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Paradigm Uniformity Effects in German Phonology

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German words like *Siedl-ung* [ziːd.lʊŋ] 'settlement', which contain a sequence of obstruent plus sonorant consonant between vowels, pose two problems assuming the heterosyllabic parse: (a) the first syllable is superheavy, but superheavy syllables are otherwise restricted in their occurrence to word-final position; and (b) the /d/ does not devoice, contrary to what one would expect, since Final Devoicing operates without exception in coda position. The problem in assuming that consonant clusters like [dl] are tautosyllabic is that they are otherwise non-occurring in word-initial position. In the present study, it is argued that the heterosyllabic parse for words like *Siedl-ung* is correct, and that (a) and (b) derive an explanation by appealing to paradigm uniformity. It is shown in an optimality-theoretic analysis that the canonical patterns capturing the distribution of superheavy syllables and Final Devoicing require the ranking "markedness » input-output faithfulness." The paradigm uniformity effects, that is, (a) and (b), require a specific output-output faithfulness constraint to dominate the markedness constraint. The proposed paradigm uniformity approach is compared to earlier treatments in which the notion of paradigm does not play a role. It is also shown that the tautosyllabic parse in examples like *Siedl-ung* is problematic.[*]

1. Introduction.

In this article I discuss a large class of German words, which can be illustrated with the two representative examples in 1.

(1)	a. Atm-ung	[aːt.mʊŋ]	'breathing'
	b. Siedl-ung	[ziːd.lʊŋ]	'settlement'

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These words have in common that they contain a sequence of obstruent plus sonorant consonant between vowels. Canonical syllabification seems to require that these sequences be heterosyllabified, since obstruent plus sonorant sequences like these are either non-occurring or extremely rare in onset position, for example, in word-initial position. However, the heterosyllabic parsing of the examples in 1 is problematic for two reasons. First, the long vowel plus consonant rhymes (that is, [a:t], [i:d]) are examples of superheavy syllables, but superheavy syllables are otherwise restricted in their occurrence to word-final position (Hall 2002a,b). Second, the /d/ in the example in 1b does not devoice, which is unexpected because German Final Devoicing operates in coda position and it is assumed not to have idiosyncratic exceptions.

In the present study I show that the two problems described with respect to the data in 1 evaporate when one considers PARADIGM UNIFORMITY (henceforth PU). The basic idea behind PU is that otherwise pervasive surface-based markedness constraints can be violated in order to make the relevant forms similar to morphologically related ones. In terms of Optimality Theory (OT; Prince and Smolensky 1993), the canonical phonological pattern is typically captured with the ranking of markedness over input-output (henceforth I-O) faithfulness, as in 2a. With respect to the examples in 1, the canonical phonology in 2a would say that obstruent plus sonorant consonant clusters are heterosyllabified. The PU effects referred to above require that the markedness constraint in 2a be dominated by an output-output (henceforth O-O) faithfulness constraint, as in 2b.[1]

(2) a. Canonical pattern: markedness » I-O faithfulness
b. PU effects: O-O faithfulness » markedness » I-O faithfulness

What I ultimately argue is that the two problems referred to above with respect to 1 are examples of PU effects and that they therefore require a specific instantiation of the general ranking in 2b. In the course of my analysis I briefly compare my PU approach to the data in 1 with the earlier treatments of these examples, which employ either cycles, lexical

[1] For recent studies on PU effects in languages other than German the reader is referred to Benua 1997, and to the contributions in Downing, Hall, and Raffelsiefen 2005. For a study in which PU effects are discussed in other areas of German phonology, see Raffelsiefen 1995.

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levels, or language-specific resyllabification rules (for example, Rubach 1990, Hall 1992) or an OT-style analysis without O-O constraints (for example, Noske 1999). I also show that these earlier approaches in which the obstruent plus sonorant consonant sequences as in 1 are analyzed as onsets are problematic (see, for example, Vennemann 1972 and Hall 1992).

This article is structured as follows. In section 2 I discuss two generalizations pertaining to the canonical phonology illustrating the general ranking in 2a, namely the distribution of superheavy syllables (section 2.1) and the syllabification of intervocalic obstruent plus sonorant clusters (section 2.2). In section 2.3 I turn to examples like those in 1 that go contrary to the canonical distribution of superheavy syllables, and argue that these words illustrate PU effects with respect to moraic structure. Here I show that the problematic examples require an O-O constraint referring to the moraic structure of vowels to outrank the markedness constraint capturing the distribution of superheavy syllables, as in 2b. In section 3 PU effects with respect to Final Devoicing are discussed. In section 3.1 I concentrate on the canonical pattern and show, following the majority of researchers who have addressed this problem, that the process operates in the syllable coda. In section 3.2 I turn to examples like the one in 1b and argue that these words require a high-ranked O-O constraint that refers specifically to the feature involved in Final Devoicing. It is demonstrated that this O-O constraint must be locally conjoined with the markedness constraint SYLLABLE CONTACT LAW (Murray and Vennemann 1983, Davis 1998) in order to prevent the alternations motivating Final Devoicing in the canonical phonology from exhibiting PU effects. In section 4 I discuss and refute two alternative treatments for Final Devoicing not involving PU effects, and in section 5 I present the conclusion.

2. Paradigm Uniformity Effects in Phonotactics.

In this section I discuss two areas of German canonical phonology, namely the distribution of superheavy syllables (section 2.1) and the syllabification of intervocalic obstruent plus sonorant clusters (section 2.2). In section 2.3 I discuss the PU effects and propose an OT treatment.

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2.1. The Distribution of Superheavy Syllables: The Canonical Pattern. Superheavy syllables are defined here as syllables ending in a short vowel plus two consonants (see 3a), a long vowel plus one or more consonants (see 3b), or a diphthong plus one or more consonants (see 3c).[2]

(3) Superheavy syllables

a. short vowel + two or more consonants

Kalb	[kalp]	'calf'
Amt	[amt]	'office'

b. long vowel + one or more consonant

viel	[fiːl]	'many'
zahm	[tsaːm]	'tame'

c. diphthong + one or more consonant

Bein	[baɪn]	'leg'
Baum	[baʊm]	'tree'
euch	[ɔʏç]	'you (pl.)'

As in English and Dutch, superheavy syllables in German are restricted in their distribution, as I have illustrated in 4.[3] In 4, we can see that superheavy syllables occur in word-final position, as in 4a, before the first part of a compound, as in 4b, and before a consonant-initial suffix, as in 4c.[4] The important restriction for our purposes is illustrated in 4d, that is, monomorphemes in which a superheavy syllable occurs internally are lacking. In 4d, I present a hypothetical monomorpheme of this structure.

[2] All examples in the present article have been taken from Drosdowski et al. 1990.

[3] See Hall 2002b and Raffelsiefen 2004 for more discussion and detailed analyses.

[4] Before vowel-initial suffixes potential superheavy syllables do not surface because the final consonant of the stem surfaces in the following onset, for example, *viel-e* [fiː.lə] 'many (adj. ending)'.

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(4) Distribution of superheavy syllables

a. Superheavy syllables in word-final position

W<u>erk</u>	[vɛʀk]	'work'
Z<u>eit</u>	[tsaɪt]	'time'
B<u>uch</u>	[buːx]	'book'

b. Superheavy syllables before a compound boundary

W<u>erk</u>-statt	[vɛʀk.ʃtat]	'workshop'
Z<u>eit</u>-geist	[tsaɪt.gaɪst]	'zeitgeist'
B<u>uch</u>-weizen	[buːx.vaɪ.tsən]	'buckwheat'

c. Superheavy syllables before a CV(C) suffix

l<u>eb</u>-los	[leːp.loːs]	'lifeless'
<u>Ein</u>-heit	[aɪn.haɪt]	'unit'
l<u>ieb</u>-lich	[liːp.lɪç]	'dearly'

d. No superheavy syllables morpheme-internally

*[a.ʀeːl.na]	(see Arena [a.ʀeː.na] 'arena')

Following Hall 2002b and Raffelsiefen 2004, I argue that German restricts the distribution of superheavy syllables to the right edge of a phonological word, as stated in the descriptive generalization in 5.[5]

(5) A superheavy syllable occurs only at the right edge of a phonological word.

With respect to the data in 4, there is consensus in the literature on German that each part of a compound (as in 4b) forms its own phonological word and that consonant-initial suffixes (as in 4c) are non-cohering in the sense that they lie outside of the phonological word of the stem to which they attach (see Booij 1985, Wiese 1996, Hall 2002b, and Raffelsiefen 2004). These authors also agree that vowel-initial suffixes

[5] Systematic counterexamples to 5 include proper names like *Leipzig* [laɪp.tsɪç]. In section 3.2 I show that proper names do not conform to a second phenomenon in the canonical phonology of German as well. For this reason, I do not consider proper names in subsequent data sets.

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are cohering, that is, they form one phonological word with the stem to which they attach.

