Phonological Grammar and Frequency: an Integrated Approach

Evidence from German, Indonesian and Japanese

Marjoleine Sloos

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Voor mijn vader

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List of symbols, glosses, and abbreviations

<…> orthographic representation
|…| lexical form (of an exemplar)
/…/ underlying form
[…] phonetic form/surface form
σ syllable

2/3SG 2nd and 3rd person singular
ACT. Active
ANIM. Animate
CAUS. Causative
DIM. Diminutive
PAST. Past tense
PLUR. Plural
SUBJ. Subjunctive

ATR Advanced Tongue Root
C1 Coder 1 (in chapter 3)
C2 Coder 2 (in chapter 3)
EPOT Exemplar-Prototype-Optimality-Theory
ET Exemplar Theory
F1 First formant
F2 Second formant
GS Grammar as Selection (van de Weijer 2012)
HF High-frequency
HG Harmonic Grammar
IDS Institut für deutsche Sprache (Institute for German language)
LF Low-frequency
MF Moderately frequent
MHG Middle High German
NHG New High German
NSG Northern varieties of Standard German (as opposed to SSG, see below)
OHG Old High German
OT Optimality Theory
SSG Swiss Standard German
TETU The Emergence of The Unmarked

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Part I

Introduction & Methodology

Tea is nought but this

First you make the water boil

Then infuse the tea

Then you drink it properly

That's all you need to know

Sen no Rikyu 1522-1591

Chapter 1

Towards hybrid modelling: Optimality Theory & Exemplar Theory

In phonology, it is not common to investigate grammar and frequency together. Grammar is usually investigated by generative phonologists, and lexical frequency is usually examined by usage-based phonologists. These are traditionally distinct approaches. During the last few years, it has become increasingly clear that linguistic data must be accounted for in a model combining aspects of both approaches. The theoretical frameworks of the mainstream phonological models have therefore been further developed. From a generative perspective, the grammar has been augmented with the possibility to account for lexical frequency effects, like in Stochastic OT and Noisy Harmonic Grammar. From a usage-based perspective, the lexical model has been expanded with a production module and the notion of a "usage-based grammar": a grammar that emerges from the lexicon. Whereas in Stochastic and Noisy Harmonic Grammar, the grammatical model is strongly developed, the role of the lexicon remains rudimentary. Contrastively, whereas in usage-based grammar the lexicon is fully developed, the model lacks a comprehensive grammar. Another important reason for the underdevelopment of these two components of language, grammar, and lexicon, is the lack of data that reveals the nature of the relation between the phonological grammar and the lexicon, that is, data that show the interaction between phonological grammar and other aspects such as frequency. This thesis provides such relevant data, to show possible interactions between the phonological grammar and the lexicon, and proposes a hybrid model with a fully fledged grammatical model as well as lexicon, and develops the connection between the two.

Linguistics during the twentieth century is characterized by a schism between two approaches. Competence vs. performance, *langue* vs. *parole*, I-language vs. E-language: these pairs all refer to two properties of language which were—and still are—usually investigated separately. De Saussure (De Saussure & Baskin 2011) was the first to make a distinction between *langue* and *parole.* These notions refer to the *system* of language and the physical realization of language, respectively. De Saussure considered *langue* and *parole* as two separate aspects of language, which are contrastive and form two different fields of study.

> "S'il est vrai que langue et parole se suppose l'une l'autre, en revanche, ils sonst si dissemblables qu'ils sont chacun leur théorie séparée."
>
> *"Although langue and parole are complementary to each other, they are so dissimilar that they form each their own, separated theory"*
>
> (De Saussure, *Cours de linguistiques générale* S2.17, in De Saussure and Baskin 2011).

For de Saussure, *langue* is the essential part of language and the only part that is relevant for linguistic investigation.

> "L'étude de language comporte donc deux parties; l'une, essentielle, a pour objet du langue, qui est sociale dans son essence et indépendante de l'individu."
>
> *"The study of language consist therefore of two parts, one, essential, is 'langue', which is social in nature and independent of the individual"*
>
> (de Saussure, *Cours de linguistiques générale* ntr IV al.5, in De Saussure and Baskin 2011).

Similarly, half a century later, Chomsky distinguished between competence and performance:

> "We thus make a fundamental distinction between *competence* (the speaker-hearer's knowledge of his language) and *performance* (the actual use of language in concrete situations)"
>
> (Chomsky 1965).

Although the separation is similar, Chomsky deviates from the Saussurian concept of *langue*, which he regards to be "a merely systematic inventory of items" (Chomsky 1965: 4). This dualistic approach resulted in linguistic research along two distinct lines during the twentieth century: on the one hand, the structuralist and generative investigation of the system of language and the innate knowledge of language, and on the other hand, the sociolinguistic, psycholinguistic, and usage-based studies of language use, variation and change.

One of the reasons for the opposition between usage-based and generative approaches in phonology lies in the nature of the data that are investigated in phonology: speech sounds and their alternations. Speech sounds may differ from each other either gradually or categorically: that is, sounds can behave as either minimally differing on a continuous scale or as discrete units (see Ernestus (2011) for an overview). Continuous variation, characterized by subtle differences on a gradient scale, is grounded in the wealth of pronunciation differences of the same words, e.g. in many lenition processes. Some textbook examples are Spanish plosive lenition (e.g. Bybee (2001) and references cited there) or vowel reduction in many languages (e.g. van Bergem (1995), Crosswhite (2001), Jurafsky et al. (2001), among many others). Usage-based phonology focuses on such continuous processes and models them in the lexicon, i.e. all memorized words or morphemes, which, strictly speaking, often belong to the field of *performance*, like frequency effects, recency effects, or speech rate. Frequency effects are differences in behaviour between high-frequency (HF) linguistic items and low-frequency (LF) linguistic items (such as words, roots, or suffixes) that cannot be explained otherwise (see below in this section). On the other hand, sounds may also behave in a categorical way. Categorical alternation between sounds is grounded in categorical perception, the general tendency to perceive items on a continuous scale as discrete units (e.g. Harnad (1990) for an overview). Categorical perception in language leads to the classic phonemic representations, vz. sounds that contribute to a difference in meaning. Allophones, different alternants of a phoneme, are also categorical: they are supposed to have a particular feature, either monovalent or binary (Archangeli (1988), Dresher et al. (1994), among others) that other allophones do not have. An example of this allophonic alternation is English nasal place assimilation, where the phoneme /n/, underlyingly coronal, surfaces as labial [m] or velar [ŋ] if the following consonant is labial or velar respectively *i[m]plement* or *i[ŋ]capable*. Phonemic, but also allophonic, representations abstract away from phonetic detail. Alternations of categorically distinct speech sounds, that occur in well-defined phonological contexts, form the backbones of phonological *competence* or phonological grammar. Phonological grammar is usually assumed to consist of a set of rules or constraints that takes a lexical form as input and generates a phonetic output. Nasal place assimilation is a well-investigated categorical process in many languages. Other examples are final -t/-d deletion in English (see Coetzee (2004) for an overview) and rendaku in Japanese (see also chapter 5 and references cited there). Whereas usage-based phonology focuses mainly on continuous variation data, generative phonology largely focuses on such systematic categorical alternations. Thus the dual behaviour of speech sounds, i.e. continuous and categorical, lies at the heart of the dichotomy between usage-based and generative phonology.

Although the lexicon and the grammar are two distinct parts of language, which will be shown in this chapter, it remains to be seen what exactly the division of labour is between the two. Therefore, a growing number of linguists currently seek a way to combine lexical and grammatical aspects in a single model. One of the challenges formulated by Jackendoff (2007) for linguistics in the future is to bridge the gap between the lexicon and the grammar. Such a gap, Jackendoff (2007) argues, does not really exist: in fact the lexicon and the grammar form a continuum. Similarly, Smolensky & Legendre (2006) claim that there is enough evidence which shows that both usage-based as well as generative approaches are on the right track; but whereas the lexical level stands for storage of concrete and detailed concepts and neural activation of these concepts, the grammar stands for the abstract concepts and higher mental representations of language. Both are needed in the architecture of a linguistic model (Smolensky & Legendre 2006). More specifically, for phonology, van de Weijer (2009, 2012) argues that a combination of usage-based and generative phonology has the advantage of being more psycholinguistically realistic, more balanced regarding storage, perception, and production, and able to account both for variation in the individual language user and the systematic typological differences between languages.

There exist, of course, different approaches to meet the call for hybrid modelling. First, one could extend the usage-based model with a grammar. Conversely, it would be possible to extend the generative model with lexical information. Thirdly, an entirely new model could be developed. Finally, one could try to combine the best of both ways: the mainstream usage-based approach and the mainstream generative approach. Section 1.1 and 1.2 will show that the possibilities to extend usage-based lexical models with a grammar and to extend the grammar with lexical information are either too limited, or the concepts are not fully articulated. New models are always a possibility, and a number of computational phonological models have been developed, although, according to Ernestus & Baayen (2011) they are also not yet fully operative. Both usage-based as well as generative phonology have developed models of either the lexicon or the grammar. The most widely used model in usage-based phonology is Exemplar Theory (Goldinger (1996), Johnson (2007)) and the leading theory in generative phonology Optimality Theory (Prince & Smolensky 2004). Advantages and shortcomings of both models will be described in §1.1 and §1.2, where I will also show that Exemplar Theory (ET) lacks a clear notion of grammar, although reference to grammar is sometimes made. On the other hand, I will show that Optimality Theory (OT) is not adequate in accounting for frequency effects, although several models claim that they can do so. In other words, neither ET, nor OT provides a full account of language. Given the strength of the two models in their respective fields, however, it seems worthwhile to investigate the possibilities to combine them. A first step towards this approach has been taken by van de Weijer (2009, 2012), discussed in §1.3.3. In order to work out this concept further, however, empirical data are needed in which clear interactions between lexical and grammatical processes are investigated. The first aim of this thesis is to provide data which show such interactions. The second aim is to model these data in a hybrid model, based on ET and OT. But let us first look at well-established facts about frequency effects.

During the past two decades, new usage-based data have rapidly become available. The possibility to store large databases stimulated corpus research, which made linguists more aware of the wealth of variation in spoken data and the role of frequency of occurrence in this variation. It also became clear that this variation is neither random, nor can it be referred to as 'noise'; systematic patterns are found in variation that are related to reduction, frequency of occurrence, and lexical diffusion. In addition, many patterns of change which were earlier considered as Neo-grammarian, i.e. discrete, sound change turned out to be lexically diffused and continuous (see Labov (1994), Phillips (2006) for an overview). Moreover, frequency effects appeared to play an important and a systematic role in lexical diffusion. Numerous studies have convincingly shown that there are two lexical frequency effects that play a role in lexical diffusion: depending on the process, HF words can either be the last words to change, or HF words are the first words to change. In analogical change, LF words are more susceptible to change to fit into the analogical pattern than HF words. A textbook example comes from the strong verbs in Germanic languages: whereas Germanic verbs historically may have had two different stems, this became regularized over time, except for HF words, which have maintained their irregular stems (e.g. write-wrote-written and read-read-read), for a thousand years or more (Bybee (2001), van de Weijer (2012: 39-42)). Let us call this frequency effect, which occurs in analogical change, a Type I frequency effect.

(1) *Type I frequency effects (analogical change)*

> Frequency of occurrence correlates with analogical change such that HF words are less likely to undergo analogical change and LF words are more likely to undergo analogical change.

This Type I frequency effect is explained by the relatively strong mental representation of HF words, which is difficult to change. The result is that, in language change, HF words appear to be conservative, unwilling to change, and may eventually retain autonomous behaviour, acting as lexical exceptions. On the other hand, HF words are the *first* to change if they are subject to lenition and reduction (Hooper 1976), or assimilation, which is also a kind of reduction (Phillips 2006). Let us refer to this reduction-related frequency effect as a Type II frequency effect.

(2) *Type II frequency effects (reduction)*

> Frequency of occurrence correlates with reduction such that HF words are more likely to undergo reduction and LF words are less likely to undergo reduction.

Type II frequency effects occur because, by their very nature of being often used, HF words are subject to more automation processes on the articulatory level and consequently undergo more reduction. Reduction processes may lead to change, however, they may also occur synchronically. One could pose the question what occurs in other situations, when neither analogical change, nor reduction occurs. For instance in stable variation without reduction or loanword integration. Such examples will be addressed in chapters 4, 5, and 6. Further, it should be noted that, of course, no sharp division line between HF and LF items exists; rather, LF and HF words form a continuum and theoretically speaking, an HF word in one process may behave as an LF word in another process. For instance, a word is subject to two patterns of change in a particular language, e.g. grammaticalization of irregular verbs and sound change. Compared to all other verbs, the word may be relatively HF. Compared to all nouns that are subject to change, the word may be relatively LF. We will see examples of this in chapter 5 and 6. We will see examples of relative frequency in chapter 5 and 6.

In this section, I discussed the fact that phonological research in the twentieth century is characterized by two approaches, generative phonology and usage-based phonology, which are usually considered to be incompatible. Subsequently, I pointed out that an increasing call for hybrid modelling exists. I will investigate the possibility to combine Exemplar Theory with Optimality Theory, on the basis of data which show an interaction between frequency effects and grammar. In the remainder of this chapter, I will introduce Optimality Theory and the way in which OT accounts for frequency effects in §1.1. Subsequently, I will introduce Exemplar Theory including the concept of usage-based grammar in §1.2. Section 1.3 provides the research questions and hypotheses. The final section (§1.4) provides an overview of this thesis.

1.1 From grammar to usage

In this section, I will outline the basic principles of Optimality Theory (§ 1.1.1), including two observations that lie at the heart of Optimality Theory, namely phonological typology (§1.1.2) and The Emergence of The Unmarked (§1.1.3). Further, we will look at the fashion in which frequency effects can be accounted for in the optimality-theoretical framework (§1.1.4).

1.1.1 Optimality Theory

The current leading generative model in phonology is Optimality Theory (OT) (Prince & Smolensky 2004), a constraint based grammar. OT fits into the feed-forward model of generative phonology, in which the lexicon provides an input for the grammar, which is an underlying, phonemic, form that is stored in the lexicon, and the grammar generates a phonetic output. The OT grammar consists of a small number of fixed components: the generator of input, candidates that are possible outputs, a set of ranked constraints, and an evaluation system EVAL. The generator GEN is a mechanism that generates candidates, possible phonetic output forms that can basically have any form, but for convenience, usually only the outputs that are the most relevant, and that differ minimally from the input, are presented. The set of constraints CON forms the grammar and works as a filter for the candidates. A candidate can either violate or satisfy a constraint. The best candidate, the winner, which represents the actual output, is the candidate that violates only the most lowly ranked constraints, in comparison with other candidates (McCarthy 2008). Basically, there are two kinds of constraints: markedness constraints and faithfulness constraints. Ideally, markedness constraints are grounded in phonetics and prohibit sequences that are difficult to articulate or perceive. Faithfulness constraints preserve lexical contrast, and require that input and output are identical (Kager 1999: 11). In principle, since markedness occurs at the cost of faithfulness, and vice versa, markedness and faithfulness constraints are in conflict with each other (Kager 1999).

As an illustration, let us consider word-final -n deletion in Dutch. In Dutch, the suffix -ən is often reduced to -ə: for instance, in the infinitive and plural marker in verbs: /lezən/ → [lezə] 'to read' (Booij (1995), van Oostendorp (2005), van de Velde & van Hout (1997)). Under the assumption that the input contains a final -n, the most relevant candidates to consider are the faithful candidate [lezən] and the winning candidate [lezə]. One constraint that is needed for word-final -n deletion in Dutch is a constraint that prohibits [ən] at the end of the word.[1]

(3) $*ən]_{\#}$

Assign a violation mark to the word-final sequence [ən].

Furthermore, a faithfulness constraint is needed that compares the output to the input: a constraint that requires all segments to be realized.

(4) MAX-IO (McCarthy & Prince 1995)

Every segment of the input has a correspondent in the output.
("No phonological deletion").

Since [lezə] is favoured over [lezən], $*ən]_{\#}$ >> (dominates) MAX-IO. A candidate that performs equally well in this mini-grammar is [lezn̩], which is ungrammatical in Standard Dutch. So, we also need a constraint that prevents [lezn̩] to be the correct output, that is, a constraint that prohibits syllabic nasals.

(5) *NUC/nasal (De Lacy 2001)

Assign a violation mark to any syllabic nasal.

Since [lezn̩] is not a possible output in Standard Dutch, we derive the ranking *NUC/nasal >> MAX-IO. The ranking between $*ən]_{\#}$ and *NUC/nasal cannot be decided, in other words, these constraints are not crucially ranked. This grammar is illustrated in tableau (6). Constraint violations are indicated by an asterisk * and if this violation is crucial, which means that there is at least one candidate that is evaluated as more 'harmonic', or more grammatical, an exclamation mark ! is added. Crucial constraint ranking is indicated by solid lines and non-crucial constraint ranking is indicated by dashed lines. Cells that are irrelevant are shaded. Finally, the winning candidate, the actual output, is pointed with ☞ (6).

[1] Final -n deletion does not occur in stems (van Oostendorp (2005)), but for reasons of clarity this is omitted from the analysis.

(6) *Tableau of final -n deletion in Dutch (to be revised).*

/lezən/	*ən]#	NUC/vowel	MAX-IO	{RIGHT}ANCHOR-IO
[lezən]	*!			
[lezn̩]		*!	*	
☞ [lezə]			*	*

1.1.2 Typology

Constraints in OT are supposed to be universal and different languages vary in their constraint ranking. OT as such makes a typological prediction (which is absent from rule-based approaches). If the constraints that we used above are re-ranked, we arrive at other possible grammars. Typology is a core property of OT, which is formulated in the principle of Richness of the Base:

> "Richness of the Base. The source of all cross-linguistic variation is constraint re-ranking. In particular, the set of inputs to the grammars of all languages is the same. The grammatical inventories of a language are the outputs which emerge from the grammar when it is fed the universal set of all possible inputs"
>
> (Prince & Smolensky 1993: 191).

A comparison between word-final *-en* reduction in Dutch and German illustrates how typology is accounted for in OT. Many Dutch-German cognates exist in which reduction of the suffix <en> occurs, but the two languages differ in the way reduction is applied. Let us take the cognate Dutch <lezen> /lezən/ and German <lesen> /lezən/ 'to read'. Whereas in Dutch, the final -n is deleted (see §1.1.1), in German, the schwa is deleted (Kohler & Rodgers 2001), resulting in [lezn̩] 'to read'. The same constraints as in (6) are used. Additionally, in order for [lezn̩] to be the winning candidate, the final consonant should be realized and therefore we invoke the constraint {RIGHT}ANCHOR-IO.[2]

(7) {RIGHT}ANCHOR-IO (McCarthy & Prince 1995)

Any element at the designated periphery of the input has a correspondent at the designated periphery of the output.

[2] Anchor-IO belongs to the family of alignment constraints, which requires that certain prosodic boundaries coincide with morphological boundaries. Here the initial segment of the phonological word coincides with the right edge of the morphological word.

Since [lezn̩] is favoured over [lezə] in German, the partial ranking must be {RIGHT}ANCHOR-IO >> MAX-IO, *NUC/vowel. The ranking between *ən and {RIGHT}ANCHOR-IO cannot be decided. The tableau for German [lezn̩] is provided in (8).

(8) *Tableau for schwa deletion in German.*

/lezən/	*ən]#	{RIGHT}ANCHOR-IO	MAX-IO	*NUC/vowel
[lezən]	*!			
☞ [lezn̩]			*	*
[lezə]		*!	*	

Since constraints are universal, {RIGHT}ANCHOR-IO is also supposed to be present in Dutch, although it must be low-ranked (9).

(9) *Tableau of word-final -n deletion in Dutch.*

/lezən/	*ən]#	*NUC/vowel	MAX-IO
[lezən]	*!		
[lezn̩]		*!	*
☞ [lezə]			*

Tableaux (8) and (9) show the typological difference in final -en deletion between Dutch and German, just by re-ranking the constraints. The fact that typology naturally emerges from the universal character of the constraints and the ranking mechanism makes OT superior to rule-based phonology.

1.1.3 The Emergence of the Unmarked

Constraints may be so low-ranked that they do not contribute to usual output. But in some cases, i.e. when there is no lexical input, one can observe that these low-ranked constraints do exist in the language. This is called the Emergence of the Unmarked (TETU) and was first described by McCarthy & Prince (1994). TETU effects typically occur in epenthesis and reduplication. The reason is that if there is no lexical input, faithfulness constraints, which compare lexical input to the output, are all vacuously satisfied and therefore candidates can only violate markedness constraints. As a result, the most unmarked candidate will win. For instance, in epenthesis, if a vowel is inserted, it is usually the most unmarked vowel (which is a central vowel, or, if there is no central vowel, a front vowel (Rice 1995). If a consonant is epenthesized, it is generally *h*, which has no supralaryngeal place features (Lombardi 2002). As for reduplication, the reduplicant is usually formed in relation to the base, the output rather than in relation to the input. Thus the reduplicant has no lexical input, and will vacuously satisfy all IO-correspondence constraints. The most unmarked candidate will thus be the winner. This can be illustrated by reduplication in Leti.

In Leti, an Austronesian language spoken on the island Leti, reduplication occurs at the left-hand side of the base. Any marked structure of the base,[3] however, is not copied in the reduplicant. Whereas lexical forms may have geminates, the reduplicant does not. Whereas lexical forms may have long vowels, the reduplicant does not. And whereas the lexical forms may contain a consonant cluster, the reduplicant does not (Sloos & van Engelenhoven 2011).

(10)	*Lexical form*	*Gloss*	*Reduplication*	*Gloss*
	mmerna	to become swift	<u>me</u>-mmerna	swift(ly)
	luuβu	rest, remnant	<u>lu</u>-luuβu	remaining, rest. ADV
	mlilu	to be sour	m-<u>li</u>-lilu	sour

The markedness constraints that are responsible for the restrictions on the reduplicant are *Cː, *Vː, and *CC respectively.

(11) *Cː
Assign a violation mark to any long consonant.

(12) *Vː
Assign a violation mark to any long vowel.

(13) *CC
Assign a violation mark to any consonant cluster.

Crucially, as shown in (10), the lexical forms do allow for geminates, long vowels, and complex onset clusters, so faithfulness constraints like MAX-IO are higher ranked and therefore, without reduplication, the constraints in (11)-(13) are "invisible". The output candidate violates a maximality constraint which compares the base and the reduplicant (14). Tableau (15) shows an example of reduplication in Leti.

(14) MAX-BR (McCarthy & Prince 1995)

Every segment of the base has a correspondent in the reduplicant.

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[3] The analysis is simplified here; in Sloos & van Engelenhoven (2011) it is proposed that the reduplicant corresponds to the input rather than to the base.

(15) *Tableau of the lexical form and reduplication of 'mmerna' in Leti.*

/mmerna/	MAX-IO	*CC	MAX-BR
☞ [mmerna]		*	
[merna]	*!		
/RED/-mmerna			
[mme-mmerna]		**!	
☞ [me-mmerna]		*	*

Since the reduplicant does not have an input, the faithfulness constraints are vacuously satisfied and in order to satisfy the markedness constraints the most unmarked candidate for the reduplicant will thus be the winner. Like typology, TETU effects are predicted for by OT (which is not the case in rule-based phonology). Let us now turn towards the role of frequency effects in OT.

1.1.4 Frequency effects in Optimality Theory

In the light of the knowledge about frequency effects, some phonologists undertook the challenge to account for such frequency effects in OT. Several OT models in which frequency effects are modelled have been proposed: Stratal OT (Anttila (1997, 2006), Anttila & Cho (1998), Stochastic OT (Boersma 1998), Noisy Harmonic Grammar (Coetzee & Pater (2008), Pater (2009), Potts et al. (2010)), and also Bíró (2006). In Stratal OT, constraints that are involved in the variation are not crucially ranked, so each time an evaluation occurs, the ranking may vary. Anttila (2006) assumes that frequency effects occur precisely in case the grammar cannot decide, i.e. when the constraints are not crucially ranked. Evidence comes from assibilation in Finnish. In bimoraic verbs, and not in other cases, the grammar is indecisive about the metrical parsing and can vary: either exhaustive parsing (CVVCV) or extrametricality (CVV)CV occurs, which depends on the metrical structure of the word. When the grammar is underdetermined about the metrical structure, frequency effects occur, according to Anttila (2006). In other cases, grammar overrides the frequency. A serious concern with respect to this model is that it is extremely unlikely that both variants are identically ranked by *all* constraints, in other words, there will (almost) always be another constraint somewhere in the grammar that favours one of the two variants. Notice also that the number of possible rankings and outcomes correspond to *the ratio of the variants of a word,* which is something different than *word frequency* as described above.

Stochastic OT and Harmonic Grammar (HG) are two models that are similar to a high extent and are based on weighting of the constraints, rather than ranking in order as in classical OT (in fact, HG is the predecessor of OT (Legendre et al. (1990), Prince & Smolensky (1997)). Constraint violations are the product of the constraint weight and the candidate violation. The value of the violations is summed and results in a harmonic weight for each candidate. The candidate with the highest weight is the winner. This is illustrated for, again, word-final -n deletion in Dutch in, where I have assigned weight to the constraints so that the right output wins (16).

(16) *Tableau in Harmonic Grammar of word-final -n deletion in Dutch.*

	4	6	2	1	
/lezən/	*ən]#	NUC/vowel	MAX-IO	{RIGHT} ANCHOR-IO	Harmonic weight
[lezən]	-1				-4
[lezn̩]		-1	-1		-8
[lezə]			-1	-1	-3

An advantage of HG models is the generation of variable output by changing the weight of the constraints. Suppose variation occurs between [lezə]-[lezn̩];[4] we can easily change the weight of the constraints so that [lezn̩] wins (see e.g. Boersma (1998)). If, hypothetically speaking, the forms [lezə]-[lezn̩] vary with a ratio of 40-60%, overlap of constraints makes it possible to account for that as well. Stochastic OT and HG (and also Bíró (2006)) generate output with variation, which is to be understood as noise, and it is claimed that in this way these models can account for frequency effects—but the frequency effects mentioned in the introduction refer to a different concept. The variation that occurs by word frequency, Type I (analogy) or Type II (reduction) frequency effects, and moreover the systematicity of these frequency effects, is not accounted for by these models (this was first noticed by Coetzee & Kawahara (2013)). Since the constraint ranking and the constraint weight do not vary per word (which would of course be odd, since the grammar is supposed to be *not* word specific), these models treat all inputs identically, regardless of their frequency. Thus in Stochastic OT and HG, the ratio of [lezə]-[lezn̩] is predicted to be the same as of [wezə]-[wezn̩]. The frequency effect that is to be explained, however, is the ratio between the different variants of a word *that is dependent on the frequency of that word.* So, since the token frequency of the

[4] As can be found in Groningen, in the northeast of the Netherlands.

words *lezen* and *wezen* differs, we expect different ratios for the variants of these words. This is not accounted for in the aforementioned models.

Since stochastic OT/HG cannot account for the systematic behaviour of frequency effects, Coetzee & Kawahara (2013) developed a model, based on HG, in which frequency effects are accounted for by scaling of the constraints. The model does provide the correct output of frequency effects, but there are some theoretical complications. Coetzee & Kawahara (2013) propose that relevant constraints be scaled by scaling factors, which multiply the weight of the relevant constraints. HF words cause higher scaling factors and LF words cause lower scaling factors. The value of the scaling factor is part of the constraint, and the scaling factor itself represents the frequency value. Thus, frequency information is directly represented in CON, that is in the grammar—in my point of view, this is problematic since frequency as such is not a grammatical feature. Frequency is a property of a single word and therefore, variation on the basis of frequency is not a task of the grammar, because the grammar applies to all words equally. Moreover, it is unclear how the attribution of different scaling factors, reflecting frequency, can be justified in OT. The difficulty lies in the fact that in generative phonology, the level of activation is not represented in the lexicon. Since in generative grammar, the lexicon contains just one categorical underlying form per word, I fail to see how the lexicon can provide frequency information (as scaling factors or in any other way) to the OT grammar. In other words, variation can be captured by different constraint rankings for different individuals or different sociolinguistic strata, but "the place for statistics is outside and not inside the grammar" (Smith 1997).

In this section, I introduced Optimality Theory, which is the mainstream model for generative phonology. Its main characteristics are a fully fledged grammar and a lexicon without information that belongs to performance, such as frequency effects. OT naturally accounts for typology and TETU effects. I also discussed how frequency effects are treated in OT, namely by weighted constraints. Although variation can be generated by Stochastic OT and Harmonic Grammar, frequency effects are clearly more difficult to account for without a more developed model of the lexicon. We will now turn towards Exemplar Theory, a theory in which frequency effects receive a natural explanation.

1.2 From usage to grammar

In this section, I will introduce Exemplar Theory (§1.2.1) and explore the vision of Exemplar Theory regarding the grammar (§1.2.2).

1.2.1 Exemplar Theory

Exemplar Theory (ET) is originally a psychological theory that models concept learning by categorization (Medin & Schaffer (1978), Nosofsky (1986)). ET is concerned with storage in the memory, activation of stored items, and retrieval of stored information. Storage of newly experienced items occurs by comparison to all other stored instances. The items are categorized as exemplars on the basis of similarity with the other exemplars: they are stored in those categories which they resemble most. An item can be stored in more than one category, at different levels and in several subcategories. The activation of a category corresponds to the number of exemplars in that category. Retrieval of a stored item depends on activation levels: categories with many exemplars are retrieved faster. Retrieval also depends on recency: the most recently stored exemplars are activated faster than older exemplars, since exemplars are subject to memory decay. Exemplar models perform best for modelling group variability, since by remembering a single exemplar, the whole exemplar category is activated and its members can be directly compared to each other (Bodenhausen et al. 2003: 264).

ET has been adopted as a model for speech perception by Johnson (1997), extended to a model of speech recognition by Goldinger (1996), and elaborated on as a phonological model by Bybee (1999, 2007, 2010) and Pierrehumbert (2000, 2001). The core idea of ET as a phonological model is that memory is practically unlimited and that each linguistic item that is perceived is directly stored and categorized as an exemplar in the lexicon. The decisive factors in categorization are the meaning of a token Bybee (2007: 717) and categorical perception Pierrehumbert (2001). Since any token that is perceived is stored in the lexicon, fine-grained phonetic detail and variation are automatically part of the lexicon, i.e. any realization of the word *bird* word is stored in the category with the label *bird*, with all subphonemic detail. The ET lexicon is word-based. It mainly contains categories of exemplars of words although larger units, like fixed expressions and collocations, may also be stored as exemplars (e.g. Bybee 2010). Exemplarsare stored with both linguistic and non-linguistic information. The linguistic information that is stored in an exemplar consists of e.g. pronunciation, word class, and meaning. The non-linguistic information may consist of e.g. the speakers' voice/identity, sociolinguistic information (Pierrehumbert 2001), and orthography (see chapter 2). The words are stored in an analogical network to capture morphological relations, which is illustrated in Figure 1.1 (page 17).

The Exemplar model reflects frequency by the number of exemplars and the activation level of the category. Frequency information is not directly stored in the lexicon, but frequency effects are indirectly accounted for by the activation levels (Bybee (2001), Pierrehumbert (2001)). These activation levels are, of course, related to frequency (HF words cause higher activation levels than LF words (Morton 1969)), however, other usage-based factors also contribute to activation levels and interact with frequency effects, such as recency (e.g. Abramowicz (2007), Hay et al. (2006a)) and saliency effects (Rácz 2012). The relatively quick lexical access of HF words, the conservative behaviour of HF words in language change, and the susceptibility of HF words to reduction processes, naturally follow from either the exemplar modelling or the articulatory processes. First, HF words have relatively quick lexical access: they are represented by more exemplars than LF words, thus their mental representation is stronger, which means that their latent neural activation level is higher. Quick lexical access of HF words is also reflected in shorter reaction times in elicitation (Jurafsky 2003). Secondly, the relative strength of the lexical representation of the word corresponds to its frequency and is negatively correlated with the likelihood of change: HF words have a stronger mental representations and as such resist language change more than LF words. Finally, HF words are more susceptible to reduction effects: because they are often used, the articulatory muscles are better trained and automation processes often cause reduction (cf. Gahl (2008)). Thus, in ET, frequency effects are naturally derived from the lexicon, without reference to actual frequency values.

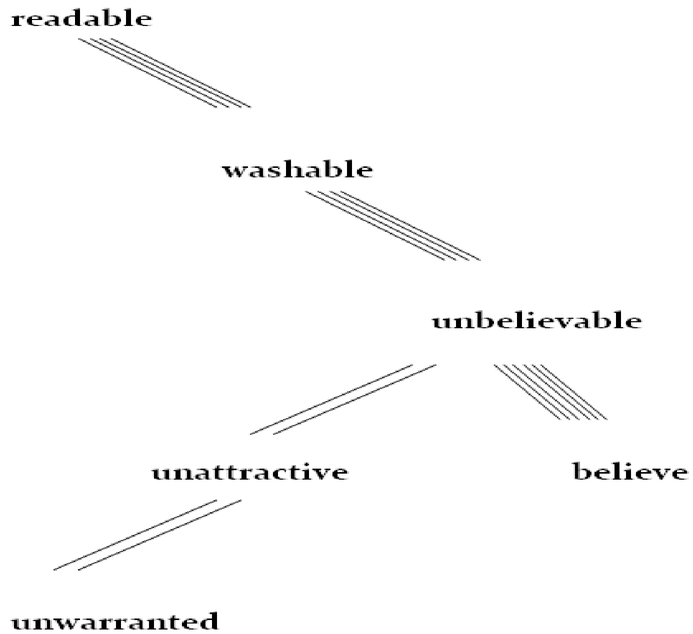

Figure 1.1. *Analogical network connections in Exemplar Theory (Bybee 2002). Morphological connections between the root 'believe' and the derivation 'unbelievable' are relatively strong (as indicated by the thickness of the association lines).*

Exemplar Theory is particularly strong in lexical storage of fine-grained phonetic detail, variation, frequency effects, recency, and saliency, i.e. a closer tie to psycholinguistics than OT. In addition, a production component has been added to ET by Pierrehumbert (2000). In the ET production model, the category is targeted through activation. Depending on the situation, different styles or social settings, different parts of the exemplar category may be targeted. Activation plays a key role in production, the higher the activation of a certain part, the higher the chance this is selected for production. However, production probably does not exactly mirror the target, since there is always deviation in the motor control. Thus each word will show a small amount of variability in production.

1.2.2 Usage-based grammar

The usage-based approach does not deny the existence of grammar, but regards grammar as the result of experience with language. This so-called usage-based grammar, as introduced by Bybee (2007), proposes that grammar is a cognitive abstraction which is formed by categorization over similarities and dissimilarities in the lexicon (see also Beckner et al. (2009) and references cited there). According to Bybee (2007), the grammar may change in different ways. For example, by the birth of prefabs, phonological reduction, and new constructions that are created out of existing constructions. Prefabs are complex expressions which are stored as one unit, like English *go bananas*. Phonological reduction occurs in HF words and constructions like *be going to*, which tends to be reduced to *gonna*. A new construction is, for instance, non-literal use of a sentence, like "What are you doing with that knife?", which can have the literal meaning "What are you doing with that knife?", but will more often be interpreted as "Why do you have that knife?" (Johnson 1997: 17). Beckner et al. (2009) also argue that grammaticalization occurs by usage, that is, phonetic changes and reorganization of categories change the grammatical form of the category. These examples support the point of view that certain categories may change, but it still seems to me that these changes occur in the lexicon, i.e. the formation of new words, rather than in the active grammar in the phonological sense. However, phonological grammars do undergo change, with a long period of lexical diffusion in which frequency effects are observed. Such changes often start as a phonetic rule, become phonologized over time, and subsequently may be morphologized (Bermúdez-Otero 2007). For instance, in German umlaut, the fronting of back vowels in the stem was initially caused by phonetic coarticulation of the stem vowel with a high front unrounded vowel [i] in the suffix. Umlaut developed to a phonological rule. Currently umlaut occurs, but only in particular morphological contexts and the trigger has disappeared, since the suffixes do no longer contain the high front unrounded vowel anymore (Bermúdez-Otero 2007). ET can make the generalization of the phonetic rule, the phonological rule, as well as the morphological rule, but grammar is more than a set of generalizations over the lexicon.

