Voicing and devoicing in English, German, and Dutch; evidence for domain-specific identity constraints

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1. Introduction

Voicing phenomena in Germanic languages have been the centre of recent phonological research, especially since the development of Optimality Theory (McCarthy & Prince 1993, 1995, Prince & Smolensky 1993). Optimality Theory (OT) has opened new ways to tackle old problems. In the first part of this paper, I point out the shortcomings of “old” rule-based accounts of voicing alternations. Traditional phonological rules miss certain cross-linguistic generalisations and ad hoc assumptions have to be made to explain, for instance, the exceptional behaviour of particular suffixes in English and Dutch. I show that an optimality-theoretic approach fares better in these respects. Recent OT-accounts of voicing alternations in English, Dutch, and German (e.g. Borowsky 1999, Lombardi 1999), however, have serious shortcomings and do not capture all relevant alternations. The main aim of the present paper is to offer a unified account of all voicing alternations in these languages. I demonstrate that – contrary to the assumptions made by e.g. Kiparsky (1998) – there is no need to assume different levels of constraint evaluation. Voicing alternations in obstruents can be explained within a constraint-based theory with the help of a set of universal markedness constraints and domain-specific identity constraints, i.e. identity constraints that are restricted to a specified morphological or prosodic domain. Languages differ in the way in which they rank these constraints with respect to each other.

The paper is structured as follows. Section 2 illustrates voicing alternations in obstruents in different languages. Section 3 compares a traditional rule-based account for these phenomena with an optimality-theoretic account. Section 4 discusses Inkelas’ (1994) proposal that within one language, an obstruent may have three specifications for the feature [voice]: it may be underspecified for this feature, it may be specified as [+voice], or it may be characterised as [-voice]. Inkelas proposes that obstruents that do not alternate in word-internal and word-final positions are fully specified, whereas obstruents that are voiceless in word-final position and voiced elsewhere are underspecified in the input representation. I adopt Inkelas’ analysis of Turkish obstruent alternations to explain English voicing assimilation in combinations of noun stems and the plural morpheme. Section 5 concludes.
2. Obstruent voicing and devoicing

The phenomenon to be considered in this paper is the voicing alternation that obstruents display in different phonological environments. Example (1) illustrates that voiced obstruents may alternate with voiceless ones in English, German, Dutch, and Polish. In the words below, orthographic representations are given except for the relevant obstruents, which are given in phonetic transcription within square brackets. Polish data are from Gussmann (1992).

(1) a. English: scri[b]e scri[pt]ure
b. German: bewei[z]en ‘to prove’ Bewei[s] ‘proof’
c. Dutch: bewij[z]en ‘to prove’ bewij[s] ‘proof’

Example (1a) illustrates that word-final obstruents may be voiced in English and that they can alternate with voiceless obstruents in some morphological contexts (i.e. when immediately followed by a voiceless obstruent within the same word). Examples (1b-d) show that in German, Dutch, and Polish, word-final obstruents are invariably voiceless. In some morphological environments, adjacent obstruents in English must agree in voicing (1a, 2a), but not in compounds (see 2b). In German, adjacent obstruents need not agree in voicing (2c). Dutch and Polish are similar to German in that word-final obstruents are voiceless in these languages (see 1b,c,d), but they differ from German in that obstruent clusters always agree in voicing (see 2d,e).

(2) a. English: lose [lu:z] lo[st]
   b. German: hou[s]e, dog hou[s,d]og
   c. Dutch: bewij[z]en ‘to prove’ bewij[s,b]aar ‘provable’
   d. Polish: z[a]b[ą]a ‘frog’ z[a,pk]a ‘frog-dim.’

The next subsection considers a traditional rule-based account for the lack of syllable-final devoicing and the occurrence of voicing assimilation in certain contexts in English. Subsequently, we discuss syllable-final devoicing and the absence of voicing assimilation in German and, finally, we consider Dutch, which exhibits both word-final devoicing and voicing assimilation.

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1 Here and in subsequent examples, syllable boundaries are indicated by a dot.
2.1 English voicing assimilation

The morpheme that expresses plural in English is realised as the voiced fricative [z] after a vowel (3a), a sonorant consonant (3b), or a voiced obstruent (3c). After a voiceless obstruent, it is voiceless (3d). This process is known as “progressive voicing assimilation”.

