the following discussion, the results of the shadowing task and those of the reading task will be compared and evaluated with regard to both the research questions formulated for the individual tasks and with regard to the larger questions that were asked in the beginning of this dissertation. It will also be asked whether the curious results obtained in the shadowing task can be traced back to the set-up of the experiment itself.

In general, participants produced more reduced and more heavily reduced adverb forms in the reading task than in the shadowing task. Generalising over the whole data set, adverbs in the reading task were realised as shorter both syllabically and durationally. However, participants also produced adverb realisations that were significantly longer durationally than in the shadowing task. It could thus be said that participants displayed a greater variability in the reading

[18] The lack of an effect of accentedness on syllabic reduction was explained by a ceiling effect in ch. 4.3.3.

task than in the shadowing task, which could be interpreted as a sign of greater naturalness.

The reading task turned out to provide more "natural" data than the shadowing task in one additional dimension. Consider the factors that influenced reduction in both tasks:

Predictor	Shadowing syllables	Shadowing duration	Reading syllables	Reading duration
iteration	n.a.	n.a.	–	–
reaction latency	– *	✓*	n.a.	n.a.
speech rate stimulus	✓	✓	n.a.	n.a.
token frequency	✓*	–	✓*	✓*
accentedness	✓*	– *	–	✓
speech rate	✓*	✓*	✓*	✓*
adverb function	– *	✓*	– *	– *
onset manner	–	–	– *	–
onset place	–	–	–	✓*

Table 4.8: Comparison of factor performance in different experimental set-ups

The factors that influenced adverb realisations according to the statistical models that were fitted to the reading data were largely the same as those in the corpus-based data. In the shadowing task, however, several variables had a counterintuitive effect on the dependent variables or no effect at all. This difference was especially noteworthy for the variables speech rate and accentedness which had the expected effect in the reading task, but not in the shadowing experiment. In addition, frequency of occurrence proved to have a much more pervasive influence in the reading experiment than in the shadowing task.

The comparison of results shows that participants produced more natural adverb realisations in the reading experiment. It is therefore rather likely that the curious behaviour of experiment participants in the shadowing task can be attributed to factors in the experimental set-up itself. As discussed in ch. 4.2.4, the stimulus items were recorded with a rather low speech rate. This feature of the stimuli might have led experiment participants to adopt a rather formal speaking style. Furthermore, the presence of reduced forms in a slow-paced environment might have confused participants which in turn led to a greater error rate in the shadowing of heavily reduced forms.

In sum, the two experiments have provided a number of additional insights into the reduction behaviour of Icelandic *lega*-adverbs. No effect of metrical rhythm on the (re)production of reduced forms was found in the shadowing experiment. This confirms the results of the corpus-based study in ch. 3. Additionally, the shadowing task provided a measure of comparison to other studies on reductive alternations which all employed experimental data. Frequency of occurrence influenced reduction in the shadowing experiment only via the reproduction of high-frequency lexicalised side-forms of *náttúrlega* and *nefnilega*. The locus of frequency effects in the speech production process could not be clarified via the shadowing experiment since, on the one hand, no clear frequency effects were found and, on the other hand, experiment participants in the overwhelming majority proved to be distant shadowers. In contrast, adverb token frequency had a pervasive effect on both syllabic and durational reduction in the reading task.

5 General discussion and conclusion

This dissertation has presented a study of phonetic reduction in Icelandic. The object of study were quadrisyllabic adverbs containing the suffix -*lega* '-ly'. Three main research questions were formulated in the initial chapter:

1. Which factors influence the production of reduced forms of Icelandic *lega*-adverbs?

2. How do these factors compare to the results of other studies?

3. Which (if any) conclusions can be drawn about the cognitive representation of reduced forms?

The thesis consisted of three parts: a corpus-based analysis and two experimental studies, a shadowing and a reading task. In all three studies, the phonetic number of syllables and adverb duration were used as measures of reduction. As data for the corpus-based analysis, the spoken subpart of the Icelandic national corpus *Íslenskt textasafn* was used. 900 *lega*-adverbs were extracted from the corpus and annotated for a number of variables which were mostly known from the literature to influence reduction. Multivariate analyses for both syllabic and durational reduction were carried out in order to evaluate which factors influence the reduction of *lega*-adverbs. In this respect, the corpus-based analysis was exploratory in nature.

