

Acquiring markedness constraints

The case of French*

Jeroen van de Weijer and Marjoleine Sloos

Shanghai International Studies University / University of Groningen

This paper questions the assumption made in classic Optimality Theory (Prince & Smolensky 1993 [2004]) that markedness constraints are an innate part of Universal Grammar. Instead, we argue that constraints are acquired on the basis of the language data to which L1 learning children are exposed. This is argued both on general grounds (innateness is an assumption that should not be invoked lightly) and on the basis of empirical evidence. We investigate this issue for six general markedness constraints in French, and show that all constraints could be acquired on the basis of the ambient data. Second, we show that the order of acquisition of the marked structures matches the frequency of violations of the relevant constraints in the input quite well. This argues in favour of a phonological model in which constraints are acquired, not innate, i.e. a model in which grammatical notions such as constraints are derived from language use.

Keywords: constraints, Optimality Theory, innateness, Universal Grammar, L1 acquisition, frequency, grammar, usage

1. Introduction

In classic Optimality Theory, i.e. the basic version of the theory proposed in Prince & Smolensky (1993 [2004]), markedness constraints are part of Universal Grammar and therefore innate. Acquisition consists of the correct ranking of these innate markedness constraints or the step-wise demotion of these (initially high-ranked) constraints (Tesar & Smolensky 2000). The innateness of constraints is usually taken for granted (as part of the Chomskyan UG paradigm) and only in rare cases is it argued that constraints must be innate on the basis of empirical evidence (Gnanadesikan 2004). However, in recent years, we observe a trend away from the assumption that linguistic and other cognitive categories are innate; rather, linguistic categories (such as distinctive features, or syllables) are argued to

emerge from the speech environment and/or are related to other, general, non-language-specific cognitive strategies (see for instance Bybee & Hopper 2001). In this paper we focus on the innateness vs. emergence debate with respect to phonological constraints.

The innateness issue with regard to constraints has been discussed in two other approaches as well, viz. constraint induction models (e.g. Hayes 1996; Hayes & Wilson 2008; Adriaans & Kager 2010) and stochastic Optimality Theory (Boersma 1997: Ch. 14 and subsequent work). Hayes (1996: 1) proposes that constraints are induced by learners by “access[ing] the knowledge gained from experience in articulation and perception”, which also seems to be at the basis of Boersma’s (1997: Ch. 14) proposal. We want to go one step further and argue that frequency of phonological patterns plays a crucial role in the acquisition of constraints. As we will show, this makes it possible to predict the order of acquisition of the constraints. Learning is ‘statistical’, i.e. pays attention to the frequency of patterns in the data (cf. ‘distributional statistics’; Thiessen 2009 and references cited there). Constraint demotion in classical OT does not take statistical learning into account at all; constraints are minimally re-ranked on the basis of the data without any reference to frequency. It is possible to make constraint demotion dependent on word frequency, as proposed in Boersma & Levelt (2000), but, crucially, this still depends on innateness of constraints. A more restrictive hypothesis is that constraints are acquired, not innate.

Specifically, we examine six segmental and prosodic markedness constraints that play a role in French. First, we will show that all these constraints could be acquired on the basis of the input that is available to the French-learning child, so that no innateness needs to be assumed. In our approach, constraints emerge as generalizations across the ambient data — they are not innately present. Some constraints are formed on the basis of almost perfect generalizations (if there are hardly any counterexamples in early input), while others are formed in the face of larger numbers of counterexamples. Thus, constraints can be stronger or weaker, and we predict that this has an effect on the order of acquisition of marked structures: Structures that violate stronger constraints will be harder to acquire, i.e. appear later in production, than structures that violate weaker constraints. Testing this prediction is our second main topic.

This paper is organized as follows. In Section 2 we introduce the six markedness constraints that are relevant to French. In Section 3 we turn to the lexical patterns that are relevant to discovery and ranking of these constraints as part of L1 acquisition, based on corpus research into French child-directed speech. The relation between constraint strength and order of acquisition is tested in Section 4. Section 5 discusses the findings and concludes.