(3) a. bee + /z/ \rightarrow bee[z]  
b. lion + /z/ \rightarrow lion[z]  
c. dog + /z/ \rightarrow dog[z]  
d. cat + /z/ \rightarrow cat[s]

A morpheme that ends in a voiced obstruent in isolation is realised with a voiceless obstruent before a suffix that consists of - or begins with - a voiceless obstruent and this process is called “regressive voicing assimilation”:

(4) a. fi/θ/ + /θ/ \rightarrow fi[θ] ‘fifth’  
b. wi/ð/ + /θ/ \rightarrow wi[tθ] ‘width’

In traditional generative phonology, phonological processes are captured by rules of the form $A \rightarrow B / C \rightarrow D$, i.e. an element “$A$” changes to “$B$” in between the elements “$C$” and “$D$”. To describe the devoicing process in (3d), one may suggest a so-called “rewrite rule” that assigns the feature [-voice] to an obstruent which is immediately preceded by a voiceless obstruent (5a). Similarly, the phonological rule for the devoicing process in (4a,b) assigns the feature [-voice] to an obstruent which is immediately followed by a voiceless obstruent (5b).

b. regressive assimilation: [-son] \rightarrow [-voice] / --- [-son, -voice]

These two rules miss important generalisations. First, the rules suggested above miss the generalisation that adjacent obstruents must agree in voicing. Second, we need two rules that both assign the same feature value, viz. [-voice] and we thus miss the generalisation that obstruents tend to be voiceless. These generalisations or “conspiracies” can be expressed as constraints against marked structure. Constraint (6a) says that neighbouring obstruents must have the same specification for the feature [voice] (see e.g. Lombardi 1996, 1999) and constraint (6b) says that obstruents may not be specified for [+voice].

(6) a. AGREE: \[ α \text{ voice} \]  
b. \* $C_{[-\text{sonorant}]}$ [α voice]  

\[ [+\text{voice}] \]
In what follows, I show that the rules formulated in (5a) and (5b) are language specific, whereas the constraints in (6a) and (6b) express universal tendencies. Furthermore, I show that these generalisations also emerge as the unmarked case in child language and in second language acquisition.

The constraints in (6a) and (6b) are not absolute in the sense that they have to be satisfied in all surface representations. Rather, the assumption in OT is that constraints express tendencies and languages may choose to assign more weight to some constraints and less weight to others. In English combinations of an obstruent final root and an obstruent initial affix, constraints (6a) and (6b) are satisfied and both obstruents are voiceless in the surface form (see 4a,b). In English compounds, adjacent obstruents may differ in their voicing specification in violation of (6a). Similarly, syllable-final obstruents are voiceless in German, even when a voiced obstruent follows, so that constraint (6a) is violated in those cases as well.

2.2 German syllable-final devoicing

In German, obstruents which are voiced word-internally are realised as voiceless obstruents in word-final position (see Wiese 1996 and references cited there):

    b. Diebe - Die[p] ‘thieves’ – ‘thief’
    c. Berge - Ber[k] ‘mountains’ – ‘mountain’
    d. Mäu[z]e - Mau[s] ‘mice’ – ‘mouse’

Furthermore, all syllable-final obstruents are voiceless, irrespective of the voicing specification of the neighbouring segment.

    b. Lie[b]e - Lie[p].l ing ‘love’ – ‘beloved, darling’
    c. bie[g]en - bie[k.z]am ‘to bend’ – ‘flexible’
    d. bewei[z]en - bewei[s.b]ar ‘to prove’ – ‘provable’

We may formulate devoicing of syllable-final obstruents as a phonological rule that assigns the feature [-voice] to an obstruent in syllable final position (9). Alternatively, one may suggest a so-called “delinking rule” which deletes the feature [+voice] from an underlying representation (cf. Lombadi 1995), or one may formulate a constraint which says that syllable-final obstruents are not voiced (10).

(9) Final devoicing: [-son] \rightarrow [-voice] / --- ]σ
Before we discuss whether or not Final Devoicing is a universal constraint (this assumption is questioned by e.g. Borowsky 1999 and Lombardi 1999), some problematic issues of a traditional rule-based analysis for Dutch voicing assimilation are introduced in the next section.

### 2.3 Voicing alternations in Dutch

Syllable-final devoicing is not a language-specific rule or constraint for German. It also occurs in, e.g., Afrikaans (see Van Rooij 1999), Breton\(^2\), Catalan, Dutch (see 11a-d), and Polish (see 1d).

\[(11) \begin{aligned} &a. \text{ hon[d]en} - \text{ hon[t]} & & \text{‘dogs’ - ‘dog’} \\ &b. \text{ die[v]en} - \text{ die[f]} & & \text{‘thieves’ - ‘thief’} \\ &c. \text{ za[k]en} - \text{ za[k]} & & \text{‘pockets’ - ‘pocket’} \\ &d. \text{ mui[z]en} - \text{ mui[s]} & & \text{‘mice’ - ‘mouse’} \end{aligned}\]