The number of truly idiosyncratic exceptions to 5 is very small. Three examples of morpheme-internal superheavy syllables are *Skulptur* [skʊlp.tuːɐ̯] 'sculpture', *arktisch* [aʀk.tɪʃ] 'arctic', and *Auktion* [aʊk.tsjoːn] 'auction'. Note that these examples have in common that the superheavy syllable ends in either a short vowel plus two consonants or a diphthong plus one consonant. Counterexamples to 5, which involve superheavy syllables with a long vowel, seem impressionistically to be much rarer, for example, *Börse* [bøːɐ̯.zə] 'stock exchange'.[6]

The generalization in 5 is captured formally with an alignment constraint, given in 6a, saying that the right edge of a superheavy syllable (SH) aligns with the right edge of a phonological word. I am not committing myself here to how superheavy syllables are represented phonologically, since this issue is peripheral to the issues I discuss below.[7] It is not enough to simply state the constraint in 6a captures the generalization in 5 because one needs to make a statement about how German would treat a potential foreign borrowing in which a superheavy syllable could potentially surface within a phonological word. The fact that German lacks examples like the one in 4d falls out from ALIGN-SH and I-O faithfulness constraints like those in 6b and 6c, which penalize the deletion of a mora and a segment, respectively. The ranking ALIGN-SH » MAX-μ in 6d is a specific instantiation of the general ranking in 2b for the canonical phonological pattern if alignment constraints are interpreted to be a kind of markedness constraint. The ranking MAX-I-O » ALIGN-SH is justified below.

[6] Not surprisingly, some speakers prefer the pronunciation with the corresponding short, lax vowel, that is, [bœɐ̯.zə].

[7] A reviewer notes correctly that alignment constraints like the one in 6a are assumed to refer to constituents, but that a superheavy syllable is not a constituent. One could solve this problem by representing the final consonant in a superheavy syllable as structurally different than the final consonant in heavy syllables. For example, the final consonant in the underlined sequences in 4 could be extrasyllabic, although this proposal is not in line with the analysis of Hall 2002a,b. I leave this issue open.

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(6) Constraints and ranking for canonical pattern of phonotactics

a. ALIGN-SH: Align the right edge of a superheavy syllable (SH) with the right edge of a phonological word.

b. MAX-μ: An input mora must have an output correspondent.

c. MAX-I-O: An input segment must have an output correspondent.

d. MAX-I-O » ALIGN-SH » MAX-μ

In the tableau in 7, I show that if the hypothetical word in 4d were to enter German as a loanword, then the ranking in 6d tells us that it would surface in such a way that the long vowel shortens.[8]

(7) A hypothetical word that could potentially violate ALIGN-SH

	/aʀeːlna/	MAX-I-O	ALIGN-SH	MAX-μ
a.	→ [a.ʀɛl.na]			*
b.	[a.ʀeːl.na]		*!	
c.	[a.ʀeː.na]	*!		

My assumption here and below is that all vowels are underlyingly moraic; hence, short vowels are prelinked to a single mora and long vowels to two. In 7, we can observe that the faithful candidate in 7b violates ALIGN-SH, and that is therefore less harmonic than the vowel shortening candidate in 7a. The additional form in 7c is important because it shows that mora deletion is preferred as a repair strategy to the deletion of an entire segment.

An interesting question is if and how German repairs potential violations to ALIGN-SH in loanwords that have no long vowel, for example, a hypothetical word like [a.ʀɛlm.na]. Recall that there are a few real words of this structure, for example, *Skulptur* [skʊlp.tuːɐ̯] 'sculpture', *arktisch* [aʀk.tɪʃ] 'arctic', and *Auktion* [aʊk.tsjoːn] 'auction'. Significantly, the ranking MAX-I-O » ALIGN-SH in 7 correctly selects the

[8] Hall and Hamann (2003) concede that historical examples illustrating vowel shortening as in 7 are difficult to find. As noted in that article (p. 71), one possible historical example illustrating this kind of vowel shortening is the word *Rektor* [ʀɛk.toːɐ̯] 'rector', because the [ɛ] was historically the long (tense) vowel [eː] in the donor language Latin.

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respective faithful forms. (There is no tendency to insert a vowel as a repair strategy; hence, the constraint penalizing output forms with epenthesis (DEP-I-O) is ranked ahead of ALIGN-SH.)

A set of morphologically complex words with surface [V:C] superheavy syllables in violation of ALIGN-SH is discussed in section 2.3. These examples pose an apparent problem for my analysis in 7, because the word-internal [V:C] syllable is not repaired by vowel shortening (or in some other way). I argue ultimately that these data require that ALIGN-SH be dominated by an O-O constraint because I show that they involve a PU effect. Before I discuss these data, however, I consider briefly in section 2.2 canonical syllabification patterns because I need to clarify how my analysis captures well-formed versus ill-formed onset clusters.

2.2. Canonical Syllabification.

The data in 8a consist of words containing two intervocalic consonants, the first of which is an obstruent and the second of which is a sonorant consonant (abbreviated henceforth as OS). In these words, the OS sequence is a permissible onset, as indicated in 8b, in which an example is provided of a word beginning with the respective OS sequence. The S in these examples can be /ʀ l n/.[9]

(8) VOSV is parsed V.OSV if and only if OS is a permissible onset

a.	Metro	[meː.tʀo]	'metro'
	Afrika	[aː.fʀi.ka]	'Africa'
	Kobra	[koː.bʀa]	'cobra'
	Iglu	[iː.glu]	'igloo'
	Problem	[pʀo.bleːm]	'problem'
	Magnet	[ma.gneːt]	'magnet'

[9] There are many German words in which the S in OS is /m/, but unlike the examples in 8, these clusters are non-occurring word-initially (see 10 and 26b below). The only other sonorant consonant is /ŋ/, which cannot occur as the second member of a consonant cluster.

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b.	Tritt	[tʀɪt]	'kick'
	frei	[fʀaɪ]	'free'
	bringen	[bʀɪŋən]	'bring'
	Glanz	[glants]	'brightness'
	Probe	[pʀoːbə]	'sample'
	Gnom	[gnoːm]	'gnome'

It can be observed from the phonetic forms in 8a that the OS sequence is syllabified as an onset—a parsing considered uncontroversial in the literature. There are two arguments for this parsing as opposed to a heterosyllabic one. First, if the OS sequence were to be heterosyllabified, then examples such as the first four would constitute violations to ALIGN-SH. Second, a heterosyllabic parse would be problematic for the final four examples in 8a, because Final Devoicing, which affects an obstruent in coda position, would incorrectly be predicted to apply to the O in these OS sequences.[10]

The examples in 9a are structurally similar to the ones in 8a because they also contain an intervocalic OS, which surfaces as an onset. The difference between the words in 8a and 9a is that the vowel following OS in the latter words begins a suffix. The examples in 9b show that the intervocalic OS sequences in 9a are well-formed onset clusters because they surface word initially.

(9) VOS-V is parsed V.OS-V if and only if OS is a permissible onset

a.	fiebr-ig	[fiːbʀɪç]	'feverish'
	ekl-ig	[eːklɪç]	'disgusting'
	nebl-ig	[neːblɪç]	'foggy'
	regn-en	[ʀeːgnən]	'rain'
b.	Brot	[bʀoːt]	'bread'
	Klang	[klaŋ]	'sound'
	Blei	[blaɪ]	'lead'
	Gnom	[gnoːm]	'gnome'

[10] See section 3.1 below for data and justification that Final Devoicing is syllable-based.

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In 10, we can see words that are structurally similar to the ones in 8a, the crucial difference being that the OS sequence in the former words is not a permissible onset in the sense that there are no words beginning with these sequences. The heterosyllabic parsing here is uncontroversial. I give here only examples in which the O is voiceless.

(10) VOSV is parsed VO.SV only if OS is not a permissible onset

Atlas	[at.las]	'atlas'
Athlet	[at.leːt]	'athlete'
Technik	[tɛç.niːk]	'technology'
ethnisch	[ɛt.nɪʃ]	'ethnic'
Schrapnell	[ʃʁap.nɛl]	'shrapnel'
Rhythmus	[ʁʏt.mʊs]	'rhythm'
Atmosphäre	[at.mo.sfɛː.ʁə]	'atmosphere'

Examples like those in 10, in which the O is voiced, are discussed in section 3, which concerns itself with Final Devoicing. Words such as those in 10, in which the OS is followed by a vowel that begins a suffix, are discussed in section 2.3 below because they are the ones that are argued to exhibit PU effects.