The focus of the shadowing task was on the effects of frequency of occurrence and metrical rhythm. Participants shadowed (i.e. quickly repeated) a number of sentences that contained *lega*-adverbs in three different degrees of reduction and in two different rhythmic environments. 35 native-speakers of Icelandic participated in the experiment. The results of the shadowing experiment showed strong effects of the task structure, which resulted in participants hardly producing any reduced forms.

The reading experiment served as a link between the shadowing task and the corpus-based analysis. Its goal was to provide additional, more natural data from the same participants that had taken part in the shadowing experiment. The material consisted of nine sentences that contained the same *lega*-adverbs as in the reading task. Participants in the reading task behaved more like the speakers in the corpus-based than in the shadowing study. The reading data could therefore indeed be called more "natural" than the shadowing data.

In the following, the results from the three different empirical analyses will be summed up with regard to the research questions formulated above. In order to avoid redundancies, the first two questions will be adressed together.

1. & 2. Which factors influence the production of reduced forms of *lega*-adverbs in Icelandic? How do these factors compare to the results of other studies?

The literature has established a number of factors that have an impact on acoustic phonetic reduction. One of the goals of this dissertation was to establish whether the same factors are also active in Icelandic. The main sources of data for these questions were the corpus-based and the reading study since as noted above, participants in the shadowing task displayed a rather formal speaking style.

Rate of speech and accentedness influenced both syllabic and durational reduction in most cases. Higher speech rates led to more reduction in both the corpus-based and in the reading analysis, and also partially in the shadowing experiment (cf. below). The effect of speech rate is well-supported by the literature and easily explained. In a fast speaking style, articulatory gestures are often compressed and not executed precisely or can even be omitted entirely. This articulatory compression in turn can lead to lenition and deletion of segments and syllables.

Pitch-accented adverbs were realised as significantly less reduced than unaccented ones in both the corpus-based and the reading study. In the shadowing task, accentedness did not play a role, presumably since participants displayed a rather formal speaking style. Similarly to the role of speech rate, the effect of accentedness is backed up by the literature which has shown that prosodic prominence correlates negatively with reduction.

The role of frequency of occurrence and other predictability factors has been analysed extensively in the literature. It has been shown that frequency of occurrence is an important factor for content, but less so for function words. In addition, suffixes and prefixes have also been shown to exhibit frequency effects.

The corpus-based and the reading study confirmed the significant role of token frequency for the explanation of reduction patterns. In both tasks, frequency correlated positively with the degree of reduction: high-frequency items were generally more reduced than low-frequency items.

Token frequency effects were found for the adverb as a whole as well as for the durations of the adverb stem and suffix. This result shows that to a certain extent, stem and suffix are reduced independently of each other. Crucially, all of the frequency effects in the two analyses remained significant even when the high-frequency adverbs *náttúrlega* and/or *nefnilega* were excluded from the database. In the shadowing task, frequency of occurrence only played a role via the lexicalised side forms of *náttúrlega* and *nefnilega* (cf. below). This pattern was explained by the structure of the shadowing task itself, which (as already mentioned) led participants to adopt a rather formal speaking style.

Two context-sensitive, frequency-based probability measures were included in the analysis: forward and backward transitional probability. Contextual predictability factors were only included as predictor variables in the corpus-based analysis. In the constructed sentences that were the basis of the shadowing and the reading task, it was attempted to hold backward transitional probabilities – from the word following the target adverb to the adverb itself – constant. Surprisingly, neither backward nor forward transitional probability proved to be significant factors in the corpus-based analysis, although in the literature, backward transitional probability has been established as the most important predictability factor for content words.

Two possible explanations were offered for this result. On the one hand, the word-class status of *lega*-adverbs could be responsible, since *lega*-adverbs are situated between function and content words. On the other hand, the corpus that was used for the calculation of the transitional probabilities could simply have been too small to provide reliable information about the predictability of *lega*-adverbs from the surrounding context. When more transcriptions of spontaneous Icelandic (outside news or other television contexts) become available, these results might therefore have to be revisited.

The role of word class and discourse function has already been alluded to in the previous paragraph. In the literature, it has been shown that function and content words differ with regard to the impact of several factors, most notably predictability-based ones. *Lega*-adverbs display two different discourse functions: sentence and intensifier adverbs. In addition, the high-frequency adverbs *nefnilega* and *náttúrlega* and their reduced side forms (cf. below) seem to have taken over discourse or modal particle functions.