In certain morpheme final positions, obstruents in Dutch are voiceless when followed by a fricative (12a,b) or a sonorant sound (12c).\(^3\) For some speakers, these obstruents are voiced when a voiced plosive follows (12d,e):\(^4\)

\[(12) \begin{aligned} &a. \text{ vrien[d]/ + -schap} - \text{ vrien[t.s]chap} & & \text{‘friendship’} \\ &b. \text{ raa[d]/ + -/z/aam} - \text{ raa[t.s]aam} & & \text{‘advisable’} \\ &c. \text{ die[v]/ + -achtig} - \text{ die[f].achtig} & & \text{‘thievish’} \\ &d. \text{ bewij[z]/ + -/b/aar} - \text{ bewij[z.b]aar} & & \text{‘provable’} \\ &e. \text{ za/k/ + /d/oek} - \text{ za[g.d]oek} & & \text{‘handkerchief’} \end{aligned}\]

Fricatives which follow plosives are always voiceless (12a,b). This generalisation also holds at the post-lexical level (see 13b). Voicing assimilation of stem final obstruents that we see

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\(^2\) The reader is referred to Krämer 1999 for a detailed analysis of voicing and devoicing phenomena in Breton.

\(^3\) In section 3.3, it will be argued that in examples (12a-e) the morpheme final consonant in question is adjacent to a segment in initial position of a prosodic word. Morpheme final obstruents which are not followed by an obstruent in initial position of the following prosodic word behave differently.

\(^4\) The data in (12) and (13) are taken from the literature (Berendsen 1983, Booij 1995), but there is a great degree of variety among speakers of Dutch with respect to these forms. Many speakers of Dutch do not have voicing assimilation in (12d,e) and (13a). I discuss this issue in section 3.3. With Berendsen (1983:29), I assume coherency for the data in this section in the sense that they may occur in one speaker/hearer.
before suffixes like –baar (12d) and in compounds (12e) can also be observed in post-lexical environments. In (13a), for example, we find regressive voicing assimilation across a word boundary.

(13) a. een klap door de molen → een kla[b.d]oor de molen
   ‘a slap by the windmill’

   b. een klap van de molen → een kla[p.f]an de molen
   ‘a slap from the windmill’

To describe regressive voicing assimilation in (12a,d,e) and (13a) and progressive voicing assimilation in (12b) and (13b), the following two rules are proposed in the literature (e.g., Berendsen 1983):

(14) a. regressive assimilation: [-son] → [α voice] / --- [-son, α voice]


The prevailing view in traditional rule-based analyses is that rules (9), (14a) and (14b) play a role in the phonology of Dutch and that they are ordered with respect to each other (e.g., Berendsen 1983, Booij 1995, Zonneveld 1983). Examples (12b) and (13b) show that syllable-final devoicing has to precede progressive voicing assimilation. Examples (12d,e) and (13a) show that regressive voicing assimilation may not be followed by syllable-final devoicing. Hence, the three rules are ordered with respect to each other as in (15) below:

(15) bewij/z/-baar raa/d/-zaam kla/p/ door kla/p/ van

<table>
<thead>
<tr>
<th>final devoicing</th>
<th>bewi/z</th>
<th>raa/d</th>
<th>kla/p</th>
<th>kla/p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s</td>
<td>t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>progressive assimilation</td>
<td>t s</td>
<td></td>
<td>p f</td>
<td></td>
</tr>
<tr>
<td>regressive assimilation</td>
<td>z b</td>
<td></td>
<td>b d</td>
<td></td>
</tr>
</tbody>
</table>

Grijzenhout & Krämer (1998) point out that this assumption makes wrong predictions in the case of inflectional endings (e.g., the past tense suffix –de) and clitics (e.g., the weak form of the 3rd sg. pers. pronoun die). In the case of inflectional endings and clitics that begin with a voiced obstruent, we expect the preceding stem-final obstruent to be voiced due to regressive voicing assimilation. In actuality, however, stem-final obstruents retain their underlying specification for voicing and the initial consonant of the inflectional ending or the clitic is voiceless:
Moreover, we now have four rules to express voicing assimilation. Rules (5a), (5b), (14a), and (14b) are different rules, they are language-specific, and they miss an important generalisation, viz. avoid adjacent voiced and voiceless obstruents in surface representations. Prince & Smolensky (1993:1) stated that within languages and across languages "the significant regularities were to be found not in input configurations, nor in the formal details of structure-deforming operations, but rather in the character of the output structures". In their Optimality Theory, a prominent role is assigned to output representations. Under this theory, output forms satisfy as best as they can universal constraints which are ranked in a language-specific order. Lombardi (1996, 1999) and others have attempted to explain obstruent devoicing and voicing assimilation in such a framework, but these accounts have failed to capture all relevant data. We will consider this issue next.