Let us now consider the two markedness constraints necessary to account for well-formed syllable-initial clusters. The first is SON (see 11a), posited independently by Raffelsiefen (1995) and Hall (2002a) to account for sonority sequencing in German. As stated below, this constraint is undominated in German because sequences that violate it (for example, $*_{\sigma}$[ld, $*_{\sigma}$[nd) are unpronounceable. Since sequences like these in other languages are repaired if they enter German as loanwords (see note 11 below), SON clearly must outrank the faithfulness constraints MAX-I-O, and DEP-I-O. The second markedness constraint necessary is OWF in 11b, which is simply shorthand for the constraints that rule out OS onsets satisfying SON, for example, $*_{\sigma}$[tl, $*_{\sigma}$[dl, and $*_{\sigma}$[tm. Illicit clusters like $*_{\sigma}$[tm are significant because they show that OWF cannot simply be reduced to some constraint specifying that the two consonants are homorganic. As pointed out by an anonymous referee, clusters like these are pronounceable (in contrast to the ones violating SON), and, in fact, they are attested in a few marginal examples in word-initial position; for example, *Tmesis* [tmeːzɪs] 'tmesis (the separation of the parts of a compound word)' and *Tlingit* [tlɪŋgɪt] 'Tlingit

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(language name)'. To account for the fact that clusters violating OWF are not repaired in some way, OWF must be outranked by faithfulness (that is, MAX-I-O and DEP-I-O). The ranking of SON, OWF, and faithfulness is presented in 11c.[11]

(11) Constraints and ranking for syllable-initial clusters

a. SON: A sonorant consonant in the syllable onset may be preceded only by obstruents (for example, $*_{\sigma}$[ld and $*_{\sigma}$[nd).

b. ONSET WELLFORMEDNESS (OWF): Certain OS sequences are ungrammatical in the onset (for example, $*_{\sigma}$[tl, $*_{\sigma}$[dl, and $*_{\sigma}$[tm).

c. SON » FAITHFULNESS (MAX-I-O, DEP-I-O) » OWF

The syllabification patterns in 8–10 require OWF as well as the two markedness constraints in 12a,b, which are familiar from the literature (see, for example, Prince and Smolensky 1993).

(12) Constraints and ranking for canonical syllabification patterns 8–10

a. NOCODA: The syllable is open.

b. NOCOMPONSET:At most one segment occurs syllable-initially.

c. OWF » NOCODA » NOCOMPONSET

The ranking in 12c captures the syllabification patterns in 8–10, as illustrated in the two tableaux in 13:

[11] The constraint MAX-I-O must outrank DEP-I-O because clusters violating SON are repaired by epenthesis and not deletion. For example, the Bantu language *Ndao* [ndao] would be pronounced in German [n̩dao] (with epenthesis, that is, sonorant syllabification), and not [dao] or [nao] (with deletion). In 11c, I simply have both faithfulness occupying the same niche in the constraint hierarchy because DEP-I-O plays no role in the following sections.

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(13) Tableaux illustrating canonical syllabification

	/pʀoble:m/	OWF	NoCoda	NoCompOnset
a.	→ [pʀo.ble:m]			*
b.	[pʀob.le:m]		*!	

	/atlas/	OWF	NoCoda	NoCompOnset
c.	[a.tlas]	*!		*
d.	→ [at.las]		*	

In 13, we can observe that the candidate in 13b with the heterosyllabic parse is not optimal because it incurs a fatal violation of NoCoda, so 13a wins out. By contrast, in the structurally similar word /atlas/, the form with the heterosyllabic parse in 13d is selected over the one in 13c because the latter candidate violates OWF fatally. Since NoCoda and NoCompOnset do not play a role in the following analysis, I ignore them in all subsequent tableaux.

In the tableau in 14, I have presented a hypothetical (and phonotactically ill-formed) word, which is akin to the hypothetical example in 7. The difference between the hypothetical example in 14 and the real example in 13d is that the first vowel is short in the latter word, whereas it is long in the former one.

(14) A hypothetical word that could potentially violate Align-SH if it surfaced faithfully

	/a:tlas/	Max-I-O	OWF	Align-SH	Max-μ
a.	[a:.tlas]		*!		
b.	[a:t.las]			*!	
c.	[a:.las]	*!			*
d.	→ [at.las]				*

The tableau in 14 shows that if a word like /a:tlas/ were the input, then the expected outcome would be the form in 14d with vowel shortening. Candidate 14a cannot be selected because it violates OWF, candidate 14b because it violates Align-SH, and candidate 14c because it violates Max-I-O.

Note that my analysis predicts that clusters that could potentially violate OWF if they were to surface in the onset are always

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heterosyllabified if these clusters are word internal, for example, the /tm/ in *Rhythmus* in 10. By contrast, word-initial clusters violating OWF surface faithfully; for example, the marginal examples *Tmesis* and *Tlingit* mentioned above. One question my analysis does not answer is why there are so few examples of words like *Tmesis* and *Tlingit*. This is a question I leave open.

2.3. The Distribution of Superheavy Syllables: PU Effects.
In this section, I show that ALIGN-SH has systematic counterexamples that, I argue, make sense if they are analyzed as a PU effect. From a formal point of view, ALIGN-SH is shown to be outranked by a specific O-O constraint referring to the moraic structure of vowels. The problem discussed below has not been discussed in the literature on German to my knowledge.

The examples in 15a are like the ones in 10 because they contain an intervocalic OS, in which OS is not a permissible onset. Note that, in contrast to the words in 10, the items in 15a have a morpheme boundary between the OS sequence (which occurs at the end of the stem) and the following vowel (which is the first segment of the suffix). It should also be noted that the vowel before OS in 15a is long. There is no generalization concerning the kind of suffix that can be present in these words, since it can be either derivational or inflectional. The underlying form of the stems in 15a contains no schwa, as I have shown in 15c. Thus, I adopt the majority view in German phonology that the schwa in stems of this structure is epenthetic (Giegerich 1987, Wiese 1988, Hall 1992, Noske 1993, Wiese 1996, and Noske 1999). The O in the OS sequences of 15a is either voiceless (in the first two examples) or voiced (in the final four). That Final Devoicing does not apply here is an issue discussed in section 3.2 below.

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(15) Words containing V:OS-V; OS is not a permissible onset (see 15a)

a.	Atm-ung	[aːt.mʊŋ]	‘breathing’		
	atm-e	[aːt.mə]	‘breathe, 1sg.’		
	Siedl-ung	[ziːd.lʊŋ]	‘settlement’		
	Siedl-er	[ziːd.lɐ]	‘settler’		
	Basl-er	[baːz.lɐ]	‘one from Basel’		
	ein-ebn-en	[aɪn.eːb.nən]	‘level off’		
b.	Atem	[aː.təm]	‘breath’	c.	/aːtm/
	siedel-n	[ziː.dəln]	‘settle’		/ziːdl/
	Basel	[baː.zəl]	‘Basel’		/baːzl/
	eben	[eː.bən]	‘even’		/eːbn/

The words in 15a are significant because they are not in line with ALIGN-SH. The reason there are word-internal superheavy syllables in these examples is that the canonical phonology (that is, the ranking in 13) demands that the OS sequence be heterosyllabified, and since the preceding vowel is long, the result is a word-internal superheavy syllable. The claim that the OS clusters in 15a are tautosyllabified is often made in the literature, but, as shown below, this view is problematic. I argue that the violations of ALIGN-SH occur in 15a because of pressure to maintain the length of the stem vowel in all words containing the same stem, as can be observed in 15b.

An analysis of the words in 15a with the ranking in 14 incorrectly predicts that the long vowel in words like *Atmung* is shortened. The problem is made clear in the tableau in 16 for the word *Atmung*—although 16a is the intended winner, 16c is incorrectly selected (indicated here and below as ←).

(16) The incorrect winner is selected given the ranking:
[MAX-I-O » OWF » ALIGN-SH » MAX-μ]

	/aːtmʊŋ/	MAX-I-O	OWF	ALIGN-SH	MAX-μ
a.	aːt.mʊŋ			*!	
b.	aː.tmʊŋ		*!		
c.	← at.mʊŋ				*
d.	a.tmʊŋ		*!		*
e.	aː.mʊŋ	*!			

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The tableau in 16 shows that 16b and 16d cannot be selected as optimal because they are not in line with OWF, and that 16e likewise incurs a fatal violation of MAX-I-O. The intended winner in 16a loses out to the incorrect winner in 16c because the former form violates ALIGN-SH.

The problem in 16 is straightforwardly resolved if the analysis refers to paradigms like those in 17 for the pair {*Atmung, Atem*}.

(17) Six paradigms for {Atmung, Atem}: A correct, B–F incorrect

A	B	C	D	E	F
aːt.mʊŋ	aːt.mʊŋ	at.mʊŋ	at.mʊŋ	aː.mʊŋ	aː.tmʊŋ
aː.təm	a.təm	aː.təm	a.təm	aː.təm	aː.təm

I offer no formal definition of paradigm here (see Downing, Hall, and Raffelsiefen 2005 for various proposals). For the purposes of this article paradigms can be thought of as a set of morphologically related words, which are evaluated together in a tableau. In 17, we can observe six possible paradigms for the pair {*Atmung, Atem*}. 17a is correct, while 17(b–f) are not. The paradigms in 17 have been simplified for the present analysis because they only contain two members. A complete paradigm for the stem *Atem* would also include all of the inflected forms, for example, [aːt.mə] 'breathe (1sg.)'. The simplified paradigms do not affect the analysis presented below.