2. Markedness in French

French phonology was chosen as a testing ground because a number of common and uncontroversial markedness constraints are actively violated in this language. We will first discuss two constraints on segmental structure, against nasal vowels and against front rounded vowels, and then focus on syllable structure.

First, a word on French phonology is in order. Both European French and Canadian French will be relevant to the discussion below. The European French vowel system is given in Figure 1 (from Fougeron & Smith 1993: 73):

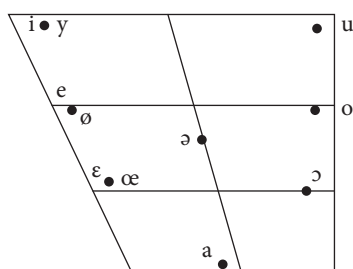


Figure 1. French oral vowels

Figure 1 shows that French has three front rounded vowels: /y/, /ø/ and /œ/, as in words like *pure* ‘pure’ [pyr], *ceux* ‘those’ [sø] and *oeuvre* ‘oeuvre’ /œvr/. Canadian French also has these vowels, and retains some distinctions now lost in European French (Walker 1984). In addition, European French has four nasal vowels, as in *sans* [sã] ‘without’, *son* [sô] ‘his’, *vin* [vê] ‘wine’ and *brun* [brœ̃] ‘brown’. For details concerning French phonology and phonetics, we refer to general descriptions such as Fagyal, Kibbee & Jenkins (2006).

It is generally agreed that nasal vowels are cross-linguistically marked, i.e. less common, compared to their oral counterparts (e.g. Maddieson 1984: 131). In Optimality Theory, this idea is captured by a markedness constraint such as that in (1):

- (1) *NV (Kager 1999: 28): Vowels must not be nasal

The constraint in (1) favours oral vowels over nasal ones. For acquisition, it predicts that children will start out producing oral vowels and avoiding nasal vowels, which is correct. In classic Optimality Theory (Prince & Smolensky 1993 [2004]), such constraints are assumed to be innate as part of Universal Grammar. Below we will argue that it is not necessary to make such a far-reaching assumption: Instead, we argue, such constraints can be acquired on the basis of the language data.

French violates another segmental markedness constraint, namely against front rounded vowels such as /y/, /ø/ and /œ/, which are absent in many languages

of the world (Maddieson 1984:124). Cross-linguistically, front vowels tend to be unrounded and back vowels tend to be rounded. The markedness constraint against such vowels, which is well supported (see for instance Kaun 2004: 105), can be formulated as in (2):

- (2) *V_{front, round} : Vowels must not be front and rounded

Next, we turn to the realm of syllable structure. First, French allows consonant clusters both in the onset and the coda. Here we will make a distinction between consonant clusters consisting of obstruent plus liquid, such as in *très* ‘very’, which are subject to the *COMPLEX constraint as formalized in (3a) (cf. Kager 1999:97 among many others) and consonant + glide clusters, as in words like *bien* ‘good’. For the latter kinds of clusters, there are at least three possibilities: They may be analysed on a par with ‘regular’ consonant clusters (violating the same constraint); as part of the vowel nucleus (violating a constraint against complex nuclei, given in (3b)); or as secondary articulation on a single, complex consonant (violating a constraint against complex segments, as in (3c).

- (3) a. *COMPLEX : *CC (Consonant clusters are not permitted)
 b. *Diph : *VV (Diphthongs are not permitted)
 c. *COMPLEXC: *COMPLEX (Secondary articulation is not permitted)

Secondly, French violates the ONSET constraint (Prince & Smolensky 1993 [2004]), which demands that syllables start with an onset consonant. The constraint is violated by any word (or syllable, depending on the formulation of the constraint) that starts with a vowel. This constraint is given in (4):

- (4) ONSET: *[V (Vowel-initial syllables are not permitted)

This constraint may be violated much *less* often in French than might appear at first glance, because of the common process of *liaison*, in which a word final consonant resyllabifies as the onset consonant of a following vowel-initial word (see e.g. Fagyal et al. 2006:58).