The trend that emerged form the different statistical models was that sentence adverbs reduce more easily than intensifier adverbs. However, the results concerning the role of adverb function were not uniform across the three different sources of data. Additionally, they were also to a certain extent influenced by the behaviour of the high-frequency sentence adverb *náttúrlega*. In the corpus-based study, the significant effect of adverb function on the phonetic number of syllables remained when *náttúrlega* was excluded from the dataset. The effect on adverb duration, however, disappeared without *náttúrlega*. Interactions in the model predicting the reading data showed that sentence adverbs reduce more easily than intensifier adverbs, but this difference is evened out for higher speech rates.

As mentioned above, effects of adverb function are in principle in line with the literature. The data also showed that adverb function correlated strongly with accentedness: sentence adverbs were significantly less often realised as accented than intensifier adverbs. This correlation would support a prosodic explanation for the effect of adverb function. However, there were also unique effects of both adverb function and accentedness. Therefore, a second explanation in terms of semantic lightness was offered. Nevertheless, further qualitative and quantitative research is needed to fully uncover the differences between semantic and functional adverb classes.

Metrical rhythm was included as a factor due to its theoretical significance with regard to the roles of storage and implementation in the production of reduced forms (cf. below). Several studies have shown that reductive processes like schwa deletion and Final Vowel Deletion are influenced by the rhythmic environment. The application of these processes is favoured if it leads to the creation of a regular metrical structure. However, this was not the case for the reduction found in *lega*-adverbs. The rhythmic environment influenced adverb reduction neither in the corpus-based nor in the shadowing study. This result shows that there indeed seems to be a categorical distinction between "phonological" reductive processes like Final Vowel Deletion and broader phonetic reduction as found in *lega*-adverbs.

Positional factors were only included as variables in the corpus-based analysis since the adverbs in the stimulus sentences of the shadowing and the reading task were placed in sentence-medial position. Adverbs that were uttered directly preceding a pause were generally longer than other adverbs. However, this effect was mostly found for adverb duration, but to a lesser degree for the phonetic number of syllables. While in principle, this result confirms the findings in the literature, it also shows an interesting disassociation of syllabic and durational reduction. Contrary to expectations, adverbs in initial position were not realised as syllabically or durationally longer than other adverbs.

The sociolinguistic variables "gender" and "age" did not turn out to have an effect on either syllabic or durational reduction. There were no differences between male and female speakers in the corpus-based study. Since the results in the literature for the variable "gender" have been contradictory so far, the lack of an effect in the present study is not fully unexpected. Significant age differences only emerged with regard to the realisation of the adverb *náttúrlega*. Older speakers realised this adverb as significantly longer than younger speakers, which was interpreted as supporting the lexicalisation hypothesis (cf. below).

The results of the present dissertation largely are in agreement with the results from the literature. The role of token frequency, speech rate, accentedness, prepausal position and possibly also word class was confirmed in most or all sources of data. The non-effect of context-sensitive predictability factors has to be re-evaluated when larger corpora of spontaneous Icelandic become available. Similarly, the role of age and adverb function will have to be analysed more closely in the future.

3. Which (if any) conclusions can be drawn about the cognitive representation of reduced forms?

This question can be understood in two different ways. On the one hand, reduced forms can be "lexicalised" in the classical sense. This would entail some kind of representation of a reduced form that is distinct from the original lexeme. In this case, a reduced form would have achieved a relative independence from its "base" lexeme. This kind of cognitive representation is compatible with generative-abstractionist models of storage, since for this kind of storage, only one underlying form is necessary that can be an "abstract reduced" form.

On the other hand, the question could refer to the exemplar-storage of reduced forms. In an exemplar-based model, the representation of a given unit – metaphorically speaking – is made up of a cloud of different exemplars. These exemplars are constructed from actual realisations that have been encountered by a speaker in perception or production. This rich-memory conceptualisation of storage entails that the representation of a given lexeme does not consist of one abstract "underlying" form. Instead, information about pronunciation variants and indexical information is stored alongside or even instead of an abstract generalisation. An exemplar-based lexicon is of course not mutually exclusive with the notion of lexicalisation.

The present dissertation provided support for the hypothesis that disyllabic side-forms of *náttúrlega* and *nefnilega* are lexicalised in the classical sense. However, no evidence could be found for exemplar storage of reduced forms. As Ernestus (2014) notes, it is difficult to gauge from production data alone what kind of representation (exemplar-based vs. abstractionist) should be assumed. Therefore, the variable "metrical rhythm" was included in the corpus-based and the shadowing study. As mentioned above, the rhythmic environment has been shown to influence "phonological" reductive processes like schwa deletion in Dutch or Final Vowel Deletion in Icelandic.