But why do we need a grammar, if it is the case that all linguistic information is stored in the lexicon? There are a number of reasons to maintain a fully fledged grammar in phonology. First of all, the grammar is not supposed to be a passive abstraction, but rather an active mechanism, that can account for the fact that new words, i.e. neologisms, loanwords, and new combinations that are the result of word formation processes, behave according to the rules. Grammar can also account for errors in L2 acquisition. Further, ET fails to account for typology and also TETU effects (van de Weijer 2012), which are the strong points of OT, as argued in §1.1. Besides, phonology is not restricted to words, but there are phonological processes above the word level, such as nasal place assimilation on word boundaries, *raddoppiamento sintattico* in Italian (see e.g. Napoli & Nespor (1979)) among many others) and intrusive r in English (e.g. Huddleston & Pullum (2002)). As pointed out by Boersma (2012), sentence level phonology is a problem for ET, since ET is mainly word-based. So there are several motivations for maintaining the grammar in phonology, also if a richly specified lexicon with all phonetic detail is assumed.

In sum, ET proposes a model of a lexicon specified with much phonetic detail, which naturally explains many usage-based processes, including frequency effects. However, the concept of the grammar is rather passive and rudimentary. ET in its current form fails to account for underlying forms, the application of phonological rules when there is no lexical input, typology, and sentence phonology.

1.3 Towards hybrid modelling

In §1.1 and §1.2, I argued (along the lines of van de Weijer (2009, 2012)), that the mainstream models in phonology, OT and ET, have their own particular strengths and weaknesses: OT is a grammatical approach that is particularly strong in TETU effects and typology, but which seems not appropriate to account for frequency effects, while, on the other hand, ET can easily account for frequency effects, but lack a grammatical component. In this section, I will take the position that, in order to account for frequency-grammar interactions, a hybrid model of ET and OT appears to be an adequate option.

As mentioned in the introduction, in language change and in synchronic variation, frequency effects are often attested. Variation occurs in the language community, but it is also reflected in the individual lexicon. From an ET perspective, each time a variant is perceived, it is supposed to be stored as an exemplar, and the exemplar cloud is continuously updated. From a generative perspective, the underlying form and the grammar (i.e. the constraint ranking) change over time, which can even occur during a speakers' lifetime. Therefore, it is not only important to investigate variation in the language community, although variationist studies necessarily begin there, but also to examine and model language change and reduction in 'synchronic models'. In long-term change, we may distinguish clearly defined categorical changes of the grammar which must be accounted for. This is possible in OT, but it is at best a description and not an explanation (see also Gess (2003), McMahon (2000), Reiss (2003)). What occurs in between these stages is at least equally interesting and should be simultaneously accounted for (this will be shown in chapters 6 and 7).

As can be derived from the previous sections, it is clear that we process language in a categorical way, but also that we are able to store fine-grained detail in the lexicon. If we do not want to restrict ourselves to either the study of the lexicon, or the study of the grammar, but, instead, provide a fully fledged account of *language*, hybrid modelling of lexicon and grammar is necessary (Jackendoff (2007), Smolensky & Legendre (2006), van de Weijer (2009, 2012)). As mentioned above, there are different ways for hybrid modelling. One could extend generative grammar with lexical information, but we saw in §1.1 that there are a number of problems with this approach. On the other hand, it is possible to extend ET with a grammar, but although this has been proposed by Bybee (2007), usage-based grammar is not fully worked out. Another possibility is to construct other models, e.g. there are some computational phonological models. Ernestus & Baayen (2011) provide an overview of these models, but argue that they are not yet fully articulated as well. However, given that the most successful models of generative and usage-based phonology are OT and ET, respectively, and that they are complementary in that OT provides a grammatical model and ET a lexical model, as described above, I prefer to combine the two into a hybrid model.

1.3.1 Prototypes

Nonetheless, the combination of OT and ET is, technically speaking, not straightforward. The lexical input for the grammar is a challenge for combined modelling, since OT allows only for underlying representations in the lexicon, whereas, in contrast, ET requires a richly specified lexicon. This can be solved in at least two different ways: either one assumes that an abstraction is made over exemplar categories, which serves as the input for the grammar, or one assumes that there is no input at all, but that exemplars are directly available for the grammar as candidates. The first approach, which will be discussed in this subsection, is common in psychology, the second approach is adopted by van de Weijer (2012) and will be discussed in §1.3.3.

As we saw in §1.1, the grammar is supposed to take an underlying form as an input and generates a phonetic output. What are the viewpoints of ET on the underlying form and grammar? According to Pierrehumbert (2001), ET is a theory in which prototypes are easily dealt with: “Another obvious success of the model is its treatment of prototype effects” (Pierrehumbert 2001: 143). Similarly, Bybee (2007) considers it as a positive fact that ET exhibits prototype effects.

> “Exemplar clusters are categories that exhibit prototype effects. They are organized in terms of members that are more or less central to the category rather than in terms of categorical features”
>
> (Bybee 2007: 717).

The positive aspect of the prototype to which both authors refer to is that a prototype representation might be linked to what is understood as an underlying form in generative phonology. Unfortunately, the viewpoint that Exemplar Theory makes use of prototypes is not supported in the psychological literature. On the contrary, prototype models are regarded to be essentially different from exemplar models. In prototype theory, the distance to the prototype is crucial in categorization. Prototype theories have the disadvantage that there are no relations between the category members (Ross & Makin 1999). In Exemplar Theory, on the other hand, the distance to all other representations is essential in storage. Concerning linguistics, prototype models seem better suited for underlying representations. On the other hand, exemplar models are stronger in explaining variation between category members in analogical networks. Note that this paradox is not only relevant for linguistics, but also in other learning processes. Therefore, some psychologists working within the ET framework argued that the assumption of some abstractions is necessary and cannot always be distinguished from exemplars (see Barsalou (1990) for an overview). What are these abstractions? Abstractions over exemplars may contain idiosyncratic information and information about correlations between different members of the exemplar category. They are not static and unchangeable like underlying forms, but are continuously updated, since the exemplar clouds are constantly changing. In exemplar-only models, abstractions can be made in production, but they are not stored, on the other hand, in so-called mixed models (ET with abstractions or prototypes), abstractions are stored as separate items in the memory (Juslin et al. 2003). Abstractions are not necessarily the same as prototypes, however. The crucial difference seems to be the arrangement of the exemplars: connected to each other or centralized towards a prototype.

There is evidence from psychology that, generally speaking, humans learn and categorize *initially* in an exemplar-based way and form prototypes in a later stage (rather than exemplar storage only). For instance, Sherman (1996), after testing stereotypes in social development in low-experienced and high-experienced test-settings, noticed that at the initial stage of experience, the character of the category is principally exemplar-based. In later stages, the representations become more abstract and stable. Sherman (1996), therefore, called for a mixed exemplar-prototype model for category learning in psychology. Such a mixed model would be beneficent for linguistics also, since it can capture prototypes as well as analogical networks, and thus provides the input for the grammar and still account for analogical networks. This would mean that in initial stage, a newly perceived word is stored in an exemplar-based way, and prototypes are constructed when the word is perceived more frequently.

Do we really need the notion of a prototype in phonology? And if so, what kind of information is stored in the prototype? Prototypes play a crucial role in cognitive phonology (Lakoff 1993), in which they contain more information than the underlying forms in generative phonology. First, in cognitive phonology, prototypes play an important role as phonemes. Moreover, within a particular category or abstraction, there may still be perceptually different and salient contrasts. The central members of these subcategories can become a prototype as well. In this way, even allophones can also have prototypes (Välimaa-Blum (2005: 70)). So, unlike what is called an underlying form in generative phonology, prototypes are not only constructed on a phonemic base. Rather, (sub)categories with their prototypes may also be formed on the basis of different varieties, stylistic variation, and social stratification (Kristiansen (2003: 93) and references cited there). Pierrehumbert (2001) hypothesizes that different subcategories of exemplars may be targeted for production on the basis of sociolinguistic or other criteria. Comparison between different (allophonic or allomorphic) alternants may lead to a prototype that is similar to what is known as the underlying form in generative phonology. Thus we arrive at the following definition for phonological prototypes:

(11) *Prototype (in phonology)*

A prototype is an abstraction across one or more related exemplar categories and/or subcategories.

So, the prototype is not necessarily simply an average of an exemplar category, which is in line with psychological research for decades that has shown that categorization does not only depend on just exemplar storage but also on different sorts of knowledge. Moreover, categorization can be adapted to the situation (see Juslin et al. (2003) and references cited there). The prototype may consist of phonemes, but it does not necessarily consist of *only* phonemes. the prototype may be an underlying form in the generative meaning, but also a sociolinguistic salient form. Therefore, although a perfect realization is almost never perceived, speakers are often able to tell what the most well-formed realization should be: they have a prototypical realization in their lexicon. Similarly, speakers are often much aware of a particular sociolinguistic or dialectal pronunciation, although they do not use it themselves: different prototypes may exist which relate to different sociolinguistic parameters. The question whether we do need exemplar storage as well as prototypes will be addressed in part II of this thesis, where I will show that there is evidence for two kinds of lexical storage, which nicely fits into the exemplar-prototype mixed model which has been proposed by Sherman (1996).

1.3.2 EPOT (Exemplar-Prototype-Optimality Theory)

Summarizing, in order to account for grammar as well as usage-based phonology and grammar-frequency interactions, I propose a combined model based on an exemplar-based lexicon, including prototypes, and a constraint-based grammar: Exemplar-Prototype-Optimality Theory (EPOT). This model combines the strengths of ET and OT, namely a richly specified lexicon with much phonetic detail and a fully fledged grammar. EPOT is constructed as follows. Any perceived linguistic word is stored in the lexicon as an exemplar. Exemplars are stored in word categories on the basis of their similarity an dissimilarity. These categories are constructed on the basis of categorical perception and differences in meaning. In the initial state of the construction of a category, i.e. in language acquisition or very infrequent words, the category consists only of a few exemplars. In later stages, prototypes are automatically derived from categories that consist of more exemplars. These prototypes may consist of phonemes, but may also contain specific information related to certain sociolinguistic parameters, particular varieties, word specific information, or other idiosyncratic information. This suggests that words which are stored in an exemplar-based way only, may behave differently than words which have a prototype. We will see examples of this in chapter 4 and 5. The prototype forms the crucial link between the lexicon and the grammar: it may be regarded as the output of the lexicon, which is simultaneously the input for the grammar. The grammar is constraint-based, categorical, and blind for fine-phonetic detail which enters the grammar with the prototype. The grammar may change the prototype according to the grammatical rules, which I regard to be generalizations over the lexicon.

However, these alternations are always categorical. Fine-grained information, as long as it is not affected by a constraint, are retained in the output. This is worked out in detail in chapter 7. EPOT, as will be shown in this dissertation, can account for categorical and non-categorical variation in synchronic language variation (e.g. chapter 4 on rendaku in Japanese), as well as diachronic language change (e.g. chapter 7 on the variation of the long vowel <ä> in German). In synchronic variation, EPOT accounts for usage-based as well as grammatical effects. In diachronic change, different grammatical stages are assumed, represented by tableaux, with in-between changes of the lexicon. In this dissertation, data will be presented that show that both the lexicon and the grammar should be modelled in detail, and that there seem to be evidence for different patterns of storage in the lexicon: exemplar-only and prototype-based. EPOT will be tested by the case studies presented in this thesis.

1.3.3 Alternative: Grammar as Selection (van de Weijer 2012)

EPOT builds on the proposal of van de Weijer (2012): “Grammar as Selection” (GS). This hybrid model also combines ET and OT, but there is a crucial difference. Whereas in EPOT the prototype forms the input of the grammar, in GS, there are no inputs at all. Thus no input-output correspondence occurs. Instead, candidates are formed by exemplars. Tokens of exemplars, which play the role of candidates, are evaluated on the basis of output-output correspondence, that is, exemplars are compared to each other as members of analogical networks (see Benua (1997, 2000), Burzio (1998, 2000), McCarthy & Prince (1995)).

(12) OO-MAX

The output should correspond to the other output forms.

GS has a Harmonic Grammar component, in which not only are the constraints weighted, but the candidates are too. Candidate weight depends on their frequency. The summed products of candidate weight (in the rows of the tableau) and constraint weights (in the columns of the tableau) result in the harmonic weight. Violation of a constraint results in a negative value and satisfaction of a constraint results in a positive value. The winner is the candidate with the highest harmonic weight. A possible analysis for final -n deletion in Dutch in GS is provided in (13), where I added the weights and where I changed the constraint IO constraints into OO constraints, in order to make the comparison between the different candidates possible.

(13) *Tableau in Grammar as Selection (van de Weijer 2012) of word-final -n deletion in Dutch. Frequency weights of the candidates are for illustration only.*

	3	5	3	1	
	*ən]#	NUC/vowel	MAX-OO	{RIGHT}ANCHOR-OO	Harmonic weight
4 [lezə]	12	20	-12	-4	16
1 [leznฺ]	3	-5	-3	1	-4
2 [lezən]	-6	10	6	2	12

In stylistic variation, the relevant constraints have a different weight. For instance, in formal speech, it is likely that [lezən] would be the winner. The relevant constraint, which according to van de Weijer (2012) would be MAX-OO, which would be stronger so that [lezən] would have the highest harmonic weight.

Several comments are in order, regarding empirical evidence, stylistic variation, frequency values of the candidate, and (over)representation of frequency. Firstly, van de Weijer (2012) claims that GS is compatible with frequency effects, since ET is one of the two components of the model. This claim, however, comes without empirical tests. Secondly, GS is supposed to account for stylistic variation, by varying the weights of OO-correspondence constraints according to the register. In case there would be a prototypical or 'ideal' underlying form, it could be safely assumed that in formal speech styles, one tries to be closer to that 'ideal' form than in casual speech style. But in OO-correspondence, it is unclear why in formal speech the winning candidate should be "realized in an identical fashion across all instantiations" (van de Weijer 2012: 59). On the basis of exemplars only, one would expect that such a group mean as a winning candidate is formed only in the most frequent style—which is probably casual. Thirdly, in GS, frequency values are assigned to the candidates. That would not be possible if a candidate were the same as a single exemplar (since the frequency of a single exemplar is of course 1). A candidate in GS is therefore a token that consists of a mapping of exemplars that cannot be distinguished in perception. How this frequency type relates to word frequency remains unclear. Finally, in GS, faithfulness constraints emerge from generalizations across the lexicon and are represented by Output-Output constraints in order to make the grammar non-derivational (van de Weijer 2012 and references cited there). Similarly, markedness constraints are derived as abstractions over the lexicon (van de Weijer 2012: 59). These abstractions naturally contain frequency information (represented by constraint weight). This suggests that, since constraint weight represents frequency information and the candidate weight represents frequency as well, frequency appears to be doubly represented in the harmonic weight. This overrepresentation of the grammar might not be problematic, but it goes against Occam's razor, which favours the most economical explanation.

1.4 Research question and Hypotheses

This dissertation wants to provide a further contribution to the understanding how frequency effects interact with grammar. The leading research question of this thesis is:

(17) *What is the exact nature of the interaction between frequency and grammar?*

a. What is the content of the input

b. How are the input and the output derived?

Related to the main question:

(18) *a. Which insights do frequency-grammar interactions provide into the relation between grammar and lexicon?*

b. What do frequency-grammar interactions contribute to the modelling of language?

The goal of this thesis is thus two-fold. The practical goal is to collect data that show how exactly frequency may interact with grammar. The theoretical goal is to model these data in a combined Exemplar-Optimality model.

We may hypothesize that there are different possible interactions between frequency effects and grammar. A possible frequency-grammar interaction would be that different behaviour of LF and HF words only occurs within a particular grammatical context or a particular rule. For instance, -t/-d deletion in English largely depends on the variety and on phonological context, whether it is sentence-final or whether the following word starts with a vowel or a consonant (Tagliamonte & Temple 2005). A Type II frequency effect (reduction) typically occurs in -t/-d deletion in nouns, adjectives, past tense verbs, and monomorphemic words, but not elsewhere (Bybee (2002), Coetzee & Pater (2008)).

(19) *Hypothesis I*

Frequency effects within a particular variation pattern occur in particular grammatical contexts and are blocked in other grammatical contexts.

Alternatively, I hypothesize that it is also possible that frequency effects are not fully blocked, but still are dissimilar for different phonological and morphological contexts. For instance, since -t/-d deletion is a reduction process, I would hypothesize that reduction of final -t/-d would be more likely in pre-consonantal context than in pre-vocalic context, since in pre-vocalic position, resyllabification of the final -t/-d might occur. So, in both contexts Type II frequency effects may occur, but I hypothesize that the patterns differ.

(20) *Hypothesis II*

> Frequency effects within a particular variation pattern occur in all grammatical contexts, but they are sensitive to the grammatical difference between these contexts.

Still another possibility is that frequency effects largely occur across the lexicon, independent of grammar.

(21) *Hypothesis III*

> Frequency effects are independent of the grammar.

Finally, we expect all variation patterns to be sensitive to either Type I frequency effects or Type II frequency effects, since Type II frequency effects are typically involved in reduction and Type I frequency effects are typically found in other processes of phonological and morphological change.

(22) *Hypothesis IV*

> Depending on the type of process of language variation and change, either frequency Type I or frequency Type II apply.

These hypotheses will be investigated for different languages and different processes of variation and change.

1.5 Structure of this thesis

Frequency effects are often attested in language variation and change. Another source where frequency effects are to be expected, but which is an understudied field of research in frequency studies, is loanword phonology. It might be expected that frequency effects play a role in gradual adaptation of loanwords in the native grammar. In this dissertation we will test the hypotheses (19)-(22) in frequency-grammar interactions that are attested in three empirical studies: synchronic variation in a categorical rule (rendaku) in Japanese, synchronic gradient variation in Standard German long vowel <ä>, a diachronic study in the categorical rule of coalescence in Dutch loanword integration in Indonesian, and diachronic variation in Standard German long vowel <ä>. In all four studies, frequency effects which interact with grammar are attested.

Table 1.1. *Schema of the case studies in this dissertation, divided by type of variation (synchronic vs. diachronic and categorical vs. gradient).*

	Synchronic	*Diachronic*
Categorical	Chapter 4 Japanese rendaku	Chapter 6 Coalescence in Dutch loanwords in Indonesian.
Gradient	Chapter 5 Standard German long <ä> (Alemannic variety)	Chapter 7 Standard German long <ä> lowering

The different hypotheses are tested by investigating frequency effects in relation to grammatical processes, such that the relevant grammatical subcategories are taken into account. For instance, Dutch loanwords in Indonesian undergo coalescence, which affects the stem-initial consonant. Five different consonants /p t k f s/ form potentially input for coalescence with a preceding nasal. Instead of only investigating the relation between coalescence and frequency, I will also investigate whether, and how, frequency effects occur within the subclasses of words that begin with one of the consonants /p t k f s/. In this way we can observe whether frequency effects are blocked in a certain context (Hypothesis I), whether they are sensitive to the grammatical context (Hypothesis II), or whether they are insensitive to the grammar (Hypothesis III).

A relatively large part of this dissertation is concerned with the investigation of Standard German long vowel <ä>. The remainder of this, introductory, part I therefore contains a chapter on the background information of Standard German long vowel <ä>, in which we will look at the historical development of the vowel, the sources of the current variation, and the role of spelling and dialects in this variation. I will show that a former merger of the long vowel <ä> with long <e> is currently reversed, which underlies the variation and the frequency effects that we will investigate in later chapters. Chapter 3 provides the motivation for the methodology used in this thesis. It turns out that categorical ratings by native speakers probably do not constitute the most reliable methodology for analysis, hence, auditory data used in this thesis are all acoustically analysed. These chapters form the introduction for chapters 5 and 7 on the long vowel <ä> in Standard German.

Part II consists of two chapters: case studies that reveal an unexpected exceptional behaviour of LF words. Chapter 4 investigates a well-known morphophonological process in Japanese, rendaku, which involves voicing of the first segment of the right-hand member of a compound. There are, however, a number of compounds that are unlikely to undergo rendaku. We investigate whether frequency effects may play a role in this variation. Indeed, it turns out that especially LF roots sometimes do not undergo voicing. Whether they undergo the rule of rendaku or not largely depends on the frequency of both the voiced as the unvoiced variant of the root in other compounds and the root in isolation. Rendaku thus reveals a frequency-grammar interaction, in which we observe that compounds with LF roots words are less likely to undergo the rule. Chapter 5 is an in-depth experimental study about the pronunciation of the long vowel <ä> in a regional variety of Standard German. Here we observe a frequency-grammar interaction in the sense that the pronunciation of the vowel, among other factors, depends on the interaction between frequency and the morphological category. This study confirms the finding in chapter 4: LF words may behave exceptionally with regard to the grammar. Besides, we find that frequency effects are sensitive to the grammar, and that frequency effects depend on relative values rather than absolute values.

Part III forms the core of this thesis and provides two clear and comparable interactions of frequency and grammar. Chapter 6 describes an interaction between frequency and coalescence in Dutch loanwords in Indonesian. This chapter confirms the results of chapter 4 and 5 in the sense that LF words behave exceptionally with regard to the grammar and that frequency effects are sensitive to grammatical context. In chapter 6, we also find that expected frequency effects are blocked in certain well-defined phonological contexts. Further, the frequency effect interacts with the first segment of the word. Finally, chapter 7 reports on an interaction between frequency effects and the pre-r vowel lowering rule in the change of the long vowel <ä> in Standard German. It will be shown that in the process of vowel lowering three different frequency effects are involved. Finally, part IV discusses the results and concludes.

Märchen

Ich weiß ein schönes Märchen.
Es war ein schönes Pärchen,
Hieß Hänselchen und Klärchen,
Die pflückten Blum' und Ährchen,
Und aßen reife Beerchen.
Das Klärchen hatt' ein Härchen,
Das Hänselchen ein Scherchen;
Das war ein goldnes Härchen,
Und das ein silbern Scherchen.
Das Hänselchen nahm Klärchen,
Schnitt mit dem Silberscherchen
Ihr das goldne Härchen;
Da ging das goldne Härchen
Entzwei am Silberscherchen;
Da ging das Silberscherchen
Entzwei am goldnen Härchen.
Da weinte laut das Klärchen
Um ihr verlornes Härchen,
Und Hänschen mit dem Klärchen
Um sein zerbrochnes Scherchen;
Laut weinte das Pärchen
Um Härchen und Scherchen;
Gar viele, viele Zährchen.
Laut weinten Blum' und Ährchen
Und alle reifen Beerchen,
Zusammen mit dem Pärchen
Um Härchen und Scherchen.
Da saß im Busch ein Stärchen,
Das sah die vielen Zährchen,
Da sprach das kluge Stärchen:
Was weint ihr denn, ihr Närrchen?
Das Härchen und das Scherchen,
Die Zährchen und die Ährchen,
Die Beerchen, und du Pärchen,
Und ich dazu, das Stärchen,
Sind alles nur ein Märchen.

Friedrich Rückert, 1788-1866

Chapter 3

Methodological considerations: avoiding the halo effect[1]

Abstract

Sociolinguistic research often relies on transcription or coding by one, two, or maximally three native coders. Recently, it has been shown that this method is doubtful, since listeners may be biased by an overall impression of the accent of the speakers. Whereas coders are expected to judge on the basis of the acoustic signal only, possibly other factors play a role. In this chapter, I investigate whether the transcriptions of the coders and the F1 and F2 measurements of the acoustic signal of the long vowel <ä> in Swiss Standard German are comparable. I conducted a standard statistical analysis of the coders' judgements, which was compared to an analysis of the acoustic measurements of the same vowels. It will be shown that the coders only partly rely on the acoustic signal. Moreover, the coders seem to be biased with relation to an overall Swiss accent of the speakers or the dialectal accent of the speakers, which points towards a linguistic halo effect. This bias leads to statistical results that considerably differ from the acoustic analysis. The comparison of the two types of analyses, based on categorical judgements of native speakers and on acoustic measurements, shows that this type of sociolinguistic research should be treated with great care.

[1] A version of this chapter has been submitted to the Australian Review of Applied Linguistics. Paper presented at *The Applied Linguistics Association of Australia* (ALAA) 2012 Conference, 12-14 November 2012, Perth, Australia. Also presented as a poster at *LabPhon 13*, Stuttgart, Germany, 27-29 July, 2012.

Native speakers' transcriptions are often used to investigated the nature of the variation in sociolinguistic and dialectological studies. In chapter 2, we analysed the long vowel <ä> and <e> in the Upper German area by acoustic measurements, however. Would it not be useful, or even better, to ask native speakers to code the data categorically, with a forced choice of only [eː] or [ɛː]? The methodology of having one, two, or at most three native speakers as coders of the data is very common in several subdisciplines of linguistics (Hall-Lew & Fix (2012), Milroy & Gordon (2003)), not only used in many sociolinguistic and dialectological studies, but also in linguistic fieldwork, second language acquisition, and clinical linguistics. Some recent examples in sociolinguistics are numerous studies on l-vocalization (Hall-Lew & Fix 2012), an individual study on Pittsburgh /aw/ (Johnstone et al. 2002), and diphthongs in Italian (van der Veer 2006).[2] Although common practice, many dialectologists and sociolinguists are aware of a serious drawback of this method, viz. the danger of 'coder bias': coders perceive the data according to their expectations. Such biases (called reversed linguistic stereotypes by Kang & Rubin (2009)) are investigated in perception studies, although not with professional linguists as subject-coders. Particularly interesting examples show that subject-coders are easily led to believe that a particular speaker uses a particular variety, and subsequently attribute prototypical pronunciations belonging of that variety to that speaker. For instance, Niedzielski (1999) found that in the perception of the vowel /aʊ/ participants were more likely to judge the vowel as raised if there was a visual suggestion that the speaker was Canadian (a raised pronunciation is common in Canada). However, the speaker was always the same, the vowel was always the same—and the speaker was not Canadian at all—but from Detroit, where the vowel is also raised, but subjects were not aware of this fact. Hay et al. (2006b) found similar results for the vowel /ɪ/ in New Zealand English and Australian, but without informing the participants about the speakers. While performing the test, the participants guessed whether the speaker was a New Zealander or an Australian. Hay & Drager (2010) found that even a toy kangaroo or koala (which is associated with Australian) or a toy kiwi (which is associated with New Zealand) bias the perception in the expected direction. Not only regional variety, but also sociolinguistic factors such as apparent age, gender, and socio-economic status are found to enhance biased results (Drager (2011), Hay et al. (2006b), Strand & Johnson (1996)). These studies show that a general impression of a speaker who uses a particular dialect or accent may lead to the supposition that certain features that are characteristic for this variety occur in their speech, also when this is actually not the case. The subjects of the studies mentioned were normal participants and not trained linguists. Still, to be on the safe side, some scholars who ask native speakers to code their data try to minimize bias effects, but no common approach exists. For instance, Johnstone et al. (2002) used a preparatory stage in which coders are trained with movies to become aware of the different pronunciations. Another approach is

[2] Van der Veer (2006) uses the analyses of native speakers of Italian and also of trained phoneticians whose native language was not Italian and, perhaps surprisingly, found agreement *within* both groups of coders, but simultaneously disagreement *between* the two groups.

not to inform the coders about the purpose of the study, which is, however, not always a viable option.

We may expect that linguists, who are trained, are less biased. But is this really the case? Since coders are usually linguistically trained, and must be, they will often be able to guess what topic is being investigated. If coders are not unbiased regarding the variety they have to code, many analyses on the basis of coders' judgments may become unreliable. Very recently, in a post-hoc experiment, Hall-Lew & Fix (2012) investigated a coder bias with regard to l-vocalization in English. These researchers first examined the inter-coder reliability in an online survey among linguists who were asked to rate the pronunciation of English /l/ as either consonantal or vocalized. Subsequently, they looked at possible correlations between the perceived accent and the ratings of l-vocalization by the coders. Their conclusions are twofold: although inter-coder reliability scores were high, despite the coders' different linguistic backgrounds, considerable deviations from the mean were attested. The main factor that caused this inconsistency was the coders' ethnolinguistic awareness. The coders perceived particular features and drew conclusions about the ethnolinguistic background of the speakers of whom they coded the data. These perceptions may or may not have corresponded to the actual situation, but they apparently influenced the analyses.

This phenomenon that judgements of individual characteristics are influenced by an overall impression, is well-known in psychology as the *halo effect* (e.g. Nisbett & Wilson (1977), Sahoo et al. (2010), Thorndike (1920) among many others). Typically, a halo effect shows that subjects are not able to keep different factors apart. It is most obviously noticed in physical appearance, which influences the judgement of personality. Physically attractive people are assigned positive qualities like more intelligence and happiness than physically non-attractive people. Furthermore, this mechanism is unconscious: people think they are unbiased, where they clearly show such a halo effect. For example; in an experiment, Nisbett & Wilson (1977) showed that subjects who had to evaluate the appearance, mannerism, and accent of a college instructor, were biased by the fact that he acted as either cold or warm. Moreover, the subjects reported that their dislike of the instructor did not influence their ratings.

So the question arises how much any preconceptions may influence a particular analysis that is done in the traditional way of having two coders rating data categorically. This chapter focuses on the risks of these impressionistic analyses. To what degree are coders reliable and to what extent are they unreliable? I used the methodology of having just two coders who made a categorical analysis of the long vowel <ä> in a particular variety of Standard German, namely Swiss Standard German (SSG). One of the most salient features of SSG pronunciation is the long vowel <ä>: in colloquial SSG, the standard pronunciation is [ɛː], whereas in northern varieties of Standard German (NSG), in colloquial speech, the preferred pronunciation is [eː]. In SSG, the long vowels <e> and <ä> are phonemic, and therefore I suppose that SSG speakers are able to discriminate between the two sounds: even if the variation is continuous (and it is), categorical perception should make it possible to categorically differentiate between the long <e> and the long vowel <ä>. In order to test the validity of this method, I also measured the main acoustic values, F1 and F2 of the vowel, which were Bark-transformed (see also §2.4.2). The two analyses were compared to each other. The results turned out to be surprisingly different. This raised other questions. To what extent do coders rely on the acoustic signal proper? To what extent are they biased towards an overall accent of the speakers that they have to code? In order to answer these questions, I carried out a second experiment to quantify the level of accentedness of the speakers. Subsequent analyses of the coders' ratings and the acoustical measurements, with accentedness of the speakers as one of the variables, showed that, although the coders rely to a substantial degree on F1 and F2, they also appear to be biased towards the overall accent or the dialect of the speakers they coded.

This chapter is structured as follows. Section 3.1 provides more background information on the variable pronunciation of the long vowel <ä> in Swiss Standard German. In §3.2, the analysis on the basis of the coders' ratings is provided. Section 3.3 provides the results of the acoustic analysis and compares this to the analysis of the coders' ratings. Section 3.4 reports on an internet-based survey which provided a quantification of the accentedness of the speakers that were analysed. Section 3.5 includes this accentedness in a newly conducted statistical analysis of the coders' ratings. Finally, §3.6 discusses and concludes.

3.1 Swiss Standard German and the long vowel <ä>

The pronunciation of Swiss Standard German long vowel <ä> is comparable to that of other varieties of Standard German: it can be realized as a long *lower*-mid unrounded front vowel [ɛː] and a long *higher*-mid unrounded front vowel [eː], any vowel in between these two, or even as a very open [æː]. This variation serves as a test case for our investigation into coder bias by comparison of an analysis based on codings and an analysis based on acoustic measurements. In this section, we investigate the factors that are likely to play a role in this variation. In §3.1.1, some relevant background on Swiss Standard German is provided. In §3.1.2, the place of the long vowel <ä> in the phonology of Swiss Standard German will be considered.

3.1.1 Swiss Standard German

Swiss Standard German (SSG) is the variety of Standard German as spoken in Switzerland and exists as the official language alongside a variety of Swiss German dialects. SSG is used as the literary language[3] and in more formal daily situations: in education, religion, and law. Although code-switching and interference between the dialects and the standard occur (Keller (1982), Rash (2002)), there is no continuum between the two varieties. In other words, Swiss speakers use either their local dialect or the standard, and there are hardly any varieties in

[3] All German speaking Swiss children learn Swiss Standard German in education (see e.g. Oberholzer (2006)), but dialect is spoken at home.

between. Ferguson (1959) introduced the term *diglossia* for this type of language situation and in fact presented the Swiss language situation, as far as German is concerned, as a typical example. According to Hove (2002), two factors affect the pronunciation of SSG: orthography and the variety of German used in the media. Since SSG is primarily a written language and, moreover, it is learned alongside reading and writing, it serves as a reference point for pronunciation. Many Swiss speakers adhere to the prescriptive tradition of spelling pronunciation, but Hove's study shows that some Swiss speakers conform to the Northern Standard German (NSG) accent in their speech, probably under the influence of the media. This is the variety that is spoken in the Low German area in the north of Germany. Hove (2002) describes three typical differences in pronunciation, namely long vowel <ä>, the rhotic, and the <s>,[4] and shows that they are correlated with each other, which means that when Swiss speakers use one NSG feature, they are also likely to use the other NSG features.

3.1.2 SSG long vowel <ä>

The long vowel <ä> is one of the most prototypical Swiss pronunciation differences: whereas in NSG the preferred colloquial variant is [eː], in SSG the standard pronunciation is [ɛː]. In NSG, the vowel is usually merged with /eː/, except in formal registers (Stearns and Voge (1979) see also §2.3). SSG, on the other hand, is characterized by a distinctive pronunciation between the long vowel <ä> and long <e>. This is related to the spelling. Since the orthographical representations of the two vowels differ, the pronunciation also differs. Notwithstanding clear pronunciation differences between SSG and NSG, the phoneme inventory of the two varieties is the same.

In order to investigate whether the analysis on the basis of categorical ratings by two native coders is comparable to an acoustic analysis, we first investigate which factors are plausible predictors for the pronunciation of the long vowel <ä>. Some factors are related to sound change, other factors are more general. On the assumption that sound change is ongoing, changing the SSG pronunciation [ɛː] to the NSG pronunciation [eː] (see above), it is expected that age and gender of the speakers, and also frequency play a role. First, younger speakers, especially younger female speakers, are usually ahead in innovative sound change (e.g. Labov (2001), Milroy & Milroy (1985) among many others).[5] Second, if the variation reflects sound change, we expect frequency effects to occur as well. Since there is no obvious reduction, in which HF words are affected first, we would expect that LF words are the first to change (see chapter 1 for more discussion). So more highly frequent words are expected to be pronounced with Swiss Standard German [ɛː] and words with lower frequency are expected to be pronounced with [eː]. Separate from the question of whether the variation reflects ongoing

[4] The rhotic is pronounced as an alveolar trill or tap in SSG (Ulbrich & Ulbrich (2007)), but as a uvular sonorant trill [ʀ] or a vocalized central low vowel [ɐ] in NSG. The prevocalic /s/ is voiceless in SSG, but voiced in NSG Ammon (1995).