Finally, French violates the constraint NoCODA (Prince & Smolensky 1993 [2004]), which forbids coda consonants. This constraint, which expresses the preference for open syllables, is also relatively uncontroversial (though cf. McCarthy 1993:176, who argues for a “Final-C” constraint):

- (5) NoCODA: *C] (Coda consonants are not permitted)

This constraint may be divided into several subtypes, since some languages permit a subset of consonants in the coda, e.g. sonorants (an example of this is Mandarin Chinese, which permits nasals and, in some varieties, /r/ to close a syllable). This

means that only obstruents are ruled out in the coda. Thus, the constraint in (5) could be split up into a specific and a general constraint, as in (6a) and (6b):

- (6) a. NoCODA-OBS : *C_{obs}] (Obstruent codas are not permitted)
 b. NoCODA-Gen : *C] (Coda consonants are not permitted)

We will see that this distinction may be relevant to the discussion of French.

The idea of acquisition in classic OT is that markedness constraints such as those in (1–6) are innate, and high-ranked initially, so that children will obey them in their early language output (see for instance Tesar & Smolensky 2000). This will result in output that has no nasal vowels, no front rounded vowels, no clusters, no onsetless syllables, and no coda consonants. This prediction is to a large extent correct, as cross-linguistic surveys of relevant data like those in Johnson & Reimers (2010) show. Although this proposition is attractive and has turned out to be very successful in accounting for a wide range of phenomena, the assumption that constraints are innate is not a necessary one and is not necessarily the best approach to explain phonological acquisition. An alternative is that constraints are learned, or better: *Acquired*, in the course of the language acquisition process. This approach is related to statistical language learning (e.g. Saffran 2001 and many others) and has the considerable advantage that no specific innate knowledge is assumed. We will take the position that innateness should be invoked only if it can be shown that no other option is possible, i.e. if it is not possible to explain some phonological phenomenon in any other way. In the case of phonological constraints, it is actually fairly easy to show that constraints *could* be acquired, so that this should be our initial position. The only source for acquisition available is the language input that the children are exposed to. We must therefore examine the nature of the input more closely to see if this input allows for the discovery of phonological constraints as well as their order of acquisition.

An important corollary of statistical language learning is that if a particular aspect is more frequent in language input, then it will be more easily acquired. This means that, all other things being equal, it will be acquired more rapidly, i.e. earlier. That is, we can compare different stages of acquisition with lexical statistics and we predict a close match between the two. No such prediction is present in Optimality Theory, which is blind to usage-based aspects like frequency and therefore has trouble accounting for variation of any kind (see for instance van de Weijer 2012; Sloos 2013). Let us therefore investigate the details of French lexical statistics in the next section.

3. French lexical statistics

In this section we present the statistics that are relevant to the acquisition of the marked structures introduced in the previous section: Nasal vowels, front rounded vowels, consonant clusters, secondary articulation, onsetless syllables, and coda consonants. Lexical statistics are available both for adult French (see for instance New & Pallier 2001) and for child-directed speech. Since the most relevant speech input of L1-acquiring children is child-directed speech, we decided to compute the word frequency of child-directed French. We extracted the 500 most frequent words in child-directed French, taken from CHILDES (MacWhinney 2000), which contains both European and Canadian French. The frequency of the European and Canadian French words appeared to be strongly correlated ($R = 0.75$). For illustration, the most frequent 100 words of child-directed French are given in (7) below.

- (7) tu c'est le pas ça il la est on un oui et qu' de là a les ce non je ah que hein
 qui va elle à fait des oh une dans mais veux y en as pour quoi sur bien alors
 regarde comme ils faire avec où toi voilà n' te le du sont sais si tout ben bon
 fais ouais se faut plus maman encore moi allez petit vas comment tiens ton
 lui quand vois viens y+a mettre attends ne ou aussi bah peu i' passe au me
 mets es dit pourquoi mon deux ta euh voir vu