In classical generative-abstractionist models, phonological reductive processes are distinct from phonetic reduction. While the former is said to be part of (postlexical) phonological computation, the latter is a part of phonetic-articulatory implementation. If rhythm were to influence the "phonetic" reduction that is found in *lega*-adverbs, this would entail a blurring of the distinction between phonological and phonetic reduction: "phonetically" reduced forms would have to be present during "phonological" computation in order for rhythm to influence them. This could be seen as evidence for some kind of exemplar activation during production, since reduced forms would be selected directly for production.

However, metrical rhythm failed to influence adverb reduction in both the corpus-based and the shadowing study (cf. above). Abstractionist models readily incorporate this finding since it is predicted by the strict division of labour between phonology and phonetics. In this view, metrical rhythm as well as phonological reductive processes are active in postlexical phonology. Accordingly, the reduction found in the data is not affected by rhythm since it operates in a different domain, i.e. phonetics. Exemplar-based models can account for the lack of a rhythmic effect as well. However, a greater role of articulatory implementation in reduction has to be assumed.

While the variable metrical rhythm thus failed to provide evidence for the presence of exemplars in production, there were indications in all of the three studies that disyllabic side forms of *nefnilega* and *náttúrlega* are lexicalised. In general, *náttúrlega* and *nefnilega* were realised significantly more often as disyllabic than other adverb types. In the corpus-based analysis, a difference emerged between the three age groups with regard to how they realised the adverb *náttúrlega*. Given the same circumstances, younger speakers produced more often disyllabic forms of *náttúrlega* than older speakers. Differences between age groups can be taken as apparent-time evidence for language change – in this case for the lexicalisation of a disyallabic reduced form like *náttla*.

In the shadowing task, the disyllabic forms of *náttúrlega* and *nefnilega* were the only heavily reduced adverb forms that participants shadowed regularly. This can be seen as evidence that participants recognized the disyllabic side forms out of their "natural" context. In addition, when participants reproduced disyllabic forms of *náttúrlega* and *nefnilega*, they spoke slower than usual. This pattern shows that these particular reduced forms were produced deliberately and were not (only) the result of articulatory implementation.

In sum, the data failed to provide evidence for exemplar storage. Generative models can accommodate the results quite well since they predict that most reduction is phonetic-implementational. However, exemplar models can also accommodate the data by allowing for a greater role of phonological computation during production. Therefore, the reduction found data can be said to be morpholexical on the one hand and phonetic-implementational on the other hand.

In analysing the production of reduced forms of Icelandic *lega*-adverbs in spontaneous speech and under experimental conditions, this dissertation has intended to broaden the picture of acoustic-phonetic reduction available so far. It has been shown that phonetic reduction in Icelandic is subject to much the same constraints as reduction in other languages. For some variables like discourse function, additional qualitative and quantitative research is necessary to determine their significance for reduction.

Theoretical questions were also touched upon, mostly via the variable "metrical rhythm". The evidence suggests that most of the adverb reduction encountered in the data is phonetic-implementational in nature while some reduction is morpholexical. More research on the role of exemplars and abstractions in storage, production and perception is needed to fully understand how the reduced forms of words and other items should be represented best.

Appendix I: Critical stimuli shadowing task

1. *nefnilega* – trochaic

(5.1)	*(Inga)*	*(Rósa)*	*(vildi)*	*nefnilega*	*(ekki)*	*(gera)*	*(þetta).*
	Inga	Rósa	wanted	namely	not	do	this

‘Inga Rósa namely didn’t want to do this.’

2. *nefnilega* – dactylic

(5.2)	*(Jóhanna)*	*(skrifaði)*	*nefnilega*	*(mikið*	*um)*	*(pólitík).*
	Jóhanna	wrote	namely	much	about	politics

‘Jóhanna namely wrote a lot about politics.’

3. *náttúrlega* – trochaic

(5.3)	*(Mamma)*	*(þeirra)*	*(hafði)*	*náttúrlega*	*(varla)*	*(séð*	*hann)*	*(áður).*
	Mom	their	had	naturally	hardly	seen	him	before

‘Their mom had of course hardly seen him before.’