[5] This is the case in so-called "change from below". In "change from above", females tend to adhere to the old prestige norm Cameron (2003).

change or not, three other types of factors are likely to be involved in the variation: geographical factors, pre-r context, and tautosyllabicity of the following consonant. Some places that are in contact with other varieties of German could be expected to have a pronunciation with a higher vowel quality on average, like Basel, Bludenz, and Vaduz (see §2.1.3 and Figure 3.1). A following /r/ may have a lowering effect on the vowel (see §2.1.2). Finally, the following consonant often causes a lower realization of a mid vowel when it is tautosyllabic, that is, when it belongs to the same syllable.[6] This could lead to different pronunciations of the long vowel <ä> in *Bär* 'bear' and *Bäre* 'bear.PLUR'.

Summarizing, the realization of the long vowel <ä> as [ɛː] is a prototypical SSG feature. In the following two sections, we will compare the categorical analyses of the coders with the instrumental measurements of F1 and F2. In the analyses, we will test the factors age, gender, frequency, location, pre-r context, and tautosyllabicity of the consonant following the long vowel <ä>.

3.2 Categorical analysis I

In this section, we follow the traditional methodology in which corpus data are categorically coded by two native speakers and subsequently statistically analysed. Section 3.2.1 describes the material and §3.2.2 provides some information about the coders and reports on the interrater reliability. Section 3.2.3 provides the results of the categorical analyses.

3.2.1 The data

For this chapter, I selected all Swiss locations for which data of both younger and older speakers are available from the corpus "German Today" of the *Institute für Deutsche Sprache* "Institute for German Language" in Mannheim (IDS, Project *Variation des gesprochenen Deutsch* "Variation in spoken German (Brinckmann et al. 2008), see also §2.4.1). These contain data from Basel, Biel/Bern, Brig, Luzern/Willisau, and Zurich. Furthermore, two locations outside Switzerland are included in this study: Vaduz (Liechtenstein) and Bludenz (Austria, on the Swiss border). These were included because these locations belong to the same dialect group as the Swiss dialects, viz. High-Alemannic. Figure 3.1 shows the places investigated.

[6] For example, in Canadian English, mid front vowels, in particular the mid-high front vowel /eː/, have been shown to be subject to lowering in closed syllables more than in open syllables (De Decker & Mackenzie 2000). Similarly, Latta (1972) mentions that in Chamorro and Malay, high vowels are lowered in closed syllables, which appears to be common in Indonesian and Malay varieties (van Zanten 1986).

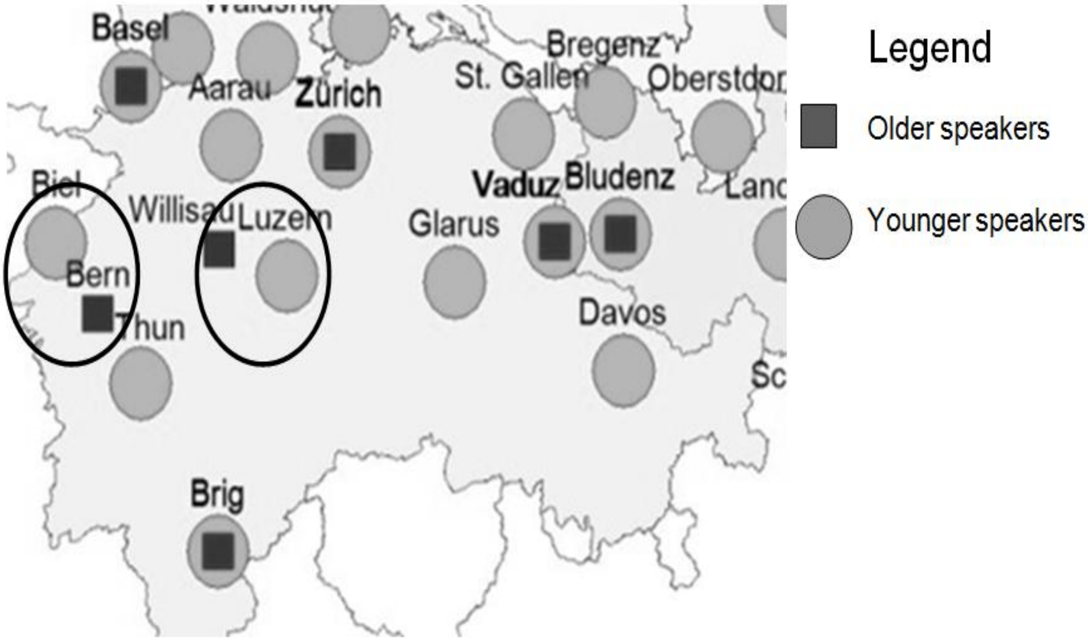

Figure 3.1. *Sites in Switzerland, Bludenz and Vaduz, investigated for the pronunciation of the long vowel <ä>. Only places with younger (circle) and older (square) speakers are investigated. Bern and Biel are treated as one location, and Luzern and Willisau are also treated as one location (indicated by the black circle).*

Frequency counts are based on the frequency of occurrence in the corpus "German Today", provided to the author by the "Institut für deutsche Sprache" in Mannheim, Germany. Token frequency may be important in investigating frequency effects, but it has been reported that lemma frequency may be an even stronger predictor than token frequency (Gahl (2008), Jescheniak et al. (2003) among others). The lemma is a set of all words having the same stem. Lemma frequency is the summed frequency of all tokens of a lemma. Especially for the data investigated in the present study, token frequency may not be reliable for two reasons, one related to umlaut and the other to suffixation. Many words in the corpus belong to the same lemma, or morphological paradigm. For instance, the verb *fahr* 'drive' in the singular present has the following forms: *fährst* 'drive.2SG', *fährt* 'drive.3SG'. The vowel of two words with identical stems but different token frequencies, such as *fährst* and *fährt*, are most likely to be pronounced similarly by the same speaker (intraspeaker variation is not impossible, but speakers would not consistently pronounce [feːɐst] alongside [fɛːɐst]). Likewise, in the nominal paradigm, speakers pronounce the vowels of *Räder* 'wheel.PLUR' and *Rädchen* 'wheel.DIM' similarly. Likewise, I classified inflections as in *Jähr-chen* 'year.DIM' and derivations like *jähr-lich* 'yearly' in the same lemma, since it is most likely that both are pronounced in the same way by a single speaker. The second reason why we do not rely on token frequency is that many different roots can be suffixed with the suffix *-ität* (deadjectival nominal suffix '-ity'). There is no evidence that the HF suffix *-ität* varies in pronunciation on the basis of token frequency of the stem. For example, speakers who pronounce HF

National-ität 'nationality' with an open vowel, also pronounce LF *Plural-ität* 'plurality' with an open vowel. Instead of lemma frequency, in this case, suffix frequency is computed. Suffix frequency is computed completely analogously to lemma frequency, except for the fact that the suffix is counted rather than the stem. In the present study, the lemma frequency ranges from 1 to 2110, in which *wär* 'be.SUBJ' is by far the most frequent (2110) and *ungefähr* the second most frequent (1074). Subsequently, lemma frequency was log-transformed in order to resemble more psycholinguistic perception of frequency.

To examine the pronunciation of the long vowel <ä>, a selection of all items spelled with <ä> representing the long lower mid front vowel was made (in German, <ä> may also represent short [ɛ], see also §2.5). Two words show variation in vowel length across the whole German-speaking area and were therefore excluded from further analysis: *Städte* 'town.PLUR' and *nächste* 'next' (see also §2.4.1).

3.2.2 The coders and intercoder (dis-)agreement

The long vowel <ä> was categorically transcribed (either [ɛː] or [eː]) by two Swiss coders from Basel and Fribourg, respectively, who were female native speakers of Swiss German and who spoke SSG fluently. The coders were not informed about the purposes of the study. Both were linguistically trained at the University of Freiburg (Germany) but did not have much experience in coding. At the time of the analysis they were 24 and 27 years old, respectively.

In sum, 579 codings were obtained, which were first tested for inter-coder agreement. The Cohen's Kappa test showed a low agreement κ=0.446. This indicates that the categorical judgments were quite different between the two coders, which is shown in Table 3.1. In 373 cases, both Coder 1 (C1) and Coder 2 (C2) rated the vowel as [ɛː] and in 87 cases both coders rated the vowel as [eː]. (C1) judged the vowel to be [ɛː] and (C2) judged the vowel to be [eː] in only 25 cases and C1 judged the vowel to be [eː] and C2 judged the vowel to be [ɛː] in 94 cases. So there are a substantial number of vowels in which C1 perceived [eː] and in which the C2 perceived [ɛː], but there are also a (smaller) number of cases in which this is reversed.

Table 3.1 The number of [eː] *and* [ɛː] *codings by Coder 1 and Coder 2.*

		Coder 2		
		eː	ɛː	sum
Coder 1	eː	87 (48%)	94 (52%)	100%
	ɛː	25 (6%)	373 (94%)	100%

3.2.3 Results

Why do the coders differ? Is it simply the difference category boundary between individuals? In that case we would expect that one coder reports simply more [eː] codings than the other, and not that the reversed also occurs, like in Table 3.1. Are the coders biased to certain factors?

In order to investigate coder bias (or a halo effect), we first conduct a usual statistical analysis, so that we can compare that to the acoustical analysis at a later stage (§3.3). Mixed-effects modelling with model comparison was used with coding as the dependent variable. The independent variables are the speakers' age, speakers' gender, frequency, and speakers' location, pre-r context and tautosyllabicity of the consonant following long vowel <ä>. The variables speaker, lemma, and the order of tokens per interview were treated as random effects.

In the analysis of the codings of C1, we find an effect of the speakers' location and frequency. Only Vaduz is significantly different from the reference level Zurich. In general, more codings of [ɛː] occur, but in Vaduz the codings [eː] and [ɛː] occur almost equally often ($z = -1.974$, $p = 0.048$). Further, more frequent words tend to be pronounced with [eː] more than less frequent words ($z = 1.971$, $p = 0.049$). The other factors (speakers' gender, speakers' age, and pre-r context) were not significant, nor could any interactions be attested. The means of C1 are provided in Table 3.2.

Table 3.2 *Number and percentages of* [eː] *and* [ɛː] *codings of Coder 1, divided by speakers' location, speakers' gender, speakers' age, and pre-r context.*

		[eː]	Percentage [eː]	[ɛː]	Percentage [ɛ ː]
Speakers' location	*Basel*	30	29.1	73	70.9
	Biel/Bern	26	38.2	42	61.8
	Bludenz	14	25.9	40	74.1
	Brig	9	11.7	68	88.3
	Luzern/Willisau	36	33.0	73	67.0
	Vaduz	49	53.3	43	46.7
	Zurich	17	23.0	57	77.0
Speakers' gender	*Female*	91	32.2	192	67.8
	Male	90	30.6	204	69.4
Speakers' age	*Old*	54	22.9	182	77.1
	Young	127	37.2	214	62.8
Pre-r context	*Pre-r*	134	36.3	235	63.7
	Non pre-r	47	22.6	161	77.4

The full mixed-models analysis is provided in Table 3.3

Table 3.3. Categorical analysis I of Coder 1. The estimates, standard error, z-value, and p-value of the factors speakers' location, with Zurich as reference level, frequency, speakers' gender, speakers' age, and pre-r context.

Random effects:

Groups	Name	Variance	S.D.
Lemma	(Intercept)	0.267	0.517
Ntoken	(Intercept)	0.059	0.244
Recording	(Intercept)	0.539	0.734

Fixed effects

	Est.	S.E.	z-value	p-value
(Intercept)	0.346	0.718	0.482	0.630
speakers' location-Basel	−0.115	0.601	−0.191	0.849
speakers' location-Biel/Bern	−0.738	0.635	−1.162	0.245
speakers' location-Bludenz	−0.023	0.646	−0.036	0.972
speakers' location-Brig	0.867	0.719	1.205	0.228
speakers' location-Luzern/Willisau	−0.242	0.604	−0.400	0.689
speakers' location-Vaduz	−1.192	0.603	−1.974	0.048*
frequency	0.402	0.203	1.971	0.049*
speakers' gender male	0.070	0.336	0.208	0.835
speakers' age young	−0.486	0.365	−1.330	0.184
pre-r context	0.461	0.313	1.476	0.140

The analysis of the codings of C2 shows almost a complementary picture: the significant predictors are pre-r context, speakers' gender, and speakers' age. In pre-r context, coding of the vowel as [eː] is more likely to occur than coding of [ɛː] (z = 2.262, p = 0.024). Also, younger speakers are coded as having more low [eː] realizations and younger speakers are coded as having more [eː] realizations than older speakers (z = -2.087, p = 0.037). Finally, males are rated to have more [eː] realizations than females (z = -2.671, p = 0.008). The means of C2 are presented in Table 3.4 and the results of the mixed models analysis of C2 are provided in Table 3.5.

Table 3.4 *Number of* [eː] *and* [ɛː] *codings of Coder 2, divided by speakers' location, speakers' gender, speakers' age, and pre-r context.*

		[eː]	Percentage [eː]	[ɛː]	Percentage [ɛ ː]
Speakers' location	*Basel*	14	13.6	89	86.4
	Biel/Bern	22	32.4	46	67.6
	Bludenz	18	33.3	36	66.7
	Brig	30	31.3	66	68.7
	Luzern/Willisau	23	21.1	86	78.9
	Vaduz	13	14.1	79	85.9
	Zurich	11	14.9	63	85.1
Speakers' gender	*Female*	38	13.4	245	86.6
	Male	74	25.2	220	74.8
Speakers' age	*Old*	37	15.6	199	84.4
	Young	75	22.0	266	78.0
Pre-r context	*Pre-r*	89	24.1	280	75.9
	Non pre-r	23	7.5	285	92.5

Table 3.5. *Categorical analysis I of Coder 2. The estimates, standard error, z-value, and p-value of the factors pre-r context, speakers' gender, speakers' age, speakers' location (with Zurich as reference level), and frequency.*

Random effects:

Groups	Name	Variance	S.D.
Lemma	(Intercept)	<0.001	<0.001
Ntoken	(Intercept)	<0.001	<0.001
Speaker	(Intercept)	<0.001	<0.001

Fixed effects:

	Est.	S.E.	z-value	p-value
(Intercept)	2.790	1.300	2.147	0.032*
pre-r context	1.082	0.478	2.262	0.024*
speakers' gender male	−3.024	1.132	−2.671	0.008*
speakers' age young	−2.065	0.989	−2.087	0.037*
speakers' gender: speakers' age	2.904	1.333	2.178	0.030*
speakers' location-Basel	1.415	1.098	1.289	0.198
speakers' location-Biel/Bern	−0.985	1.071	−0.920	0.358
speakers' location-Bludenz	−0.469	1.056	−0.445	0.657
speakers' location-Brig	0.529	1.179	0.448	0.654
speakers' location-Luzern/Willisau	0.097	1.052	0.092	0.926
speakers' location place-Vaduz	1.035	1.062	0.975	0.329
frequency	0.247	0.295	0.838	0.402

The different outcomes of these analysis are remarkable and give rise to several questions. Is one coder simply better than the other? How can we decide which analysis is the best one? And, moreover, what is the reason for these different results? As a first step, let us investigate the data by acoustic measurements, and compare the acoustic analysis with the categorical analyses.

3.3 The acoustic analysis

In the acoustic analysis, I followed the same procedure as described in §2.4.2: the F1 and F2 of each vowel are measured at the temporal midpoint of the steady state of the vowel. Subsequently, I interpolated the vowels on a scale between 0 (representing the most extreme pronunciation of [a]) and 100 (representing the most extreme pronunciation of [i]). This interpolated vowel is treated as the dependent variable and the same factors were investigated as in the categorical analysis: speakers' age, speakers' gender, and speakers' location, tautosyllabicity of the consonant following long vowel <ä>, and further pre-r context and frequency. For numeric variables, the mixed-effects model does not provide significance, but as a general threshold t-values < -2.000 or > 2.000 are expected to be significant. The results show an effect of speakers' age and of pre-r context. Younger speakers tend to have a lower, more [ɛː]-like pronunciation (t = -2.058). Further, pre-r context has a lowering effect (t = -

3.697).[7] The other factors (speakers' location, gender, age, and frequency) are not significant. The results are provided in Table 3.6.

Table 3.6. The acoustic analysis. The estimates, standard error, and t-value of the factors speakers' age, pre-r context, speakers' location (with Zurich as reference level), frequency, and speakers' gender.

Random effects:

	Name	Variance	S.D.
Lemma	(Intercept)	23	<0.001
Ntoken	(Intercept)	<0.001	<0.001
Speaker	(Intercept)	69	<0.001
Residual		147	<0.001

	Est.	S.E.	t-value
(Intercept)	66.267	6.122	10.825
speakers' age-young	−10.036	4.877	−2.058*
pre-r context	−7.669	2.075	−3.697*
speakers' location-Basel	5.364	5.709	0.939
speakers' location-Biel/Bern	−0.993	5.855	−0.170
speakers' location-Bludenz	9.099	5.677	1.603
speakers' location-Brig	0.256	6.195	0.041
speakers' location-Luzern/Willisau	3.360	5.644	0.595
speakers' location-Vaduz	9.009	5.799	1.554
speakers' gender-male	4.454	5.717	0.779
frequency	−1.688	1.303	−1.296
speakers' gender: speakers' age	3.293	6.815	0.483

This acoustic analysis is comparable to that of C2, but unlike the analysis of C2, no effect of the speakers' gender is found. Table 3.7, summarizes the significant factors of the analyses so far. Further comparison between the categorical and acoustic analyses is provided in §3.5.

[7] A prototypical pronunciation of an /ɛː/ is approximately 65 and a prototypical pronunciation value of /eː/ is around 75.

Table 3.7. Summary of the results of the acoustic and categorical analyses. The factors speakers' age, speakers' gender, speakers' location, frequency, and pre-r context and their significance in the acoustic and the categorical analyses divided by accentedness. Significance is indicated by ✓ and non-significance is indicated by ✗.

Factor	Acoustic	C1	C2
speakers' age	✓	✗	✓
pre r-context	✓	✗	✓
speakers' gender	✗	✗	✓
speakers' location	✗	✓	✗
frequency	✗	✓	✗

The analyses are all different and we may wonder how much the coders rely on the acoustic signal. Are the coders biased to a factor that we did not measure? Is this a halo effect? Or do coders 'naturally' compensate for some factors. Or did we miss an acoustic factor that is crucial for the analysis? It is not unlikely that a halo-effect could occur, given that non-linguists are easily biased towards accent, and that long vowel <ä> is a typically Swiss feature, a factor of which the Swiss coders are of course aware. We will therefore investigate whether a bias towards the level of SSG or NSG accent causes the deviations from the acoustic measurements. Before we can do so, the level of accent needs to be quantified and therefore I conducted another experiment, which is discussed in the following section.

3.4 The degree of Swiss Standard German accent: Online elicitation

In order to be able to investigate whether the coders are biased by SSG or NSG accent, the degree of accent of all speakers in the corpus must be quantified. Therefore, the original recordings were used in an internet survey to establish type and level of accent. The approach and methodology are described in § 3.4.1 and the results are provided in §3.4.2.

3.4.1 Approach

An internet survey was developed in which respondents were asked to estimate the degree of Swiss accent of short sound samples. For each Swiss speaker analysed in §3.2 and §3.3, a small sound sample of approximately twenty seconds of two or three complete sentences was randomly selected. In sum, forty sound files were created, one for each interview, which were evenly divided across two surveys, so that it was possible to complete the survey in approximately fifteen minutes. Each of the two surveys contained recordings of one younger female and one younger male per place and also one older speaker per place. Older males and females were also evenly divided across the two surveys. The internet survey consisted of three web pages: the first two pages each contained ten sound samples, the third page contained questions on the respondents' sociolinguistic background, which was optional. The respondents were asked to estimate the level of accent for each sample by selecting one out of four possibilities:

- 1 = strong Swiss accent
- 2 = average Swiss accent
- 3 = weak Swiss accent
- 4 = no Swiss accent

On the third page respondents were asked to provide the following sociolinguistic information:

- the respondent's age
- the respondent's gender
- the respondent's use and competence in dialect and standard (on a five-point scale)
- the place where the respondent was born and raised
- the place where the respondent's parents used to live

A respondent could listen to the sound files as many times as she wished and the volume could be adjusted to the respondent's needs. Furthermore, it was possible to provide comments at the end of the first two pages. Both German and Swiss respondents were recruited (which was necessary because a *respondent* bias could possibly occur on the basis of the nationality and competence of the respondents in SSG and NSG, see following section).[8]

3.4.2 Results

Both versions of the survey were returned by ten German and ten Swiss listeners, and two listeners (one German and one Swiss) filled in version A as well as B. Version A was returned by ten females and eight males and two respondents did not indicate their gender. Version B was returned by six males and thirteen females and one respondent did not provide his or her gender. The respondents' gender and mean age, per version of the survey and per nationality, are presented in Table 3.8.

[8] The respondents were recruited through the personal network of the author.

Table 3.8. The number of respondents divided by their nationality, gender and mean age for Version A and B of the online survey.

Version	Nationality of respondents	Number of respondents			Mean age
		Male	Female	Gender not specified	
A	German	4	6		44
A	Swiss	4	4	2	46
B	German	4	6		30
B	Swiss	2	7	1	49
Sum		**14**	**23**	**3**	

To evaluate the agreement between the respondents' answers, Cronbach's test for reliability between respondents was carried out. This is a correlation test which indicates the consensus of the respondents' ratings and of which the output value α is between 0 (no correlation) and 1 (perfect correlation). Cronbach's α was remarkably high for version A α = 0.959 as well for version B α = 0.966.

The accentedness ratings were further investigated in order to check whether *respondent biases* occurred. Respondent bias is related to coder bias. The difference between them lies in the fact that the respondents provide a general judgement over the recordings, whereas the coders evaluate particular speech sounds. Notwithstanding the extremely high consensus among the respondents, there might still be some systematic differences on the basis of the respondents' nationality, the respondents' age, the respondents' gender, and the respondents' competence in the standard and dialect. These factors were investigated in a mixed-effects model with speaker and respondent as random effects. Since it is likely that not only factors related to respondents play a role, but also speakers' age, speakers' gender, and speakers' location (see also §3.1.), I also investigated these factors. In addition, I also checked for an effect of the survey (whether survey A or B was taken). Model comparison showed that the best statistical model is the one with the factors survey, subjects' age, and respondents' dialect use. Only speakers' age and respondents' dialect competence turned out to be relevant factors, the effect of the survey is not significant (see Table 3.9).

Table 3.9. Results of the optimal mixed model predicting the degree of Swiss Standard German accent. The estimates, standard error, and t-values of the speakers' age, respondents' dialect competence, and survey are specified.

Random effects:

	Name	Variance	S.D.
Speaker	(Intercept)	0.381	0.617
Respondent	(Intercept)	0.065	0.255
Residual		0.552	0.743

Fixed effects:

	Est.	S.E.	t-value
(Intercept)	2.152	0.219	9.833*
speakers' age young	0.439	0.212	2.071*
respondents' dialect competence	0.081	0.033	2.427*
survey	−0.414	0.218	−1.896

As shown in Table 3.9 the speakers' age is a good predictor for the level of accentedness: younger speakers are assigned higher scores, that is more NSG accent than older speakers (mean score young speakers 2.57 and older speakers 2.17, t = 2.071). An increase in the respondents' dialect competence also leads to higher scores (t = 2.427). This is an indication that respondents may also be biased and it is a factor that should be controlled for in follow-up studies. The ratings for accentedness was averaged for each speaker in the corpus data. These results are contained in Appendix A.

3.5 The halo effect

In this section, we will again conduct the categorical analysis, but now we include the accentedness ratings which were reported on in §3.4, and also the F1 and F2 measurements (§3.5.1). Note that, if the coders fully relied on F1 and F2, this would be the only significant factor. We will see that this is not the case;other factors turn out to be significant as well. We will investigate the degree to which the speakers rely on F1 and F2 and to the other factors by categorical inference tree analyses in §3.5.2.

3.5.1 The categorical analysis II, SSG accent included

Since we have now quantified the accentedness of the speakers, we are able to investigate whether this degree of accentedness is a factor that correlates with the coders' judgements of the realization of the long vowel <ä> as either [ɛː] or [eː]. Equally important, we will investigate to what extent the coders rely on F1 and F2. If the speakers relied only on F1 and F2, i.e. if they were perfectly unbiased, we would find only a significant effect of F1 and F2 and not of any other factors. In order to examine the effect of the speakers' accentedness as well as the effect of F1 and F2, I used a mixed-effects model with model comparison in which the codings were treated as the dependent variable and the interpolated vowel height (of F1 and F2) and the degree of accentedness as independent variables. All other factors were the same as in the previous analyses (speakers' age, speakers' gender, and speakers' location, tautosyllabicity of the consonant following long vowel <ä>, and further pre-r context and frequency). Random effects are speaker, lemma, and the order of tokens in each interview.

As shown in Table 3.10, the codings of C1 strongly related to the interpolated vowel ($z = -6.208$, $p < 0.001$). This means that C1 relies on F1 and F2 to a large extent. However, C1 appears to also rely on the level of accentedness ($z = -3.165$, $p = 0.002$). Other factors were not significant.

Table 3.10. Categorical analysis II of Coder 1. The optimal mixed model results in which the estimates, standard error, and t-values of F1 and F2, the speakers' accentedness, the speakers' gender, the speakers' age, and frequency are specified.

Random effects:

	Name	Variance	S.D.
Lemma	(Intercept)	0.135	0.368
Ntoken	(Intercept)	0.026	0.161
Recording	(Intercept)	0.999	0.999

Fixed effects:

	Est.	S.E.	z-value	p-value
(Intercept)	4.294	0.861	4.985	<0.001*
the interpolated vowel	−0.050	0.008	−6.208	<0.001*
speakers' accentedness	−0.383	0.121	−3.165	0.002*
speakers' gender-male	0.582	0.416	1.399	0.162
speakers' age-young	−0.719	0.451	−1.591	0.112
frequency'	0.366	0.194	1.883	0.060

The ratings of C2 are also strongly correlated to F1 and F2 ($z = -7.841$, $p < 0.001$), so C2 also relies on F1 and F2 to a large degree. The degree of accentedness does not play a role here, so it seems that C2 is not biased towards the degree of SSG/NSG accentedness. However, the speakers' location is significant for Biel/Bern ($z = -2.985$, $p = 0.003$), which shows a bias on the basis of the location of the speaker. So the coder guesses the location, most probably by dialectal influence on SSG, which leads to more [eː]-ratings. Further, speakers' gender is significant, such that males are transcribed as having more [eː] pronunciations ($z = -2.364$, $p = 0.018$). Speakers' age correlates with the number of [eː] ratings as well: younger speakers are rated as having more [ɛː] pronunciations than older speakers ($z = -2.736$, $p = 0.006$). So biases occur not only on the basis of accent but also on the basis of sociolinguistic factors.

Table 3.11. Categorical analysis II of Coder 2. The optimal mixed model results in which the estimates, standard error, and t-values of F1 and F2, the speakers' accentedness, the speakers' gender, the speakers' age, and frequency are specified.

Random effects:

	Name	Variance	S.D.
Lemma	(Intercept)	0.447	0.669
Ntoken	(Intercept)	<0.001	<0.001
Recording	(Intercept)	2.812	1.677

Fixed effects:

	Est.	S.E.	z-value	p-value
(Intercept)	12.606	1.738	7.254	<0.001*
the interpolated vowel	−0.104	0.013	−7.841	<0.001*
speakers' location-Biel/Bern	−3.726	1.248	−2.985	0.003*
speakers' location-Bludenz	−1.670	1.212	−1.378	0.168
speakers' location-Brig	−1.463	1.367	−1.070	0.284
speakers' location-Luzern/Willisau	−1.763	1.277	−1.381	0.167
speakers' location-Vaduz	−0.151	1.200	−0.126	0.900
speakers' location-Zurich	−1.864	1.309	−1.424	0.154
speakers' gender-male	−3.101	1.312	−2.364	0.018*
speakers' age-young	−3.185	1.164	−2.736	0.006*
speakers' gender:age	3.641	1.564	2.328	0.020*

We thus find that the two coders both rely on F1 and F2, but also on SSG/NSG accentedness, speakers' location, and other factors. Table 3.12 lists the significant factors. Note that in the ideal case, the acoustic analysis and the coders' analyses *without* accentedness should be exactly the same, but the coders' analyses *with* accentedness should have only the interpolated vowel as significant factor. Deviations from this ideal pattern are indicated by an exclamation mark.

Table 3.12. Summary of the results of the acoustic and categorical analyses. The factors F1 and F2, speakers' accentedness, speakers' age, speakers' gender, speakers' location, frequency, and pre-r context and their significance in the acoustic and the categorical analyses divided by accentedness.

Factor	*Acoustic*	*C1*		*C2*	
		without accentedness	with accentedness	without accentedness	with accentedness
the interpolated vowel	NA	NA	✓	NA	✓
speakers' accentedness	NA	NA	✓!	NA	✗
speakers' age	✓	✗!	✗	✓	✓!
speakers' gender	✗	✗	✗	✓!	✓!
speakers' location	✗	✓!	✗	✗	✓!
frequency	✗	✓!	✗	✗	✗
pre r-context	✓	✗	✗	✓	✗

3.5.2 *The halo effect in detail*

In order to see how much the coders rely on F1 and F2 and how much on other factors, I performed a conditional inference regression tree analysis. A classification tree shows significant binary splits in the dataset and thus provides insight into the relative importance of the factors, the correlation between the predictors, the number of items in all classifications, and the distribution of the vowel height within all classifications (Tagliamonte & Baayen 2010). The relative importance of the factors is shown by the ranking of the leaves: the higher in the tree, the more important the factor is. The interaction of the factors is shown by the path, or the branches of the tree. The number of items is shown in the bottom nodes. The distribution of the vowel height is shown by the box plots in the bottom nodes. As for Coder 1 (see Figure 3.2.), the main predictor is the interpolated vowel (highest node F1.F2) (cf. §2.4.2). If the interpolated vowel has a value ≤ 67.455, the significant predictors are speakers' accentedness and lemma frequency and if the interpolated vowel has a value > 67.455, speakers' age is the only relevant factor. If the interpolated vowel ≤ 67.455 and the speakers' accentedness is ≤ 2.9, which includes strong SSG accent, moderate SSG accent, and moderate NSG accent, then about 85% of the cases are coded as [ɛː] (in the bottom leaf node [3], which explains 289 cases). If the interpolated vowel ≤ 67.455 and the speakers' accentedness > 2.9, that is a strong NSG accent, lemma frequency comes into play. The nine most infrequent words (with lemma frequency ≤ 1.38) are all coded as [eː] (bottom leaf node [5]) and the more frequent words are coded for about 60% as [ɛː] (node [6], 87 cases). If the interpolated vowel > 67.455, and the speakers' age is young, nearly 40% is coded as [ɛː] (node [8], 96 cases) and if the speakers' age is old, more than 60% is coded as [ɛː] (node [9], 96 cases).

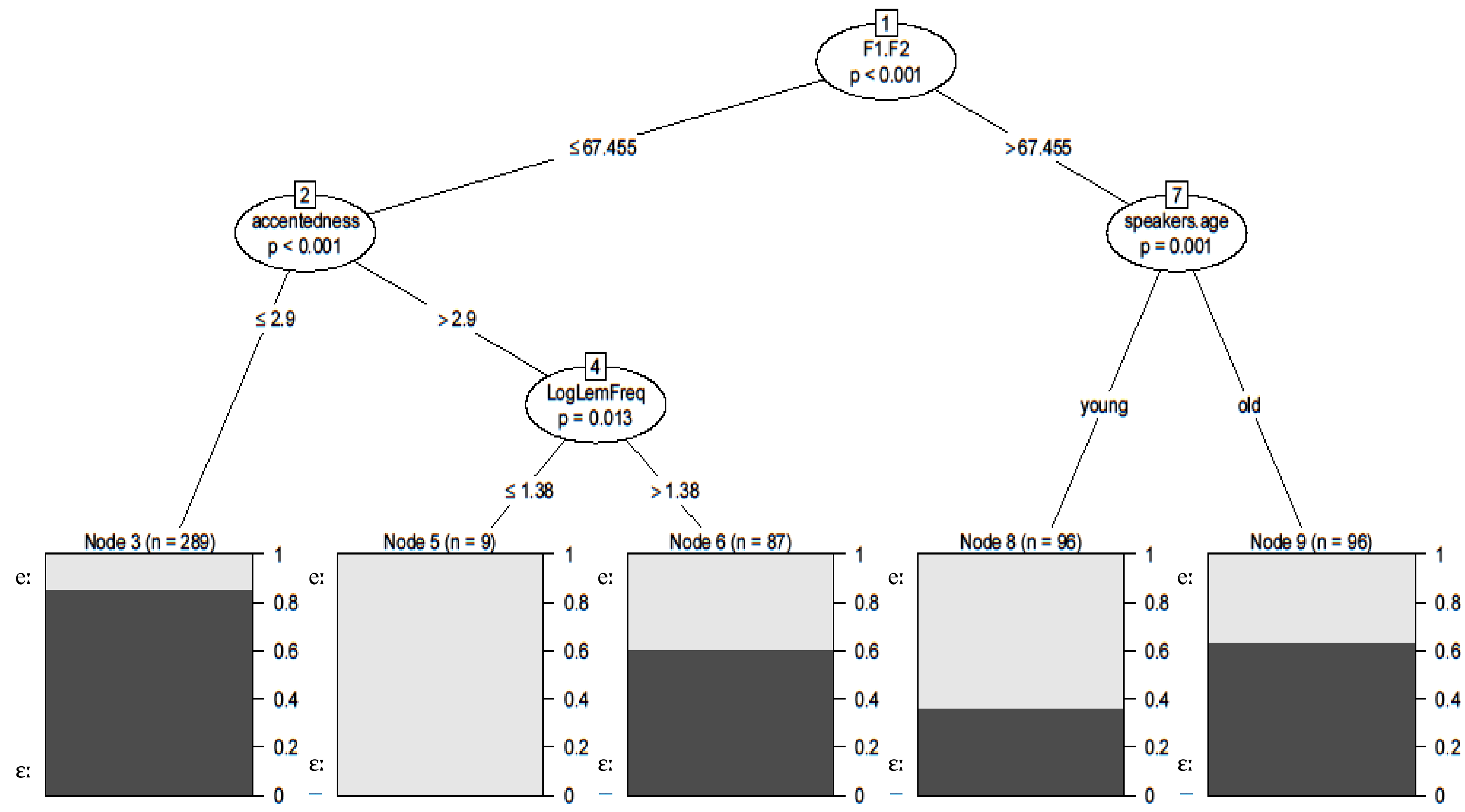

Figure 3.2. *Regression tree of the codings of Rater 1, with F1 and F2 as main predictor and accentedness, speakers' age, and frequency as other predictors for the codings of* [eː] *and* [ɛː]. *The darkened area shows the fraction of* [ɛː] *that the coders transcribed.*

So, C1 does rely on F1 and F2 to a great extent. However, a halo effect seems to exist in case of speakers with an overall strong NSG accent for vowels which are relatively low [node 5 and 6]: these vowels are less likely to be coded as [ɛ:] (0 and 60% respectively) than if they had been produced by speakers with a more SSG accent [node 3: 80% [ɛ:]. Further, although in the acoustic analysis we also found an effect of the speakers' age, we would not expect to find an age effect for the coders' data if we included F1 and F2 values: if coders relied only on the interpolated vowel , no effect of the speakers' age would appear in the analyses of the coders' data. The fact that we do find a speakers' age effect in the coders' analysis [node 7-9] suggests that the speakers' age effect is somewhat exaggerated by C1, that is, the codings show a larger effect than can be explained on the basis of F1 and F2 measurements.