Note that the list in (7) contains quite a number of exclamations (*ah*, *oh*, *euh*), clitics (*n'*, *qu'*), and constructions like *y+a*. We chose not to exclude these forms, because in the initial stages of acquisition there would be no reason for the child to suspect that these words might have a different status from 'normal' lexical items. We did exclude, however, proper names, since these are often related to the circumstances of individual children. We transcribed the words phonetically (using Bogaards 2000 and checked by a native speaker) and coded each word for the number of nasal vowels, front rounded vowels, consonant clusters, cases of secondary articulation, onsetless syllables, and coda consonants, scoring 1 for each markedness violation. We added up the numbers and computed the percentage of the violations for the 500 most frequent words. We also computed the log frequency since this reflects perception more closely than raw token frequency. Two issues should be mentioned here: First, final *-r* in words like *pour* 'for' and *encore* 'still' was counted separately as a sonorant coda, following the usual classification in works on the phonology of French (see for instance Walker 2001:iv; Fagyal et al. 2006:43). Secondly, words of the type *être* 'to be' and *prendre* 'to take' were transcribed as having a final cluster (not a final schwa), following Bogaards (2000), as well as the online *Larousse*.

Table 2 shows the number of instances of the ‘marked’ structures that appear in the 100, 200 and 500 most frequent words in child-directed speech, both in absolute numbers and percentages.

Table 1. Absolute number and percentages of markedness violations (nasal vowels, front rounded vowels, clusters, secondary articulation, onsetless syllables, and coda obstruents) in child-directed French, based on the first 100, the first 200, and the first 500 most frequent words

	100		200		500	
	n	%	n	%	n	%
Nasal vowels	18	18	39	20	108	22
Front rounded vowels	11	11	16	8	39	8
Clusters	3	3	25	13	72	14
Secondary articulation	11	11	20	10	52	10
Onsetless syllables	29	29	49	25	93	19
Coda obstruents	4	4	21	11	81	16
Coda sonorants (excl. -r)	6	6	14	7	52	10

As Table 1 shows, all patterns we investigate are underrepresented in the sense that they are observed less often than would be expected on the basis of equal distribution: Nasal vowels are much less common than oral vowels and front rounded vowels are less common than front unrounded vowels or back rounded ones, etc. This means that the constraints against nasal vowels, clusters, etc., can be regarded as generalizations across the data; e.g. 97% of the 100 words most frequently used in child-directed speech contain no clusters. It is reasonable to assume that the child will make the generalization “only oral vowels”, and dismiss the nasal vowels as “exceptions” initially. In OT terms, this translates into the constraint in (1) above. No assumption of innateness is necessary and the other constraints, too, can be acquired in a similar way. All we need to assume is that children make such generalizations, which seems natural enough, given the fact that the need to make generalizations also arises in other cognitive domains. Thus, instead of assuming specific constraints such as NoCODA, we assume that children, in building up their lexicon, keep track of the features of their language and have the ability to generalize. This does not mean that there is no role for innateness at all. After all, such an approach must specify what to pay attention to (e.g. nasality vs. orality) and on what basis (e.g. at the word level), which is cogently discussed by Yang (2004), among others.

On the basis of the relation between lexical frequency and learning, a strong prediction can be made which is absent in nativist approaches. In general, markedness violations that are relatively common are expected to be “resolved”, i.e. appear

in the child's output, earlier than markedness violations that are relatively uncommon. After all, a constraint against clusters will initially be very strong (only 3 counterexamples in the 100 most frequent words), while a constraint against nasal vowels will be weaker (18 violations). Table 2 shows the number of instances and the log frequency of the 'marked' structures that appear in the 500 most frequent words in child-directed speech.

Table 2. Token and log frequency of markedness violations (nasal vowels, front rounded vowels, clusters, secondary articulation, onsetless syllables, coda obstruents, and coda sonorants) in child-directed French, based on the 500 most frequent words

	Token frequency	Log frequency
Nasal vowels	190,321	5.28
Front rounded vowels	136,975	5.14
Clusters	87,974	4.94
Secondary articulation	126,627	5.10
Onsetless syllables	323,931	5.51
Coda obstruents	188,375	5.28
Coda sonorants (excl. -r)	162,047	5.21

Thus, Table 2 suggests an *order of acquisition*. In classic Optimality Theory, where all constraints are pre-given, there is no prediction like this — acquisition only consists of reranking the existing constraints on the basis of the data. It should be pointed out, of course, that testing the actual predictions that a frequency-based markedness account makes must be modulated by a number of factors. Obviously, physical/cognitive maturation may also be a factor: The language-acquiring child may be 'ready' to produce certain sound types earlier than others. Secondly, the approach pursued here must go hand-in-hand of an account how word boundaries are discovered (see again Yang 2004 and, importantly, Adriaans & Kager 2010). In the next section we will investigate whether our approach, in which we expect that exceptions to a 'strong' generalization will be harder to produce than exceptions to a weaker generalization, can be tested against the available data.