The present treatment requires the two additional constraints in 18a,b. The former constraint, O-O-IDENT-μ-V, is a specific example of an O-O constraint because it refers to the relationship between the two output forms in a paradigm. O-O-IDENT-μ-V states that the moraic structure of a vowel in some stem is identical with the moraic structure of the same vowel in derived words containing the same stem. Constraint 18b is a markedness constraint, which derives motivation from other languages (see Murray and Vennemann 1983 and Ham 1998). It needs to be stressed here that the present analysis requires not only reference to the output forms in paradigms, but also to the underlying representation (that is, the input). This point is made clear below.

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(18) Constraints and rankings required for the PU effect

a. O-O-IDENT-μ-V: The moraic structure of a vowel in "stem A" is identical with the moraic structure of the same vowel in derived words containing "stem A."

b. STRESSED SYLLABLE LAW (SSL): Stressed syllables are heavy.

c. O-O-IDENT-μ-V, SSL » MAX-I-O » OWL » ALIGN-SH » MAX-μ

The ranking in 18c accounts for the fact that for the form *Atmung* in 17a there is a violation of ALIGN-SH.

Consider now the tableau in 19. The six candidates correspond to the six paradigms in 17. Note that the ranking O-O-IDENT-μ-V » ALIGN-SH is a specific instantiation of the general ranking in 2b for PU effects.

(19) Correct winner is selected, given the ranking in 18c

	/a:tm-ʊŋ/	O-O-IDENT-μ-V	SSL	MAX-I-O	OWF	ALIGN-SH	MAX-μ
a.	→ A					*	
b.	B	*!	*			*	*
c.	C	*!					*
d.	D		*!				**
e.	E			*!			**
f.	F				*!		**

Consider first paradigms B and C. We can observe in 19 that both of these paradigms violate the O-O constraint O-O-IDENT-μ-V. The reason is that for paradigm B the first vowel in *Atmung* is long (see 17), but the same vowel is short in *Atem*. For C, the first vowel in *Atmung* is short and the same vowel in *Atem* is long. Since the two vowels in paradigms B and C differ in terms of moraic structure, they violate O-O-IDENT-μ-V. Consider now candidates A and D. Both paradigms are in line with O-O-IDENT-μ-V, because the vowels in the respective stems have the same number of moras. However, in D the word *Atem* violates the SSL, because the first syllable is stressed and yet it is monomoraic. An examination of candidate A reveals that neither of the two words violates the SSL, and for that reason this paradigm is more harmonic. A comparison of the winner in A with E reveals that the latter one cannot

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be selected as optimal because it is not in line with MAX-I-O.[12] Paradigm E is therefore important, since it reveals that the present analysis must also refer to the underlying representation (that is, /aːtm-ʊŋ/) and not only to the output forms in paradigms. Paradigm F is less harmonic than A, because the former one is not in line with OWF (which is violated in its first member [aː.tmʊŋ], see 17).

What the tableau in 19 therefore shows is that an otherwise pervasive markedness constraint—in this case it is the constraint ALIGN-SH—is violated in certain words in order to ensure that a PU effect for vowel length is maintained.

3. PU Effects in Final Devoicing.

In section 3, I show that the process of Final Devoicing has a systematic set of counterexamples that I argue are accounted for by appealing to PU. I show first in section 3.1 that the canonical pattern of Final Devoicing operates in the syllable coda, and that it requires a specific instantiation of the ranking in 2a, that is, markedness » I-O faithfulness. In section 3.2, it is demonstrated that this markedness constraint is dominated by a specific O-O constraint referring to the feature [voice]. This O-O constraint must be locally conjoined with the markedness constraint SYLLABLE CONTACT LAW (Murray and Vennemann 1983, Davis 1998)

[12] Recall that one of the defining characteristics of the words in 15a is the length of the stem vowel; hence, in 19 a word was evaluated in which the stem vowel is long. Consider now the examples below:

i. eitl-es	[aɪt.ləs]	'vain (adj. ending)'
ii. Ordn-ung	[ɔʀd.nʊŋ]	'order'

In these words, we can observe that ALIGN-SH violations involve either a diphthong plus consonant (in i) or short vowel plus two consonants (in ii). That the present treatment correctly predicts these forms to be the optimal ones falls out from the ranking MAX-I-O » ALIGN-SH in 19. To see this, consider the correct paradigm for *Ordnung* and the related word *orden-t-lich* [ɔʀdəntlɪç] 'orderly': {[ɔʀd.nʊŋ], [ɔʀ.dənt.lɪç]} with its closest competitor {[ɔʀ.nʊŋ], [ɔʀ.dənt.lɪç]}. The latter paradigm is less harmonic than the former one because the first word ([ɔʀ.nʊŋ]) is not in line with MAX-I-O. Recall from section 2.1 that the ranking MAX-I-O » ALIGN-SH is required to account for the fact that word-internal superheavy syllables in the three rare examples *Skulptur*, *arktisch*, and *Auktion* surface faithfully.

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in order to prevent the alternations motivating Final Devoicing in the canonical phonology from exhibiting PU effects.

3.1. Final Devoicing: The Canonical Pattern.
The examples in 20a illustrate that German has alternations between voiced and voiceless obstruents. Words like the ones in 20b show that the alternations in 20a cannot be analyzed as a process involving the voicing of underlying voiceless obstruents in prevocalic position. That Final Devoicing sets in at the end of the stem in the second column of 20c, but not in the fifth column, can be explained by analyzing the domain of Final Devoicing as (a) the syllable coda, or (b) the right edge of a phonological word. Recall from section 2.1 that consonant-initial suffixes like *-sam* lie outside of the phonological word of the stem to which they attach. I follow the majority view that (a) is correct (see Vennemann 1972, Wiese 1988, Rubach 1990, Hall 1992, Wiese 1996, Noske 1999, Lombardi 1999). The problem with the (b) alternative is discussed below.

(20) Alternations between voiced and voiceless obstruents

a.					
Dieb	[diːp]	‘thief’	Dieb-e	[diː.bə]	‘thieves’
Rad	[ʀaːt]	‘wheel’	Rad-es	[ʀaː.dəs]	‘wheels’
Tag	[taːk]	‘day’	Tag-e	[taː.gə]	‘days’
Nerv	[nɛʀf]	‘nerve’	nerv-ös	[nɛʀ.vøːs]	‘nervous’
Haus	[haʊs]	‘house’	Haus-es	[haʊ.zəs]	‘houses’
orange	[oʀaŋʃ]	‘orange’	orang-e	[oʀaŋ.ʒə]	‘orange (adj.)’
b.					
bunt	[bʊnt]	‘colorful’	bunt-e	[bʊn.tə]	‘colorful (adj.)’
krank	[kʀaŋk]	‘sick’	krank-e	[kʀaŋ.kə]	‘sick (adj.)’
c.					
streb-sam	[ʃtʀeːp.zaːm]	‘ambitious’	streb-e	[ʃtʀeː.bə]	‘strive, 1sg.’
Bünd-nis	[bʏnt.nɪs]	‘alliance’	Bund-es	[bʊn.dəs]	‘alliance, gen.sg.’
bieg-sam	[biːk.zaːm]	‘bendable’	bieg-en	[biː.gən]	‘bend, 1pl.’
les-bar	[leːs.baːʁ̞]	‘readable’	les-en	[leː.zən]	‘read,1pl.’

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Some recent work has argued that the alternations in 20 are not accounted for with a rule altering the feature [voice], but instead [spread glottis]; for example, Iverson and Salmons (1995), and Jessen and Ringen (2002). In the present analysis, I am assuming that [voice] is the correct feature. An alternative treatment of the canonical "devoicing" pattern and the morphologically complex examples in section 3.2 in terms of [spread glottis] would be compatible with my analysis provided that there is some equivalent O-O constraint for that feature (as opposed to the feature [voice]). This is an alternative I leave open for further study.

The additional examples in 21 are similar structurally to the ones presented earlier in 10. Both sets of examples are monomorphemic loanwords that contain an intervocalic CC cluster in which CC is not a well-formed onset. In 21a and 10 the consonant cluster is OS, and in 21b it is OO. Note that in all of the examples in 21a,b the syllable-final obstruent is voiced in the donor language but devoiced in German.[13] In the first two examples in 21b, the second O is voiced; hence, the devoicing of the first O cannot be attributed to regressive assimilation. The devoicing pattern in 21 makes sense if the OS and OO sequences are analyzed as heterosyllabic.