Coder 2 shows a remarkably different picture (Figure 3.3). Again, the most important factor is the interpolated vowel . There are two cut-off points: 70.089 (under node [1]) and 64.068 (under node [2]). If the interpolated vowel $\leq$ 64.068, 90% is coded as [ɛ:] (bottom node [3]), which explains 343 cases. If 64.068 < the interpolated vowel $\leq$ 70.089, the younger speakers are most likely to be coded as pronouncing [ɛ:] (60% of 36 cases, node [5]). Older speakers are even more likely to be coded as pronouncing [ɛ:]: older speakers from Bludenz (Bd), Bern (Bn), and Zurich (Zr) are coded with [ɛ:] for 85% (node [7], only 8 cases) and older speakers from Basel (Bs), Brig (Br), Luzern (Lz), and Vaduz, are coded as pronouncing [ɛ:] for almost 100% (node [8], 33 cases). If the interpolated vowel > 70.089, and the speakers' location is either Bludenz, Bern, or Zurich, the number of [ɛ:] codings is relatively low (about 30% (node [10], 52 cases). Younger speakers in Basel (Bs) and Vaduz (Vd) are rated as pronouncing [ɛ:] for more than 60% (node [13], 40 cases), but younger speakers in Brig (Bg) and Luzern (Lz) are coded for only less than 20% as pronouncing [ɛ:] (node [14], 18 cases). This is very much in contrast with the older speakers who are coded as pronouncing [ɛ:] for 80% (node [15], 47 cases).

In sum, C2 relies for 343 out of 577 cases only on F1 and F2, which is 59%, and which forms a homogeneous class of the lower vowels. For the higher vowels, we find a speakers' age effect in which older speakers are more likely to be rated with the typical SSG [ɛ:] pronunciation. Regarding the speakers' locations, all things being equal, the vowels of the speakers from Bludenz, Bern, and Zurich are more likely to be rated as [e:] and vowels of the older speakers from Brig, Basel, Luzern, and Vaduz are more likely to be coded as [ɛ:]. This suggests a halo effect towards the speakers' location (which could easily be detected by the Swiss coder on the basis of perception and dialectal awareness).

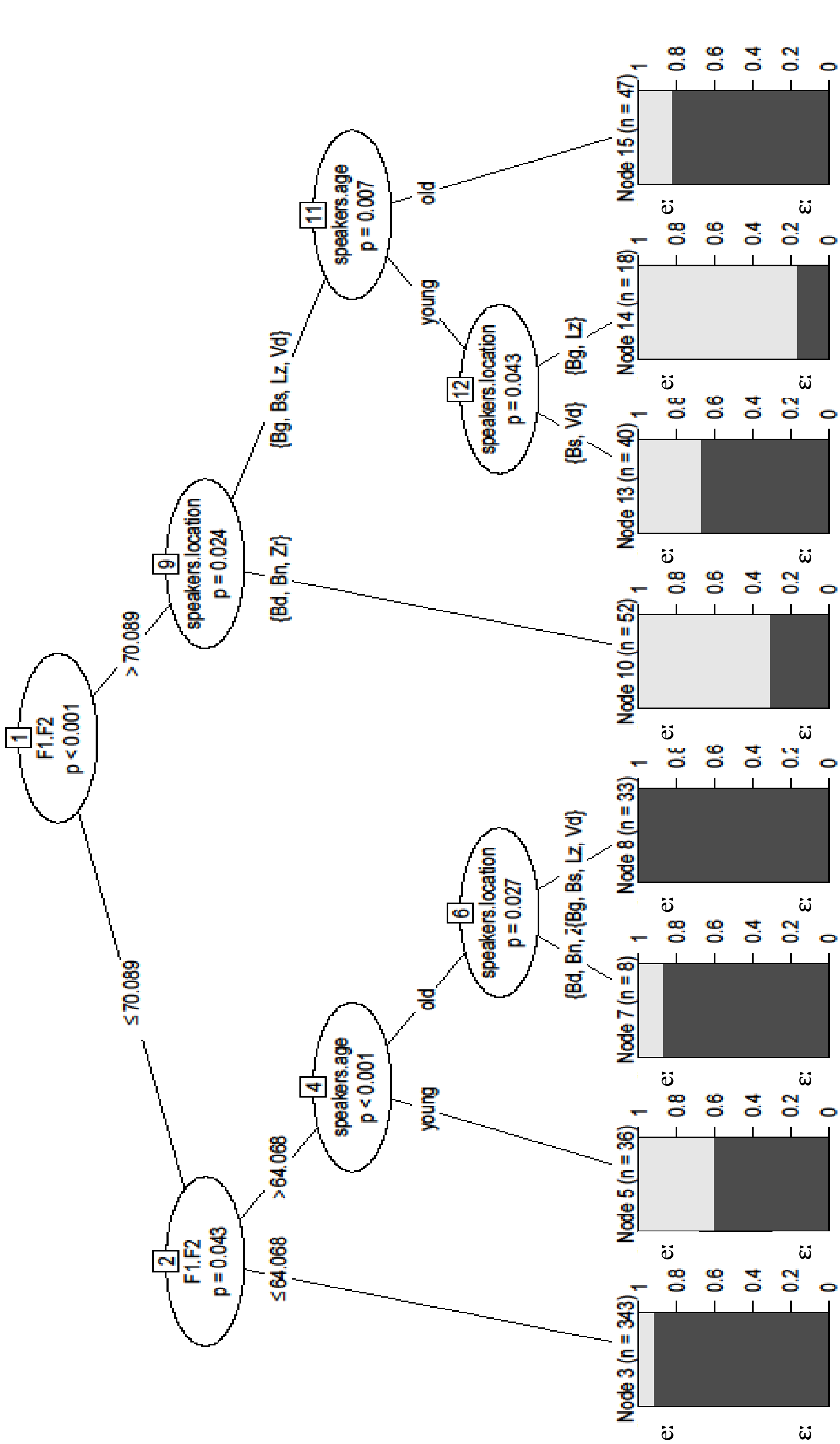

Figure 3.3. *Regression tree of the codings of Coder 2, with F1 and F2 as main predictor and accentedness, speakers' age, and speakers' location as other predictors for the codings of [eː] and [ɛː]. The darkened area shows the fraction of [ɛː] that the coders transcribed.*

In this section, we saw that the coders do rely on the interpolated vowel for a large part, but we detected halo effects for NSG accent (C1) and the speakers' location (C2). Further, the coders seem to assign more importance to the difference between younger and older speakers than is justified by the acoustic analysis.

3.6 Discussion and conclusion

The aim of this chapter was to decide whether coding the data by native speakers is reliable or not. Therefore, I compared the analysis on the basis of codings with an acoustic analysis. This resulted in three considerably different analyses. Subsequently, I investigated in more detail to what extent the coders relied on F1 and F2 and to what extent the coders relied on other factors, including Northern Standard German and Swiss Standard German accentedness. The results showed that although the most important cue for the codings was indeed F1 and F2, the speakers' accentedness (C1) or the speakers' location (C2) were also good predictors for the codings. Furthermore, the effect of speakers' age is perceived more strongly by the coders than is justified by the F1 and F2 measurements.

The results show that the coders do rely on the acoustic signal to a certain extent, but that in particular cases they don't. Since the variation is continuous and the coders were given the task to categorically code the data, one could argue that probably in cases in which the vowel quality is unclear, i.e. neither prototypical [eː] nor prototypical [ɛː], coders are led to rely on other factors. If this were the case, we still would expect the lowest vowels to be coded as [ɛː] and the highest vowels to be coded as [eː] (although with different cut-off points for different coders). This is only the case for the lowest vowels coded by C2. Instead, the coders appeared to be sensitive to the accentedness of the speakers, both on the small-scaled local level (different locations of the speakers) as well as the large-scaled contrast between Northern Standard German and Swiss Standard German. We saw that one coder showed a halo effect towards the overall NSG and SSG accentedness, whereas the other coder showed a halo effect towards the dialectal accent. The results point towards a coder bias, in line with recent findings in perception studies among non-linguists. In studies like (Drager (2011), Hay et al. (2006a, 2006b), Hay & Drager (2010), Hay & Drager (2010), Niedzielski (1999)), subjects were led to believe that the speech they had to code was of a particular dialectal or sociolinguistic variety by means of suggestive questions or national symbols. When presented with exactly the same or neutral data, the codings were also biased, corresponding to the subjects' belief regarding the variety in which the data were presented. Similarly, in Hall-Lew & Fix (2012), the ethnic identification of the coders in l-vocalization in English correlated with their codings of the degree of vocalization. These coders were not necessarily linguists (it was an internet-based study), but still the results correspond closely to the findings in this chapter. Whereas all these studies show a bias towards the accent which the subjects are led to believe they hear, there is a crucial difference with the present study, in which the subjects were not lay people, but linguistically trained coders.

So this chapter has shown that not only lay-people, but also linguistically trained coders may be susceptible to biases related to accentedness. Although to investigate the halo effect in linguistics requires more large-scale experiments with more coders, we have to realize that the method of having two or maximally three coders is very common in sociolinguistic and dialectological research and that the present study shows that this methodology is highly suspicious. Many studies in the past relied on this method. The results of the present study are especially inconvenient, since a very large part of these studies would become unreliable if coder bias would appear to be a wide-spread halo effect. Similarly, in second-language acquisition, speech therapy, and clinical linguistics, halo effects may be wide-spread—and unrecognized. It is therefore important for different fields in linguistics that the linguistic halo-effect is studied in more depth. Halo effects in linguistics should be better understood, which means that it is necessary to determine whether or when halo effects occur, to determine how contextual factors affect measures of observed halo effects, and to determine whether or to what extent halo errors are harmful (Murphy et al. 1993). A comparison between acoustic and coder analysis seems to be the safest method, but we cannot be entirely sure at this point that the acoustic measurement is completely sound; maybe we missed one or more acoustic features that are relied upon by the coders, such as F3, the transitions, the loudness, pitch, or any other unknown feature. In other words, it is still possible that coders perform better than the acoustic measurements in this study. Experimental investigation is needed to investigate coder bias under more controlled conditions. Another factor to investigate is the experience of the coders: does experience automatically lead to more accurate codings? How can the halo effect be avoided in linguistic research? This might involve reducing the rating time, increasing the familiarity between coder and subject, clear questionnaires which separate the effects of different factors, making the coders aware of the halo effect, and train them accordingly (see Sahoo et al. (2010)) and references cited there).

The main problem, of course, is the wrong analysis that results from coder bias. In the present study, we found that in the acoustic analysis pre-r context is the strongest predictor. As outlined in §2.1.2, the lowering effect of /r/ in Germanic languages is a well-known factor and, as we will see in each of the other chapters on the pronunciation of the long vowel <ä> in this thesis, pre-r context is a very robust and almost always the most important predictor. Crucially, this factor is entirely unimportant in the coders' analyses. This means that vowel lowering is not perceived before an /r/, in other words, the coders' perceptually compensate for pre-r vowel lowering. Comparison of the coders' and the acoustic analysis thus not only provides information about possible halo effects, but also to neutralization. This means that where long vowel <ä> is lowered before /r/, the coders do not perceive the lowering, so they report a higher value for the vowel. Neutralization of phonetic and phonological processes thus also seems to be a potential risk for methodologies which make use of native speakers' codings.

Although more research is surely needed to investigate coder bias in more detail, we saw in this chapter that the coders' analyses were not only different from the acoustic analysis, but also different from each other. Given also the fact that halo effects are very common as a psychological phenomenon, that halo effects have been found in earlier linguistic studies, that neutralization effects are possible, and that existing factors may be exaggerated in the coders' analyses (speaker age), I conclude that the method of native speaker transcription is not reliable enough for the investigation of the pronunciation of the long vowel <ä> in German. This is why the acoustic method was preferred in chapter 2 and why this method is also used in the remaining chapters on this topic.

Part II

Competition in Low-Frequency Words

Though I sweep and sweep

Everywhere my garden path

Though invisible

On the slim pine needles still

Specks of dirt may yet be found

Sen no Rikyu 1522-1591

Chapter 4

Rendaku love and hatred: opaque morphological structure[1]

Abstract

Some roots in Japanese compounds always undergo the rule of rendaku, others never undergo the rule, and still others vacillate. In this chapter, we investigate this kind of lexical variation from the perspective of the frequency of such roots. Different types of frequency are considered, such as that of roots in isolation (=token frequency), and the roots' frequency of occurrence as a left- or right-hand member of compounds (=family size and family frequency). We show that frequency matters for the status of roots in the rendaku process. The data in which these frequency effects occur, however, are relatively infrequent, and words with higher frequency undergo rendaku according to the phonological grammar. Very infrequent words thus seem to be exceptions to the rule. Since rendaku clearly involves phonological factors as well as frequency effects, we argue that this result should be interpreted in a model which integrates usage-based factors into phonology.

[1] A version of this chapter has been published as: van de Weijer et al (2013).

Generative and usage-based perspectives sometimes have to be combined in order to account for a particular linguistic pattern (see §1.3). This chapter discusses the Japanese rule of *rendaku* (lit. "sequential voicing") from this point of view. Rendaku voices the first segment of a compound if a number of conditions are satisfied. The history of this rule, as well as its (ir)regularity and the conditions on its application in present-day Japanese, have attracted a great deal of attention in the morphological and phonological literature. One aspect has been especially problematic for past analyses: even if all conditions on its application are taken into account, rendaku appears to have a considerable number of lexical exceptions. That is, some lexical items are more prone to undergo the rule than others, on a seemingly idiosyncratic basis. We will show that the propensity of these roots for rendaku can be related to the frequency with which these roots occur in isolation as well as in compounds. Apart from contributing to the solution of a long-standing puzzle in Japanese morphophonology, a general conclusion that can be drawn from this analysis is that the frequency with which words are used (both in compounds and in isolation), should be included in the explanation for their phonological behaviour. The frequency effect we observe in rendaku neither belongs to Type I frequency effects (analogy), nor Type II frequency effects (reduction), but should be regarded as a Type III frequency effect (opaque structure). Since rendaku is also governed by purely phonological constraints (such as Lyman's Law, see below), a satisfactory solution must combine aspects of theoretical linguistics and of usage-based approaches.

This chapter is organized as follows. in §4.1, we illustrate the basic mechanisms of rendaku and point out some of the relevant conditions on the application of the rule that have been uncovered so far in the literature. In §4.2, we introduce the lexical variation which forms the main topic of this chapter and formulate a number of hypotheses to explain this behaviour. Section 4.3 describes the methodology and the data set we investigated. Section 4.4 provides the statistical results of our investigation. Section 4.5 provides an analysis of the data in EPOT and §4.6 concludes.

4.1 Rendaku

The rule of sequential voicing in Japanese, normally referred to as *rendaku*, has been a topic of discussion in the Japanese and general literature for a very long time (see e.g. Haraguchi (2001), Irwin (2005), Irwin (2009), Itô & Mester (2003), Kubozono (2005), McCawley (1968), Otsu (1980), Rosen (2001), Vance (1987), Vance (2005), Vance (2007), Itô & Mester (1986) and references cited there, also to the extensive literature in Japanese). The basics of the rule are straightforward: the initial voiceless obstruent of a root becomes voiced when the root appears as the right-hand member of a compound (subject to a number of conditions, see below). Examples, taken from various standard sources, are given in (1):

(1) *Examples of rendaku*

k→g	shima	-	kuni	→	shima-guni
	'island'		'country'		'island country'
h→b	roten	-	huro	→	roten-buro
	'outdoor'		'bath'		'outdoor bath'
s→z	maki	-	sushi	→	maki-zushi
	'roll'		'sushi'		'rolled sushi'
t→d	isi	-	tooroo	→	isi-dooroo
	stone		lantern		'stone lantern'

Historically, there was a particle *no* (possessive) between the two compounds, which was reduced and caused the voicing. There are two things to note: the voiced counterpart of /s/ is [dz] (conventionally transcribed as z), and the voiced counterpart of /h/ is [b] (the source for this latter alternation is historical: /h/ derives historically from /p/) (see Frellesvig (2010: Ch.2), Vance (1987: Ch.10), many of the contributions to van de Weijer et al. (2005) and references cited there, for discussion of the history of this phenomenon and other relevant information).

There are a number of conditions on the application of rendaku, some of which are regular and well-known, and some of which are the object of debate. First, rendaku is almost exceptionlessly blocked if there is a voiced obstruent in the second part of the compound itself. This condition on the application of rendaku, which is illustrated in (2), is usually referred to as Lyman's Law (Lyman (1894) and see Vance (1987: 136ff.) and many other sources for discussion).

(2) *Lyman's Law: Rendaku is blocked if it would create two voiced obstruents in one root.*

kami	-	ka**z**e	→	kami-ka**z**e	'kamikaze'
'divine'		'wind'		(kami-*gaze)	

There is also an exception to this generalization, viz. the single lexical item in (3), in which the [g] in the second member does not block voicing of [h] to [b].

(3) *Rendaku is, unexpectedly, not blocked* (Vance 1987: 137).

nawa	-	hasi**g**o	→	nawa-basi**g**o	'rope ladder'
'rope'		'ladder'			

Second, rendaku applies almost exclusively to native Japanese words, and less often to words borrowed from Chinese (which are referred to as Sino-Japanese) or other languages (i.e. older or more recent loanwords). In fact, Martin (1952) claimed that the process is frequent only in native Japanese words, but research since then has shown that there is a considerable number of examples involving Sino-Japanese words, older loanwords (e.g. from Portuguese), and even some more recent loanwords that undergo rendaku (see Takayama (2005), Irwin (2011: 151f)). This suggests that rendaku is a productive rule. See Vance (1987: 140-141) for examples and discussion, also of the extent to which rendaku applies in mimetics (reduplicated vocabulary) and in other parts of the morphology such as derivation and inflection. In this chapter we will focus on the status of rendaku in native Japanese compounding.

Apart from Lyman's Law and the restriction to loanwords, other conditions on the application of rendaku that have been discussed are related to prosodic size (see e.g. Irwin (2009), vowel length (Horton & Minami 2011), syntactic branching in longer compounds (Otsu (1980), Kubozono (2005)), semantic inclusion/exclusion relationships (Shibatani 1990: 174), and the location of accent (see e.g. Zamma (2005), Ohta (2013), Yamaguchi & Tanaka (2013)). Some of these conditions are (almost) exceptionless (such as Lyman's Law), and others represent tendencies that may block rendaku in a certain percentage of cases, i.e. they are variable. It is also possible that other categories influence the application of rendaku, such as the initial consonant or the initial mora of the root that undergoes the rule: some consonants or moras might be more susceptible for rendaku than others, e.g. because an alternation between [h] and [b] might be less transparent than an alternation between [t] and [d]. Second, the number of syllables of the left-hand side of the compound might matter, or whether the left-hand side of the compound contains a voiced consonant or not (cf. the "extended Lyman's Law", see e.g. Vance (2007). There is isolated discussion of these topics in the literature cited above.

In our investigation, we will focus on disyllabic words where rendaku would be expected, i.e. words in which Lyman's Law is not relevant. We will only take into consideration compounds consisting of two roots, to abstract away from phrasal effects. Similarly, we exclude words with long vowels (Horton & Minami 2011), to avoid any interference of vowel length. Finally, we will not consider semantic aspects of compounds that do or do not undergo rendaku. The properties that were taken into consideration will be spelled out in detail below (§4.3).

First, however, we need to discuss the fact that, even if all of the constraints on rendaku outlined above are taken into account, some lexical items do and other lexical items do not undergo the rule, in a seemingly unpredictable fashion.

4.2 Lexical variation

Individual roots behave differently with respect to rendaku in Japanese. That is, some roots that would at first glance be expected to undergo rendaku do not undergo the process at all, or they show rendaku in some compounds but not in others. Vance (1987: 146) refers to this situation as the "fundamental irregularity" of rendaku, and Miller (1967: 195) describes the (non-)application of the rule as "completely bewildering" (see also Ohno (2000), Rosen (2001)). Vance (1987: 147) gives a number of words that, unexpectedly, resist rendaku, which are reproduced in (4):

(4) *Exceptions to rendaku "never"*

a.	soko bottom	-	tuti soil	sokotuti 'subsoil'	(*soko-duti)
b.	kutu shoe	-	himo lace	kutuhimo 'shoelace'	(*kutu-bimo)
c.	suna sand	-	kemuri cloud	sunakemuri 'sand cloud'	(*suna-gemuri)
d.	yubi finger	-	saki tip	yubisaki 'fingertip'	(*yubi-zaki)
e.	asa morning	-	sio tide	asasio 'morning tide'	(*asa-zio)

Note that conditions like Lyman's Law play no role in these forms, since the right-hand members have no voiced segments and all involve native Japanese roots. Thus, they are phonologically fully comparable to the examples in (1). In other words, the fact that they form exceptions to rendaku cannot be attributed to any of the known conditions on rendaku. The question is therefore how these forms should be dealt with: have we missed a condition that is relevant? Are they exceptions that must somehow be marked in the lexicon? Or is the exceptional status of these words due to factors outside the grammar? If rendaku is a productive rule in Japanese, and if no conditions can be found that explain the "exceptions" in (4), then such compounds must be marked as lexical exceptions.

The question whether rendaku is a productive rule or not in contemporary Japanese is relevant here. The issue is discussed in detail by Kubozono (2005). After a consideration of the evidence, partly on the basis of experiments with Specific Language Impairment-speakers (Fukuda & Fukuda 2000), he concludes that rendaku voicing is a productive rule in Japanese, although some cases of voicing (and, presumably, cases where voicing does not take place) may be lexicalized (see also Itô & Mester (2003: 124)). Hence, the question how the non-application of rendaku in forms such as those in (3) should be accounted for is an important one.

Rosen (2001: Appendix D) lists 19 further examples of roots like those in (3) which he characterizes as "never" undergoing rendaku, besides roots which always undergo rendaku ("rendaku-lovers"). He also distinguishes one other category: roots that vacillate between the two options ("rendaku-haters") (citing p.c. from Haruo Kubozono who used similar terms). He also draws attention to the lexical nature of the distinction, i.e. whether a word is a "lover" or a "hater" is unpredictable from any of the (known) conditions on rendaku.

Rosen provides 113 examples of "rendaku-lovers", i.e. words that always or almost always undergo the rule. The relatively large number of "lovers" also suggests that rendaku should be considered a productive rule in Japanese. Examples of rendaku "lovers" are given in (5):

(5) *"Rendaku lovers"*

huro	'bath'	e.g.	uti-buro	'inside bath'
			soto-buro	'outside bath'
			mizu-buro	'water-bath'
kiwa	'brink'	e.g.	yama-giwa	'mountain brink'
			hae-giwa	'receding hairline'
			te-giwa	'skill' [hand brink]
sake	'sake'	e.g.	nama-zake	'raw sake'
			taru-zake	'barrel sake'
			sio-zake	'salt salmon'

(from Rosen (2001: Appendix E))

Both Vance and Rosen note that a number of words vary in their status, i.e. they show rendaku in some compounds but not in others. Rosen refers to such roots as "haters", but we propose to refer to them as "doubters". Vance provides the example in (6a), and Rosen (2001: Appendix F) lists examples of compounds with four of such "doubter" roots, such as those in (6b):

(6) *"Rendaku doubters"*

a. ki	'tree'	cf.	niwa - ki	'garden tree'
		vs.	yama - gi	'mountain tree'
b. hara	'field'	cf.	sino - hara	'bamboo field'
			sasa - hara	'bamboo grass field'
		vs.	una - bara	'ocean field'
			kuwa - bara	'mulberry field'
kusa	'grass'	cf.	ira - kusa	'nettle' [thorn grass]
			natu - kusa	'summer grass'
		vs.	hituzi - gusa	'sheep grass'
			no - gusa	'wild grass'

At first sight, it seems impossible to predict in which category a root might fall, i.e. whether a given compound shows rendaku or not (recall the quotes from Vance and Miller above). However, we suspect that if the notion of frequency is taken into account, it is possible to predict whether roots belong in the category of "never" (4), "lovers" (5), or "doubters" (6), see also our considerations below (8).

We need to define exactly what types of frequency might be relevant in this respect. First, however, it is necessary to take into consideration that in rendaku, a root typically has two allomorphs, one of which is the 'basic' (non-rendaku) form and the other is the rendaku form. These terms are illustrated in (7) (cf. the examples in (5) above):

(7) root: /huro/ 'bath'

allomorphs: [furo] *non-rendaku form*

(i) in isolation
(ii) as left-hand member in compounds

[buro] *rendaku form*

(i) as right-hand member in rendaku compounds

Below, we will investigate whether the frequency of occurrence of both allomorphs of a root is responsible for the variation in rendaku. Consider a root which appears extremely frequently in its *non*-rendaku form (i.e. in isolation or on the left side in compounds) but almost never in its rendaku form. The non-rendaku allomorph will be more strongly represented in the mental lexicon ("entrenched" in Exemplar Theoretical terms) and it is thus possible that it is more likely to impose its shape on the rendaku allomorph (the effect might be compared to a "majority rule" or "paradigm uniformity" effect (see e.g. Kenstowicz (2005)). This would make such roots "rendaku-haters". If roots appear in their rendaku form relatively frequently, we may expect the rendaku allomorph to be sufficiently well-entrenched in order to surface when the phonological conditions for rendaku are satisfied. This would make the root a "rendaku lover". The rendaku forms and non-rendaku forms may also surface in a "reasonable" frequency proportion (where what is "reasonable" should of course be determined on the basis of a statistical investigation). This would make such roots "rendaku doubters".

What types of frequency are relevant here? We will now discuss the probable influence of the frequency of the root in isolation, family frequency of the root as a left-hand member of the compound, family size of the root as a left-hand member of the compound, family frequency of the root as a right-hand member of the compound, family size of the root as a right-hand member of the compound. First, the frequency of a root in isolation can be measured as the number of tokens in a given corpus, and can be determined rather straightforwardly. The number of compounds with a particular root as its left- or right-hand member could be counted in two ways, viz. either as *family frequency* or as *family size*. *Family frequency* refers to the summed token frequencies of compounds in which a particular root appears (regardless of how many different compounds the root appears in). *Family size*, on the other hand, refers to the *number* of compounds formed with a particular root, i.e. it is a type frequency variable. We suppose that a large number of compounds with a particular root in the left-hand side of a compound (regardless of their token frequency) may impose the shape of that root on the right-hand side of a compound (again, following the same rationale as for the previous hypothesis). The literature shows that this “family size” aspect may have an effect on (processing of) morphological structure (e.g. de Jong et al. (2000)). We hypothesize that both larger family size as well as higher family frequency of a root as the *left*-hand member of a compound (i.e. in its non-rendaku form) correlate with avoidance of rendaku (“hatred”). Conversely, we expect that both higher family size as well as higher family frequency of a root as the *right*-hand member of a compound (in its rendaku form) correlate with likelihood of rendaku occurring (“love”). Note, finally, that family size and family frequency are logically independent types of frequency: both, either, or none could be found to play a role in rendaku.

So, three types of frequency are hypothesized to interact with the propensity for rendaku in the sense that higher frequency scores are expected to block or reduce rendaku. In (8), we summarize the relevant hypotheses related to rendaku “hatred”, together with the types of frequency on which they are based.

(8) *Hypothesis 1*

The frequency of a root in isolation is negatively correlated with its propensity for rendaku.

Hypothesis 2

The family size of the root as the left-hand member in compounds is negatively correlated with its propensity for rendaku.

Hypothesis 3

The family frequency of a root as the left-hand member in compounds is negatively correlated with its propensity for rendaku.

On the other hand, two types of frequency are hypothesized to interact with rendaku in the sense that higher frequencies are expected to enhance rendaku (“love”).

(9) *Hypothesis 4*

The family size of the root as the right-hand member in compounds is positively correlated with its propensity for rendaku.

Hypothesis 5

The family frequency of the root as the right-hand member in compounds is positively correlated with its propensity for rendaku.

Apart from word frequency, we also took into account three other factors which might play a role but about which we had no strong *a priori* expectations: mora frequency, the number of syllables at the left-hand side of the compound, the occurrence of another voiced obstruent in the left-hand side member of the compound. First, we suspect that the frequency of the different initial moras involved in rendaku, e.g. [fu] and [bu] in *huro* and *buro*, respectively, have an influence on the propensity of rendaku. Perhaps some moras are favoured (i.e., more frequent) than others in Japanese and therefore preferred (cf. Pierrehumbert (2006: 526)). With respect to this factor, other considerations could also come into play, e.g. the preference for a voiced allophone in intervocalic position or the general preference for voiceless obstruents over voiced ones. The second factor was the number of syllables on the left-hand side of the compound: is rendaku more likely to occur after shorter or longer roots? Thirdly, we included in the database whether another voiced obstruent was contained in the left-hand member of the compound (cf. extended Lyman's Law, see above). These three factors were treated as random variables, we will return to them in §4.4. In the next section, we will describe the methodology which we used to test the hypotheses in (8) and (9).

4.3 Methodology

To investigate the relevance of frequency for the lexical variation in rendaku, we selected a number of roots based on the appendices in Rosen (2001) (§4.3.1). Subsequently, we constructed a database of around 2,700 compounds in which these roots appear as either a left-hand member or a right-hand member (§4.3.2). Finally, we added frequency information of the roots in isolation and their frequency and family size as a left-hand side member and righ-hand side member of the compounds to each compound (§4.3.3).

4.3.1 Selection of the roots

Appendices D-F in Rosen (2001) form the starting-point of our investigation. These appendices contain 113 "*lovers*" (which (almost) always undergo rendaku), 19 "*haters*" (which (almost) never undergo rendaku – Rosen refers to these as the "never" category), and 4 "*doubters*" (which show variation, and which Rosen refers to as the "hater" category). Since our investigation focuses on the latter two categories, we intended to include all compounds with the roots that are marked as "haters" or "doubters" in Rosen (2001). However, we were forced to leave out two of the 19 "haters" (viz. *kera* 'mole cricket' and *kasa* 'shade'), because there were no compounds with these roots in the database created by Ogawa et al. (2005), which was consulted in the second phase of the construction of our database (see the next section). The final sets of 17 "haters" and four "doubters" are given in (10a) and (10b), respectively:

(10) a. *Rendaku "haters" (roots that almost never undergo rendaku) in the database*

1. sio	'tide'	10. himo	'string'
2. kata	'shoulder'	11. kami	'above'
3. hime	'princess'	12. take	'mushroom'
4. take	'measure'	13. siro	materials'
5. kuso	'dung'	14. kasu	'dregs'
6. suso	'cliff'	15. koi	'love'
7. saki	'tip'	16. tuti	'earth'
8. kase	'shackles'	17. tuyu	'dew'
9. tami	'people'		

b. *Rendaku doubters (roots that show rendaku variation)*

1. hara	'field'	3. kusa	'grass'
2. kawa	'skin'	4. kuse	'habit'

The large number of rendaku "lovers" in Rosen (2001) made it necessary to make a selection of "lovers" that satisfied a number of conditions relevant for our purposes. A number of these conditions are connected to the segmental and prosodic composition of these roots. In order to control for any influence of the segmental material of the first mora of these roots (see §4.2), we tried to include the same number (viz. 2) of roots for each initial consonant-vowel combination. Given the fact that there are four consonants that may undergo rendaku (/t s k h/), and a total of five vowels in Japanese, our ideal set of "lovers" consisted of 2 × 4 × 5 = 40 roots. Unfortunately, some CV-combinations are not included in Rosen (2001) appendix (e.g. roots starting with /ti/), or represented by only one item (e.g. roots starting with /hi/). Therefore, seven forms in our "lovers" database were randomly selected from the remaining "lovers", without paying attention to the initial consonant. This resulted in the following set of "lovers":

Table 4.1. *Forty rendaku "lovers" in the database, systematically varied for the consonant and the vowel of the first mora.*

	/t/	/s/	/k/	/h/
/i/	--	sima 'stripe' siri 'buttocks' siru 'soup'	kimo 'kidney' kiri 'mist'	hire 'fin'
/e/	tera 'temple'	semi 'locust'	keta 'beam'	hera 'spatula' heri 'rim'
/a/	tama 'ball' tana 'shelf' tane 'seed'	sake 'alc. drink' sato 'village'	kai 'shell' kami 'paper'	hai 'ash' hako 'box' hato 'pigeon' hana 'flower' hana 'nose'
/o/	toki 'time' tori 'bird'	soko 'bottom' sono 'garden' sora 'sky'	koke 'moss' kosi 'hips'	hone 'bone' hosi 'star'
/u/	tuna 'rope' tuti 'hammer' tutu 'pipe'	sumi 'ink'	kuma 'bear' kutu 'shoes'	hue 'flute' huta 'lid'

To check whether the frequency of the initial mora might have an effect on rendaku variation, we included corpus-based frequency information for every mora, provided by Tamaoka & Makioka (2004).

In all, our database therefore consisted of 61 roots in total (17 "haters", 4 "doubters", and 40 "lovers"). Having established the set of roots which we investigated, let us now turn to the compounds in which these roots appear.

4.3.2 Selection of the compounds

As a second step, we collected as many compounds as possible in which the roots in our database actually occur and that were relevant for our investigation. For this, we used the Ogawa et al. (2005) database, which contains all 78,426 two-kanji words extracted from the fourth edition of the Kōjien dictionary (Kōjien 1991). All characters in these compounds belong to the set of 2,965 standard characters (Japanese Industrial Standard Level 1). By restricting the investigation to two-kanji roots, we obtained only compounds of two members, thus avoiding any effect of branching in longer compounds (see §2). In order to control for the other factors which might influence variation (see again §2), we excluded all compounds with a Sino-Japanese morpheme as the left member. Similarly, all compounds with left-hand members containing a long vowel were excluded. Compounds ending in the moraic nasal /N/

were discarded as well, since post-nasal voicing makes it impossible to determine whether voicing of an initial consonant on the right-hand side is due to rendaku or not.

This resulted in a data set of 2,702 compounds in which the 61 roots appear. In the next section, we explain how we collected frequency information on these roots and compounds.

4.3.3 Frequency

We included the following compound-dependent frequency types in the database (cf. the hypotheses in (8) and (9) above).

(11) a. Token frequency of the roots under investigation in isolation.

b. Token frequency of each compound.

c. Family size left: The number of different compounds in which a particular root appears as the left-hand member.

d. Family frequency left: The sum of all token frequencies of all compounds in which a particular root appears as the left-hand member.

e. Family size right: The number of different compounds in which a particular root appears as the right-hand member.

f. Family frequency right: The sum of all token frequencies of all compounds in which a particular root appears as the right-hand member.