4. Acquisition in French

This section investigates the relation between the strengths of the generalizations (i.e. markedness constraints) uncovered above and the order of acquisition. Acquisition data for French are based on Rose (2000) and Brak (2011), resulting in data for ten children in all. We determined at which point a specific feature like 'nasal vowels' had roughly been acquired by these children. This is not

unproblematic for several reasons. First, in the acquisition of ‘nasal vowels’, for instance, there may be differences between different vowels, so one nasal vowel may be acquired well before another. For example, Brak (2011: 41ff.) finds that [ã] is acquired much earlier than [ê]. Secondly, different authors may differ as to when exactly a sound (or class of sounds) is considered to have been acquired. Further research is therefore definitely warranted.

As pointed out above, we predict that counterexamples to ‘strong generalizations’, i.e. constraints which have been formed on the basis of few counterexamples, such as that against front rounded vowels, will be harder to produce for L1-acquiring children than counterexamples to ‘weaker generalizations’, i.e. constraints which have been formed in spite of there being more counterexamples, such as that against nasal vowels. We present the available acquisition data for individual children below, side by side with the log frequencies copied from Table 2. We selected the markedness violations of the 500 most frequent words since it is reasonable to assume, following Swingley (2007), that children when they start producing forms have built up a lexicon of roughly this size, so that this is the number of words available for generalization.

Table 3. Comparison of the log frequency of violations of markedness and the date of acquisition for ten children. Underlining indicates deviant time of acquisition

	Onset	Nasal vowels	Coda obstr	Coda son.	Front round. V	Second. art.	Clusters
Log	5.51	5.28	5.28	5.21	5.14	5.10	4.94
Marilyn		1;11	<1;11	2:04–07			2;03–08
Clara	1;05	<u>1;02</u>	1;07	1;07	1;07	1;07	1;09
Theo	<1;05		2;03	2;03		2;05	2;05
Madeleine-1	1;04	<u>1;04</u>	1;06	<u>1;07</u>	1;06		
Adrien	2;01	<u>3;05</u>	2;05	2;09	<u>2;03</u>		
Anaïs		1;02			1;04		
Marie		1;02			1;10		
Nathan		1;03			1;04		
Theotime		1;03			<u>1;03</u>		
Madeleine-2		1;01			1;07		

Table 3 shows that the number of times a specific markedness constraint is violated correlates quite well with the stage at which a feature such as nasal vowels will be acquired. Nasal vowels, which are relatively common in words that are frequent in child-directed speech, tend to appear early, while less frequent sounds and sound types appear later. Note that there are missing values in Table 3 and also that there are six counterexamples to the tendency that common marked

features are acquired earlier than less common ones, which we attribute to common individual differences in phonological acquisition (see for instance Vihman & Greenlee 1987). In order to investigate the strength of the correlation between the age of acquisition (in months) and the frequency of the marked structures, we performed Spearman's correlation tests for the data of the five children for which we had more than two data points for the order of acquisition (see Table 4).

Table 4. Correlation between the age of acquisition for five children and the frequency of the violations

	Correlation R	p-value
Marilyn	-0.97	0.005*
Clara	-0.87	0.005*
Theo	-0.95	0.014*
Madeleine-1	-0.84	0.038*
Adrien	-0.55	0.257

Table 4 shows a strikingly high negative correlation coefficient for four of these children between the age of acquisition and the frequency of the violations. This supports our claim that word frequency plays a crucial role in the acquisition of the relevant markedness constraints.