[13] A remark in an unpublished manuscript by Steriade (1997:40, note 18) suggests that she does not believe devoicing before nasals, as in 21a, to be the canonical pattern. Her evidence is that no Final Devoicing applies before nasals in proper names (for example, *Abner*, *Bodmer*) and in the obscure nautical term *Bodmerei* 'bottomry'. As stated in note 5, there are good reasons for ignoring proper names. Drosdowski et al. (1990) transcribe *Bodmerei* with a [d], but I do not consider a single example of a word no one has heard of to be enough to invalidate my claim that the devoicing pattern in 21 is canonical. More generally, I do not discuss the licensing-by-cue approach to Final Devoicing as proposed in Steriade 1997, because it cannot account for all of the data in this section, in particular the examples illustrating PU effects in section 3.2.

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(21) VCCV parsed VC.CV, only if CC not permissible onset (as in 10)

a.	Admiral	[at.mi.ʀaːl]	'admiral'
	Badminton	[bɛt.mɪn.tən]	'badminton'
	Kidney(bohne)	[kɪt.ni]	'kidney bean'
	Kadmium	[kat.mi.ʊm]	'cadmium'
	Charisma	[ka.ʀɪs.ma]	'charisma'
b.	Rugby	[ʀak.bi]	'rugby'
	absurd	[ap.zʊʀt]	'absurd'
	Wodka	[vɔt.ka]	'vodka'

Since the examples in 21, in contrast to the ones in 20, do not have alternants in German with a voiced obstruent, I assume that the underlying representations have been restructured with voiceless obstruents, for example, /ʀakbi/ and not /ʀagbi/ for *Rugby*. Note that this restructuring took place in coda position and not at the right edge of a phonological word. For this reason the examples in 21 provide evidence against the phonological word environment in 21b above, but they make sense given the coda context in 21a.[14]

I account for the Final Devoicing data in 20 (and the restructuring of the underlying forms in 21) with the constraints in 22a,b. Constraint 22a is a markedness constraint penalizing voiced obstruents in coda position, and the second one is an I-O faithfulness constraint penalizing the change from [+voice] to [–voice].[15]

[14] Jessen and Ringen (2002:212) argue that their equivalent of Final Devoicing operates at the right edge of a phonological word: "A prosodic word-final obstruent is [spread glottis]." However, it is unclear how Jessen and Ringen's treatment accounts for the examples in 21. Steriade (1997:58) considers devoicing in the examples in the second column of 20c to be PU effects. I follow Raffelsiefen (2005), who examines similar data sets from other languages and concludes that they exhibit "boundary-effects" as opposed to PU effects. (In the examples in 20c, the relevant boundary is the right edge of a syllable.)

[15] Lombardi's (1991, 1999) treatment of German relies on a markedness constraint stating that laryngeal features are licensed by a following tautosyllabic sonorant. The difference between my markedness constraint and Lombardi's is not relevant for the following analysis.

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(22) Constraints/rankings for canonical pattern of alternations in 23

a. *[–son, +vc]]$_{\sigma}$: No voiced obstruent in coda position.

b. I-O IDENT-[vc]: The specification for the feature [voice] of an input segment must be preserved in its output correspondent.

c. *[–son, +vc]]$_{\sigma}$ » I-O-IDENT-[vc]

The ranking in 22c, a specific version of 2a, is illustrated in the tableau in 23 for the word *Dieb*, representative of the data in 20.

(23) *Dieb* [di:p] (from /di:b/) (illustrating ranking in 22c)

	/di:b/	* [–son, +vc]]$_{\sigma}$	I-O-IDENT-[vc]
a.	→ [di:p]		*
b.	[di:b]	*!	

In this tableau, we can observe that the faithful candidate in 23b incurs a fatal violation of the high ranked markedness constraint and therefore 23a is selected.

The tableau in 24 for the word *Admiral* is representative of examples like those in 21. The underlying form /admiʀa:l/ is understood here to be the perceptual input from the donor language.

(24) *Admiral* [at.mi.ʀa:l]

	/admiʀa:l/	OWF	*[–son, +vc]]$_{\sigma}$	I-O-IDENT-[vc]
a.	[ad.mi.ʀa:l]		*!	
b.	[a.dmi.ʀa:l]	*!		
c.	→ [at.mi.ʀa:l]			*

It is shown in this tableau that the ranking *[–son, +vc]]$_{\sigma}$ » I-O-IDENT-[vc] and OWF tell us that the voiced obstruent devoices.

3.2. Final Devoicing: PU Effects.

With the analysis of the canonical phonology for voicing alternations in mind, we can now consider the words in 25a. These examples have a similar structure to the ones in 15a, the one significant difference being that in 25a I have only included examples in which the O is voiced. In

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25a, the OS sequence is preceded by either a long vowel or a short vowel plus consonant. As noted above, the examples below have been taken from Drosdowski et al. 1990; they also form the basis of the various treatments proposed in the theoretical literature discussed below. The underlying form of the stems in 25c does not contain schwa, in conformance with the majority view in German phonology (Giegerich 1987, Wiese 1988, Hall 1992, Noske 1993, Wiese 1996, and Noske 1999). In section 4, I consider and reject Lombardi's (1991) treatment of German, which relies on underlying forms with schwa for the first stem morpheme in 25a, for example, /ziːdəl/. There is no reason to distinguish inflectional from derivational suffixes in 25a, since the ALIGN-SH violations occur before both.

(25) a.

Siedl-ung	[ziːd.lʊŋ]	'settlement'
Siedl-er	[ziːd.lɐ]	'settler'
Handl-ung	[hand.lʊŋ]	'act'
handl-e	[hand.lə]	'act (1sg.)'
Pendl-er	[pɛnd.lɐ]	'commuter'
Paddl-er	[pad.lɐ]	'paddler'
Basl-er	[baːz.lɐ]	'one from Basel
Ordn-ung	[ɔʀd.nʊŋ]	'order'
ordn-en	[ɔʀd.nən]	'put in order'
ein-ebn-en	[aɪn.eːb.nən]	'level off'

b.

siedel-n	[ziː.dəln]	'settle'
handel-n	[han.dəln]	'act'
pendel-n	[pɛn.dəln]	'commute'
paddel-n	[pa.dəln]	'paddle'
Basel	[baː.zəl]	'Basel'
orden-t-lich	[ɔʀ.dənt.lɪç]	'orderly'
Ebene	[eː.bə.nə]	'level'

c.

/ziːdl/
/handl/
/pɛndl/
/padl/
/baːzl/
/ɔʀdn/
/eːbn/

An examination of the phonetic transcriptions in 25a reveals that the O is analyzed as syllable-final, meaning that the examples in 25a constitute systematic exceptions to Final Devoicing.[16] My treatment of the OS

[16] That the [d] in words like *Handlung* in 25a is phonetically voiced has been demonstrated by an acoustic experiment conducted by Jessen and Ringen (2002: 207ff.). All of the words in 25a, with the exception of [pad.lɐ], also violate

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sequences in 25a as heterosyllabic is occasionally found in the literature (for example, Rubach 1990), but as a whole the majority of researchers treat these sequences as tautosyllabic.

I account for the problematic examples in 25a by analyzing them as a PU effect, that is, the reason the syllable-final obstruent in the stems in 25a is voiced is that there is a morphologically-related word in which the same obstruent is predicted by the canonical phonology to be voiced. My surface-based PU analysis of the data in 25 is not shared by the majority of researchers, who analyze the words in 25a in some other way, for example, in terms of cycles (Rubach 1990), a language-specific rule of resyllabification (Hall 1992), or by analyzing German as a language "not in harmony with the Law of Initials" (Vennemann 1972). While it is not my intention to discuss each of these alternative proposals, I make passing reference to the problems a non-PU analysis of the data in 25a poses. In section 4, I discuss two alternative non-PU approaches to the German data that were brought to my attention by an anonymous referee and show their drawbacks.

That the non-application of Final Devoicing in 25a is attributed to PU derives support from two factors. First, all of these forms are heteromorphemic and have some morphologically related word containing the same stem in which the obstruent is predicted to be voiced by the canonical phonology (see 25b). Second, monomorphemes illustrating the same problem with respect to Final Devoicing are extremely rare (see below for discussion). Since PU effects by definition involve words that are related morphologically, then the existence of morphologically related forms and the absence of monomorphemes illustrating the same problem should come as no surprise.

The observation that monomorphemes of the same phonological structure as 25a are very rare is a point that needs elaboration because it goes contrary to the assumption of many writers. The one monomorpheme commonly discussed in the literature, which is akin to the data in 25a, is presented in 26a. Assuming the heterosyllabic parse in this

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ALIGN-SH. For words like *Siedlung*, in which the stem contains a long vowel, the ALIGN-SH violations can be captured formally with the ranking in 19 above. For words like [ɔʀd.nʊŋ], the surface violation of ALIGN-SH follows from the ranking MAX-I-O » ALIGN-SH. I have no explanation for why there are so few examples like [pad.lɐ].