All token frequencies of roots and compounds were computed on the basis of the Chunagon database of the Balanced Corpus of Contemporary Written Japanese (BCCWJ 2011). We used the online version of the database, which is based on a corpus of written Japanese containing texts written between 1971 and 2008, taken from all kinds of genres: newspapers, magazines, textbooks, poetry, PR brochures, legal texts, recordings of meetings of the Japanese Diet, and the internet (such as blogs). This online version contains ten million words. All possible different spellings (if applicable) were included in the frequency count. The frequencies of compounds in the database ranged from 0 (e.g. *imogai* 'cone shell') to 7,147 (*tegami* 'letter'). It should be noted that, since the database is ultimately based on a general dictionary, it contains many infrequent words.[2]

All frequency counts were log-transformed, since frequency is processed in memory in logarithmic values rather than absolute values (Shapiro 1969). The different log-transformed frequencies vary as follows:

[2] For many words in the corpus, the token frequency is zero. In the log transformation, the value was also set on zero.

(12)	Root in isolation	< 5.2
	Compounds	< 3.9
	Family Frequency Right	< 3.9
	Family Frequency Left	< 3.9
	Family Size Right	< 2.1
	Family Size Left	< 1.8

These figures mean that the frequency range of roots in isolation was largest and the frequency range for Family Size Left was smallest.

4.4 Results

We performed a logistic regression test (R Development Core Team (2009), Baayen (2008)) with the different frequency factors as variables (i.e. root frequency in isolation, family frequency and family size of the root as a left-hand side member and as a right-hand side member of the compound). We also checked the random variables of initial mora and its frequency, the number of syllables on the left-hand side of the compound, and the presence of another voiced segment in the left-hand member of the compound (see §4.2). The frequency of the root in isolation was positively correlated with the propensity of the root for undergoing rendaku ($z = 6.499$, $p < 0.001$). Similarly, the family size of the root as a left-hand side member was positively correlated with the likelihood of the root for undergoing rendaku ($z = 4.884$, $p < 0.001$). On the other hand, the family frequency of the root as a left-hand side member was *negatively* correlated with the probability of the root for undergoing rendaku ($z = -10.17$, $p < 0.001$). Mora frequency was negatively correlated with rendaku, that is, the higher the mora frequency, the less likely it is to undergo rendaku ($z = -4.549$, $p < 0.001$). Finally, the number of syllables on the left-hand side of the compound turned out to be significant ($z = -6.096$, $p < 0.001$). The results are summarized in Table 4.2.

Table 4.2. Results of rendaku: the optimal logistic regression results, showing the estimates, S.E, z-value, and p-value for the log frequency of the root in isolation, the log family size and the family frequency of the root as a left-hand side member of the compound, the frequency of the initial mora of the root, and the number of syllables at the left-hand side of the compound.

	Est.	S.E.	z-value	p-value
(Intercept)	−2.609	0.456	−2.029	0.043
Log Frequency Isolation	0.816	0.128	6.499	<0.001*
Log Family Size Left	0.909	0.184	4.884	<0.001*
Family Frequency Left*1000	−0.481	0.047	−10.17	<0.001*
Frequency Mora*1000	−0.004	−0.001	−4.549	<0.001*
Number of syllables	0.179	0.105	−6.096	<0.001*

Let us consider some concrete examples. Table 4.2 shows that roots with a low frequency in isolation, such as *siro* 'materials' (log frequency in isolation 0.8), are unlikely to undergo rendaku and roots with a higher frequency in isolation, such as *toki* 'time' (log frequency in isolation 5.2) are more likely to undergo rendaku. For example, in our database, *siro* undergoes rendaku in 2 out of 55 cases (3.6%) and *toki* undergoes rendaku in 51 out of 58 cases (75.9%). Further, although rendaku is concerned with nouns on the right-hand side of compounds, the results show that we should also take into account the occurrence of such roots when they appear on the *left-hand* side of compounds if we wish to understand the behaviour of "lovers", "haters", and "doubters" in rendaku. Family size of the root as a left-hand side member of roots positively correlates with rendaku. When we compare *kuse* 'habit' with *tama* 'ball', both have a log frequency in isolation of 3.6, we find that *kuse* (log family size left 0.5), undergoes rendaku in 7 out of 19 cases (36.8%), whereas *tama* (log family size left 1.8) undergoes rendaku in 40 out of 52 cases (76.9%).

We hypothesized that the frequency of the root on the left side of the compound has a negative effect on rendaku. This hypothesis is born out. In an Exemplar Theory approach, this makes sense, because this non-rendaku allomorph (with a voiceless consonant) will have a mental representation that is relatively strong compared to the rendaku form (with a voiced consonant). However, the other hypotheses initially spelt out in (8) and (9) are not confirmed. First, we did not find any effect of the frequency of the root as a right-hand member of the compound (either in terms of family size or of family frequency). Moreover, our hypotheses about the negative effect of the root in isolation and family size at the left side of the compound, which would lead to less rendaku in right-hand position, are even disconfirmed. Unexpectedly, higher root frequency leads to more rendaku and likewise larger family size of the root as a left-hand side member also leads to more rendaku. Note, besides, that the frequencies in our database are relatively low (log frequency <5.2 out of a corpus of 10 million words, see (12)), which indicates that the variation in rendaku occurs exactly in very infrequent words. In the following section, we will try to interprete and model the results in EPOT.

4.5 Rendaku analysis in EPOT

We saw that rendaku voices the first consonant of the second part of a compound—which can be characterized as a phonological rule. This process can be captured either by a (number of) (morpho-)phonological rules or as a result of constraint interaction (see, among others, Itô & Mester (2003)). That is, the process is partly subject to purely phonological conditions, some of which are near-categorical (e.g. Lyman's Law, see (2)). The variation to which rendaku is subject should, however, not be ignored. In order to explain this kind of lexical variation, i.e. whether Japanese roots behave as "rendaku-lovers" or "rendaku-haters", we found that frequency of use and morphological family size are relevant. This holds especially true for cases in which rendaku fails to apply. In other words, in order to provide a full account for rendaku we need to make reference to phonological rules, i.e. grammar, as well as to frequency. Thus, *both* the frequency of particular items *and* phonological rules (or constraints) play a role in the application (or non-application) of this process.

We should emphasize that variation occurs only in a small subset of the Japanese lexicon— it affects mostly roots that occur in infrequent compounds. In frequency studies, it is well known that high-frequency word often behave in an idiosyncratic way, due to an extremely strong mental representation, which prevents (analogical) change throughout time (Bybee 2002). However, our results show that low-frequency words may also behave differently. Noticeably, this frequency effect does not resemble the two well-known frequency effects mentioned in §1.4: rendaku does not involve reduction of the roots, so it cannot show a Type II frequency effect (reduction, which affects HF words first); nor can the results be attributed to a Type I frequency effect of analogical change which affect LF words first (see the introduction in chapter 1). The frequency effect we found in rendaku differs and we call this Type III frequency effect (opaque structure). In the following chapter, we will consider another case in which low-frequency words are exceptional with regard to a particular pattern of change: lowering of long <ä> in German.

Since we observed a phonological rule as well as usage-based effects, rendaku forms a good test-case for EPOT. The tasks of EPOT are (1) to account for the frequency effects, (2) to decide on the input, and (3) to account for the grammatical rule. Let us first consider the frequency effects, which are modelled in the lexical component of EPOT. Since frequency effects occur especially in LF words (and words with higher frequency undergo the rendaku rule), we tentatively suggest that the morphological status of compounds with roots that are extremely infrequent may be unclear for some speakers. In order to recognize morphological patterns and regularities, a reasonable number of similar words must be stored in the lexicon. Some of the words in our database might not be recognized as compounds and therefore it might be unclear whether rendaku should be applied or not. Suppose a compound with extremely low frequency and a small family size at the left side of the compound is perceived; the listener may not realize that this is a compound and will store it as a monomorphemic word. Without the morpheme boundary being recognized, (almost) no connections with the morphemes in other compounds in the lexicon will be made. For instance, a typical "hater" like *tumisiro* 'atonement' (low log frequency in isolation 0.8 and low log family size 0.6) may not be treated as a compound by the language system, hence it does not undergo the rule of rendaku. Also, the log family frequency left is moderate (2.7), which will lead to lexical competition between the different exemplars and give the voiceless variant a relatively strong representation. A typical case of a "doubter" is *kusa* 'grass' (which has a moderate frequency of the root in isolation 3.5, a moderate family frequency left frequency 2.1, as well as a moderate family size left frequency 2.7). Depending on the outcome of the lexical competition between the different forms, sometimes, the root in the "doubter" will be recognized as such and sometimes it will not be recognized as such. Therefore such a compounds vacillates. Usually, however, roots occur frequently enough to be recognized as such in compounds, and so they will appear as "lovers".

So, we assume that the root frequencies correlate with the probability that a root can be recognized as a separate morpheme. If enough exemplars in the lexicon of a root in isolation or of the root as a left hand member of the compound ocuur, the compound will be recognized as a morphological complex word. If not enough of such exemplars are present in the lexicon, the compound will be stored as an exemplar of a monomorphemic root, without connections to exemplars of roots. In other words, as for the structure of the lexicon, we suppose that whether a compound undergoes rendaku or not crucially depends on the strength of the connections between exemplars. HF roots have strong connections and will be easily recognized as a separate morpheme within a compound. LF roots, on the other hand, have looser connections (some connections on the basis of similar forms will always exist). The exemplar storage is illustrated in Figure 4.1a for the LF root *siro* substitution' and in Figure 4.1b for the root *hue* 'flute'. The illustrations are simplified for reasons of clearity. Numerous other connections exist, such as the connections between all words in the figures and the connections with roots on the left-hand side of the compounds.

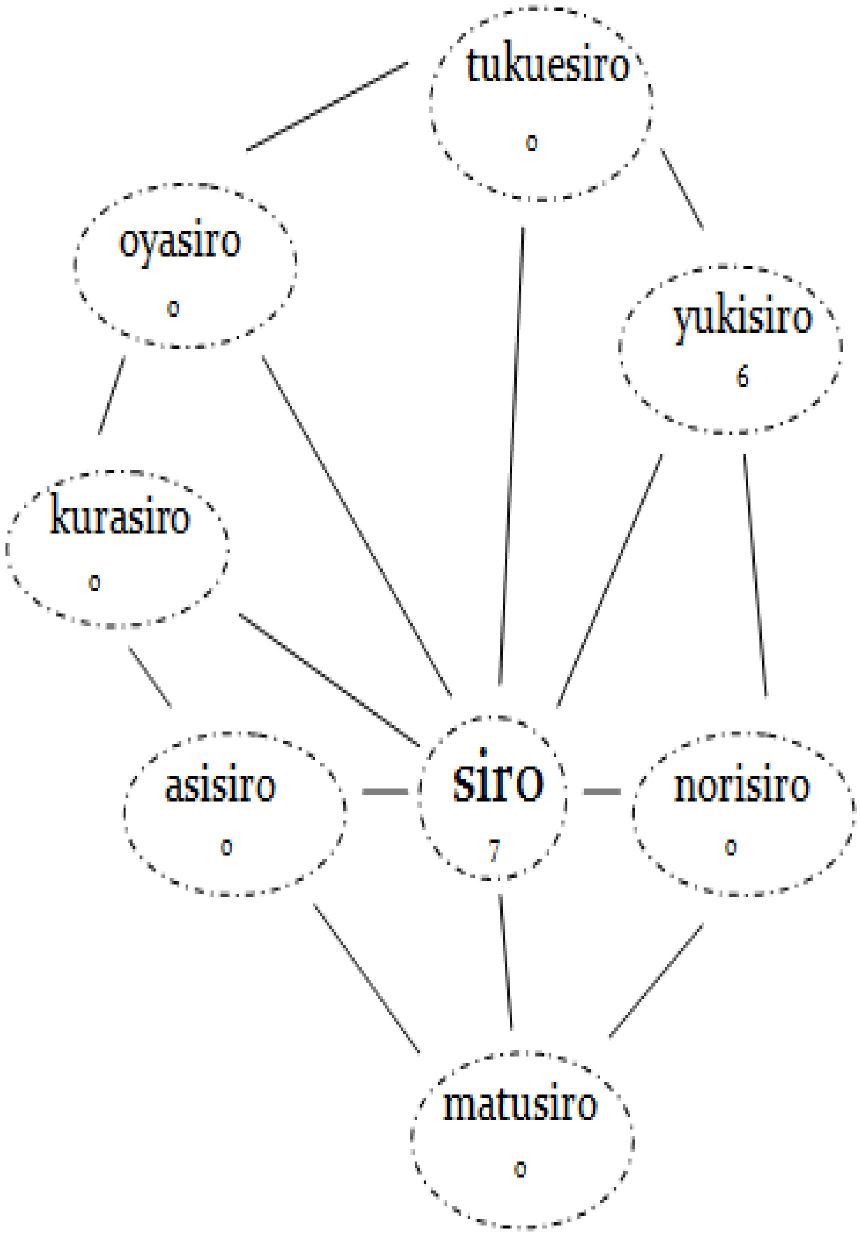

Figure 4.1a. *Exemplars and connections of the LF root 'siro' and compounds with 'siro'. The relative strength of the exemplar categories is indicated by the size of the letters and the relative strength of the exemplar connections is indicated by the width of the lines. The frequency of the words is given in the exemplar clouds. The connections are all very loose.*

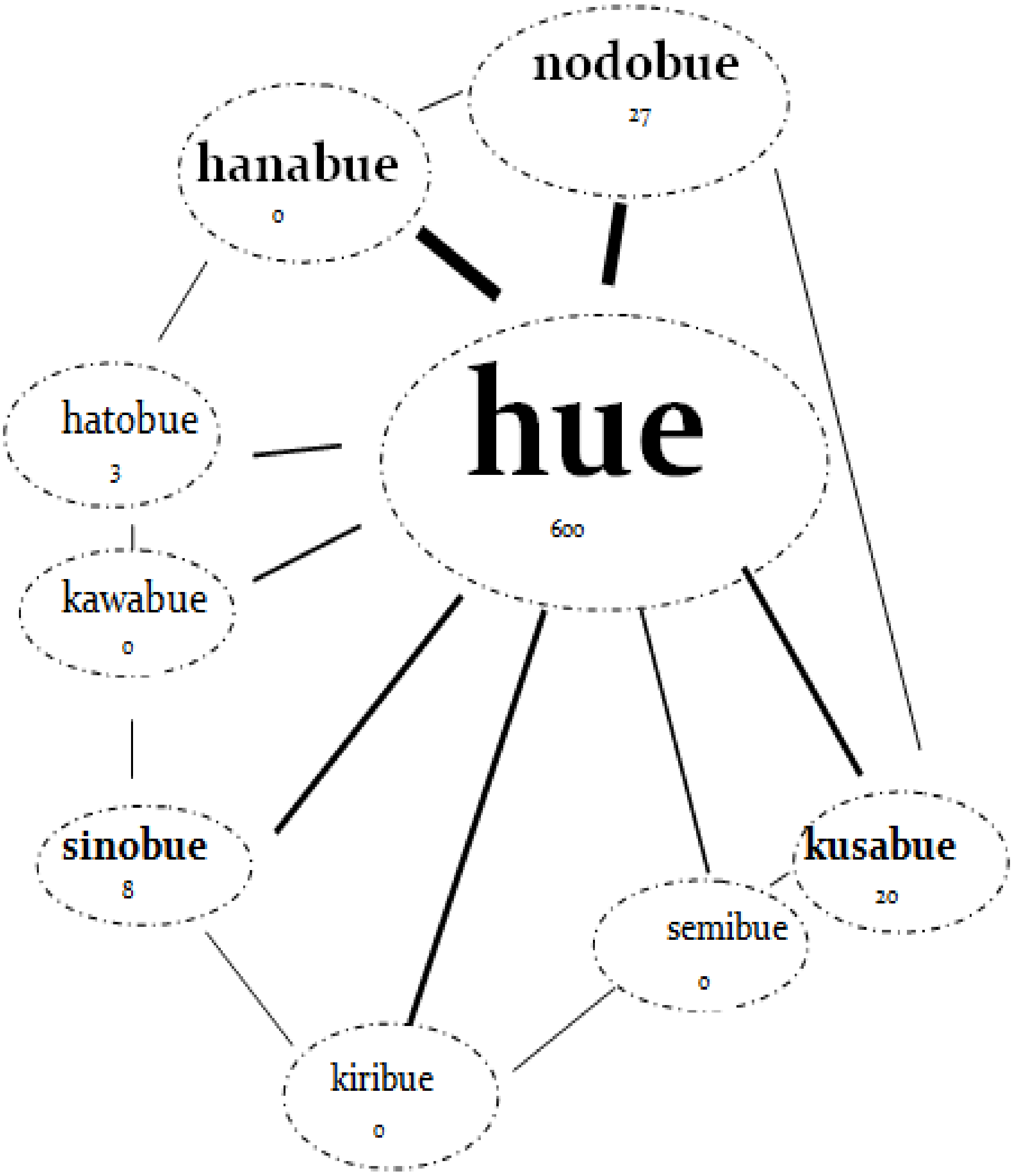

Figure 4.1b. *Exemplars and connections of the HF root hue and compounds with hue. The relative strength of the exemplar categories is indicated by the size of the letters and the relative strength of the exemplar connections is indicated by the width of the lines. The frequency of the words is given in the exemplar clouds. The connections are relatively strong.*

Given the difference in representation for LF and HF words in the lexicon, the next question is how EPOT selects an input for the grammar. As explained above, the morphological structure of the word crucially depends on the interplay of different types of frequency. The input is determined by the activation of a particular root or variant of that root. The extremely LF compounds are supposed to be stored more or less separately from the root and other compounds containing that root, and will thus appear as a monomorphemic unit in the input. Words that have higher frequencies are supposed to be recognized as compounds and their input will thus consist of two roots. The right-hand side will be formed by the *prototype* of the root. Roots in isolation are the most frequent, thus these variants (the non-rendaku form) will have the highest activation. Therefore, the non-rendaku form will be selected in the input. Thus, the extremely infrequent word *tumisiro* 'atonement' will appear in the input as $[\text{tumisiro}]_N$ and the more frequent *sinobue* will appear in the input as $[[\text{sino}]_N[\text{hue}]_N]_N$ 'bamboo flute'.

As for the OT account, I follow Ito & Mester (1986, 1998) and Fukuzawa & Kitahara (2001). Ito & Mester (1986, 1998) proposed that rendaku can be best understood as a linking morpheme that bears the feature [voice] (recall that, historically, the linking morpheme was the possessive particle *no*, which got reduced to a single feature [voiced]).

(13)

Stem 1		Stem 2
sino	ρ	hue
	|	
	[voice]	

The relevant constraints are REALIZE-MORPHEME and IDENT[voice].

(14) REALIZE-MORPHEME

A morpheme in the input should be realized in the output.

(15) IDENT[voice]

Assign a violation mark to any output segment that does not correspond in voicing with an input segment.

Further, Lyman's Law is analysed as an OCP rule (Obligatory Contour Principle) on [voice] that blocks two voiceless consonants in the compound.

(16) OCP[voice]

Assign a violation mark to a morpheme that contains two voiced consonants.

Tableau (17) shows the evaluation of *sinohue* and *tumisiro.*

(17) *Tableaux for sinohue, tumisiro, and kamikaze.*

[[sino]$_N$ ρ [hue]$_N$]$_N$	OCP[voice]	REALIZE-MORPHEME	IDENT[voice]
sinohue		*!	
☞ sinobue			*

[tumisiro]$_N$	OCP[voice]	REALIZE-MORPHEME	IDENT[voice]
☞ tumisiro			
tumiziro			*!

[[kami]$_N$ ρ [kaze]$_N$]$_N$	OCP[voice]	REALIZE-MORPHEME	IDENT[voice]
☞ kamikaze		*	
kamigaze	*!		*

The tableaux show the effect of the grammar on inputs with different morphological structure which provides an output with rendaku in case of a morphologically complex input and an output without rendaku in case of a monomorphemic input.

4.6 Conclusion

In this chapter, I presented an example how EPOT accounts for the modelling of rendaku. Rendaku is a phonological rule in Japanese compounding, but we found that LF words, due to their opaque structure, do not always undergo the rule. The lexicon is modelled on the basis of the frequency effects that we observed. I provided (simplified) illustrations of the lexical representation of a root with relatively strong lexical connections and a lexical representation of a root with relatively weak connections. Lexical strength depends on the frequency of the root in isolation and the occurrence of the root as a left-hand side member of compounds. Compounds with stronger connections are supposed to be morphologically analysed as complex words, i.e. the root is recognized as such. On the other hand, compounds with weaker connections are supposed to be stored as monomorphemic units, i.e. the root is not recognized as such. Subsequently, I proposed that EPOT selects the input on the basis of the difference in lexical organization (due to different frequency values) of these compounds. Either a monomorphemic word is the input, or the compound with the root as it appears in isolation is the input. The—invariable—EPOT grammar provides outputs that vary only on the basis of the morphological structure of the input.

Part III

Changing lexicons, changing grammars

There is no fixed rule

As to when the window should

Closed or open be

It depends on how the moon

Or the snow their shadows cast

Sen no Rikyu 1522-1591

Chapter 6

Dutch loanwords in Indonesian: frequency effects are sensitive to the grammar[1]

Abstract

In Indonesian, prefixation with məŋ- or pəŋ- leads to coalescence between the prefix-final nasal and the stem-initial consonant. Dutch loanwords vary with respect to this rule: sometimes they undergo coalescence and sometimes they do not. This chapter shows that words with borrowed structure, such as initial /f/, consonant clusters, and polysyllabic words, are less likely to undergo coalescence. In borrowed words without foreign structure, aType III frequency effect (opaque structure) occurs. The interaction between the coalescence rule and the frequency effect shows that (1) frequency effects are sensitive for phonological context and (2) frequency effects are blocked in certain phonological contexts. These data serve as a test case for EPOT: the grammatical component accounts for the coalescence rule and the fact that the rule applies to native and nativized words but not to loanwords; and the lexical component accounts for the facts that loanwords gradually loose their lexical status as 'loanword' and become indistinguishable from native words. The input, or prototype, is thus accordingly labelled either as 'loanword' or as 'native' word.

[1] This chapter will appear as Sloos et al (2013). Paper presented at the 2[nd] *Shanghai Phonology and Phonetics Conference*, Shanghai, China, 21-22 April 2012.

In chapters 4 and 5, we found that low-frequency words in language variation tend to be exceptional to the rule or the general pattern. I hypothesize that this Type III frequency effect (opaque structure) may occur in loanword integration as well, since HF words plausibly adapt better to the borrowing language than LF words. Therefore, in this chapter, we investigate the integration of Dutch loanwords in Indonesian with regard to coalescence in *məŋ*-prefixation, which shows (a particular type of) variation. We will investigate *məŋ*-prefixation in different phonological contexts, in order to test the hypotheses formulated in chapter 1 (repeated here for convenience).

(1) *Hypothesis I*

> Frequency effects within a particular variation pattern occur in particular grammatical contexts and are blocked in other grammatical contexts.

(2) *Hypothesis II*

> Frequency effects within a particular variation pattern occur in all grammatical contexts, but they are sensitive to the grammatical difference between these contexts.

This chapter sheds more light on (1) the interaction between grammar and frequency, (2) Type III frequency effects (opaque structure), and (3) the way EPOT accounts for a changing lexicon. First, we will see that loanword integration of *məŋ*-prefixation affects high-frequency words first. A positive correlation between integration and frequency shows a Type III frequency effect (opaque structure); low-frequency words do not (yet) undergo the phonological rule due to unclear or non-native lexical structure, but gradual increase in frequency leads to more integration. We will also see that this frequency type occurs in different phonological contexts, but in each relevant context slightly different, and that frequency effects may even be totally blocked in particular well-defined contexts. Finally, we will argue that loanword integration depends on changes in the lexical status of words.

In Bahasa Indonesia, verbs like <*tuduh*> 'accuse' and nominals such as <*panggil*> 'call', can be prefixed with the active verbalizer *məŋ*,[2] which can be affixed to adverbial, nominal, and verbal stems. This prefixation leads to a morphophonological process with different outcomes. Whereas sonorant-initial stems trigger deletion of the prefix-final nasal (as exemplified in (1a)), stem-initial voiced obstruents trigger assimilation of the prefix-final nasal

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[2] The general analysis for Indonesian is that the underling form is /məŋ/, since if the stem begins with a vowel, and the surface form is [məŋ]. Lapoliwa (1981) assumes that the underlying form is /mən/, in accordance with analyses of nasal place assimilation of many languages, in which the unmarked nasal is considered to be a coronal. However, in the analysis of Lapoliwa, an extra rule is needed for this context: /n/→[ŋ]/ _V. For the remainder of this chapter, the shape of the underlying form is largely irrelevant, we leave this to further study.

as in (1b). Stem-initial *voiceless* consonants undergo coalescence with the prefix-final nasal, see (1).[3]

(1)	a.	[latih]	'smoke'	me-latih	'to smoke.ACT'
	b.	[beri]	'give'	me**m**beri	'to give.ACT'
	c.	[paŋgil]	'call'	me**m**anggil	'to call'
		[tuduh]	'accuse'	me**n**uduh	'to accuse'
		[ketuk]	'knock'	me**ŋ**etuk	'to knock'

In this coalescence process, the surface form [m] receives its nasality from the nasal of the prefix and it receives its [labial] place feature from the stem-initial consonant (e.g. Pater (1999)). Similarly, the nasal gets the [coronal] place feature if the stem-initial consonant is coronal /t/. The nasal gets the [palatal] place feature if the stem-initial consonant is /s/, which, according to Chaer (2002), is realized as a laminopalatal fricative in Indonesian. The phonemic transcription of the laminopalatal strident is /s/.[4]

Coalescence can thus be characterized as follows.

(2)	[+nas]	[–nas]		[+nas]
	|	|		|
	ŋ$_1$	p$_2$	→	m$_{1,2}$
	|	|		|
	[velar]	[labial]		[labial]

Coalescence in Indonesian occurs on affix boundaries, but not within the stem. For example, the stem /tonton/ has a faithful surface form [tonton], but not *[tonon].

Loanwords in Indonesian can also undergo prefixation, but they show variation with regard to coalescence. The Dutch loanword <*publik*> 'public' (Du. *publiek* [pyblik]), may undergo coalescence when prefixed with *məŋ-*, resulting in <*memublik*> 'public.ACT', or it may be faithful to the input, resulting in <*mempublik*>. This and other examples of variation, found on www.google.com (search April 2012) in Indonesian, are given in (3):

(3)	publik < Du. publiek	'portrait'	[mə**m**ublik]	~	[mə**mp**ublik]
	koleksi < Du. collectie	'collection'	[mə**ŋ**oleksi]	~	[mə**ŋk**oleksi]
	teken < Du. teken	'sign, draw'	[mə**n**eken]	~	[mə**nt**eken]
	foto < Du. foto	'photo'	[mə**m**oto]	~	[mə**mf**oto]
	sorter < Du. sorteer	'to sort'	[mə**ɲ**ortir]	~	[mə**ns**orter]

[3] All examples have been checked for spelling and translation in the Kamus Besar Bahasa Indonesia (Comprehensive Dictionary of Indonesian (2005)).
[4] We will return to this in §6.1.

Note that in the last example we neither find *məɲsortir nor *məɲʃortir. Palatalization is typically Malay, rather than Indonesian.[5] We will therefore not include coalescence in s-initial words. A similar pattern of variation is also attested for prefixation with *pəŋ-*, an agent prefix, in loanwords (e.g. [pə**ŋ**oleksi]~[pə**ŋk**oleksi] 'collection.AGENT'). We will therefore take the variation of *pəŋ*-prefixation into account as well. This variation in *məŋ-* and *pəŋ*-prefixation does not occur in native Indonesian words, like the words in (1).

This chapter is structured as follows. Section 6.1 provides some background information on the native and loanword phonology of Indonesian. Section 6.2 describes the methodology of the corpus investigation. In §6.3 the results are provided. Section 6.4 contains the phonological analysis in Optimality Theory. Section 6.5 contains the analysis of the lexical change and §6.6 discusses and concludes.

6.1 Loanword phonology of Indonesian

Malay forms the core, native lexicon and grammar of Bahasa Indonesia (Indonesian). Due to several language contact situations, this core lexicon was extended by new layers of loanwords entering the language. As a result of early trading connections, Malay came into contact with Sanskrit, Chinese (Amoy), and Arabic, and Persian (Jones 2008). From these languages, many words, especially in the fields of religion, education, anatomy, and health, were borrowed (Jones (2008), Sneddon (2003)). In the early sixteenth century, the Portuguese reached Malaysia, and as a result some Portuguese loanwords also survived in Indonesian (Jones 2008). During the late sixteenth century, the administration of Malaysia was taken over by the Dutch. Intensive and long term contact between Dutch and Malay was the source for many borrowings between the two languages. In the seventeenth century, the British arrived in Malaysia and in 1824, the Anglo-Dutch treaty divided the country into Malaysia as a British colony and Indonesia as a Dutch colony. The Dutch stayed in Indonesia until World War II. The language accordingly developed slightly differently in the two areas, particularly regarding loanword borrowings (Sneddon 2003: 11-12). The two variants share a large part of the lexicon, however: eighty percent of the words are cognates (Lewis 2009). Besides Malay and Indonesian, there were hundreds of local languages in Indonesia, and eventually it was recognized that there was a need of a "language of national unity". In 1928, Bahasa Indonesia "Indonesian Language" was proclaimed as such (Sneddon 2003: 5).

Due to such intensive language contact, Indonesian may be regarded as a language with a core, native, Malay lexicon and grammar, and a number of loanword strata, which all contributed to the lexicon and phonology of Malay (see Figure 6.1). This means that the earliest strata form subsets of the later strata.

[5] Aone van Engelenhoven p.c.

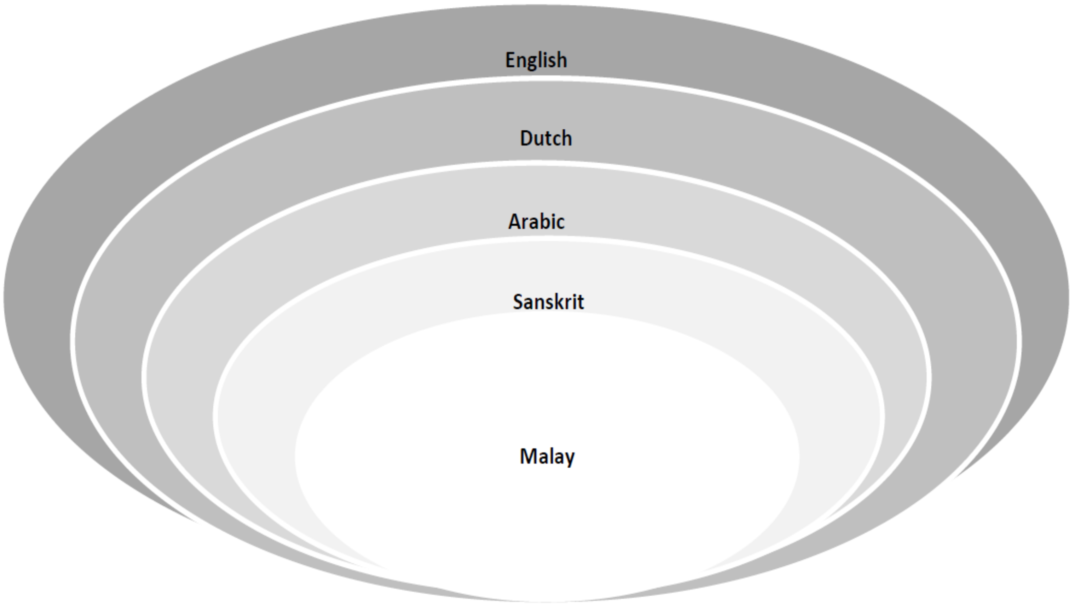

Figure 6.1. *The most prominent lexical strata of Indonesian: Malay, Sanskrit, Arabic, Dutch, and English.*

The different source, or donor, languages contributed not only new words but also new phonemes and phonotactic structures that originally did not occur in Malay. The core Malay consonant inventory is provided in (4).

(4) *Consonant inventory of Malay.*

	Labial	*Alveolar*	*Palatal*	*Velar*	*Glottal*
Plosive	p b	t d	c ɟ	k g	ʔ
Fricative		s			
Nasal	m	n		ŋ	
Approximant	w		j		h
Lateral		l			
Trill		r			

In this consonant inventory, only one fricative is found: the lamino-palatal strident, phonologically categorized as belonging to the natural class of alveolars. Later, Malay borrowed a whole range of fricatives /f ð ʃ z x ɣ/ from Arabic. The examples in (5) are from Onn (1976: 27).

(5)	ta**f**akur	/tafakur/	'plunged into thought'
	zalim	/ðalim/	'to be cruel'
	syarat	/ʃarat/	'condition'
	ba**kh**il	/baxil/	'stingy'
	ba**g**al	/baɣal/	'donkey'

The phonotactics of Malay is relatively restricted. Malay syllable structure allows only CV and CVC (Onn 1976: 87-88). Malay does not allow geminates (Onn 1976: 61). Malay words are preferably disyllabic (Onn 1976: 87). Malay coda obstruents must be voiceless (Onn 1976: 15). Malay medial clusters can only be nasal-obstruent clusters, and must be homorganic within the prosodic word (Onn 1976: 21-24), see the examples in (6).

(6)	bangga	/ba**ŋg**a/	'to be proud'
	banci	/ba**ɲc**i/	'census/trans-gender'
	ke-bandar	/kəba**nd**a/	'to the city'
	ke-bimbang-an	/kəbi**mb**aŋan/	'anxiety, fear'

Initially, many borrowed features were 'repaired' to fit into the Malay phoneme inventory and phonotactic structure, but gradually, loan phonemes and 'loan phonotactics' surfaced in the language. When Malay initially came into contact with Dutch, not only had Arabic loan phonemes already entered the Malay consonant inventory, but other non-native structures occurred as well. Many Sanskrit loanwords had a syllable structure which was non-native for Malay and, also, the Sanskrit loanword stratum contained many words that are longer than two syllables (7).

(7)	aksara	<Skr. akʃara	'letter'
	biara	<Skr. vihara	'monastery'
	utara	<Skr. uttara	'north'

Nevertheless, in the initial stages, Dutch loanwords with an initial consonant cluster, underwent cluster resolution: /stɛm/ (Du. 'voice') was epenthesized with a schwa in Malay e.g. [sətɛm] 'voice'. In later stages, clusters were borrowed like /sχorsiŋ/ (Du. 'suspension') which is pronounced as [skorsiŋ] in Indonesian. Similarly, although the segment /f/ had already been borrowed during the Arabic language contact period, initial /f/ in Dutch *<f>* /fabrik/ 'factory' was initially borrowed as [pabrik], but later as [fabrik], and variation still occurs.[6] Integration of loan segments into the native grammar may also depend on the position in the syllable. The voiceless velar fricative /χ/, which is frequent in Dutch, is sometimes faithfully borrowed, but may also be realized as a velar plosive, or a glottal approximant, like biolo[χ]i~biolo[g]i~biolo[h]i (Lapoliwa 1981: 102). One entirely new feature was introduced in

[6] In Dutch and English loanwords, we find orthographic <v>, which is not distinct from <f>.

Dutch borrowings: monosyllabic words, which were faithfully borrowed in Indonesian. Although the monosyllabic words, like the consonant /f/ and consonant clusters were largely faithfully borrowed, we will see that the grammar still treats these features as ‘foreign’ in prefixation of *məŋ*- and *pəŋ*-.