4. *náttúrlega* – dactylic

(5.4)	*(Jóhannes)*	*(hjólaði)*	*náttúrlega*	*(stundum*	*í)*	*(vinnuna).*
	Jóhannes	cycled	of.course	sometimes	in	work.the

‘Jóhannes of course sometimes rode his bike to work.’

5. *sennilega* – trochaic

(5.5)	*(Helgi)*	*(Rúnar)*	*(fékk*	*sér)*	*sennilega*	*(nóg*	*af)*	*(mat*	*og)*
	Helgi	Rúnar	got	himself	probably	enough	of	food	and
	(víni).								
	wine								

‘Helgi Rúnar probably helped himself to enough food and wine.’

6. *sennilega* – dactylic

(5.6)	*(Lögreglan)*	*(nefnir*	*það)*	*sennilega*	*(bráðum*	*á)*	*(fundinum).*
	police.the	names	it	probably	soon	at	meeting.the

‘The police are probably going to mention that later at the meeting.’

7. *greinilega* – trochaic

(5.7)

(Skóla)(stjórinn)	*(hafði)*	*greinilega*	*(sjálfur)*	*(sett*	*up)*	*(leikrit).*
headmaster.the	had	clearly	self	set	up	play

'The headmaster clearly had set up a play himself.'

8. *greinilega* – dactylic

(5.8)

(Nemandinn)	*(kláraði)*	*greinilega*	*(mikilvægt)*	*(verkefni).*
student.the	finished	clearly	important	assignment/project

'The student cleary finished an important assignment.'

9. *svakalega* – trochaic

(5.9)

(Önnu)	*(fannst*	*hann)*	*(vera)*	*svakalega*	*(harður)*
Anna.DAT	found	he	be	tremendously	hard
(stuðnings)(maður).					
supporter					

'Anna thought he was a tremendously ardent supporter.'

10. *svakalega* – dactylic

(5.10)

(Kennarinn)	*(mælti með)*	*svakalega*	*(spennandi)*	*(skáldsögu).*
teacher.the	recommended	tremendously	thrilling	author.story

'The teacher recommended a tremendously thrilling novel.'

11. *rosalega* – trochaic

(5.11)

(Einar)	*(Valur)*	*(átti)*	*rosalega*	*(dýrar)*	*(lopa)(húfur).*
Einar	Valur	possessed	terribly	expensive	wollen.caps

'Einar Valur had (some) terribly expensive wollen hats.'

12. *rosalega* – dactylic

(5.12)

(Maðurinn)	*(talaði)*	*rosalega*	*(lélega)*	*(íslensku).*
man.the	spoke	terribly	poor	Icelandic

'The man spoke terribly poor Icelandic.'

13. *virkilega* – trochaic

(5.13)

(Bróðir)	*(hennar)*	*(orti)*	*virkilega*	*(fyndnar)*	*(drykkju)(vísur).*
brother	her	composed	really	funna	drinking.songs

'Her brother wrote really funny drinking songs.'

14. *virkilega* – dactylic

(5.14)	*(Krakkarnir)*	*(höfðu*	*það)*	*virkilega*	*(frábært*	*í)*	*(Frakklandi).*
	children.the	had	it	really	excellent	i	France

'The children had a really good time in France.'

15. *ofsalega* – trochaic

(5.15)	*(Fata)(búðin)*	*(selur)*	*ofsalega*	*(fínar)*	*(galla)(buxur).*
	clothes.shop.the	sells	terribly	fine	jean.trousers

'The clothing store sells terribly good jeans.'

16. *ofsalega* – dactylic

(5.16)	*(Amma*	*mín)*	*(sendi*	*mér)*	*ofsalega*	*(fallega)*	*(barnabók).*
	grandmother	my	sent	me	terribly	beautiful	children's book

'My grandmother sent me a really beautiful childrens book.'

17. *voðalega* – trochaic

(5.17)	*(Helgi)*	*(reyndist)*	*(vera)*	*voðalega*	*(slæmur)*	*(lista)(maður).*
	Helgi	turned.out	be	tremendously	bad	art.man

'Helgi turned out to be a tremendously bad artist.'

18. voðalega – dactylic

(5.18)	*(Sigríður)*	*(vaknaði)*	*voðalega*	*(snemma*	*í)*	*(fyrradag).*
	Sigríður	woke.up	tremendously	early	in	before.day

'Sigríður woke up really early the day before yesterday.'