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word (which falls out from my analysis in section 2), we can observe here that the first syllable ends in a voiced obstruent. To my knowledge, this is the only true idiosyncratic exception to my analysis of Final Devoicing. Note that this word is also one of the rare idiosyncratic exceptions to the generalization in 4, which describes the distribution of superheavy syllables. There exists a sizable number of monomorphemic words in 26b that are unlike *Adler* because they are systematic exceptions to my analysis. The reason these words are systematic exceptions, as opposed to true exceptions, is that they all involve the same cluster, namely [gm] (and no other one).

(26) Idiosyncratic and systematic exceptions to the present analysis

a. Idiosyncratic exception

Adler	[aːdlɐ]	'eagle'

b. Systematic exceptions (that is, only one cluster, namely [gm])

Magma	[magma]	'magma'
Segment	[zɛgmɛnt]	'segment'
Pigment	[pɪgmɛnt]	'pigment'
Sigma	[zɪgma]	'sigma'
Fragment	[fʀagmɛnt]	'fragment'
Stigma	[stɪgma]	'stigma'
Phlegma	[flɛgma]	'phlegm'
Dogma	[dɔgma]	'dogma'
Syntagma	[zʏntagma]	'syntagma'
Diaphragma	[diafʀagma]	'diaphragm'
Paradigma	[paʀadɪgma]	'paradigm'
Änigma	[ɛnɪgma]	'enigma'
Pragmatik	[pʀagmatɪk]	'pragmatics'
Pygmäe	[pʏgmɛːə]	'pygmy'
Stalagmit	[ʃtalagmiːt]	'stalagmite'

Raffelsiefen (2004) points out that there are good reasons for considering words like *Magma* in 26b to be different from other OS sequences not in line with OWF (see also Kumashiro 2000, which comes to a similar

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conclusion).[17] First, and most obviously, the [g] in [gm] does not devoice, contrary to the canonical pattern in 21 for monomorphemic words like *Admiral*. Examples like *Admiral* are important because they show that Final Devoicing affects an obstruent before both [m] and [n] of the ON sequence if it is not a well-formed onset. Second, the vowel preceding [gm] onsets seems to be consistently short, whereas it is typically long before obstruent plus liquid sequences in monomorphemic words (recall 8a). While I can offer no explanation for the special behavior of [gm] clusters (other than the one proposed in Raffelsiefen 2004), it suffices to say that the correct treatment requires some mechanism not related to PU.[18]

The advantage of the present treatment is that the violations to Final Devoicing in 25a are predicted to occur exclusively in morphologically complex words. Likewise, the disadvantage of earlier approaches that analyze the OS sequences in 25a as tautosyllabic is that they miss the generalization that the overwhelming number of examples like these are

[17] I summarize here Raffelsiefen's treatment and another one she does not consider, but I leave open which of the two should be adopted in my own analysis. Raffelsiefen (2004) proposes that constraints are evaluated at two levels, that is, lexically and postlexically. The lexical level selects the heterosyllabic parse for words not in line with OWF, for example, [mag.ma], but postlexically these heterosyllabified [gm] clusters are tautosyllabified; that is, [ma.gma] is the correct output form. At the lexical level, OWF and constraints stating that syllables cannot end in a short vowel are undominated, but they lose their undominated status in the postlexical component. In a similar approach, one could argue—given my own analysis of syllabification in section 2—that [gm] is tautosyllabified in words like *Magma* (that is, [ma.gma]) by ranking the constraint $*_{\sigma}$[gm lower than the structurally similar constraints that were grouped together under the cover term OWF. This analysis would then see the lack of word-initial [gm] as accidental. Note that this approach works technically, but it cannot explain why [gm] is the only OS cluster not occurring word-initially, that is tautosyllabified.

[18] Several authors also include proper names in their discussion of German syllabification, for example, *Leibniz* [laɪbnɪts]. See Giegerich 1992, Hall 1992, and Yu 1992. Recall from note 5 that I do not consider proper names in my analysis because they are not representative of canonical phonological patterns. From a formal point of view one might want to say that proper names have their own constraint ranking. This is an issue I leave open.

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heteromorphemic, and that the tautomorphemic words like *Adler* in 26a are extremely rare, not to mention the fact that [gm] deserves special treatment (Vennemann 1972, Hall 1992, Yu 1992, Giegerich 1992, and Noske 1999).[19]

Consider now the three paradigms in 27 for the pair {*Siedlung, siedeln*}, which is representative of all of the examples in 25a. In the Standard German dialect described here, A is correct and B and C are not. In the Northern dialects discussed in Vennemann 1972 and Brockhaus 1995:40, Final Devoicing affects the O, so that B is correct and A and C are not. I consider first Standard German and then I return to the Northern dialects.

(27) Three paradigms for the pair {*Siedlung, siedeln*}: A is correct

A	B	C
ziːd.lʊŋ	ziːt.lʊŋ	ziː.dlʊŋ
ziː.dəln	ziː.dəln	ziː.dəln

Paradigms for {*Siedlung, siedeln*} with shortened vowels as in 17 (for example, {[zɪd.lʊŋ], [ziː.dəln]}) will not be dealt with here because the analysis posited in section 2.3 always treats the paradigms in A and B in 27 as more harmonic than paradigms with shortened vowels. Another candidate I do not consider here is one in which the stem is identical in both forms, that is, {ziː.dəlʊŋ, ziː.dəln}. This paradigm is clearly more uniform than the correct one in A, but it loses out to the latter one because the first word in it (that is, ['ziː.də.lʊŋ]) does not satisfy the metrical constraint guaranteeing that the foot is trochaic (see Féry 1998). By contrast, both members of the correct paradigm in A above satisfy the constraint TROCHEE.

Crucial for my treatment is the O-O constraint O-O-IDENT-[vc] in 28a, which says that the value of the feature [voice] is the same for all of the members in a paradigm. Recall from above that some linguists have argued that [spread glottis] and not [voice] is distinctive for German

[19] The criticism that the "exceptions" to Final Devoicing involve heteromorphemic examples does not apply to Rubach 1990, in which the cyclic treatment correctly predicts this to be the case. In contrast to Rubach 1990, my analysis requires no cycles.

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obstruents. If this is the case, then the O-O constraint in 28a would refer to [spread glottis].

(28) a. O-O-IDENT-[vc]: The value of [voice] for an obstruent in "stem A" is identical with the value of the feature [voice] of the corresponding obstruent in derived words containing "stem A."

b. O-O-IDENT-[vc], OWF » *[–son, +vc] $]_{\sigma}$ » I-O-IDENT-[vc] (ranking to be modified below)

The ranking of O-O-IDENT-[vc] over the markedness constraint *[–son, +vc]$]_{\sigma}$ in 28b is a specific version of the general ranking in 2b for PU effects. This is the ranking discussed below, although later on in this section I demonstrate that it needs to be modified slightly.

An examination of the three paradigms in 27 reveals that paradigm A satisfies O-O-IDENT-[vc] because the [d] is present in both examples, but that in paradigm B, O-O-IDENT-[vc] is violated because the [t] in the first word corresponds to a [d] in the second word. Paradigm C is not optimal because its first member (that is, [ziː.dlʊŋ]) violates OWF. The analysis is illustrated in the tableau in 29.

(29) Evaluation for the paradigm {*Siedlung, siedeln*}

	/ziːdl-ʊŋ/	O-O-IDENT-[vc]	OWF	*[–son, +vc]$]_{\sigma}$	I-O-IDENT-[vc]
a.	→ A			*	
b.	B	*!			*
c.	C		*!		*

The treatment of PU effects in this tableau is revised in 34 below.

Some data from the Northern dialects mentioned above have been presented in 30. Observe that the syllable-final obstruent devoices in 30a (Vennemann 1972).

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(30) Syllable final obstruent devoicing in Northern German dialects

a.	Siedl-ung	[ziːt.lʊŋ]	‘settlement’		
	Handl-ung	[hant.lʊŋ]	‘act’		
b.	siedel-n	[ziː.dəln]	‘settle’	c.	/ziːdl/
	handel-n	[han.dəln]	‘act’		/handl/

The ranking for the Northern dialects is illustrated in the tableau in 31.

(31) Evaluation for the paradigm {*Siedlung, siedeln*} in N. German

	/ziːdl-ʊŋ/	*[–son, +vc]]$_{\sigma}$	OWF	O-O-IDENT-[vc]	I-O-IDENT-[vc]
a.	A	*!			*
b.	→ B			*	
c.	C		*!		