It has been observed by Lapoliwa (1981: 108) and Hiramoto (2007) that in *məŋ*-prefixation, Dutch and English loanwords are in a transition period: they gradually integrate into the native grammar and show variation with respect to coalescence. In order to check whether variation occurs at all in native Indonesian words, we checked 20 native Indonesian words that have a potential input for coalescence: words with one of the initial voiceless consonants /p t k/. For all words, Google returned fewer than 1% hits of non-coalesced forms. So, under the assumption that spelling reflects pronunciation, in native Indonesian, the rule of coalescence is (almost) free of variation.

We focus on Dutch loanwords, since these are the best documented, and show much variation in coalescence. It is necessary to pay attention to the difference between words with native structure and non-native structure (viz. words with the loan phoneme /f/, initial onset clusters, monosyllabic words, and polysyllabic words). First, besides words with initial /p t k/, words with initial /f/ are also possible input for *məŋ*- and *pəŋ*-prefixation: <*məmfoli*> ~ <*məmoli*> ‘to foil.ACT’. But our impression is that they are less likely to undergo coalescence than other words. Second, although they have non-native structure, theoretically speaking, polysyllabic words and words with initial onset clusters might also be input for coalescence <*mentransformasi*> ~ <*menransformasi*>. However, coalescence seems not to occur in consonant clusters. Finally, monosyllabic words, if prefixed with *məŋ*- or *pəŋ*-, typically undergo schwa insertion (Lapoliwa 1981: 104).[7]

(8) /məŋ-film/ → [məŋefilm] ‘film.ACT’
/məŋ-cek/ → [məŋecek] ‘check.ACT’

Apparently, prefixation may only occur if the stem is disyllabic. Stems that are monosyllabic need an epenthetic schwa in order to become heavy enough for prefixation. This reasoning is supported by the fact that monosyllabic loanwords with a native suffix do not undergo schwa epenthesis: *mem-film-kan* ‘film.ACT.CAUS.’ *<*mengefilmkan*>. Schwa insertion in monosyllabic words shows that, even though monosyllabic words are faithfully borrowed in Bahasa Indonesia, the grammar still requires an adaptation in *məŋ*-prefixation.

In this section, we saw that Dutch loanwords were borrowed with non-native structure: the phoneme /f/, onset clusters, and monosyllabic, and polysyllabic roots. In *məŋ*-prefixation of monosyllabic words, schwa epenthesis occurs, which shows that grammatical adaptations may be necessary in morphological processes. In this study, we will investigate the effects of the non-native structure (initial /f/, polysyllabic words, and initial onset clusters) in the variation of coalescence in *məŋ*- and *pəŋ*-prefixation.

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[7] Although currently the schwa is often not pronounced anymore, Hein Steinhauer, p.c.

6.2 Methodology

In this section, we will describe the corpus that we used to investigate the variation in coalescence in Dutch loanwords (§6.2.1). We will clarify the computation of the frequency values and the proportion of coalesced variants in §3.2. Section 3.3 provides the hypotheses.

6.2.1 Database

The most exhaustive source of Dutch loanwords in Indonesian is van der Sijs (2010), which contains 5550 Dutch loanwords, words that originally belonged to the Dutch vocabulary, in Indonesian. We selected all words with potential input for coalescence, i.e. words that start with /p t k f/. Monosyllabic roots are included only when they combine with the suffix *-kan*, in which case the stem for *məŋ-* and *pəŋ*-prefixation is disyllabic and coalescence may occur.[8] Homonyms and words that were used as proper names were excluded from the data set. Words that are ambiguous were also deleted from the data set, since their frequency count could not be separated. For instance, *məŋ-koperasi-kan* 'co-operation.ACT.CAUS.', when coalesced, becomes *məŋoperasikan*, which could also mean 'surgery.ACT.CAUS.' For all selected words, it was checked whether they could occur with *məŋ-* and *pəŋ*-prefixation on the internet by using www.google.com in Bahasa Indonesia as a search engine. The search was restricted to pages from Indonesia. The words were searched for with and without coalescence. The final selection contained 167 disyllabic and polysyllabic roots with initial /p t k f/, which occurred with either the prefix *məŋ*-, or the prefix *pəŋ*-, or both and with suffix *-kan*. The database was later augmented with words that have the suffix *-kan* (see §2.2.3). The data are contained in Appendix C.

6.2.2 Frequency

Since there is no frequency dictionary and no corpus in which the frequency of all (or most) of the words in our data set could be found, we computed the frequency of the lemma by using search hits of words in which this stem occurred from www.google.com in Indonesian. Frequency determination by using www.Google.com is regularly used in linguistic research (Meyer et al. 2003). Our search was restricted to pages from Indonesia. Since *məŋ-prefixation* is extremely productive and *pəŋ*-prefixation sometimes also significantly contributes to the lemma frequency, the occurrence of the stem with the prefixes *məŋ-* or *pəŋ*-, with and without coalescence, were also taken into account for frequency computation. We checked Stevens & Schmidgall-Tellings (2004) for derivations that affected the lemma frequency, including stems that had an alternative form (e.g. <*fanatik*> ~ <*fanatis*> 'fanatic') and stems with alternative spellings (such as <fabrik> and <pabrik>). In sum, we collected the frequency of the stem under the following conditions:

[8] As outlined in section 2, monosyllabic stems undergo schwa insertion and are not subject to coalescence.

- isolation
- *məŋ*-prefixation with coalescence
- *məŋ*-prefixation without coalescence
- *pəŋ*-prefixation with coalescence
- *pəŋ*-prefixation without coalescence
- derivations
- stems with different spellings

The frequency of these words was added per lexeme and is referred to as the lemma frequency. In order to stay close to the experienced frequency, we log transformed the token frequencies (see e.g. Shapiro (1969)).

In the following section, we will investigate which factors can predict the proportion of the coalesced variants for each word. Since *məŋ* -prefixation is by far more productive than *pəŋ*-prefixation, stems with *məŋ*-prefixation and *pəŋ*-prefixation cannot be simply added to each other; the higher numbers of *məŋ*-prefixation would bias the value. As an example, we compute the proportion of coalesced forms of <*koreksi*>. We first computed the lemma frequency <*koreksi*>, and subsequently computed the proportion of coalesced forms in *məŋ*-prefixation and in *pəŋ*-prefixation. These frequency counts are provided in Table 6.1.

Table 6.1. Token frequency counts of koreksi. Frequency and sums of coalesced and non-coalesced stems in məŋ- and pəŋ-prefixation.

Word	*Token Frequency*	*Sum*
meŋoreksi	797,000	
peŋoreksi	22,600	
sum coalesced stems		**819,600**
meŋkoreksi	363,000	
peŋkoreksi	2,760	
sum non-coalesced stems		**365,760**
sum stems		**1,185,360**

The proportion of coalesced forms of stems is (819,600/(365,760+819,600))*100 = 69.2. This proportion was computed for each stem. In the next section we will analyze the extent to which this proportion can be predicted on the basis of the log lemma frequency and the grammatical predictors.

6.2.3 Hypotheses

We will investigate a number of hypotheses regarding coalescence in Dutch loanwords in Indonesian. First, when a word is first borrowed into a language, the frequency of the loanword is (close to) one, but frequency successively increases. Words that are more frequent are more familiar and therefore more likely to adapt to the borrowing language (9).

(9) *Hypothesis 1.*

Frequency is positively correlated with the proportion of coalescence.

Further, coalescence occurs only in words that have /p t k f/ as the initial consonant. As mentioned in the introduction of this chapter, the frequency of the phonemes and their alternants may influence the variation and interact with grammar. Although we do not know the phoneme frequency of Indonesian, we might expect an interaction, such that the frequency effect slightly differs (viz. is stronger or weaker) within the different subcategories of words starting with one of the consonants /p t k f/. So we reformulate the hypotheses as mentioned in the introduction as follows.

(10) *Hypothesis 2*

Frequency effects occur in coalescence in Dutch loanwords in Indonesian within some subcategories of words starting with one of the consonants /p t k f/ and are blocked in other subcategories of words starting with one of the consonants /p t k f/.

(11) *Hypothesis 3*

Frequency effects in coalescence in Dutch loanwords in Indonesian occur in all grammatical contexts, but they are sensitive to the grammatical difference between these contexts.

Further, we hypothesize that initial onset clusters may prevent coalescence, since this would lead to phonotactically ill-formed clusters (see §6.2).

(12) *Hypothesis 4*

Consonant clusters have a negative effect on the proportion of coalescence.

In addition, the number of syllables may play a role as well: disyllabic words seem to undergo coalescence more often than polysyllabic (i.e. trisyllabic or longer) words.[9]

(13) *Hypothesis 5*

Polysyllabic roots are less likely to undergo coalescence than disyllabic roots.

In order to investigate whether it is just the number of syllables of the *stem* to which *məŋ-* or *pəŋ-* is attached or the number of syllables of the loanword *root*, we also investigated suffixed disyllabic loanwords. Words which are prefixed with *məŋ-* or *pəŋ-* may in most cases also be suffixed with the causative *-kan*. Thus we considered disyllabic roots, e.g. *parkir* 'park' and its suffixed form *parkir-kan*, and compared them to trisyllabic roots. We extended the database with 78 words that have disyllabic roots with the suffix *-kan*.

[9] We are grateful to Ahmad Zaharani (p.c.) for bringing this to our attention.

6.3 Results

The database contained 144 disyllabic roots, 93 polysyllabic roots, and 8 monosyllabic roots with suffix -*kan*, with a mean log lemma frequency of 6.2. The frequency of the disyllabic and polysyllabic words did not much differ from each other. The mean coalescence percentage of all words was 19.4%. For 120 words (49.0%), less than 1.0% underwent coalescence.[10] A relatively large part of the words that resisted coalescence had an initial onset cluster (the observed clusters are /pl pr kr kl tr fr fl/). There were 36 words with initial clusters with regular log lemma frequencies (mean 6.4), but of which 24 (66.7%) never occurred with coalescence.

We performed logistic regression modelling in the statistical package R (R Development Core Team 2009), in order to predict the proportion of coalesced forms. The results are presented in Table 6.2. The strongest factor is initial cluster, which has a negative impact on the proportion of coalescence (t = -5.271, p < 0.001). Similarly, we found a negative effect for the number of syllables of the roots. We investigated whether the number of syllables of the root was a better predictor than the number of syllables of the stem and found that the number of syllables of the root is a better predictor (t = -2.255, p = 0.025). Further, no main effect of either the initial consonant or log lemma frequency was found, but we found interactions between log lemma frequency and words with initial /k p t/. This indicates that more frequent words tend to undergo coalescence more often in words that have an initial /k p t/. For initial /f/, however, no significant difference could be found, which indicates that /f/-initial words do not interact with frequency.

[10] Compare with section 2, where we found that in native words less than 1.0% of the words do not undergo coalescence.

Table 6.2. Results of məŋ- prefixation in Dutch loanwords in Indonesian: the optimal logistic regression model, providing the estimates, standard error, t-value and p-value of the factors initial cluster, the number of syllables of the stem, the initial consonant, and the log lemma frequency.

	Est.	S.E.	t-value	p-value
(Intercept)	25.4	13.6	1.867	0.063
Initial Cluster	-32.7	6.199	-5.271	<0.001*
Number of syllables of the root	-7.80	3.459	-2.255	0.025*
LogLemmaFreq:Initial Consonant f	0.041	1.788	0.023	0.982
LogLemmaFreq:Initial Consonant k	4.059	1.686	2.407	0.017*
LogLemmaFreq:Initial Consonant p	5.163	1.826	2.828	0.005*
LogLemmaFreq:Initial Consonant t	6.908	2.204	3.134	0.002*

Residual standard error: 28.71 on 238 degrees of freedom
Multiple R-squared: 0.225 Adjusted R-squared: 0.206
F-statistic: 11.52 on 6 and 238 DF, p-value: <0.001

The frequency effect is illustrated in Figure 6.2. The plot shows the effect of frequency on the percentage of coalescence for words that begin with one of the consonants /p t k f/. Words with initial clusters are excluded from this graph, since they strongly resist coalescence. All groups except for /f/-initial words show a positive correlation with frequency. So /p t k/-initial words undergo more coalescence if their frequency increases. Words with initial /f/ do not show an interaction with frequency, and since a main effect of the initial consonant cannot be found, we conclude that /f/-initial words resist coalescence (except for a few extremely HF words, such as *fabrik* 'factory', *fiksi* 'fiction', and *figur* 'figure'). For words that start with /p k/, we find that an increase of log frequency with 1 leads to an increase of 10% coalesced forms. There are few words with initial /t/, but still they show a positive correlation, although a stronger one.

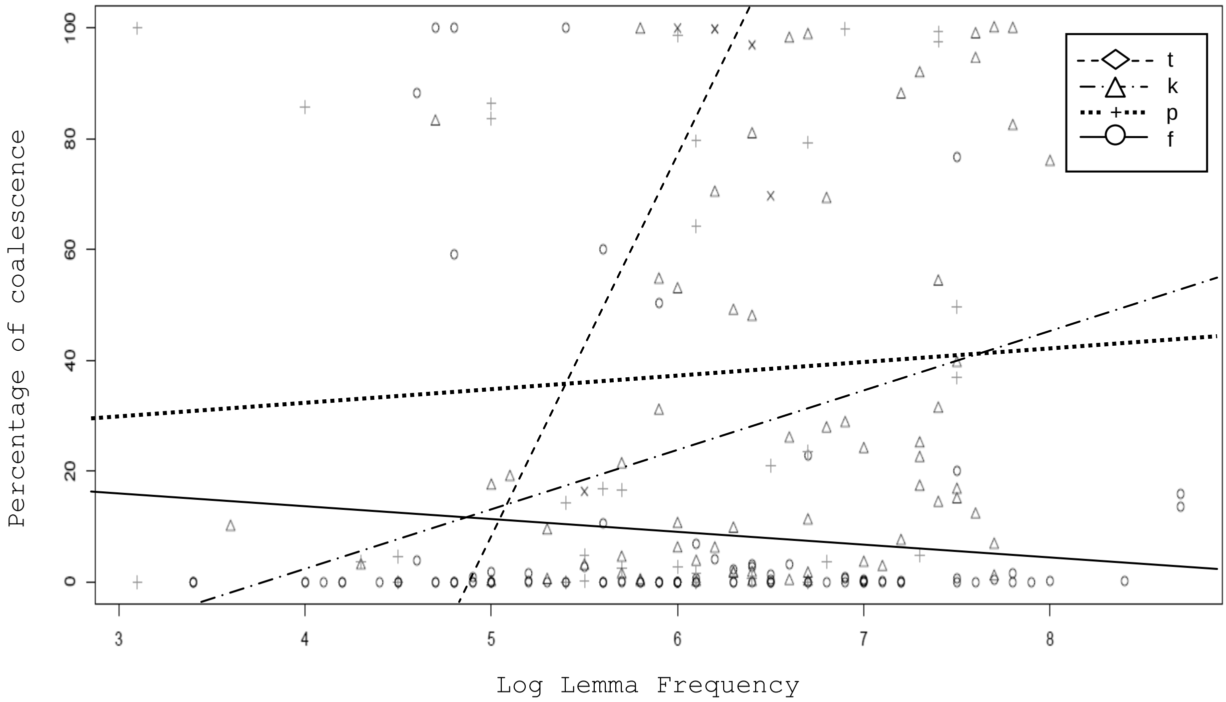

Figure 6.2. *Percentage of coalescence in Dutch loanwords in Indonesian plotted as a function of the log lemma frequency of Dutch loanwords in Indonesian starting with /p t k f/ and their percentage of coalescence.*

Figure 6.2 also shows that frequency is relative: a /t/-initial stem with log lemma frequency 5 behaves as an LF stem, whereas a /p/-initial stem with log lemma frequency 5 behaves as an MF stem. Similarly, /t/-initial stems with log lemma frequency 6 behave as HF stems, whereas /p/-initial stems with log lemma frequency 6 behave like MF stems.

So, foreign structure, i.e. initial /f/, consonant clusters, and polysyllabic roots, resist coalescence. This suggests that foreign structure elsewhere in the word would also lead to less coalescence. In order to test this, we marked each word in the database that had /f/ or a consonant cluster anywhere in the word, and included polysyllabic words in the 'foreign structure' set. We carried out the analysis again, which showed a significant effect of 'foreign', but the model was weaker compared to the model presented in Table 6.2, so it did not add to our understanding.

In this section, we found that frequency of the loanword positively correlates with the propensity to undergo coalescence. On the other hand, borrowed structure has a negative effect on coalescence. Frequency effects are blocked in cluster-initial words and /f/-initial words. We also found that the frequency effects have the same pattern within /p t k/-initial words, but that the frequency effect is strongest in /t/-initial words and the weakest in /p/-initial words (see Figure 6.2). This shows that frequency effects are *relative* with regard to the subcategory in which they occur.

6.4 The initial and the final stage of loanword integration

In this and the following section, we will provide an analysis of the data in EPOT. This section accounts for the initial and the final stage of the life cycle of a loanword, in which we use a particular type of OT that is used in loanword phonology: Lexical OT, introduced in §6.4.1. The analysis of məŋ-prefixation in native words as well as loanwords is provided in §6.4.2.

6.4.1 Lexical OT

Dutch loanwords show variation with regard to coalescence in *məŋ-* and *pəŋ*-prefixation, whereas native words always undergo coalescence in that context. Such differences in the treatment of loanwords as opposed to native words have often been observed and have usually been treated in Optimality Theory on the basis of lexical indexation or a stratified lexicon (Itô & Mester (2001, 2008), Nagarajan (submitted), Pater (2005)). Faithfulness constraints, which compare the lexical input with the output, may be directly related to a particular stratum. The ranking of the universal markedness constraints is interspersed with these loanword-specific faithfulness constraints. Let us illustrate this by examples from Indonesian. The core stratum of a lexicon is the most restricted and each subsequent stratum may be evaluated by dominating correspondence constraints, which allow more faithful realizations. For Indonesian, the core stratum is Malay, which is indeed the most restricted in terms of phoneme inventory, syllable structure, and the requirement that a word is disyllabic. As outlined in §6.2, Sanskrit extended the lexicon with polysyllabic words and consonant clusters, so we assume MAX-IO$_{\text{SANSKRIT}}$>>*CC, PROSODICWORD=FOOT.

(14) *Tableau for the Sanskrit loanword 'utara'.*

/utara/	MAX-IO$_{\text{SANSKRIT}}$	*CC	PROSODICWORD=FOOT
☞ [utara]			*
[utar]	*!		

Subsequently, Arabic enriched the phoneme inventory with fricatives other than /s/. Ignoring /s/, which already existed in Malay, for the moment, the ranking is FAITH(FRIC)$_{\text{ARABIC}}$>>*FRIC.

(15) *Tableau for the Arabic loanword 'tafakur'.*

/ tafakur /	FAITH(FRIC)$_{\text{ARABIC}}$	*FRIC
☞ [tafakur]		*
[tapakur]	*!	

Thereafter, Dutch added monosyllabic words to the language, violating *σ_{FT}.

(16) *σ_{FT}

Assign a violation mark to any monosyllabic foot.[11]

(17) *Tableau for the Dutch loanword 'bom'.*

/ bom /	FAITH$_{DUTCH}$	*σ_{FT}
☞ [bom]		*
[bomə]	*!	

The faithfulness constraints are bound to a particular stratum. At first sight, this would seem to be incompatible with the idea that constraints are universal. However, faithfulness constraints compare the input to the output, and the input is already marked for a particular stratum. Markedness constraints, on the other hand, cannot bear lexical indexation, because they are independent from the input. The faithfulness constraints intersperse the constraint ranking of the universal markedness constraints in Malay such that the latest stratum corresponds with the highest ranking of faithfulness constraints. Tableau (18) illustrates the analysis for the Dutch loanword /fabrikasi/ 'fabrication' (Du < *fabrikatie*), in which the winner violates the constraints *CC, PROSODICWORD=FOOT, and *FRIC.

(18) *Loanword specific constraint ranking.*

/fabrikasi/	FAITH$_{DUTCH}$	FAITH(FRIC)$_{ARABIC}$	*FRIC	MAX$_{SANSKRIT}$	PROSODICWORD=FOOT	*CC
☞ [fabrikasi]			**		*	*
[pabrikasi]	*!		*		*	*
[fabrik]	*!		*			*
[pabikati]	*!				*	

[11] Note that it is not possible to use FOOTBIN here, since polysyllabic syllables are faithfully borrowed.

6.4.2 Coalescence in loanwords and native words: An OT analysis

In the native grammar, the nasal in the prefix *məŋ-* or *pəŋ-* and the stem-initial consonant undergo coalescence if the stem-initial consonant is /p t k/. This is due to a highly ranked constraint that prohibits that a nasal being followed by a voiceless consonant (Pater 1999).

(19) *NÇ̥

Assign a violation mark to any sequence of a nasal and a voiceless consonant.[12]

Markedness constraints are supposed to be universal, a condition which is met by constraint (19). *NÇ̥ is highly ranked in many languages, e.g. Austronesian languages and Japanese. *NÇ̥ is phonetically grounded, since a nasal followed by a voiceless consonant requires an unnaturally quick velar closure. *NÇ̥ is relevant in language acquisition, e.g. in English, Greek, and Spanish (Pater 1999). The interested reader is referred to Pater (1999) for more details about the motivation of *NÇ̥. Further, coalescence is not only driven by *NÇ̥, but also by nasal place assimilation, as shown in (2). We therefore assume AGREE(place)Nas-Cons:

(20) AGREE(place)Nas-Cons

Assign a violation mark if a nasal and a following consonant do not agree in place of articulation.

When fusion occurs, the surface form violates a faithfulness constraint that requires each output segment to correspond to a single input segment. We adopt UNIFORMITY-IO—which was originally formulated by McCarthy & Prince (1995) as an anti-coalescence constraint.

(21) UNIFORMITY-IO

Assign a violation mark if a single output segment corresponds to multiple input segments.

In case of coalescence, the ranking of these two constraints is *NÇ̥ >> UNIFORMITY-IO. There is a caveat, however. As noticed in §6.1, coalescence occurs only at prefix-stem boundaries and not stem internally, which is captured by IDENT-IO$_{\text{PLACE}}$(stem).

(22) IDENT-IO$_{\text{PLACE}}$(stem)

Assign a violation mark if the place feature of an input segment in the stem is not preserved in an output segment.

[12] Note that the voiceless palatal plosive is not subject to coalescence, which can be accounted for by a dominating Faithfulness constraint. This is irrelevant for the rest of the discussion.

Finally, MAX-IO(stem) prevents deletion of the segments of the stem. The constraint ranking is illustrated in tableau (24). The prefix-final nasal in the input and its corresponding outputs in the candidates are indicated with subscript 1 and the stem-initial consonant and its corresponding outputs in the candidates are indicated with subscript 2, as explained in (2), repeated here as (23) for ease.

(23) [+nas] [–nas] [+nas]

ŋ$_1$ p$_2$ → m$_{1,2}$

[velar] [labial] [labial]

Coalescence is thus indicated with subscripts 1,2 in the output segment. Deletion of the stem-initial consonant as in [məŋ$_1$ɑŋgil] leads to violation of MAX-IO(stem), but coalescence as in [məm$_{1,2}$ɑŋgil] does not. Coalescence violates only UNIFORMITY-IO. Tableau (24) shows the analysis of *məŋ-prefixation* of the native word *panggil* 'to call'. The form of the root in isolation /*panggil*/ is taken as the prototype, together with the 'underlying form' of the prefix *məŋ*.

(24) *Tableau for prefixation of native 'panggil'.*

/məŋ$_1$-p$_2$ɑŋgil/	AGREE(place) Nas-Cons	MAX-IO(stem)	IDENT-IO$_{PLACE}$ (stem)	*NC̥	Uniformity-IO
məŋ$_1$p$_2$ɑŋgil	*!			*	
məm$_1$p$_2$ɑŋgil				*!	
☞ məm$_{1,2}$ɑŋgil					*
məŋ$_1$g$_2$ɑŋgil			*!		
məŋ$_{1,2}$ɑŋgil			*!		
məŋ$_1$ɑŋgil		p!			
məm$_{1,2}$ɑŋil		g!			*

Let us now turn to Dutch loanwords. For a considerable part, Dutch loanwords resist coalescence (see §6.3), which is expressed by the anti-coalescence constraint that applies only to loanwords and which dominates *NC̥ .

(25) UNIFORMITY-IO(Loan)

Assign a violation mark to a single output segment that corresponds to a loanword segment as well as any other segment (no coalescence involving loanwords).

The constraint UNIFORMITY-IO(Loan) violates e.g. [məm$_{1,2}$ublik] (input /məŋ$_1$- p$_2$ublik/), since /ŋ$_1$p$_2$/ coalesced to [m$_{1,2}$]. The tableau in (26) shows this ranking for the Dutch loanword *publik* 'public', a word that undergoes coalescence in 50% of the cases.

(26) *Tableau for məŋ-prefixation of 'publik' as a Dutch loanword.*

/məŋ$_1$-p$_2$ublik/(Loan)	AGREE(Place) NasCons	UNIFORMITY-IO(Loan)	MAX-IO (stem)	IDENT-IO$_{PLACE}$(stem)	*NC̥	UNIFORMITY-IO(Nat)
məŋ$_1$p$_2$ublik	*!				*	
☞ məm$_1$p$_2$ublik					*	
məm$_{1,2}$ublik		*!				*
məŋ$_1$ublik			*!			
məŋ$_{1,2}$ublik		*!		*		

Notice that speakers do not have to be conscious of the degree of integration of the loanword. We just observe that borrowings may behave in either of the two following ways: as a loanword, i.e. deviant from native words, or nativized and thus identical to native words. The lexicon is correspondingly stratified, with loanword strata and a native stratum. A single word may belong to the loanword stratum in one speaker, and to the native stratum in the other speaker (this will be discussed in more detail in §6.5). UNIFORMITY-IO(loan) applies only to borrowings. If *publik* is treated as a loanword, the output is *mempublik*. If *publik* is treated as a native or nativized word, it vacuously satisfy UNIFORMITY-IO(loan), and the output of the grammar will be memublik (27).

(27) *Tableau for məŋ-prefixation of 'publik' as a nativized word.*

/məŋ$_1$-p$_2$ublik/(Nat)	AGREE(Place) NasObs	UNIFORMITY-IO(Loan)	MAX-IO (stem)	IDENT-O$_{PLACE}$(stem)	*NC̥	UNIFORMITY-IO(Nat)
məŋ$_1$p$_2$ublik	*!				*	
məm$_1$p$_2$ublik					*!	
☞ məm$_{1,2}$ublik						*
məŋ$_1$ublik			*!			
məŋ$_{1,2}$ublik				*!		

As we saw in §6.3, words with initial onset clusters are even more resistant to coalescence (73.3% never undergo coalescence). If the stem has an obstruent-sonorant cluster, as in <*transform*> 'transform', the output after coalescence would contain a sonorant cluster *məŋransform, which is not allowed in Indonesian (see §6.2). However, in some cases, coalescence may occur, so words with consonant clusters may eventually be integrated to Indonesian grammar, although it takes much longer than the integration of words without initial clusters. Tableau (28) shows *məŋ*-prefixation of CC-initial Dutch loanwords and (28) shows *məŋ*-prefixation of CC-initial nativized loanwords.

(28) a. *Tableau for məŋ-prefixation of CC- initial Dutch loanwords.*

/məŋ$_1$-t$_2$r$_3$ansform/(loan)	AGREE(Place) NasObs	UNIFORMITY-IO(loan)	MAX-IO(stem)	IDENT-IO$_{PLACE}$(stem)	*NC̥	*$_\sigma$[CC	UNIFORMITY -IO (Nat)
məŋ$_1$t$_2$r$_3$ansform	*!				**	*	
☞ mən$_1$t$_2$r$_3$ansform					**	*	*
mən$_1$t$_2$r$_3$anform			*		**	*	*
mən$_{1,2}$r$_3$ansform		*!			*		*
məŋ$_1$r$_3$ansform			*t!		*		

(28) b. *Tableau for məŋ-prefixation of CC- initial nativized words.*

/meŋ$_1$-t$_2$r$_3$ansform/(N)	AGREE(Place) NasObs	UNIFORMITY-IO(loan)	MAX-IO(stem)	IDENT-IO$_{PLACE}$(stem)	*NC̥	*$_\sigma$[CC	UNIFORMITY-IO(Nat)
meŋ$_1$t$_2$r$_3$ansform	*!				**	*	
men$_1$t$_2$r$_3$ansform					**!	*	*
☞ men$_{1,2}$r$_3$ansform					*		*
men$_{1,2}$r$_3$anform							
meŋ$_1$r$_3$ansform			*t!		*		

All nativized words once entered the language as a loanword and an increase in frequency, viz. an increase in usage, eventually may lead to nativization (see also §6.5). The constraint ranking as exemplified above accounts for the behaviour of a loanword proper, in the initial stage of the borrowing, as well as for the behaviour of a fully integrated word, in the final stage of the borrowing. OT, however, cannot account for the lexical shift from loanword to integrated word. The reason for this is that this shift is not dependent on the grammar, but on the organization of the lexicon. The grammar is blind to the input. The grammar is also blind to lexical frequency. The grammar does not count how many times a word occurs; the grammar just applies to any input. However, words develop from loanwords into native words and they do so according to well-defined pattern: we have seen that nativization is positively correlated with frequency.

6.5 Gradual change from loanword to nativized word

In section 6.4.2, we used lexical OT to account for the difference in behaviour between loanwords and native words. The assumption was that each word belongs to either the loanword stratum or the native stratum—we observed, however, variation in the behaviour of loanwords. This variation relates to the word's frequency as well as its structure. Although lexical OT can account for the initial stage and the final stage (viz. fully nativized) of a loanword, the observed variation remains unexplained. Actually, the grammar cannot account for the following results:

- Frequency is positively correlated with the likelihood of coalescence
- Frequency interacts with the initial consonant

EPOT accounts for these observations by an Exemplar Theoretical analysis, which is directly related to the loanword stratification and the loanword specific faithfulness constraint

UNIFORMITY-IO(loan). In §6.5.1, we will discuss the frequency effect type observed in the Dutch loanword integration. Section 6.5.2 discusses the interaction between the frequency effect and the grammar.

6.5.1 Loanwords and Type III frequency effects (opaque structure)

Loanwords gradually change their lexical indexation from loanword to native word. To account for this change, we need a more detailed modelling of the lexicon, for which we adopt Exemplar Theory (see §1.2). For loanwords, we suppose that they are initially recognized as such and are stored in an exemplar category with the label 'loanword'. However, by usage, speakers become more familiar with the words and eventually the words may not be recognized anymore as loanwords. I suppose that the rate at which a word loses its loanword status is related to frequency as well as foreign structure. HF words are expected to undergo nativization at a faster rate than LF words, due to the fact that their familiarity increases. The change from loanword to native word, as we saw in §6.3, occurs *gradually* by usage, but is also supposed to be dependent on the structure of the word. Words with clear foreign structure, (viz. initial /f/, consonant clusters, or polysyllabic structure), are more likely to be recognized as loanwords for a very long time. Although frequency may increase, the loan structure is an indication that the word is originally a loanword and its exemplar will be stored under that label. Thus, besides the frequency effects, it is more difficult for loanwords with borrowed structure to lose the status 'loanword' and to become nativized than for loanwords with no foreign structure.

HF words change first, as expected, but can we be sure that this is a Type III frequency effect (opaque structure)? As pointed out in chapter 1, there are two frequency effects known in the literature: Type I frequency effects, in which LF words change first, and Type II frequency effects, in which HF words change first. Further, in part II, we discovered Type III frequency effects, in which LF words do not follow the grammar. At first blush, the gradual nativization in Dutch loanword integration in Indonesian is comparable to analogical change: Dutch loanwords gradually adapt to the Indonesian morphophonological structure. In analogical change, typically, Type I frequency effects are observed, in which HF words change last. However, in Dutch loanword integration in Indonesian, the HF words change first. So they do not show a Type I frequency effect. Could it be the case that coalescence, like assimilation, is to be regarded as a kind of reduction process, since two segments fuse into one? In that case we would observe a Type II frequency effect. This is not impossible, but a similar effect has recently been found by Coetzee & Kawahara (2013), who studied devoicing of geminate clusters of English loanwords in Japanese. In Japanese, voiced geminates occur only in loanwords. The native Yamato stratum has only voiceless geminates but no voiced geminates. English loanwords with a final voiced consonant are borrowed with a voiced geminate and start alternating with voiceless geminates, like e.g. *good* → *guddo~gutto*. Coetzee & Kawahara (2013) show a correlation between familiarity and devoicing: higher familiarity leads to more devoicing. More generally speaking, higher familiarity leads to better integration into Japanese phonology. If, as Coetzee & Kawahara (2013) suggest, familiarity is strongly related to frequency, this would support the idea that in loanword integration Type III frequency effects (opaque structure) are the most likely to occur[13]

(29) *Frequency Type III (opaque structure)*

LF words have opaque linguistic structure and lack a strong unified representation. Therefore they are subject to lexical competition. Depending on the outcome of this competition, they may not be subject to a particular phonological rule.

6.5.2 Frequency effects are sensitive to the grammar

In §6.3, we found that frequency effects are sensitive to the grammar in the sense that Type III frequency effects (opaque structure) occur differently dependent on the stem-initial consonant and the presence of borrowed structure. The frequency values are relative: a /t/-initial word and a /p/-initial word with log lemma frequency 5 behave as an LF word and an MF word, respectively. What is more, in /f/-initial words (the most 'foreign' words), the effect is almost fully blocked, similar to words with initial consonant clusters. This supports hypotheses I and II as introduced in §1.3:

(30) *Hypothesis I*

Frequency effects within a particular variation pattern occur in particular grammatical contexts and are blocked in other grammatical contexts.

(31) *Hypothesis II*

Frequency effects within a particular variation pattern occur in all grammatical contexts, but they are sensitive to the grammatical difference between these contexts.

As assumed in §1.3, these hypotheses are not in conflict, but it is surprising that they occur in the same process. We found a particular reason for the inhibitory effects of /f/- initial and CC-initial words: in both types, borrowed structure is involved.

The observation that frequency effects are relative, i.e. dependent on grammatical structure (here the stem-initial consonant and /f/-initial words), relates to the results found in chapter 5, where frequency effects interacted with the morphological category. This suggests that lexicon and grammar communicate with each other, as advocated in Parallel Architecture, which suggests that structural information becomes available as soon as a word is stored in the lexicon (Jackendoff (1997, 2007)). Relative frequency effects form a topic for

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[13] The supposed strong correlation between familiarity and frequency should be treated with great care, however, since the age of acquisition seems to overrule frequency effects (Barry, Hirsh et al. (2001), Brown & Watson (1987), Morrison & Ellis (1995)).

further research. If frequency effects are generally sensitive to grammatical structure, it may be worthwhile to use relative values for frequency, rather than absolute values, in quantitative studies and probabilistic modelling, which may be more psycholinguistically realistic.

In sum, we proposed that the difference in behaviour between loanwords and native words, regarding coalescence, is captured by EPOT as follows. The lexicon is stratified: words may be labelled as loanwords or native words. Gradually, under the influence of increasing frequency, the words are supposed to be regarded as native: that is, the more frequent the word is, the more integrated it will be integrated (Type III frequency effects). The input for the grammar is labelled as either loanword or native word. Depending on the status, loanword or native, the candidates in OT are either actively or vacuously evaluated by the dominating loanword specific faithfulness constraint.