Appendix 2: Critical stimuli reading task

Each stimulus consisted of two question and answer pairs. Only the sentences containind *lega*-adverbs are translated word-by-word.

1. *nefnilega*

Er systir hans sóði? 'Is his sister a slob?' – *Systir hans er mikill sóði.* 'His sister is a big slob. ' – *Af hverju veistu það?* 'How do you know that?'

(5.19) *Systir hans kastaði nefnilega glerflösku úr bílnum.*
sister his threw namely glass.bottle out car.the
'His sister actually threw a glas bottle out of the car.'

2. *náttúrlega*

Hver kemur í afmælispartý? 'Who's coming to the birthday party?' – *Helga og Jónina koma í afmælispartý.* 'Helga and Jónina are coming to the birthday party.' – *En af hverju geta Jón og Einar ekki mætt?* 'And why can't Jón and Einar come?'

(5.20) *Jón og Einar fara náttúrulega bráðum til Þýskalands.*
Jón and Einar go of.course soon to Germany
'Jón and Einar are of course going to Germany soon.'

3. *sennilega*

Hvernig var veðrið í Reykjavík í dag? 'How was the weather in Reykjavik today?' – *Veðrið í Reykjavík var mjög gott og sólin skein.* 'The weather in Reykjavik was very nice and the sun was shining.' – *Verður líka sól í Reykjavík á morgun?* 'Is it going to be sunny in Reykjavík tomorrow as well?'

(5.21) *Í Reykjavík verður sennilega skýjað allan daginn*
in Reykjavík becomes probably clouded all day.the
'It's probably going to be cloudy in Reykjavík.'

4. *greinilega*

Hvað gerði Guðrún Eva með Halldóru í gær? 'What did Guðrún Eva do with Halldóra yesterday?' – *Guðrún Eva fékk sér bjórkollu með Halldóru.* 'Guðrún

Eva had a (mug of) beer with Halldóra yesterday.' – *Var Halldóra edrú?* 'Was Halldóra sober?'

(5.22)	*Halldóra*	*hafði*	*nú*	*greinilega*	*líka*	*drukkið*	*mikið.*
	Halldóra	had	PART	clearly	too	drunk	much

'Well, Halldóra clearly had been drinking a lot, too.'

5. *svakalega*

Hvert fór Halldóra í gær? 'Where did Halldóra go yesterday?' – *Halldóra fór á stefnumót.* 'Halldóra went on a date.' – *Var þetta skemmtilegt stefnumót?* 'Was it an interesting date?'

(5.23)	*Þetta*	*reyndist*	*vera*	*svakalega*	*leiðinlegt*	*stefnumót.*
	this	turned.out	be	tremendously	boring	date

'It turned out to be an incredibly boring date.'

6. *rosalega*

Hvað gaf Jón Hildi sem þökk? 'What did Jón give Hildur as a thank-you-gift?' – *Jón gaf Hildi ávaxtakörfu sem þökk.* 'Jón gave Hildur a fruit basket as a thank-you-gift.' – *Var þetta lítil karfa sem Jón gaf vinkonu sinni?* 'Was it a small basket that Jón gave his friend?'

(5.24)	*Jón*	*gaf*	*vinkonu*	*sinni*	*rosalega*	*stóru*	*körfu*	*í gær.*
	Jón	gave	female.friend	his	terribly	big	basket	yesterday

'Jón gave his friend a really big basket yesterday.'

7. *virkilega*

Hvað gerðist hjá fornleifafræðingunum? 'What happened at the archeologists'?' – *Prófessorinn fann leirkönnu við götuna.* 'The professor found a clay jug at the side of the road.' – *Var þetta nýleg kanna sem fræðimennirnir fundu í gær?* 'Was it a recent jug that the researchers found yesterday?'

(5.25)	*Fræðimennirnr*	*fundu*	*virkilega*	*gamla*	*könnu*	*í gær.*
	resarchers.the	found	really	old	jug	yesterday

'The researchers found a really old jug yesterday.'

8. *ofsalega*

Hvernig er maturinn í Hámu í dag? ‘How is the food at Háma [= university canteen] today?’ – *Maturinn í Hámu í dag er mjög góður.* ‘The food at Háma is very good today.’ – *Er maturinn alltaf góður í Hámu?* ‘Is the food always good at Háma?’

(5.26)	*Í*	*Hámu*	*fæst*	*stundum*	*ofsalega*	*vondur*	*matur*	*líka.*
	at	Háma	is.available	sometimes	terribly	bad	food	also

‘Sometimes you get terribly bad food at Háma as well.’