This tableau shows that the B candidate can be selected in the Northern dialects by demoting O-O-IDENT-[vc], so that it is lower in the hierarchy than the markedness constraint *[–son, +vc]]$_{\sigma}$, which bans voiced obstruents in the coda. Put differently, in Standard German there are PU effects involving Final Devoicing, but in the Northern dialects it is the canonical phonology that wins and reference to PU is therefore not necessary.[20]

Consider once again the PU analysis for Standard German in tableau 29. Although the ranking in that tableau correctly captures the fact that the syllable-final obstruent in the words in 25a does not devoice, it is problematic because it incorrectly predicts that the alternations in 20a,c should show PU effects as well. This problem is made clear in the following tableau for the paradigm {*Dieb, Diebe*} ‘thief, thieves’ from 20a. I consider here three paradigms, namely the correct (but non-uniform) one, {diːp, diː.bə}, as well as two that seem to be more harmonic than the correct one because they exhibit consistent PU effects with respect to the feature [voice]: {diːb, diː.bə} and {diːp, diː.pə}.

In tableau 32, the intended winner in 32a incurs a fatal violation of the PU constraint O-O-IDENT-[vc] (since the [p] in [diːp] differs from the

[20] Note that the heterosyllabic parse of the OS in a word like *Siedlung* for candidate B (that is, [ziːt.lʊŋ]) falls out from the ranking OWF » NOCODA » NOCOMPONS for the canonical phonology in 12–13.

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[b] in [diː.bə]). The markedness constraint *[–son, +vc]]$_{\sigma}$ is responsible for ruling out the 32b form, so that the unintended winner in 32c is incorrectly selected as optimal.

(32)

	/diːb/	O-O-IDENT-[vc]	*[–son, +vc]]$_{\sigma}$	I-O-IDENT-[vc]
a.	diːp dː.bə	*!		*
b.	diːb diːbə		*!	
c.	← diːp diː.pə			**

Consider once again the phonetic representation of the data in 25a. These items all have a phonological similarity in the sense that the first syllable ends in an obstruent and the second one begins with a sonorant consonant. By contrast, none of the examples in 20 are of this structure. Thus, from the point of view of markedness all of the forms in 25a violate the SYLLABLE CONTACT LAW (SCL) in 33a.[21] Raffelsiefen (1995) argues that the SCL plays an important role in her treatment of German schwa. Since there are many SCL violations in German (for example, words like *Atlas* [at.las] in 10), we can conclude that SCL must be dominated by faithfulness constraints (for example, MAX-I-O and DEP-I-O). This ranking MAX-I-O, DEP-I-O » SCL is necessary because the SCL violation in words like *Atlas* is not repaired in some way (for example, [a.tə.las] or [a.tas]), and instead these words surface faithfully. It cannot be determined how SCL is ranked with respect to the other constraints discussed above.

(33) a. SYLLABLE CONTACT LAW (SCL): In α.β the sonority of α is greater than the sonority of β.

b. {O-O-IDENT-[vc] & SCL}, OWF » * [–son, +vc]]$_{\sigma}$ » I-O-IDENT-[vc]

[21] For pre-OT work on the SCL, see Murray and Vennemann 1983 and Vennemann 1988. The status of the SCL in the OT framework is discussed in Bat El 1996, Green 1997, Davis 1998, Davis and Shin 1999, and Green 2003.

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In the revised analysis below, I argue that the examples in 25a (and not the ones in 20a,c) can be analyzed as PU effects if the PU constraint, that is, O-O-IDENT-[vc], is locally conjoined with SCL and if this local conjunction dominates the markedness constraint *[–son, +vc]]$_{\sigma}$, as in 33b.[22]

Consider now the following tableau for the paradigm {*Siedlung, siedeln*}, in which the ranking in 33b is illustrated.

(34) PU effects for 25a given the ranking in 33b

	/ziːdl/	O-O-IDENT-[vc] & SCL	OWF	* [–son, +vc]]$_{\sigma}$	I-O-IDENT-[vc]
a.	→ ziːd.lʊŋ ziː.dəln				
b.	ziːt.lʊŋ ziː.dəln	*!			*
c.	ziː.dlʊŋ ziː.dəln		*!		

Paradigm 34c cannot be optimal because its first member does not satisfy OWF. Paradigm 34b is not in line with the constraint conjunction because this pair of words violates both O-O-IDENT-[vc] (by virtue of the fact that there is a [t] in the first word in the paradigm but a [d] in the other one) and the SCL (that is, in [ziːt.lʊŋ]). By contrast, paradigm 34a satisfies the conjunction, since this pair of words does not violate the O-O constraint, O-O-IDENT-[vc].

The tableau in 35 is an evaluation of the paradigm {*Dieb, Diebe*}. Three paradigms have been included in the tableau; the one with the non-uniform paradigm in 35a is correct, and the ones with uniform paradigms in 35b,c are not.

[22] For literature on local conjunction in OT, see Łubowicz 2002, Alderete 2004, and Kirchner 2004. See also McCarthy 2003 for a useful survey of the literature, and Hall 2005, which shows that the SCL is locally conjoined with an onset-specific constraint to account for the fact that the regular process of Glide Formation in German is systematically blocked in certain phonologically defined contexts.

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(35) No PU effects for 20 given the ranking in 33b

	/diːb/	O-O-IDENT-[vc] & SCL	*[–son, +vc]]$_{\sigma}$	I-O-IDENT-[vc]
a.	→ diːp diː.bə			*
b.	diːb diː.bə		*!	
c.	diːp diː.pə			**!

An examination of the three paradigms in 35 reveals that none of them violates the constraint conjunction {O-O-IDENT-[vc] & SCL}, because all six words are in line with the SCL. What this means is that the evaluation of the paradigms in 35 is put off until the second round, in which 35b incurs a fatal violation of the markedness constraint *[–son, +vc]]$_{\sigma}$. That 35a is correctly selected over 35c can only be ascertained in the final column, in which it is shown that the latter paradigm incurs two violations of I-O-IDENT-[vc] and 35a only one.[23]

Note that the modified analysis for Standard German in 34–35 with the constraint conjunction does not require a reanalysis for Northern German (recall the data in 30 and the analysis in 31). Thus, to obtain the correct output forms (that is, 34b) the constraint conjunction must be lower ranked than *[–son, +vc]]$_{\sigma}$. However, this reranking does not affect the outcome in 35 so that 35a is selected for Northern German as well.

One question discussed in the literature on constraint conjunctions is what kinds of constraints can and cannot be locally conjoined (see, for example, Łubowicz 2002 and McCarthy 2003 and references cited therein). Note that my proposed conjunction {O-O-IDENT-[vc] & SCL} conjoins an O-O constraint with a markedness constraint. To my know-

[23] The analysis in 34 holds for words of the 25a type, that is, words like *Siedl-ung* containing prevocalic OS, in which the O is voiced and in which OS is not a permissible onset. Note that the same analysis is predicted for words like *wappnen* [vap.nən] 'to arm', in which the O is voiceless (see *Wappen* [vapən] 'coat of arms', /vapn/). Thus, the ranking in 34 predicts the heterosyllabic parse in [vap.nən] because the candidate with a tautosyllabic parse (that is, [va.pnən]) is not in line with OWF.

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ledge none of the constraint conjunctions proposed in the literature involves constraints from these two families. I consider this gap to be purely accidental and attribute it to the general lack of studies dealing with PU effects in natural languages. It should be noted that constraints from the markedness family and the O-O constraint family have in common that they both refer to the output forms on the surface (as opposed to the input). I conclude that the burden of proof now lies on the shoulders of linguists who contend that an analysis of German is possible without my proposed conjunction.[24]

I conclude this section by considering once again the morphologically complex words like *nebl-ig* presented earlier in 9a (repeated in 36a), since my implicit claim is that these examples, contrary to the structurally similar ones in 25a, do not show PU effects. An examination of the phonetic forms in 9a reveals that Final Devoicing does not set in, but in contrast to words like *Siedl-ung* in 25a, the syllable boundary is assumed to precede the OS. Note that each of the stems in 36a occurs without a suffix in 36b and that the intervocalic O is predicted by the canonical phonology to be voiced.

[24] It is interesting to note that one of the constraints in the proposed conjunction, namely the SCL, has been argued to be present in another conjunction to account for the fact that Glide Formation is blocked in one context (see Hall 2005). One could speculate that constraint conjunctions between constraints belonging to different families are only allowed if one or more of these constraints is present in another conjunction in the same language. Concerning the OT literature on constraint conjunctions, McCarthy (2003:26) criticizes Łubowicz's (2002) proposal that markedness constraints should be conjoined with I-O faithfulness constraints in order to account for non-derived environment blocking effects. The primary reason why he criticizes this type of constraint conjunction is that it does not capture Kiparsky's (1973) original notion of a "derived environment." Note that McCarthy's criticisms cannot be extended to the conjunction in 34, which involves a markedness constraint and an O-O faithfulness constraint, because (a) this conjunction involves an O-O constraint, and (b) it is not intended to capture a derived environment. See Hall "in press" for criticisms of McCarthy's (2003) theory of comparative markedness.