6.6 Discussion and conclusion

In this chapter, we investigated the factors that predict the variation in coalescence in Dutch loanwords in Indonesian when they are prefixed with *məŋ-* or *pəŋ-*. We found that foreign structure as initial /f/ and initial clusters have a strong negative effect on coalescence (which confirm Hypothesis I). Loanwords without borrowed structures show Type III frequency effects (opaque structure): LF words do not behave conform the grammar, which requires coalescence. Rather, they are faithfully realized. In addition, the frequency of these words appeared to be relative with regard to the subcategory of initial consonants (which confirms Hypothesis II). The fact that frequency is relative to a linguistic subcategory was also attested in chapter 5, where frequency interacted with the morphological category.

We proposed to model the data in EPOT, adopting the lexical OT approach with a stratified lexicon to account for the behaviour of loanwords and native (or fully nativized) words. Dutch loanwords are categorized in the loanword stratum and evaluated by UNIFORMITY-IO(loan), whereas native words are vacuously satisfied by this loanword specific constraint. UNIFORMITY-IO(loan) dominates *NÇ̥, leading to the correct output for loanwords as well as native words. The grammar also accounts for the fact that CC-initial words generally do not undergo coalescence. However, the grammar is unable to explain the frequency effects among the loanwords. Adopting the Exemplar Theoretical approach for lexical modelling, we suggested that listeners store each variant they perceive as either a loanword or a native word. Any non-native structure will lead to categorization in the loanword stratum, these are initial /f/, initial CC clusters, and polysyllabic words (including disyllabic stems which are suffixed). Other words, viz. words without foreign structure, are initially also stored and labelled as a loanword, but as frequency increases, their category slowly changes and they lose their loanword status. The combination of lexical and grammatical modelling accounts for all data. The connection between the lexicon and the grammar crucially depends on the input, the abstraction over the exemplars of a single word which forms the input for the grammar.

Note that this detailed lexical modelling is as important as the grammar. First, the ever-changing lexicon accounts for gradual loanword nativization, and thus gradual change of the lexical category. Second, one of the core properties of the lexicon is categorization (Bybee 2010: 7). The task of the grammar is to apply categorical changes over these well-defined (lexical) categories. Some regular processes or changes, in this case coalescence, are applied over particular categories, viz. native and nativized words starting with /p t k/. This generalization over the native lexicon is expressed by the universal markedness constraint *NÇ̥. The interaction between frequency and grammatical categories is thus captured by EPOT, a hybrid model of a richly specified lexicon in combination with a constraint-based grammar, in which the constraints are to be understood as generalizations over the lexicon. EPOT thus can easily account for the changing lexicon. Sometimes, however, grammar also changes. This is investigated in the next chapter.

One factor may also play a role in this variation, but cannot be investigated at this moment. The date at which the Dutch loanwords entered Indonesian is unknown, and might be a significant factor in the variation. It would also be interesting to investigate coalescence of loanwords in the older Arabic and newer English strata. We leave this for further research. Also, it would be interesting to compare our data with actual spoken language, since the frequency of the written forms on the internet may not always correspond to the spoken data. Moreover, spoken data could provide information on whether variation occurs in individual speakers, and if so, in which proportion, or whether the observed variation is only observed in the language community and not in individual speakers.

Part IV

Discussion and Conclusions

If I look upon

The still mirror of my heart

What there do I see?

Is it the same mind as it was

Yesterday, or is it changed?

Sen no Rikyu 1522-1591

Chapter 8

Discussion & Conclusion

In the light of the division of labour between generative and usage-based approaches in phonology, and the more recent call for hybrid modelling, the goal of this thesis was to investigate the relation between the phonological grammar and the lexicon. The investigation consisted of the collection of more relevant data and on the basis of these findings a further step in phonological hybrid modelling was taken. The relation between the grammar and the lexicon was investigated by examining casestudies in which an interaction between grammar and frequency was attested. Such interactions were found in the variation of the pronunciation of Standard German long vowel <ä>, Dutch loanword integration in Indonesian, and sequential voicing (rendaku) in Japanese. The theoretical framework of this thesis is a combination of Exemplar Theory and Optimality Theory, incorporating the notion of the prototype: the resulting model is referred to as Exemplar Prototype Optimality Theory (EPOT).

This discussion summarizes the results on the basis of previous findings about frequency effects in the literature and the hypotheses as defined in chapter 1 in §8.1. Further, in §8.2, the modelling of the data in EPOT is discussed. The final conclusion is provided in §8.3.

8.1 Results

The findings of this thesis build on prior frequency studies, which have shown that two basic frequency effects can be distinguished in language variation and change, namely frequency effects in analogy and frequency effects in reduction, as defined as follows:

(1) *Type I frequency effects (analogy)*

Frequency of occurrence correlates with analogical change such that HF words are less likely to undergo analogical change and LF words are more likely to undergo analogical change.

(2) *Type II frequency effects (reduction)*

Frequency of occurrence correlates with reduction such that HF words are more likely to undergo reduction and LF words are less likely to undergo reduction.

In general, frequency studies suggest that frequency effects, the differences in pronunciation of similar words which depend only on differences in frequency of occurrence, affect the whole lexicon. On the other hand, grammar is supposed to be blind for frequency. As far as I know, possible interactions between frequency and grammar had not been investigated systematically before. Sporadically, however, some interactions were reported, like Bybee (2002) and Coetzee & Pater (2008) who found that English -t/-d deletion occurs more often in nouns, adjectives, past tense verbs, and monomorphemic words. Through an in-depth statistical analysis of new data, I investigated the exact nature of the interaction between frequency effects and grammar, to shed light on the relation between grammar and lexicon, the content of the input and how the input is derived.

In this thesis, I investigated synchronic categorical variation in Japanese rendaku, synchronic gradient variation in the pronunciation of the long vowel <ä> in the Alemannic variety of Standard German, diachronic categorical variation in coalescence in Dutch loanword integration in Indonesian, and diachronic gradient change in the pronunciation of the long vowel <ä> in Standard German. We found an interaction between frequency and grammar in all four cases. The novel findings can be summarized as follows.

(3) *Type III frequency effects (opaque structure)*

In chapter 4, we investigated Japanese rendaku, which showed that compounds with roots that are lowly frequent in isolation, are less likely to undergo the morphophonological rule of rendaku. Rendaku, voicing of the initial obstruent of the right-hand member of a compound, is a phonological rule which has a number of exceptions. Whereas usually HF words behave idiosyncratically regarding the grammar, in rendaku we found that the exceptions are LF words. Similarly, in chapter 5, we found that in the Alemannic variety of Standard German, the dialectal [eː] as pronunciation for long vowel <ä> is substituted for [ɛː], catalysed by pre-r vowel lowering. HF words in non pre-r contexts which are the result of umlaut, are also lowered, but LF words do not follow this rule. Subsequently, in chapter 6, the integration of Dutch loanwords in Indonesian, clearly shows that HF frequency words change first, which is probably not a reduction effect. Finally, in chapter 7, a three-level frequency effect, of low-, mid-, and high-frequency words, was observed in the change of the long vowel <ä> in Low-Saxon. I suggest that Type III frequency effects are default frequency effects, which occur in the absence of Type I and Type II frequency effects. Type III frequency effects may also combine with Type I frequency, leading to a three-level distinction of HF, MF, and LF words (like in chapter 7 on the long vowel <ä> in Standard German). Type III frequency effects seem to occur when the structure (lexical or grammatical) of a word is opaque.

(4) *Frequency effects are sensitive to the phonological* or *morphological context*

Frequency effects interact with grammar such that, depending on the context, frequency effects may be blocked or different frequency types may co-occur. In Dutch loanwords in Indonesian, we found that Type I frequency effects are blocked in non-native phonological contexts. In Standard German long vowel <ä> lowering, Type I frequency effects occur in non pre-r context and Type II frequency effects occur in pre-r context.

(5) *Frequency is relative depending on the grammatical context*

Within a particular case of variation, we find the same frequency type within subcategories. Words with a frequency *F* may in context α may behave as a relatively LF word, and (other) words with frequency *F* in context β may behave as relatively HF words. Thus, frequency is a relative notion. This was illustrated for coalescence in Dutch loanword integration in Indonesian, where words with a particular frequency value behave as LF words among /t/-initial words, but as HF words among /p/-initial words. I would suggest that future frequency studies carefully investigate whether relative frequency effects occur and, if so, whether it is useful for quantitative studies and probabilistic modelling, to use relative frequency values, rather than absolute frequency values.

In the light of these results, let us evaluate the hypotheses that were formulated in §1.4, repeated below for convenience.

(6) *Hypothesis I*

Frequency effects within a particular variation pattern occur in particular grammatical contexts and are blocked in other grammatical contexts.

Frequency effects may be blocked in a particular grammatical context. Dutch loanwords in Indonesian show a Type III frequency effect (opaque structure), in which HF words change first, except for words that begin with a loan phoneme /f/ of with a consonant cluster. This effect is, however, parasitic upon the fact that words with borrowed structures do not integrate into the native grammar. Words that have non-native structure will hardly be integrated, so there is no variation and hence no frequency effects occur.

(7) *Hypothesis II*

Frequency effects within a particular variation pattern occur in all grammatical contexts, but they are sensitive to the grammatical difference between these contexts.

Dutch loanwords in Indonesian may undergo coalescence, but the proportion of coalesced forms depends on the initial consonant of the stem (which is part of the input for coalescence) and a Type III frequency effect occurs in different subcategories slightly different, on the basis of the stem-initial consonant. So Hypothesis II is confirmed.

(8) *Hypothesis III*

Frequency effects are independent of the grammar.

In none of the studies, frequency effects were independent of the grammar, as explained above In all cases that were investigated in this thesis, variation and change in Standard German long vowel <ä>, Japanese rendaku, and Dutch loanwords in Indonesian, frequency effects were sensitive to the grammar in one way or another. In Standard German long vowel <ä>, pre-r context or non pre-r context determine which frequency type occurs; in the Alemannic variety, we saw an interaction between frequency and umlaut; in Japanese, an interaction between frequency and rendaku has been showed; in Dutch loanwords in Indonesian, an interaction between frequency and coalescence occurred. So Hypothesis III is rejected. But the fact that we did not find grammar-independent frequency effects does not mean, of course, that they do not exist. What the investigation shows is that future variation studies in linguistics should be carried out with more attention for the co-occurrence of grammatical factors and frequency effects.

(9) *Hypothesis IV*

In a particular process of language variation and change, either Type I frequency or Type II frequency applies.

Surprisingly, we found that in German long vowel <ä> lowering, a Type I frequency effect occurred in non pre-r context, and a Type II frequency effect occurred in pre-r context. We also found that it is possible that in non pre-r context, a Type III frequency effect (opaque structure) occurs and in pre-r context, a Type II frequency effect occurs. So Hypothesis IV must be rejected.

Besides these frequency-grammar interactions, we found two other significant facts about language processing. The first is that native coders of linguistic data may be susceptible to halo effects or coder bias. This is an important topic for further investigation, which could have repercussions in all fields of linguistic research that make use of coding or transcription: clinical linguistics, dialectology, fieldwork, second language acquisition, and sociolinguistics. A thorough investigation of this topic should clarify what the scope of coder bias is, to what extent coders may be biased by accent, how coder bias can be avoided, whether experience of the coders diminishes coder bias, whether coders can be trained to avoid coder bias, and, if so, how. The comparison between acoustic and auditory analyses seems a suitable way to investigate coder bias, but more coders have to be investigated, in a more systematic manner.

Furthermore, we found that in the reversal of a merger, orthography may serve as a reference point. This implies that orthography should be represented in the lexicon as well. However, orthography seems to play a role only in case of competition of different forms and in the absence of other decisive cues for the pronunciation. The way orthographical representation is stored must therefore differ from other lexical information. This lexical representation of the phonology-orthography relation is left for future research.

8.2 Exemplar-Prototype-Optimality-Theory (EPOT)

We saw that frequency effects may interact in different ways with grammar. Further, we also found that words that are very infrequent behave differently from words that have a “normal” or high frequency. The results were modelled in Exemplar-Prototype-Optimality-Theory (EPOT): a combined model with a lexicon that can account for frequency effects and with a fully fledged grammar. The lexicon is modelled such that perception of each linguistic item is stored as an exemplar and categorized on the basis of (dis-)similarity between the exemplars, where similarity depends on categorical perception and meaning. Exemplars are stored at different levels, linguistic and non-linguistic, and thus represent fine phonetic detail, sociolinguistic information, and also orthographical information (chapter 2). So far, the EPOT lexicon is identical to ET. However, I suggest that only very infrequent words, or newly perceived words, are stored exclusively in an exemplar-based manner, since when more exemplars are stored, automatically an abstraction is made: a prototype. The prototype may be the “mean” or the “weighted mean” of the category, but this is not necessarily always the case. Psychological experiments have shown that prototype construction also relies on personal relevance and motivation (Sherman 1996). For linguistics, I suggest that, besides frequency, saliency, recency, and new innovative forms that are related to social economic status are factors that could contribute to the construction of a prototype, which is in line with cognitive phonology. Prototypes can also be formed on the basis of analogical networks, in which case they are comparable with underlying forms in generative grammar. The prototypes differ from the usual concept of underlying forms, however, in that they may contain fine phonetic detail and that more prototypes of the same word may be formed. In EPOT, prototypes form the connection between lexicon and grammar, since, on the one hand, they are an abstraction over lexical storage and, on the other hand, they serve as input for the grammar. Fine phonetic detail thus enters the grammar in the input. In chapter 7, I showed that a restriction on GEN, which requires that candidates differ only minimally, but still categorically, can assure that gradiency is retained in the output, which captures the frequency effect in production. Crucially, the grammar itself remains categorical and free from frequency values.

EPOT can account for stable variation as well as diachronic change, or in other words, EPOT functions as a model of the individual language user as well as the language community. Stable variation and loanword integration can be modelled in EPOT as follows. Since LF words are supposed to have opaque morphological, morphophonological, or lexical structure, which makes them susceptible for neighbourhood frequency effects, their linguistic output may vary. Words with higher frequency have stronger prototypes, which behave in a usual, grammatical, way. Diachronic change is accounted for in EPOT in the following way. The initial and final stages of change, as well as the phonological processes during change, are modelled in constraint-based grammar. Like the prototypes, which are abstractions over lexical categories, I also regard constraints as generalizations but over the whole lexicon rather than over exemplars of a single word. Between the initial and final stages of language change, lexical reorganization may occur: each perceived instance is stored as an exemplar and due to changes in category storage, the prototype of the category may change over time. In EPOT, these changes are modelled in the lexical component.

In §1.3.3, I introduced "Grammar as Selection" (van de Weijer (2012)) on which EPOT builds. I outlined some potential problems of GS: lack of empirical evidence, unclear account of stylistic variation, frequency assignment to groups of examplars rather than an account of word frequency, and possibly overrepresentation of frequency. This thesis provided empirical data, and showed that they can easily be modelled in EPOT. Stylistic variation was not accounted for, but works similar as the account for the German data: different prototypes of a single word may exist and occur in the input. Word frequency is accounted for by exemplar modelling, which has a direct inpact on the form of the prototype, so groups of exemplars do neither occur as input nor as candidates in the grammar. Frequency is represented by the exemplar storage but not as constraint weight, so that no overrepresentation of frequency occurs.

8.3 Conclusion

In conclusion, this thesis contributed to hybrid modelling in phonology by data which show a clear interaction between frequency and grammar. There appear to be different frequency-grammar interactions: frequency effects are sensitive to the grammatical context or may be blocked in a certain grammatical context. We unexpectedly found a third frequency type. We also found that orthographical information should be incorporated in the lexical representation. Further, I suggested that lexical storage involves exemplar-based storage as well as prototype storage. The first occurs in new, very infrequent words, the latter occurs in more frequent words. These results were modelled in a combined Exemplar-Prototype-Optimality-Theory. In future research, this model should be tested on the basis of language acquisition, loanword phonology, and other areas of phonology. EPOT can also easily be extended with a probabilistic component.

Further research is also needed to examine Type III frequency effects (opaque structure) and frequency-grammar interactions in more detail. I hypothesize that Type III frequency effects migh generally occur in loanword integration, language acquisition (van de Weijer & Sloos, forthcoming), and stable variation (where it might co-occur with Type I frequency effects). In addition, it should be investigated whether there is neurolinguistic evidence for an exemplar-only based storage for newly acquired and extremely infrequent words, on the one hand, and prototype storage for more frequent words, on the other hand. I hope to have shown in this dissertation that frequency and phonological grammar should be studied simultaneously in order to get a full picture of phonological processing.

Summary

Phonological grammar and frequency: an integrated approach

Language consists of two internal components: the mental lexicon, all memorized morphemes, and the grammar, a set of language rules. In phonology, these two parts are almost always studied independently, viz. usage-based phonology typically investigates the lexicon and generative phonology usually focuses on the grammar. During the last decades, the call for a combined model has gradually become stronger (Ernestus & Baayen (2011), Pierrehumbert (2002), Smolensky & Legendre (2006), van de Weijer (2012)). Hybrid models combine a richly specified lexicon with a fully fledged grammar. The combined models that have been proposed are not yet fully articulated; one of the problems is a lack of data which shows precisely how the lexicon and the grammar are connected. The first goal of this thesis is therefore to gather data which shed light on this relation. Such data are found in language variation and change. Concretely, I observed such frequency-grammar interactions in ongoing vowel change of long <ä> in German, Dutch loanword integration in Indonesian, and in the sequential voicing rule 'rendaku' in Japanese.

Language is continuously changing and does so in a highly systematic way: among other things, language change correlates with lexical frequency. Previous research has shown that two frequency effects can typically be observed in language change (Bybee (2001), Phillips (2006)). Frequency effects of the first type, which are typical for analogical change, begin with low-frequency words and gradually spread to words with higher frequency. Frequency effects of the second type of effect, which are typical for phonological reduction, start with high-frequency words and gradually spread to words with lower frequencies. Both of these kinds of changes involve words, i.e. the lexicon. However, not only do words change, but new phonological rules may also come into existence. How does frequency relate to changes of this kind? The second goal of this thesis is to model these different types of frequency effects as well as the grammar in a combined model.

I used different research methods in order to investigate the interaction between grammar and frequency: corpus research, an experimental study, and an internet-based survey. First, by examining data from a text corpus (BCCWJ 2011), we investigated variation in the Japanese rule of rendaku, i.e. voicing of the initial segment of the right-hand member of a compound. The rule is variable: it occurs in, for instance, *hituzi* + *kusa* → *hituzi-gusa* ‘sheep grass’, but, unexpectedly, does not in *natu+kusa* → *natu-kusa* ‘summer grass’. Secondly, by using the internet as a corpus, we examined variation in Dutch loanwords in Indonesian which are potentially and variably subject to coalescence, or fusion, of the stem-initial consonant and a prefix-final nasal, e.g. *meng-parkir* → *memarkir~memparkir* ‘to park.ACT’. Thirdly, by using a corpus of spoken German (Brinckmann et al. 2008), I investigated variation in the pronunciation of the long vowel <ä> in Standard German, which can be pronounced as [eː] or [ɛː] (or any realization between these two), e.g. B[eː]der~B[ɛː]der ‘bath.PLUR’. Finally, I conducted a production experiment in which I used a novel technique of combining sentence shadowing (immediate repetition of perceived speech), with a phoneme restoration task. The critical stimuli were replaced by noise, but were supposed to be pronounced as usual by the subjects (van der Veer 2006). Further, I invented a methodology to estimate the degree of dialect in spoken data via the internet.

A comparison of the empirical data shows similar patternings regarding frequency and the interaction between frequency and grammar. Generalizing, the three main findings of this research project are the following:

1) We uncovered a third frequency effect (Type III): extremely infrequent words are exceptional with regard to the grammar (Japanese rendaku and German long vowel <ä> lowering).

2) Frequency interacts with the grammar in that, within a single case of variation, and depending on the phonological context, Type I and Type II frequency effects may occur (German long vowel <ä> lowering) or Type I frequency effects are blocked in a particular context (Indonesian coalescence).

3) Frequency is relative depending on the grammatical context: within a certain case of variation, we find the same frequency type within subcategories. But a particular frequency can count as low in one subcategory and as high in another subcategory (Indonesian coalescence).

In conclusion, frequency interacts with grammar. On the other hand, words may be so infrequent that they seem not to conform to the grammar at all. These interactions are modelled in the mainstream models of generative and usage-based phonology: Optimality Theory (OT) and Exemplar Theory (ET), augmented with prototype-based storage, resulting in EPOT (Exemplar-Prototype-Optimality-Theory). EPOT is a model with a richly specified lexicon, including prototypes, combined with a fully fledged grammar. In EPOT, each time a word is perceived, an exemplar is stored in the lexicon. I assume that very infrequent words have exemplars that are loosely connected with each other, but storage of more frequent words, automatically, leads to the construction of a prototype. This prototype forms the input of the grammar. For extremely infrequent words, such a prototype does not exist and, in production, lexical competition occurs between the exemplars, in which the final selection may also be influenced by activation of similar exemplars of other words. This difference between exemplar-based and prototype-based storage explains the Type II frequency effect that we observed. EPOT assumes that the lexicon and the grammar communicate back and forth with each other, which accounts for the fact that frequency effects appear to be relative regarding grammatical categories. Further, in the grammar, there is a restriction on the possible outputs, which that fine phonetic detail between the lexical representation and the final output is maintained. Concerning language change, the initial and final stages of change, as well as the phonological processes during change, are modelled in OT. I assume that the constraints that are used to model the grammar in OT are generalizations across lexical patterns. In between these clearly defined stages, lexical reorganization occurs: the prototypes change over time. The change of the content of the lexicon and the prototypes are modelled in the lexical component of EPOT.

Apart from the fact that this thesis provides more insight in hybrid modelling in phonology, it makes us aware of the fact that frequency may be sensitive to the grammar: in fact, grammar-frequency effects were found in all cases. It shows that future studies on frequency should take the grammar into account in much more detail than in previous studies, and vice versa. Further, the exceptional behaviour of infrequent words must be investigated in more detail, for instance in loanword phonology and language acquisition.

Equally important, although a side result of our investigation into frequency-grammar interaction, is the finding that linguistically trained native coders may be biased in their codings towards an overall accent. The German speech data were categorically analysed by linguistically trained native speakers in either [eː] or [ɛː]. This method—which is often used in linguistic research—was tested for reliability: since perception tests show that listeners can be biased in their judgements of speech sounds by an overall perception of accent (e.g. Hay & Drager (2010)), I tested whether the coders were also biased towards the speakers' accent or not. The categorical analysis was therefore compared to an acoustic analysis of the first and second formant of the vowel. The degree of the speakers' accentedness was quantified by means on an internet-based survey, in which respondents estimated the level of accentedness of the speakers that were coded. The results of the comparison between the categorical and the acoustic analysis led to the conclusion that the coders were indeed biased towards the overall accent. This is certainly a topic for further investigation, which could have repercussions in different fields of linguistics: clinical linguistics, dialectology, fieldwork, second language acquisition, and sociolinguistics.

Samenvatting

Frequentie en fonologische grammatica: een geïntegreerde benadering

Taal bestaat uit twee interne componenten: het mentale lexicon, dat wil zeggen alle gememoriseerde morfemen, en de grammatica, een verzameling taalregels. Gewoonlijk worden in de fonologie frequentie en grammatica gescheiden van elkaar bestudeerd, dat wil zeggen, de gebruiksgebaseerde fonologie richt zich met name op het lexicon en de generatieve fonologie concentreert zich op de klankgrammatica. Gedurende de laatste decennia echter ontwikkelt zich een groeiende behoefte aan een gecombineerd model (Ernestus & Baayen (2011), Pierrehumbert (2002), Smolensky & Legendre (2006), van de Weijer (2012)). Zulke hybride modellen combineren een rijk gespecificeerd lexicon met een volwaardige grammatica. De gecombineerde modellen die tot nu toe zijn voorgesteld, zijn mijns inziens nog niet volledig ontwikkeld; één van de problemen is een tekort aan data die aantonen hoe het lexicon en de grammatica zich precies tot elkaar verhouden. Het eerste doel van deze dissertatie is dan ook om data te verzamelen die deze relatie belichten. Dit soort data is over het algemeen te vinden in taalverandering en taalvariatie. Dit proefschrift belicht vier empirische studies, namelijk klinkerverandering van de lange <ä> zoals in *Bären* 'beren' in het Standaard Duits, en meer specifiek in het Alemannische dialectgebied, de inburgering van Nederlandse leenwoorden in het Indonesisch en een bekende fonologische regel (rendaku) in het Japans.

Taal verandert voordurend en doet dat op een heel systematische manier: zo vinden we onder andere een correlatie met lexicale frequentie. Onderzoek in het verleden heeft aangetoond dat er in principe twee frequentie-effecten kunnen worden geobserveerd in taalvariatie en -verandering (Bybee (2001), Phillips (2006)). Het eerste type frequentie-effect vinden we in analogische verandering. Dit type heeft eerst betrekking op laagfrequente woorden en breidt zich dan successievelijk uit over meer frequente woorden. Het tweede type frequentie-effect komt voor in fonetische en fonologische reductieprocessen. Dit type is eerst te vinden in hoogfrequente woorden en breidt zich geleidelijk uit naar minder frequente woorden. Tijdens fonologische veranderingen kunnen ook fonologische regels ontstaan.

Welke rol speelt frequentie in deze regelvorming? Hoe verhouden frequentie-effecten zich tot de grammatica? Dit brengt ons tot het tweede doel van deze dissertatie: het modelleren van de verschillende frequentietypen en de grammatica in een gecombineerd model.

In dit promotieonderzoek heb ik verschillende methoden gebruikt om de interactie tussen frequentie en grammatica te onderzoeken: corpus onderzoek, een experimentele studie, en onderzoek met behulp van internet. Ten eerste hebben we variatie in rendaku in het Japans onderzocht door middel van een tekstcorpus (BCCWJ 2011). In rendaku wordt een stemloze initiële consonant stemhebbend als hij als rechter lid van een samenstelling voorkomt. Deze regel is variabel: rendaku vindt plaats in, bijvoorbeeld, *hituzi+kusa* → *hituzigusa* 'schaap gras', maar onverwacht niet in bijvoorbeeld *natu+kusa* → *natusukusa* 'zomer gras'. Verder hebben we via internet onderzoek gedaan naar Nederlandse leenwoorden in het Indonesisch, die mogelijkerwijze fusie zouden kunnen ondergaan in een bepaald morfologisch proces. Indonesische woorden kunnen geprefigeerd worden met *meng-*, waarbij de prefix-finale nasaal fuseert met de initiële consonant van de stam. Dit gebeurt ook met Nederlandse leenwoorden, maar niet altijd: zo vinden we *meng-parkir* → *memarkir~memparkir* 'parkeren'. Daarnaast heb ik de variatie van de lange <ä> in het Standaard Duits onderzocht met behulp van een corpus gesproken Duits (Brinckmann et al. 2008). Deze klinker kan worden uitgesproken als een [eː] of een [ɛː], of een realisatie daartussen in. Tenslotte heb ik een experimenteel onderzoek gedaan naar de uitspraak van de lange <ä> in het Standaard Duits in het Alemannisch dialectgebied, waarbij ik een nieuwe onderzoekstechniek heb gebruikt, die schaduwtechniek (onmiddellijke herhaling van waargenomen spraak) combineert met een foneemrestauratie taak. Daarbij waren de kritische stimuli waren vervangen door ruis, maar ze werden wel verondersteld uitgesproken te worden door de luisteraars (van der Veer 2006). Verder heb ik een methode ontwikkeld om via internet de mate van dialect van gesproken data vast te stellen.

Een vergelijking tussen de verschillende empirische studies onthult vergelijkende patronen ten aanzien van frequentie en de interactie tussen frequentie en grammatica. De drie belangrijkste resultaten van dit onderzoeksproject zijn:

1) Een derde frequentie-effect: extreem laag frequente woorden gedragen zich uitzonderlijk ten opzichte van de grammatica in alle deelstudies.

2) Frequentie interacteert met grammatica zodanig dat, in een enkel variatieproces, en afhankelijk van de fonologische context, zowel type 1 frequentie-effecten (analogie) als type 2 frequentie-effecten (reductie) kunnen plaatsvinden (Duits), ofwel dat binnen bepaalde fonologische contexten type 1 frequentie-effecten geblokkeerd worden (Indonesisch).

> 3) Frequentie is relatief binnen een bepaalde grammaticale context: binnen een zeker variatieproces vinden we hetzelfde frequentietype in subcategorieën. Maar een bepaalde frequentiewaarde kan als laag gelden in één fonologische subcategorie en als hoog in een andere subcategorie (Indonesisch).

Samenvattend, frequentie interacteert met grammatica. Aan de andere kant kunnen woorden zo infrequent zijn dat ze zich niet lijken te conformeren aan de grammatica. Deze interacties zijn gemodelleerd in de meest gangbare modellen van gebruiksgebaseerde en generatieve grammatica, respectievelijk Exemplar Theory en Optimaliteitstheorie, uitgebreid met een prototypemodel, resulterende in Exemplar-Prototype-Optimality-Theory (EPOT). In EPOT wordt, iedere keer wanneer men een woord waarneemt, een exemplar opgeslagen in het lexicon. Ik neem aan dat, wanneer een woord heel laag frequent is, de exemplars van dat woord op losse wijze met elkaar verbonden zijn, terwijl in meer frequente woorden automatisch een prototype gevormd wordt. Dit prototype is vervolgens input voor de grammatica. Voor extreem laagfrequente woorden is een prototype niet aanwezig en vindt lexicale competitie tussen de weinige exemplars plaats waarbij de uiteindelijke selectie beïnvloed kan woorden door gelijkvormige exemplars in het lexicon. Deze combinatie van exemplargebaseerde lexicale opslag en prototypegebaseerde lexicale opslag verklaart het derde frequentietype dat we geobserveerd hebben. EPOT neemt aan dat het lexicon en de grammatica in beide richtingen met elkaar communiceren, wat de relatieve frequentie met betrekking tot de grammaticale categorieën verklaart. Wat betreft taalverandering zijn de beginstadia en de eindstadia, zowel als de fonologische processen tijdens de verandering, gemodelleerd in de grammaticale component van EPOT: Optimaliteitstheorie. Ik neem aan dat de constraints die gebruikt worden om de grammatica in Optimaliteitstheorie te modelleren, in wezen generalisaties zijn over het lexicon. Tussen deze duidelijk onderscheiden fasen vindt lexicale reorganisatie plaats, dat wil zeggen, prototypes veranderen in de loop der tijd. Deze veranderingen in het lexicon, inclusief van de protypen, worden gemodelleerd in de lexicale component van EPOT. Opdat de fijne fonetische details van de input behouden blijven, die de frequentie effecten reflecteren, worden er restricties opgelegd aan de mogelijke outputvormen van de grammatica.

Behalve dat deze dissertatie meer inzicht geeft in hybride modellering van de fonologie, maakt het ons bewust van het feit dat frequentie gevoelig is voor de grammatica: grammatica-frequentie interacties zijn in alle deelstudies gevonden. Dit geeft aan dat in toekomstig onderzoek naar frequentie-effecten, grammatica eveneens in ogenschouw moet worden genomen en omgekeerd zal generatief onderzoek zich bewuster moeten worden van frequentie effecten die mogelijkerwijze met de grammaticale categorieën kunnen interacteren. Verder zou het derde frequentietype, waarbij laagfrequente woorden zich aan de grammatica lijken te onttrekken, beter onderzocht moeten worden, bijvoorbeeld in leenwoordfonologie en taalverwerving.

Even belangrijk, alhoewel een neveneffect van dit onderzoek, is het resultaat dat moedertaalsprekers niet betrouwbaar genoeg bleken voor een categoriale analyse van spraakklanken: ze werden duidelijk beïnvloed door het accent van de sprekers die ze moesten beoordelen. De Duitse data zijn categoriaal geanalyseerd in hetzij [eː] of [ɛː] door linguïstisch opgeleide moedertaalsprekers. Deze methode—die vaak gebruikt wordt in dialectologie, sociolinguïstiek, en andere disciplines van taalkundig onderzoek—heb ik getest op betrouwbaarheid. Recente perceptietests hebben namelijk aangetoond dat luisteraars ontvankelijk zijn voor een systematische afwijking in hun beoordeling van individuele spraakklanken op basis van een meer algemene waarneming van het accent van de spreker die ze moeten beoordelen (e.g. Hay & Drager (2010)). Daarom heb ik de categoriale analyse (op basis van de beoordelingen van de luisteraars vergeleken met een akoestische analyse van de eerste en de tweede formant van de klinker. De mate van accent van de sprekers van wie de uitspraak geanalyseerd werd, was gekwantificeerd door middel van een internetenquête. De resultaten van de categoriale en de akoestische analyse leidde tot de conclusie dat de beoordelaars inderdaad in hun keuze beïnvloed werden door het accentniveau van de sprekers. Dit is zeker een onderwerp voor vervolgonderzoek, dat belangrijke gevolgen kan hebben binnen diverse disciplines van taalkundig onderzoek, zoals klinische taalkunde, dialectologie, tweede taalverwerving en sociolinguïstiek.

Zusammenfassung

Die Frequenz und die phonologische Grammatik: Ein integrierter Ansatz

Sprache besteht aus zwei internen Komponenten: Dem mentalen Lexikon, d.h. allen abgespeicherten Morphemen, und der Grammatik, dem Regelsystem einer Sprache. In der Phonologie werden diese beiden Teile fast immer unabhängig voneinander untersucht. Typischerweise fokussiert die gebrauchsbasierte Phonologie das Lexikon, während die generative Phonologie sich auf die Grammatik konzentriert. In den vergangenen Jahrzehnten aber ist die Forderung nach einem kombinierten Modell stetig gestiegen (Ernestus and Baayen (2011), Pierrehumbert (2002), Smolensky und Legendre (2006), van de Weijer (2012)). Hybride Modelle vereinen ein reich spezifiziertes Lexikon mit einer voll entwickelten Grammatik. Die bisher vorliegenden kombinierten Modelle sind allerdings noch nicht voll entwickelt. Eines der Probleme besteht in einem Mangel an Daten, die zeigen, wie das Lexikon und die Grammatik genau miteinander verbunden sind. Das erste Ziel dieser Studie ist daher, Daten zu sammeln, die Aufschluss über diese Verbindung geben; Solche Daten bieten der Sprachwandel und die Sprachvariation. Einblick in solche Frequenz-Grammatik-Interaktionen bieten derzeitig stattfindender Vokalwandel des langen <ä> im Deutschen, die Integration niederländischer Lehnwörter im Indonesischen und die Sequential Voicing Rule ‚rendaku' im Japanischen.

Sprache verändert sich ständig und tut dies auf sehr systematische Weise. Unter anderem korreliert Sprachwandel mit lexikalischer Frequenz. Vorherige Studien haben gezeigt, dass gewöhnlich zwei Frequenzeffekte im Sprachwandel beobachtet werden können (Bybee (2001), Phillips (2006)). Frequenzeffekte des ersten Typs, typisch für analogischen Wandel, beginnt mit niedrigfrequenten Wörtern und breitet sich schrittweise auf Wörter mit höherer Frequenz aus. Frequenzeffekte des zweiten Typs, typisch für phonologische Reduktion, beginnt mit hochfrequenten Wörtern und breitet sich schrittweise auf Wörter mit niedrigerer Frequenz aus. Beide Typen der Frequenzeffekte betreffen Wörter, also das Lexikon. Allerdings verändern sich nicht nur Wörter, sondern es entstehen auch neue phonologische Regeln. Wie verhält sich die Frequenz zu dieser Art des Wandels? Das zweite Ziel dieser Studie besteht darin, diese verschiedenen Arten der Frequenzeffekte sowie die Grammatik in einem kombinierten Modell zu modellieren.