9. *voðalega*

Hvað gerðist í stjórnmálum í Reykjavík? ‘What happened in politics in Reykjavík?’ – *Í Reykjavík var gerð skoðanakönnun í gærkvöldi.* ‘An opinion poll was conducted in Reykjavík yesterday.’ – *Var þetta lítil könnun sem var gerð?* ‘Was it a small poll that was conducted?’

(5.27)	*Það*	*var*	*reyndar*	*gerð*	*voðalega*	*umfangsmikil*	*könnun.*
	it	was	actually	done	tremendously	comprehensive	poll

‘Actually, a really big survey was conducted.’

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Phonetische Reduktion von Adverbien im Isländischen

Zur Rolle von Frequenz und anderen Faktoren

Die bisherige Forschung zu phonetischer Reduktion hat eine Reihe von Faktoren erarbeitet, die Reduktion beeinflussen. So kann zum Beispiel der Einfluss von Token-Frequenz oder Akzentuiertheit als gesichert gelten. Die Objektsprachen dieser Studien beschränken sich jedoch hauptsächlich auf das Englische, Niederländische und Deutsche. Es ist somit unklar, ob die gefundenen Einflussfaktoren auch für andere Sprachen Gültigkeit haben. Für das Isländische sind bereits eine Reihe von reduktiven Prozessen katalogisiert worden, die in der Sprache aktiv sind; Einflussfaktoren auf Reduktion sind jedoch bisher nicht untersucht worden.

Die vorliegen Dissertation beschäftigte sich daher mit akustisch-phonetischer Reduktion im Isländischen anhand von viersilbigen Adverbien mit dem Suffix -*lega* '-lich' (z.B. *náttúrlega* ‚natürlich' oder *rosalega* ‚sehr'). Folgende Forschungsfragen lagen der Arbeit zu Grunde:

1. Welche Faktoren beeinflussen die Adverbreduktion?
2. Inwieweit stimmen diese Faktoren mit denen überein, die für andere Sprachen gefunden worden sind?
3. Welche Schlüsse lassen sich ziehen über etwaige kognitive Repräsentation von reduzierten Formen?

Die oben genannten Fragen wurden in drei verschiedenen empirischen Studien untersucht: einer korpusbasierten und zwei experimentellen, einem Shadowing-Experiment und einem Lese-Experiment. Reduktion wurde in der Arbeit operationalisiert zum Einen als Silben-Elision und zum anderen als Dauer-Reduktion.

Grundlage der korpusbasierten Untersuchung war der gesprochensprachliche Teil des isländischen Nationalkorpus *Íslenskt textasafn* ‚Isländische Textsammlung'. Aus diesem wurde ein Sample von 900 viersilbigen *lega*-Adverbien extrahiert und für eine Reihe von Faktoren annotiert. Diese Faktoren sind zum guten Teil aus der Literatur bekannt, der Faktor Metrischer Rhythmus ist jedoch noch nicht im Hinblick auf phonetische Reduktion untersucht worden. In mehreren multivariaten Analysen wurden anschließend die Faktoren ermittelt die Silben- und Dauer-Reduktion der *lega*-Adverbien beeinflussen.

Der Fokus des Shadowing-Experiment lag auf den Faktoren Token-Frequenz und Metrischer Rhythmus, die hier gezielt untersucht werden sollten. Aufgabe der Experiment-TeilnehmerInnen war es, eine Reihe von Sätzen möglichst schnell nachzusprechen (zu „shadowen"). Jeder kritischer Stimulus-Satz enthielt eines von neun *lega*-Adverbien. Die Adverbien waren dabei in unterschiedlichen Reduktionsstufen (vier-, drei-, zweisilbig) und in unterschiedlichen rhythmischen Umgebungen zu hören. Die Ergbnisse des Experiments zeigten, dass die TeilnehmerInnen stark von der Task-Struktur beeinflusst waren und daher kaum reduzierte Formen produzierten.

Das Lese-Experiment diente als Brücke zwischen Korpus-Studie und Shadowing-Experiment. In diesem zweiten Task lasen die selben TeilnehmerInnen wie im Shadowing-Experiment eine Reihe von Sätzen, die *lega*-Adverbien beeinhalteten. Die Erwartung war dabei, dass sich die TeilnehmerInnen beim Lesen „natürlicher", also eher wie die SprecherInnen im Korpus, verhalten würden. Diese Erwartung wurde bestätigt.