5. Discussion and conclusion

It turns out that acquisition of French markedness constraints and the order of acquisition can largely be predicted on the basis of frequency of markedness violations in the input to which children are exposed. This obviously makes sense, because if a learner is more frequently exposed to a certain pattern, it will be easier to acquire. Mainstream Optimality Theory cannot replicate this result, because constraints are assumed to be innate. More recent approaches took learnability of constraints into account, but frequency plays no role in how the content of the grammar, i.e. the constraints, is acquired. Proponents of a “frequency-free” OT might argue that acquisition is part of performance and OT deals with competence. We think this is not the correct approach, in the light of an accumulating amount of evidence that shows that usage-based aspects of language play important roles in the structure and development of language (see for instance Bybee 2001, 2006, 2010). Rather, we think that usage-based aspects such as frequency should be incorporated in formal models, leading to so-called “hybrid” approaches (e.g. van de Weijer 2012; Sloos 2013) that try to combine the “best of both worlds”: A richly-specified lexicon combined with a fully-fledged grammatical module, which may

take the shape of a constraint-based grammar.¹ In such a grammar, we submit, constraints are acquired, not innate.

Our second goal in this paper was to show that the order of acquisition corresponds quite closely to the number of times with which violations of these markedness constraints are violated in the most frequent words in French. This strengthens the idea that constraints are nothing more (or less) than generalizations that children make in order to structure their language environment. If a generalization is strong, i.e. has few exceptions, it will be difficult to unlearn and thus the exceptions will show up later in the acquisition process. Although more factors play a role here, this is borne out to a very large extent for the markedness constraints explored here.

Our approach, acquisition of constraints on the basis of frequency, makes two important predictions. First, if two languages have the same marked structures, the order of acquisition in our model may be different, according to the relative frequency of the structures. Other approaches in OT would assume that acquisition depends on the relative markedness, hence the order of acquisition would be the same for both languages. This is the line of research we are currently pursuing. Secondly, we assume that constraints are acquired on an as-needed basis: If no evidence for a constraint exists, it will not be acquired. We leave this for future research.

Notes

* We would like to thank audiences at presentations at the TIN-dag, Shanghai International Studies University, East China Normal University, the Child Phonology Conference Nijmegen 2013, and the 21th Manchester Phonology Meeting 2013 for comments and discussion. We are also grateful to three anonymous LIN reviewers and the editors of this volume for comments and insightful discussion, which helped us to express some of the ideas in this paper much more clearly. All remaining deficiencies are our own.

1. Such a model can capture frequency information, but also, for instance, orthographical or sociolinguistic information.

References

- Adriaans, Frans & René Kager. 2010. Adding generalization to statistical learning: The induction of phonotactics from continuous speech. *Journal of Memory and Language* 62(3). 311–331.
- Boersma, Paul. 1997. *Functional phonology — Formalizing the interactions between articulatory and perceptual drives*. Amsterdam: University of Amsterdam PhD dissertation.