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(36) VOS-V is parsed V.OS-V if and only if OS is a permissible onset

a.	nebl-ig	[neː.blɪç]	'foggy'
	fiebr-ig	[fiː.bʀɪç]	'feverish'
	regn-en	[ʀeː.gnən]	'rain'
b.	Nebel	[neː.bəl]	'fog'
	Fieber	[fiː.bɐ]	'fever'
	Regen	[ʀeː.gən]	'rain'

One might argue that there is no difference between 36a and 25a, and that the latter ones are therefore syllabified like the former ones (for example, [neːb.lɪç]), implying that both sets of words are captured in terms of PU effects. (See Kumashiro 2000:367–368, who proposes a PU account for words like the ones in 36a, which is cast in a very different theoretical framework.)

While the alternative analysis of the *nebl-ig* words in 36a in terms of PU might work technically given the ranking in 35, I assume that this is not the case and they instead indicate the canonical pattern because of the following asymmetry: For VOSV in which OS is a well-formed onset there are many examples of (a) monomorphemes (see 8a) and (b) heteromorphemic examples (see 36a). However, for VOSV in which OS is not a well-formed onset there are many heteromorphemic examples (see 25a), but not monomorphemes (see 26a). This asymmetry makes sense if words like *Siedlung* in 25a are analyzed in terms of PU but not examples like *neblig* in 36a.[25]

[25] Several writers have pointed out that the medial obstruent in words like *Siedlung* in 25a (as well as ones like *neblig* in 36a) can optionally undergo Final Devoicing in Standard German in more colloquial registers (Wiese 1988, Hall 1992, Yu 1992, Brockhaus 1995:186, and Wiese 1996). I analyze this free variation for words like *neblig* as a permutation of the ranking of NoComplexOnset and NoCoda. Thus, in 12–13 the ranking of NoCoda over NoComplexOnset holds for the style of speech captured in the citation forms in the pronouncing dictionaries (for example, Drosdowski et al. 1990), but the reverse ranking describes a more colloquial speech register. For words like *Siedlung*, the devoiced /d/ implies that in colloquial speech the highest two constraints are switched in the ranking.

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4. Alternative Analyses.

An anonymous reviewer suggests two alternative analyses for German Final Devoicing that do not involve O-O constraints. In this section I summarize these alternatives and show that they suffer serious drawbacks that do not hold for the present analysis.

According to the first approach, Final Devoicing operates syllable-finally, but must be limited to morphologically composite environments, that is, the segment that devoices must be syllable-final *and* morpheme-final. Thus, on this view the process sets in word-finally (as in *Dieb* [diːp] 'thief', see 20a), and morpheme-finally followed by a consonant-initial suffix (as in *Bünd-nis* [bʏnt.nɪs] 'alliance', see 20b). By contrast, Final Devoicing does not set in before vowel-initial suffixes. In a word like *Dieb-e* [diː.bə] 'thieves' (see 20a), the [b] stays voiced even though it is morpheme-final because it is syllable-initial. In an example like *nebl-ig* [neː.blɪç] 'foggy' (see 26a), the syllable-initial [b] remains voiced because it is not final in a morpheme. The explanation for the lack of devoicing in words like *Handl-ung* [hand.lʊŋ] 'act' (see 25a), is similar: Final Devoicing does not set in because the [d] is not morpheme-final. According to this reviewer's suggestion even the [d] in *Adler* [aːd.lɐ] in 26a is correctly predicted not to undergo Final Devoicing, because it is not final in a morpheme. Thus, from this perspective, the alternative just described is superior to the one I propose because it has no exceptions.[26]

This alternative analysis suffers from two weaknesses. First, and most seriously, it cannot explain why the syllable-final obstruent in words like *Admiral* [at.mi.ʀaːl] (recall 21) is devoiced when these words enter German. (The reason the syllable-final /d/ in the donor language is expected to surface in German as [d] is that this sound is not morpheme-final). Although the literature on German Final Devoicing has traditionally concentrated exclusively on words that alternate (e.g. *Die[p]* vs. *Die[b]e*), a truly complete analysis needs to take monomorphemic loan words like *Admiral* into consideration as well. The second drawback with the alternative sketched above is that it does not explain why the "exceptional" words like *Handlung* in 26a are heteromorphemic. Thus, the reviewer's suggested analysis does not capture the true

[26] According to the reviewer a constituent-final environment counts as a "derived environment." For incorporation of the Derived Environment Con-straint into OT, see Kim 2002 and Iverson 2004.

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generalization: The exceptional forms are bimorphemic and therefore show PU effects.

According to the second alternative (proposed in Lombardi 1991:67–68 and surveyed in Iverson 1997), the absence of expected Final Devoicing in one form correlates with the presence of an additional vowel in a related form. Thus, in the case of *Sied.lung*, where Final Devoicing does not take place, the related word is *sie.deln*, with schwa preceding [l]. Lombardi suggested that the underlying form of the stem contains an "empty" vowel, which is filled in *sie.deln* (or just manifested as syllabicity in the [l]) but remains empty in *Sied.lung*, that is, *Sie.dV.lung*. This places the [d] structurally into an onset at an abstract stage in the derivation and so handles the paradigm relatedness matter rather directly. That is, the underlying stem /ziːdVl/ is realized as [ziːdl] in *Siedlung*, but as [ziːdəl] in *siedeln*. On this view, the claim is that the [d] in *Siedlung* escapes Final Devoicing because it is prosodically syllable-initial at an abstract stage, as it is in related *siedeln*, and hence is not a candidate for neutralization with [t].

The problem with this approach is that it requires stems ending in two consonants that rise in sonority from left to right, such as /ziːdVl/, to have an underlying "schwa" (that is, an empty V) that is subject to deletion in words like *Handlung*. As I noted above in section 2.3, there is consensus that schwa in stems of this structure is epenthetic (see Giegerich 1987, Wiese 1988, Hall 1992, Noske 1993, Wiese 1996, and Noske 1999). The reason these authors (and others) see stems like *siedl-* as being schwa-less (i.e. /ziːdl/) is that the schwa is predictable as a function of syllable structure. Put differently, schwa is epenthesized in stems like /ziːdl/ (or alternatively the /l/ is made syllabic) to make the stem pronounceable. To argue that the underlying forms of all "exceptional" forms contain an underlying schwa accompanied with a derivation in which schwa deletion is ordered before Final Devoicing, misses this generalization.

5. Summary and Conclusion.

In this article, I have shown that German has systematic counterexamples to two generalizations for the canonical phonology. First, there exist words containing superheavy syllables of the form [V:C] within a phonological word, although such syllables are normally restricted to word-final position. Second, there are many words containing syllable-

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final obstruents that do not devoice, contrary to the canonical pattern of Final Devoicing in the syllable coda. It was argued above that both problems are examples of PU effects that can be captured formally by positing that two specific O-O constraints dominate the markedness constraints responsible for the canonical patterns. One of these O-O constraints refers to the moraic structure of vowels and the other to the feature [voice]. The latter constraint was argued to be locally conjoined with the markedness constraint SYLLABLE CONTACT LAW. The present analysis is very different from earlier treatments on German phonology, which make no reference to PU.

There are at least two theoretical questions my analysis raises. One is whether or not there are constraints on the kinds of features that can be referred to in an O-O constraint. My preliminary answer is negative; one could easily imagine some language in which specific O-O constraints refer to distinctive features other than [voice] or to the moraic structure of consonants (as opposed to the moraic structure of vowels). If languages are not attested with such specific O-O constraints, then I would argue that this is simply an accident due to the relative paucity of PU-style analyses for other languages.

A second question is why German would choose to make paradigms uniform along certain dimensions (that is, the moraic structure of vowels, the feature [voice]), but not along others. One very obvious example of a segmental phenomenon typically not subject to the kind of PU analysis proposed above involves the umlauted vowels in the German nominal and verbal systems. For example, in the singular, indicative conjugation of the verb *tragen* 'carry', we have *trag-e* (1sg.), *träg-st* (2sg.), *träg-t* (3sg.), *trag-en* (1pl.), *trag-t* (2pl.), *trag-en* (3pl.), but this is a non-uniform paradigm due to the allomorphs *trag-* and *träg-*. One could easily rank the relevant O-O constraint (O-O-IDENT-[back]) lower down in the constraint hierarchy from a formal point of view, but this approach begs the question of why certain O-O constraints are highly ranked whereas others are not. Although there might not be a purely formal difference between features like [voice] versus [back], one needs to consider the morphological function of these features as well. Many linguists (for example, Wurzel 1984) have pointed out that umlaut in examples such as the one mentioned above has a morphological (as opposed to a phonological function). For example, in the form *träg-t*, the morphological categories "third person, singular, indicative" are

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expressed not only with the suffix *-t,* but also with the change in backness of the stem vowel. By contrast, the feature [voice] has a purely phonological function in German. What this discussion therefore suggests is that the only kinds of features that cannot be present in a high-ranking O-O constraint are those features that have some kind of morphological function. By contrast, features that have a purely phonological function are the only ones that can potentially be present in a high-ranking O-O constraint. Whether or not this idea can be shown to be correct for other dialects of German or for other languages is a question I leave open for further study.

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