Die Ergebnisse der drei empirischen Studien bestätigten weitgehend die Resultate der bisherigen Forschung. Token-Frequenz wurde als wichtiger Faktor bestätigt, der sowohl Silben-Elision als auch Dauer-Reduktion beeinflusst. Hochfrequente Adverbien reduzieren stärker und häufiger als niedrigfrequente Adverbien. Kontext-sensitive Prädiktiktabilitätsmaße hatten entgegen der Erwartung keinen Einfluss auf die Adverb-Reduktion. Eine mögliche Erklärung hierfür liegt in der begrenzten Größe des Korpus, das zur Berechnung der Prädiktabilitäts-Werte herangezogen worden war.

Akzentuiertheit und Sprechgeschwindigkeit beeinflussten die Adverbreduktion, im Einklang mit den Ergebnissen aus der Literatur. Ebenfalls Einfluss hatte die Position der Adverbien. Adverbien vor Pausen reduzierten weniger als Adverbien im Innern einer Äußerung. Hingegen spielte eine äußerungsinitiale Position keine Rolle. Die Rolle von Wortart bzw. Diskursfunktion konnte nicht vollständig geklärt werden. Es zeigten sich jedoch Tendenzen, dass Satzadverbien stärker reduzierten als Intensifier-Adverbien. Von den soziolinguistische Variablen, die einbezogen wurden, beeinflusste nur der Faktor Alter Reduktion zum Teil; das Geschlecht der SprecherInnen spielte keine Rolle.

Metrischer Rhythmus hatte weder in der Korpusstudie noch im Shadowing-Experiment Einfluss auf Reduktion. Dieser Faktor war wegen seiner theoretischen Signifikanz in die Untersuchung mit einbezogen worden. Der Effekt von Metrischem Rhythmus ist kategorisch, d.h. Silben fallen weg um einen gleichmäßigen Rhythmus zu erreichen.

Kategorische Effekt werden gewöhnlich auf der Ebene der Phonologie angesiedelt. Wenn nun die phonetische Reduktion der *lega*-Adverbien von der rhythmischen Umgebung beeinflusst worden wäre, hätte dies als Hinweis auf die kognitive Präsenz von reduzierten Formen gedeutet werden können. Da dies nicht der Fall war, sind die Ergebnisse der Studie eher mit generativ-abstrakten Modellen in Einklang zu bringen. Leicht modifizierte exemplar-basierte Modelle können die Daten jedoch auch erklären.

Während es somit keine Hinweise auf die Speicherung „gewöhnlicher" reduzierter Formen gab, zeigten sich, dass zweisilbige reduzierten Formen von *náttúrlega* und *nefnilega* als lexikalisiert gelten können. Diese Adverbien treten besonders häufig in zweisilbigen Formen auf. Darüberhinaus zeigten sich nur bei diesen Lexemen Unterschiede zwischen den Altersgruppen. Auch der Shadowing-Task lieferte Evidenz für eine Lexikalisierung der zweisilbigen Nebenformen.

Die vorliegende Dissertation hat einen Beitrag geleistet zur Erforschung von Reduktionsphänomenen und den Faktoren, die Reduktion beeinflussen. Die Ergebnisse der Literatur zu anderen Sprachen wurden weitestgehend bestätigt. Es ergaben sich jedoch auch Felder, wo die weitere Forschung ansetzen kann. Gerade was die Rolle von Abstraktionen und Exemplaren in Produktion und Perzeption angeht, sind noch weitere Untersuchungen nötig.

This book represents a contribution to the study of phonetic reduction. It presents the first quantitative investigation of acoustic-phonetic reduction in Icelandic and deals with the reduction patterns of a class of Icelandic adverbs ending in the suffix –*lega*. Three questions are asked: What factors influence the reduction patterns of these adverbs? How do the factors compare to those found for other languages? What conclusions can be drawn from adverb reduction about the possible mental storage of reduced forms?

The data used for this study are both corpus-based and experiment-based. The corpus-based part investigates a range of factors that could influence reduction, most importantly adverb token frequency and metrical rhythm. Two experimental studies further investigate the production of reduction patterns. In a shadowing task, metrical rhythm and frequency are studied in closer detail and a reading task provides additional data for a comparison between data types. From these data, conclusions are drawn about the nature of adverb reduction in Icelandic and the factors that influence reduction patterns.

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