- Boersma, Paul & Clara Levelt. 2000. Gradual constraint-ranking learning algorithm predicts acquisition order. *Proceedings of the Child Language Research Forum* 30. 229–237.
- Bogaards, Piet. 2000. *Van Dale groot woordenboek Nederlands-Frans*, 3rd edn. Utrecht: Van Dale.
- Brak, Jantina. 2011. L'acquisition segmentale et suprasegmentale des enfants français. Utrecht: University of Utrecht MA thesis.
- Bybee, Joan L. 2001. *Phonology and language use*. Cambridge and New York: Cambridge University Press.
- Bybee, Joan L. 2006. From usage to grammar: The mind's response to repetition. *Language* 82(4). 711–733.
- Bybee, Joan L. 2010. *Language, usage and cognition*. Cambridge: Cambridge University Press.
- Bybee, Joan L. & Paul Hopper. 2001. Introduction to frequency and the emergence of linguistic structure. In Joan L. Bybee & Paul Hopper (eds.), *Frequency and the emergence of linguistic structure*, 1–24. Amsterdam and Philadelphia: John Benjamins.
- Fagyal, Zsuzsanna, Douglas Kibbee & Frederic Jenkins. 2006. *French: A linguistic introduction*. Cambridge: Cambridge University Press.
- Fougeron, Cécile & Caroline L. Smith. 1993. Illustrations of the IPA: French. *Journal of the International Phonetic Association* 23(2). 73–76.
- Gnanadesikan, Amalia E. 2004. Markedness and faithfulness constraints in child phonology. In René Kager, Joe Pater & Wim Zonneveld (eds.), *Constraints in Phonological Acquisition*, 73–108. Cambridge: Cambridge University Press.
- Hayes, Bruce. 1996. Phonetically driven phonology: The role of Optimality Theory and inductive grounding. *Proceedings of the 1996 Milwaukee Conference on Formalism and Functionalism in Linguistics*. Available in Rutgers Optimality Archive, <http://roa.rutgers.edu>.
- Hayes, Bruce & Colin Wilson. 2008. A Maximum Entropy model of phonotactics and phonotactic learning. *Linguistic Inquiry* 39(3). 379–440.
- Johnson, Wyn & Paula Reimers. 2010. *Patterns in child phonology*. Edinburgh: Edinburgh University Press.
- Kager, René. 1999. *Optimality theory*. Cambridge: Cambridge University Press.
- Kaun, Abigail R. 2004. The typology of rounding harmony. In Bruce Hayes, Robert Kirchner & Donca Steriade (eds.), *Phonetically Based Phonology*, 87–116. Cambridge: Cambridge University Press.
- Larousse. French-English dictionary (online edition) <http://www.larousse.com/en/dictionaries/french-english> (15 February, 2013).
- MacWhinney, Brian. 2000. *The CHILDES Project: Tools for Analyzing Talk*. 3rd edn. Mahwah, NJ: Lawrence Erlbaum Associates.
- Maddieson, Ian. 1984. *Patterns of sounds*. Cambridge: Cambridge University Press.
- McCarthy, John J. 1993. A case of surface constraint violation. *Canadian Journal of Linguistics* 38(2). 169–195.
- New, Boris & Christophe Pallier. 2001. <http://www.lexique.org> (2 September, 2012).
- Prince, Alan & Paul Smolensky. 1993 [2004]. *Optimality Theory — Constraint interaction in generative grammar*. London: Blackwell.
- Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Montréal: McGill PhD dissertation.
- Saffran, Jenny R. 2001. Words in a sea of sounds: The output of statistical learning. *Cognition* 81. 149–169.

- Sloos, Marjoleine. 2013. *Phonological grammar and frequency: An integrated approach. Evidence from German, Indonesian, and Japanese*. Groningen: University of Groningen PhD dissertation.
- Swingley, Daniel. 2007. Lexical exposure and word-form encoding in 1.5-year-olds. *Developmental Psychology* 43(2). 454–464.
- Tesar, Bruce & Paul Smolensky. 2000. *Learnability in Optimality Theory*. Cambridge, MA: MIT Press.
- Thiessen, Erik. 2009. Statistical learning. In Edith L. Bavin (ed.), *The Cambridge handbook of child language*, 35–50. Cambridge: Cambridge University Press.
- Weijer, Jeroen M. van de. 2012. *Grammar as selection: Combining Optimality Theory and Exemplar Theory*. Nagoya: Kougaku Shuppan.
- Vihman, Marilyn May & Mel Greenlee. 1987. Individual differences in phonological development: Ages one and three years. *Journal of Speech, Language and Hearing Research* 30(4). 503–521.
- Walker, Douglas C. 1984. *The pronunciation of Canadian French*. Ottawa: University of Ottawa Press.
- Walker, Douglas C. 2001. *French sound structure*. Calgary: University of Calgary Press.
- Yang, Charles D. 2004. Universal Grammar, statistics or both? *Trends in Cognitive Sciences* 8(10). 451–456.

Authors' addresses

Jeroen van de Weijer
College of English Language and Literature
Shanghai International Studies University
550 Dalian Xi Lu
Shanghai 200083
China

jeroen.van.de.weijer@gmail.com

Marjoleine Sloos
Department of Dutch
University of Groningen
Oude Kijk in 't Jatstraat 26
9712 EK Groningen
The Netherlands

marj.sloos@gmail.com