Es wurden verschiedene Forschungsmethoden verwendet, um die Interaktion zwischen Grammatik und Frequenz zu untersuchen: Korpusrecherche, eine experimentelle Studie und eine internetbasierte Erhebung. Zuerst wurde auf der Grundlage eines Textkorpus (BCCWJ 2011) Variation in der japanischen rendaku-Regel untersucht, die die Stimmhaftigkeit des initialen Segments des Zweitglieds eines Kompositums betrifft. Die Regel ist variabel: Sie tritt z.B. auf in *hituzi+kusa* → *hituzi-gusa* 'Schafgras', unerwarteterweise aber nicht in *natu+kusa*→ *natu-kusa* 'Sommergras'. Als zweites wurde mithilfe des Internets als Textkorpus Variation in niederländischen Lehnwörtern im Indonesischen untersucht. Diese Lehnwörter unterliegen potentiell und variabel einer Koaleszenz oder Verschmelzung des stamminitialen Konsonanten mit einem präfixfinalen Nasal, z.B. *meng-parkir* → *memarkir~memparkir* 'parken.ACT'. Als drittes wurde auf Grundlage eines Korpus von gesprochenem Deutsch (Brinckmann et al. 2008) Variation in der Aussprache des Langvokals <ä> im Standarddeutschen, welcher als [eː] oder [ɛː] (oder als eine Realisierung zwischen diesen beiden) realisiert werden kann, z.B. B[eː]der~B[ɛː]der 'das Bad.PLUR'. Abschließend wurde ein Produktionsexperiment durchgeführt. In einer neuen Technik wurden hierbei sentence shadowing (die unmittelbare Wiederholung wahrgenommener Sprache) mit Phonemrestauration kombiniert, wobei die relevanten Stimuli durch Geräusche ersetzt wurden, dabei von den Teilnehmern aber auf gewöhnliche Weise ausgesprochen werden sollten (van der Veer 2006).

Ein Vergleich der empirischen Daten zeigt ähnliche Muster mit Blick auf Frequenz und die Interaktion zwischen Frequenz und Grammatik. Die drei Hauptbefunde dieses Forschungsprojekts sind insgesamt die Folgenden:

1) Ermittelt werden konnte ein dritter Frequenzeffekt (Typ III): Extrem niedrig frequente Wörter verhalten sich mit Blick auf die Grammatik auffällig (rendaku im Japanischen und die Absenkung des Langvokals <ä> im Deutschen).

2) Frequenz interagiert mit der Grammatik insofern als innerhalb ein- und desselben Falls von Variation und abhängig vom phonologischen Kontext Frequenzeffekte der Typen I und II auftreten können (Absenkung des Langvokals <ä> im Deutschen) oder Frequenzeffekte des Typs I in einem bestimmten Kontext blockiert sein können (Koaleszenz im Indonesischen).

3) Frequenz verhält sich unterschiedlich je nach grammatischem Kontext: Innerhalb eines bestimmten Falls von Variation ist derselbe Frequenztyp innerhalb von Subkategorien anzutreffen. Aber dieselbe Frequenz kann innerhalb einer Kategorie als niedrig und in einer anderen als hoch gelten (Koaleszenz im Indonesischen).

Insgesamt zeigt sich, dass Frequenz mit der Grammatik interagiert. Andererseits können Wörter so niedrigfrequent sein, dass sie der Grammatik gar nicht zu unterliegen scheinen. Diese Interaktionen werden in Mainstream-Modellen generativer und gebrauchsbasierter Phonologie modelliert: Optimalitätstheorie (OT), Exemplartheorie (ET), erweitert um prototypenbasierte Speicherung, resultierend in EPOT (Exemplar-Prototype-Optimality-Theory). EPOT ist ein Modell mit einem reich spezifizierten Lexikon, das Prototypen enthält, kombiniert mit einer voll entwickelten Grammatik. In EPOT wird jedes Mal, wenn ein Wort wahrgenommen wird, ein Exemplar im Lexikon abgespeichert. Es wird davon ausgegangen, dass sehr niedrigfrequente Wörter Exemplare haben, die lose miteinander verbunden sind, aber die Abspeicherung eines frequenteren Worts führt zur Konstruktion eines Prototypen. Dieser Prototype stellt den Input der Grammatik dar. Für extrem niedrigfrequente Wörter existiert kein solcher Prototyp und bei der Produktion kommt es zu lexikalischer Konkurrenz zwischen den Exemplaren, wobei die endgültige Auswahl auch durch die Aktivierung ähnlicher Exemplare beeinflusst werden kann. Diese Kombination exemplarbasierter und prototypbasierter Abspeicherung erklärt den beobachteten Frequenzeffekt des Typs III. EPOT geht davon aus, dass das Lexikon und die Grammatik miteinander kommunizieren, was erklärt, dass Frequenzeffekte sich je nach grammatischer Kategorie unterscheiden. Weiterhin existiert in der Grammatik eine Restriktion bezüglich der möglichen Outputs, sodass feine phonetische Details zwischen der lexikalischen Repräsentation und dem endgültigen Output aufrechterhalten werden.

In Bezug auf Sprachwandel werden die initiale und finale Phase des Wandels sowie die phonologischen Prozesse während des Wandels in OT modelliert. Es wird davon ausgegangen, dass die constraints die verwendet werden, um die Grammatik in OT zu modellieren, Generalisierungen über lexikalische Muster sind. Zwischen diesen klar definierten Phasen kommt es zu lexikalischer Reorganisation: Die Prototypen verändern sich im Laufe der Zeit.

Der Wandel des Inhalts des Lexikons und der Prototypen werden in der lexikalischen Komponente von EPOT modelliert. Die vorliegende Studie verschafft mehr Einblick in hybride Modellierungen in der Phonologie und macht darauf aufmerksam, dass Frequenz sensitiv gegenüber der Grammatik ist: Grammatik-Frequenz-Interaktion wurden in allen Fällen entdeckt. Dies zeigt, dass zukünftige Studien zu Frequenz die Grammatik detaillierter berücksichtigen müssen als bisher. Gleiches gilt umgekehrt. Weiterhin muss das außergewöhnliche Verhalten niedrigfrequenter Wörter näher untersucht werden, zum Beispiel in der Lehnwortphonologie.

Genauso wichtig, wenngleich ein Nebenergebnis dieser Untersuchung zur Frequenz-Grammatik-Interaktion, ist der Befund, dass linguistisch geschulte muttersprachliche Kodierende bei ihrer Kodierung durch die Akzentstärke des Sprechers beeinflusst werden können. Die deutschen Sprachdaten wurden von linguistisch geschulten Muttersprachlern kategorisch als entweder [eː] oder [ɛː] analysiert. Diese Methode—die in der Linguistik sehr häufig angewended wird—wurde auf ihre Reliabilität hin überprüft: Da Perzeptionstests zeigen, dass Hörer in ihrer Wahrnehmung von Sprechlauten durch die allgemeinere Wahrnehmung eines Akzents beeinflusst werden können (z.B. Hay and Drager (2010)), wurde überprüft, ob die Kodierenden durch den Akzent des Sprechers beeinflusst wurden. Die kategorische Analyse wurde deshalb mit einer akustischen Analyse des ersten und zweiten Formanten des Vokals verglichen. Die Akzentstärke wurde mithilfe einer internetbasierten Erhebung quantifiziert, in der die Teilnehmer die Akzentstärke der kodierten Sprecher einschätzten. Die Ergebnisse des Vergleichs zwischen der kategorischen und der akustischen Analyse führten zu dem Schluss, dass die Hörer tatsächlich durch die Akzentstärke des Sprechers beeinflusst wurden. Dies ist sicher ein Thema für weitere Untersuchungen, das Auswirkungen auf verschiedene Felder der Linguistik haben könnte, wie etwa die klinische Linguistik, Dialektologie, Feldarbeit und Zweitspracherwerb.

Appendices

Appendix A (chapter 3) The degree of accentedness of all Swiss speakers

Degree of accentedness stratified by place, gender, and age. Highest possible score is 4, which correlates with the most northern Standard German pronunciation.

	Location	*Gender*	*Age*	
1	Basel	f	y	2.40
2	Basel	f	y	3.60
3	Basel	m	y	2.50
4	Basel	m	y	1.85
5	Basel	m	o	2.95
6	Basel	m	o	2.95
7	Biel/Bern	f	y	3.50
8	Biel/Bern	f	y	2.05
9	Biel/Bern	m	y	1.20
10	Biel/Bern	m	o	2.40
11	Biel/Bern	f	o	1.50
12	Bludenz	m	y	2.60
13	Bludenz	m	y	2.40
14	Bludenz	f	y	3.30
15	Bludenz	f	y	2.10
16	Bludenz	m	o	2.05
17	Bludenz	f	o	2.60
18	Brig	m	y	3.40
19	Brig	f	y	3.40
20	Brig	m	y	1.75
21	Brig	m	o	2.25
22	Brig	m	o	2.25
23	Luzern/Willisau	f	y	2.06
24	Luzern/Willisau	f	y	1.25
25	Luzern/Willisau	m	y	3.65
26	Luzern/Willisau	m	y	1.95
27	Luzern/Willisau	m	o	2.00
28	Luzern/Willisau	f	o	1.70
29	Vaduz	m	y	3.47
30	Vaduz	f	y	3.25
31	Vaduz	f	y	2.30
32	Vaduz	m	y	1.85
33	Vaduz	m	o	1.65
34	Vaduz	f	o	2.85
35	Zurich	m	y	3.45
36	Zurich	m	y	1.58
37	Zurich	f	y	3.50
38	Zurich	f	y	2.50
39	Zurich	f	o	1.55
40	Zurich	m	o	1.63

Appendix B (chapter 5): Stimulus material experiment

	Sentence	*Stimulus*	*Context*	*Tauto-syllabic*	*Word Cat*	*Token Freq *1000*	*LOG Token Freq*
1	Viele Menschen die zu dick sind, hoffen, dass das Befolgen einer Diät ihnen hilft.	Diät	_t	TRUE	Stem	3270	3,515
2	Frauen, die schwanger sind, machen sich oft Gedanken darüber, ob es ein Junge oder ein Mädchen sein wird.	Mädchen	_t	TRUE	Stem	25100	4,400
3	Eine Lösung für ein Problem zu finden bringt Freude. Sogar die Kinder lösen gerne ein einfaches Rätsel auf.	Rätsel	_t	TRUE	Stem	5170	3,713
4	Ein neues Fahrrad, ein neues Auto, ein Boot, und dann ein Flugzeug, der Mensch wünscht sich immer ein größeres Gefährt.	Gefährt	_r	TRUE	Stem	435	2,638
5	Für die Informationen im Internet, wird oft keine Gewähr übernommen.	Gewähr	_r	TRUE	Stem	23600	4,373
6	Den Kindern liest man abends vor dem Schlafengehen gerne noch ein Märchen vor.	Märchen	_r	TRUE	Stem	4490	3,652
7	Aus Milch werden Butter, Joghurt und Käse gemacht.	Käse	_s	FALSE	Stem	4310	3,634
8	Ein männlicher Löwe unterscheidet sich von einem weiblichen Löwen durch eine Mähne.	Mähne	_n	FALSE	Stem	253	2,403
9	In jedem Haushalt sollten zumindest ein Hammer, ein Schraubenzieher und eine Säge zu finden sein.	Säge	_g	FALSE	Stem	8950	3,952
10	Im Mittelalter wurden oft nach dem Tod eines Menschen seine Knochen und sein Schädel aufbewahrt.	Schädel	_d	FALSE	Stem	978	2,990
11	Menschen spielen verschiede Rollen im Alltagsleben: In öffentlichen Bereichen verhalten sie sich anders als in der privaten Sphäre zu Hause.	Sphäre	_r	FALSE	Stem	1030	3,013
12	Nicht nur bei Trauer, sondern auch bei Freude kann das Auge eine Träne absondern.	Träne	_n	FALSE	Stem	346	2,539
13	Am Feiertag haben die meiste Läden zu.	Läden	_d	FALSE	Plur	2290	3,360
14	Für verschiedene Getränke werden auch verschiedene Gläser benutzt.	Gläser	_z	FALSE	Plur	1240	3,093
15	In den alten Friedhöfen sind oft sehr schöne Gräber zu finden.	Gräber	_b	FALSE	Plur	750	2,875
16	Viele Menschen leiden unter Heuschnupfen-das ist eine Allergie gegen die Blüten der Gräser.	Gräser	_z	FALSE	Plur	591	2,772
17	Rotterdam, Antwerpen und Hamburg haben die drei größten Häfen Europas.	Häfen	_f	FALSE	Plur	2100	3,322
18	Das Verdauungssystem von Menschen und Tieren kann sehr unterschiedlich sein: Zum Beispiel haben Kühen sogar vier Mägen, während die meisten anderen Tiere nur einen haben.	Mägen	_g	FALSE	Plur	88	1,944

	Sentence	*Stimulus*	*Context*	*Tauto-syllabic*	*Word Cat*	*Token Freq *1000*	*LOG Token Freq*
19	Viele Probleme mit den Füssen entstehen dadurch dass man nicht rechtzeitig die Nägel versorgt.	Nägel	_g	FALSE	Plur	1380	3,140
20	Wichtig für den Hobbyschneider; Gerade und schöne Nähte sind nur dann richtig, wenn sie nicht auffallen.	Nähte	_t	FALSE	Plur	1110	3,045
21	In Strassburg und Brüssel kommen regelmäßig die EU Nationalräte zusammen.	Räte	_t	FALSE	Plur	144	2,158
22	Wenn Freunde beim Umzug helfen, kommt ihre Haftpflichtversicherung im Ernstfall nicht für Schäden auf.	Schäden	_d	FALSE	Plur	37200	4,571
23	Die größten Wasservögel in Deutschland sind die Schwäne. Sie können eine Flügelspannweite von zwei Metern vierzig haben.	Schwäne	_n	FALSE	Plur	277	2,442
24	Es ist heutzutage fast üblich, dass zu einem Elternabend in der Schule, nicht nur die Mütter, sondern auch die Väter kommen.	Väter	_t	FALSE	Plur	3790	3,579
25	In Worms ist für Behinderte und ältere Menschen eine zusätzliche Verkehrsverbindung zum Zoo eingerichtet. Die Fahrt mit dem Bähnchen kostet nur drei Euro.	Bähnchen	_n	TRUE	Dim	27	1,431
26	Die beliebtesten Geflügelrezepte betreffen wohl Hähnchen.	Hähnchen	_n	TRUE	Dim	776	2,890
27	Babys weinen manchmal sehr viel, wenn sie die ersten Zähnchen bekommen.	Zähnchen	_n	TRUE	Dim	103	2,013
28	Babys werden meist kahl geboren, aber manche haben bei der Geburt schon kleine Härchen.	Härchen	_r	TRUE	Dim	139	2,143
29	Wenn man aus den Ferien heim kommt, will man oft gleich wieder zurück fahren, aber die meisten müssen doch noch ein Paar Monaten oder ein Jährchen warten.	Jährchen	_r	TRUE	Dim	168	2,225
30	Im Mittelalter wurden adlige Kinder oft schon sehr jung verheiratet: So ein junges Pärchen wohnte dann meist im Haus des Bräutigams bis beide erwachsen waren.	Pärchen	_r	TRUE	Dim	1700	3,230
31	Für ein Hauskonzert braucht man nicht viel Raum: Ein Wohnzimmer oder ein kleines Sälchen in einem Gasthaus reichen aus.	Sälchen	_l	TRUE	Dim	10	1,000
32	Die Japaner trinken gerne Reiswein, Sake genannt, und zwar aus einem sehr kleinen Schälchen und nicht aus einem Glas.	Schälchen	_l	TRUE	Dim	182	2,260
33	Ein schlangenartiger fetter Fisch heißt Aal. Seine kleinen Kinder würden Älchen heißen.	Älchen	_l	TRUE	Dim	1,52	0,182
34	Am faserigen Stück Stoff hängen viele Fädchen.	Fädchen	_t	TRUE	Dim	109	2,037
35	Ein dickes Kabel besteht immerhin aus einer Menge feiner, dünner Drähtchen, die zusammen unglaublich stark sind.	Drähtchen	_t	TRUE	Dim	53	1,724
36	In großen Organizationen fühlen sich die Mitarbeiter oft wie ein kleines Rädchen in einem Uhrwerk.	Rädchen	_t	TRUE	Dim	515	2,712

Appendix C (chapter 6): Database Indonesian

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
1	forsir	forceren	N	N	2	2	0.21
2	forsirkan	forceren	N	Y	2	3	3.85
3	perleng	verlengen	N	N	2	2	0
4	perlengkan	verlengen	N	Y	2	3	0
5	fabrik	fabriek	N	N	2	2	0.02
6	fabrikasi	fabrikage	N	N	3	3	0
7	fabrikkan	fabriek	N	Y	2	3	100
8	fakultas	faculteit	N	N	3	3	0
9	familiair	familiair	N	N	3	3	0
10	fanatik	fanatiek	N	N	3	3	4.17
11	fantasi	fantasie	N	N	3	3	0
12	faset	facet	N	N	2	2	1.49
13	fasetkan	facet	N	Y	2	3	0
14	fasilitas	faciliteit	N	N	3	3	0.03
15	favorit	favoriet	N	N	3	3	0
16	feminisme	feminisme	N	N	3	3	0
17	fenomen(a)	fenomeen	N	N	3	3	0
18	fermen	ferment	N	N	2	2	0
19	fermenkan	ferment	N	Y	2	3	0
20	fermentasi	fermentatie	N	N	3	3	0
21	fiasko	fiasco	N	N	3	3	0
22	fiat	fiat	N	N	2	2	0
23	fiatkan	fiat	N	Y	2	3	0
24	figur	figuur	N	N	2	2	6.94
25	figurkan	figuur	N	Y	2	3	0.47
26	fiksi	fictie	N	N	2	2	0
27	fiksikan	fictie	N	Y	2	3	0.22
28	fiktif	fictief	N	N	2	2	2.78
29	fiktifkan	fictief	N	Y	2	3	3.23
30	filantrop	filantroop	N	N	3	3	0
31	filatelis	filatelist	N	N	3	3	0
32	filial	filiaal	N	N	3	3	0
33	filmkan	film	N	Y	1	2	0.02
34	filologi	filologie	N	N	3	3	0
35	filter	filter	N	N	2	2	0.01
36	filterkan	filter	N	Y	2	3	0
37	firus	virus	N	N	2	2	0.81
38	firuskan	virus	N	Y	2	3	100

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
39	fisik	fysiek	N	N	2	2	0
40	fisikkan	fysiek	N	Y	2	3	20
41	fiskus	fiscus	N	N	2	2	0
42	fiskuskan	fiscus	N	Y	2	3	0
43	fitkan	fit	N	Y	1	2	3.13
44	flatkan	flat	Y	Y	1	2	0
45	fokus	focus	N	N	2	2	0.01
46	fokuskan	focus	N	Y	2	3	0.46
47	folder	folder	N	N	2	2	2.22
48	folderkan	folder	N	Y	2	3	0
49	foli	folie	N	N	2	2	88.27
50	folikan	folie	N	Y	2	3	0
51	folio	folio	N	N	3	3	50.26
52	fork	vork	N	N	1	2	0
53	formalin	formaline	N	N	3	3	0
54	formasi	formatie	N	N	3	3	0
55	formulasi	formulering	N	N	3	3	0
56	formulir	formulier	N	N	3	3	0
57	fortifikasi	fortificatie	N	N	3	3	0
58	foto	foto	N	N	2	2	15.86
59	fotokan	foto	N	Y	2	3	13.51
60	fotokopi	fotokopie	N	N	3	3	1.36
61	fotomodel	fotomodel	N	N	3	3	0
62	foton	foton	N	N	2	2	0
63	fotonkan	foton	N	Y	2	3	0
64	foya-foya	fooi	N	N	2	2	0
65	frais	frees	Y	N	2	2	0
66	fraiskan	frees	Y	Y	2	3	0
67	fuli	foelie	N	N	2	2	59.1
68	fulikan	foelie	N	Y	2	3	100
69	fumigasi	fumigatie	N	N	3	3	0
70	fungsi	functie	N	N	2	2	0.44
71	fungsikan	functie	N	Y	2	3	1.55
72	fusi	fusie	N	N	2	2	0
73	fusikan	fusie	N	Y	2	3	10.45
74	kader	kader	N	N	2	2	9.6
75	kaderkan	kader	N	Y	2	3	1.48
76	kalibrasi	kalibratie	N	N	3	3	6.01
77	kalkulasi	calculatie	N	N	3	3	10.44
78	kampanye	campagne	N	N	3	3	17.18

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
79	kanalisasi	kanalisatie	N	N	3	3	83.12
80	kanibal	kannibaal	N	N	3	3	6.03
81	kantor;kanokat	kantoor	N	N	2	2	98.88
82	kantorkan	kantoor	N	Y	2	3	94.44
83	karantina	quarantaine	N	N	3	3	52.84
84	kartel	kartel	N	N	2	2	0.27
85	kartelkan	kartel	N	Y	2	3	0
86	katalisis	katalyse	N	N	3	3	2.98
87	klaim	claim	Y	N	2	2	0.06
88	klaimkan	claim	Y	Y	2	3	0
89	klasifikasi	classificatie	Y	N	3	3	10.46
90	klopkan	klop	Y	Y	1	2	0
91	kode	code	N	N	2	2	0.96
92	kodekan	code	N	Y	2	3	6.7
93	kolaborasi	collaboratie	N	N	3	3	27.7
94	koleksi	collectie	N	N	3	3	75.84
95	kolonisasi	kolonisatie	N	N	3	3	18.94
96	komando	commando	N	N	3	3	70.28
97	kombinasi	combinatie	N	N	3	3	7.37
98	komentar	commentaar	N	N	3	3	99.97
99	kompas	kompas	N	N	2	2	91.84
100	kompaskan	kompas	N	Y	2	3	25
101	kompensasi	compensatie	N	N	3	3	11.09
102	kompilasi	compilatie	N	N	3	3	25.88
103	komposisi	compositie	N	N	3	3	23.96
104	kompres	kompres	N	N	2	2	54.58
105	kompresi	compressie	N	N	3	3	47.85
106	kompreskan	kompres	N	Y	2	3	99.75
107	koneksi	connectie	N	N	3	3	2.67
108	konfigurasi	configuratie	N	N	3	3	1.48
109	konfirmasi	confirmatie	N	N	3	3	14.9
110	konfrontasi	confrontatie	N	N	3	3	21.22
111	konfrontir	confronteren	N	N	3	3	2.95
112	konsentrir	concentreren	N	N	3	3	4.35
113	konsep	concept	N	N	2	2	39.52
114	konsepkan	concept	N	Y	2	3	16.62
115	konservasi	conservatie	N	N	3	3	28.66
116	konsolidir	consolideren	N	N	3	3	0.05
117	konstatir	constateren	N	N	3	3	9.94
118	konstruksi	constructie	N	N	3	3	12.15
119	konsumsi	consumptie	N	N	3	3	31.29
120	kontak	contact	N	N	2	2	82.3
121	kontakkan	contact	N	Y	2	3	99.85

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
122	kontaminasi	contaminatie	N	N	3	3	30.9
123	kontra	contra	N	N	2	2	1.61
124	kontrakan	contra	N	Y	2	3	80.83
125	kontribusi	contributie	N	N	3	3	54.22
126	kontrol	controle	N	N	2	2	87.99
127	kontrolkan	controle	N	Y	2	3	98.75
128	konversi	conversie	N	N	3	3	3.44
129	koordinasi	coordinatie	N	N	3	3	14.27
130	koordinir	coordineren	N	N	3	3	1.33
131	korek	correct	N	N	2	2	98.09
132	korekkan	correct	N	Y	2	3	0.17
133	koreksi	correctie	N	N	3	3	69.14
134	korting	korting	N	N	2	2	17.38
135	kortingkan	korting	N	Y	2	3	0
136	korup	corrupt	N	N	2	2	48.94
137	korupkan	corrupt	N	Y	2	3	1.59
138	kredit	krediet	Y	N	2	2	1.4
139	kreditkan	krediet	Y	Y	2	3	0.49
140	kritik	kritiek	Y	N	2	2	5.3
141	kritikkan	kritiek	Y	Y	2	3	0.37
142	kualifikasi	kwalificatie	N	N	3	3	22.36
143	kultus	cultus	N	N	2	2	0.34
144	kultuskan	cultus	N	Y	2	3	9.3
145	kurskan	kurs	N	Y	1	2	0
146	pabrikasi	fabricage	N	N	3	3	1.57
147	pakum	vacuuem	N	N	2	2	3.65
148	pakumkan	vacuuem	N	Y	2	3	85.71
149	paraf	paraaf	N	N	2	2	83.6
150	parafkan	paraaf	N	Y	2	3	86.36
151	parasit; parokas	parasiet	N	N	3	3	79.66
152	parkir	parkeren	N	N	2	2	99.3
153	parkirkan	parkeren	N	Y	2	3	97.64
154	penetrasi	penetratie	N	N	3	3	21.01
155	pengkulturan	cultuur	N	N	2	3	3.63
156	pengkulturankan	cultuur	N	Y	2	3	0
157	pentil	ventiel	N	N	2	2	98.68
158	pentilkan	ventiel	N	Y	2	3	2.65
159	perbal	verbaal	N	N	2	2	4.55
160	perbalkan	verbaal	N	Y	2	3	0
161	perban	verband	N	N	2	2	16.63
162	perbankan	verband	N	Y	2	3	2.5
163	pergol	verguld	N	N	2	2	100
164	pergolkan	verguld	N	Y	2	3	0

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
165	perlak	verlakt	N	N	2	2	0.17
166	perlakkan	verlakt	N	Y	2	3	4.79
167	permak	vermaken	N	N	2	2	0.58
168	permakkan	vermaken	N	Y	2	3	64.29
169	pernis	vernis	N	N	2	2	14.25
170	perniskan	vernis	N	Y	2	3	0
171	persepsi	perceptie	N	N	3	3	3.6
172	plagiat	plagiaat	Y	N	3	3	0.33
173	polarisasi	polarisatie	N	N	3	3	16.9
174	politikus	politicus	N	N	3	3	0
175	potret	portret	N	N	2	2	99.92
176	potretkan	portret	N	Y	2	3	79.37
177	praktek	praktijk	Y	N	2	2	6.3
178	praktekkan	praktijk	Y	Y	2	3	0.36
179	produk	product	Y	N	2	2	0.1
180	produkkan	product	Y	Y	2	3	0
181	produsir	produceren	Y	N	3	3	0
182	program	programma	Y	N	2	2	53.07
183	programkan	programma	Y	Y	2	3	31.56
184	propaganda	propaganda	Y	N	3	3	99.61
185	proses	proces	Y	N	2	2	34.15
186	proseskan	proces	Y	Y	2	3	0.03
187	proteksi	protectie	Y	N	3	3	0.13
188	protes	protest	Y	N	2	2	30.1
189	proteskan	protest	Y	Y	2	3	0
190	publik	publiek	N	N	2	2	49.68
191	publikasi	publicatie	N	N	3	3	4.83
192	publikkan	publiek	N	Y	2	3	36.84
193	teken	tekenen	N	N	2	2	99.87
194	tekenkan	tekenen	N	Y	2	3	100
195	teror	terreur	N	N	2	2	69.72
196	terorkan	terreur	N	Y	2	3	96.98
197	tolerir	tolereren	N	N	3	3	16.35
198	tradisi	traditie	Y	N	3	3	0.34
199	traktir	trakteren	Y	N	2	2	4.7
200	traktirkan	trakteren	Y	Y	2	3	25
201	transformasi	transformatie	Y	N	3	3	50
202	transfusi	transfusie	Y	N	3	3	0.33
203	transkripsi	transcriptie	Y	N	3	3	0
204	transmisi	transmissie	Y	N	3	3	0.04
205	transpor	transport	Y	N	2	2	0.01
206	transporkan	transport	Y	Y	2	3	0
207	trapkan	trap	Y	Y	1	2	0

Item	Word	Dutch	Initial Cluster	Suffix	Number of syllables of the root	Number of syllables of the stem	Lemma Frequency
208	tripkan	trip	Y	Y	1	2	0
209	vaksin	vaccin	N	N	2	2	0.71
210	vaksinasi	vaccinatie	N	N	3	3	0.4
211	vaksinkan	vaccin	N	Y	2	3	0.48
212	validasi	validatie	N	N	3	3	0
213	valuta	valuta	N	N	3	3	0
214	vandal	vandaal	N	N	2	2	1.66
215	vandalkan	vandaal	N	Y	2	3	0
216	variasi	variatie	N	N	3	3	0
217	vegetaris	vegetarisch	N	N	3	3	0
218	vegetasi	vegetatie	N	N	3	3	0
219	vegetatif	vegetatief	N	N	3	3	0
220	velodrom	velodroom	N	N	3	3	0
221	ventrikel	ventrikel	N	N	3	3	0
222	verifikasi	verificatie	N	N	3	3	0.08
223	verjaring	verjaring	N	N	3	3	0
224	versi	versie	N	N	2	2	76.65
225	versikan	versie	N	Y	2	3	0.63
226	veteran	veteraan	N	N	3	3	0
227	veto	veto	N	N	2	2	0
228	vetokan	veto	N	Y	2	3	60
229	viaduk	viaduct	N	N	3	3	0
230	vibrasi	vibratie	N	N	3	3	2.68
231	vinil	vinyl	N	N	2	2	0
232	vinyet	vignet	N	N	2	2	0
233	vinyetkan	vignet	N	Y	2	3	0
234	visi	visie	N	N	2	2	0
235	visikan	visie	N	Y	2	3	22.8
236	visualisasi	visualisatie	N	N	3	3	0
237	visum	visum	N	N	2	2	0
238	visumkan	visum	N	Y	2	3	0
239	voli	volley	N	N	2	2	0
240	volikan	volley	N	Y	2	3	0
241	vonis	vonnis	N	N	2	2	23.48
242	voniskan	vonnis	N	Y	2	3	0
243	vulkan	vulkaan	N	N	2	2	0
244	vulkanisir	vulkaniseren	N	N	3	3	0
245	vulkankan	vulkaan	N	Y	2	3	0

Appendix D (chapter 7): Results frequency-grammar interactions in Standard German long vowel <ä>

Mixed-effects models after model comparison of the data in the corpus "German Today".

Austria

```
Random effects:
 Groups    Name        Variance    S.D.
 Recording (Intercept)  47.49    6.891
 Residual              274.76  16.576
Number of obs: 377, groups: Interview, 27

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)               84.68   2.518     33.63
rContext                 -11.40   3.053     -3.73
LemmaFrequency             0.002  0.004      0.40
rContext:LemmaFrequency  -0.009   0.005     -1.84
```

Bavarian

```
Random effects:
 Groups    Name          Variance   S.D.
 Recording (Intercept)    81.13  9.007
 Residual               231.45 15.213
Number of obs: 628, groups: Interview, 41

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)              73.630   2.521    29.209
gender-male              -6.706   3.163    -2.120
rContext                  1.724   2.415     0.714
LemmaFrequency            0.011   0.003     3.513
rContext:LemmaFrequency  -0.013   0.003    -4.055
```

East Low German

```
Random effects:
 Groups    Name          Variance   S.D.
 Recording (Intercept)   130.27  1.414
 Residual               217.51 14.748
Number of obs: 500, groups: Interview, 35

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)               79.95   2.470     32.37
rContext                 -26.73   2.640    -10.12
LemmaFrequency            0.001  <0.001      0.34
rContext:LemmaFrequency  <0.001  <0.001     -0.06
```

```
High Franconian

Random effects:
 Groups    Name        Variance    S.D.
 Recording (Intercept)    69.42   8.332
 Residual                225.93  15.031
Number of obs: 570, groups: Interview, 35

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)               74.257   2.998   24.771
age-young                -11.214   3.343   -3.354
rContext                  -8.401   2.371   -3.544
LemmaFrequency             0.012   0.003    3.695
rContext:LemmaFrequency   -0.014   0.004   -4.042
```

```
Low Saxon

Random effects:
 Groups    Name        Variance    S.D.
 Recording (Intercept)    40.92   6.397
 Residual                193.09  13.896
Number of obs: 1714, groups: Interview, 99

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)                75.52   1.017    74.28
rContext                  -15.42   1.278   -12.06
LemmaFrequency             0.008   0.002     4.64
rContext:LemmaFrequency   -0.010   0.002    -5.27
```

```
West Middle German

Random effects:
 Groups    Name        Variance   S.D.
 Recording (Intercept)    81.89  9.049
 Residual                231.45 15.214
Number of obs: 1221, groups: Interview, 70

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)               66.673   1.481    45.03
rContext                  -7.983   1.637    -4.88
LemmaFrequency             0.008   0.002     3.41
rContext:LemmaFrequency   -0.010   0.002    -4.07
```

Swabian-Alemannic in Germany

```
Random effects:
 Groups    Name        Variance   S.D.
 Recording (Intercept)   118.57 10.889
 Residual                190.38 13.798
Number of obs: 627, groups: Interview, 44

Fixed effects:
                            Est.    S.E.  t-value
(Intercept)               65.047   2.124   30.619
rContext                  -5.532   2.260   -2.448
LemmaFrequency             0.008   0.003    2.720
rContext:LemmaFrequency   -0.013   0.003   -3.888
```

Switzerland

```
Random effects:
 Groups    Name        Variance   S.D.
 Recording (Intercept)    67.50   8.21
 Residual               168.47  12.98
Number of obs: 434, groups: Interview, 25

Fixed effects:
                           Est.    S.E.   t-value
(Intercept)               57.65    2.775   20.777
gender-male                7.51    3.573    2.101
rContext                  -3.84    2.229   -1.724
LemmaFrequency           <0.001    0.003    0.294
rContext:LemmaFrequency -0.006    0.003   -1.714
```

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Curriculum Vitae

Marjoleine Sloos was born in Woerden, The Netherlands, on January 5, 1970. She attended the Rijnlands Lyceum in Oegstgeest and obtained her VWO diploma in 1989. From 1989 until 1993, she studied Early Music at the Conservatory of Utrecht and continued her musical education at the Academy for Music and Dance in Rotterdam, where she graduated in 1996. As a music teacher, she gradually specialized in teaching music to individuals with Autism Spectrum Disorders. She worked at several music schools and worked in her own praxis as a private teacher for musical education from 1988 until 2009.

In 2004, she started to study linguistics at Leiden University and received her BA. degree with distinction in 2007. She continued the research master "Linguistics: Variation and Structure in the Languages of the World" at Leiden University, where she graduated with distinction in 2009. During her MA, she did an internship at the Meertens Institute, where she discovered her passion for linguistic research.

After graduation, she moved to Germany, to start a PhD research in the project "Frequency Effects in Language" at Freiburg University. Two years later, she continued this research at the University of Groningen. During the first semester of 2011/2012, she returned to Leiden University, where she worked as a tutor and a lecturer in phonology. In 2012, she was a visiting PhD student at Shanghai International Studies University for three weeks.

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