3. Correspondence Theory (CT)

In recent versions of Optimality Theory (usually referred to as “Correspondence Theory”, see McCarthy & Prince 1995) it is assumed that underlying elements (Inputs) correspond to surface elements (Outputs). So-called “identity constraints” require that output segments should have the same feature specifications as their corresponding input forms:

(17) IDENT(Feature): Output correspondents of an input [YF] segment are also [YF]

The identity constraint in (18) says that an obstruent in the output form should have the same specification for voicing as in its input form:

(18) IDENT(voice): Obstruents in the output have the same value for the feature [voice] as in the input.

This constraint interacts with constraints militating against marked structure (the so-called “markedness constraints”). We already encountered markedness constraints in (6a) and (6b). The latter constraint expresses the fact that the unmarked value for obstruents is [-voice] and it is repeated here for convenience as (19a). I will illustrate in sections 3.2 and
that in some languages, this generalisation holds only in restricted phonological environments, e.g., at the end of prosodic words or syllables (19b,c):

(19) a. \textsc{devoicing}: *[+voice] (obstruents are voiceless)
    b. \textsc{pwfinaldev}: *[+voice])\textsc{pw} (word-final obstruents are voiceless)
    c. \textsc{finaldev}: *[+voice])\textsc{syllable} (syllable-final obstruents are voiceless)

In Correspondence Theory, constraints are universal, they are violable, and differences between languages are explained by different constraint rankings. The interaction of constraints may be illustrated by the following simplified grammar for German. A straight line between two constraints means that the constraint to the left of the line is ranked higher than the constraint to the right. That is to say, candidate output forms that violate the higher ranked constraint are less optimal than candidates that satisfy that higher ranked constraint. The symbol "*" marks a constraint violation, "*!" marks a fatal violation, and the pointing finger "|" marks the optimal candidate. Candidate (20a) is identical and, hence, most faithful to the input form /di:b/ 'thief'. This candidate violates the highest ranked constraint FINALDEVOICING and for this reason it loses. Candidates (20b) and (20c) both violate the next constraint, because an obstruent which is voiced in the input is voiceless in the output. Candidate (20c) violates IDENT(voice) more often than (20b) and for this reason (20c) is less optimal than (20b). Candidate (20b) is selected as the optimal candidate, even though it violates *[+voice].

<table>
<thead>
<tr>
<th>(20) Input: /di:b/</th>
<th>FINALDEV</th>
<th>IDENT(voice)</th>
<th>*[+voice]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) [di:b]</td>
<td>*!</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>(b) [di:p]</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(c) [ti:p]</td>
<td>* *!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following section presents an account of voicing alternations in English.

3.1 English voicing assimilation in Correspondence Theory

In English, word-final obstruents may be voiced. This implies that in the grammar of English, IDENT[voice] is ranked higher than FINALDEVOICING.

(21) a. scribe
    b. wide
    c. five

In the case of suffixes that attach to a root (22a-d) we find regressive voicing assimilation. In the case of suffixes that attach to a stem (23a-d), we find progressive voicing assimilation. Provisionally, one may argue that this suggests that it is more important to preserve underlying...
feature specifications in stems than in roots (cf. Borowsky 1999). Consider in this respect that in compounds, a stem-final obstruent and an adjacent stem-initial obstruent may differ in their voicing specifications (24a,b), i.e. voicing specifications in stems do not alter in order to conform to markedness requirements such as AGREE.

(22) a. scripture, script  [pt]  (/b/ --> [p] / --t)  
c. width  [tθ]  (/d/ --> [t] / --θ)  
d. fifth  [fθ]  (/v/ --> [f] / --θ)  

(23) a. dogs  [gz]  
b. cats  [ts]  (/z/ --> [s] / t --)  
c. hugged  [gd]  
d. kicked  [kt]  (/d/ --> [t] / k--)  

(24) a. blackbird  [k.b]  
b. dog-fight  [g.f]  
c. house-dog  [s.d]  

The fact that a segment may have a different specification for voicing as its input under voicing assimilation (see the root-final consonant in 22a-d, and the suffixal consonants in 23b,d) suggests that the constraint AGREE is ranked higher than IDENT[voice].

Examples (22a-d) suggest that in the grammar of English, the aforementioned constraints are ranked as follows: AGREE >> IDENT[voice] >> FINALDEVOICING, *[+voice].

(25) Input:  fi/v/Root + /θ/  

<table>
<thead>
<tr>
<th></th>
<th>AGREE</th>
<th>IDENT[voice]</th>
<th>FINALDEVOICING</th>
<th>*[+voice]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) fi[vθ]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>(b) fi[vt]</td>
<td></td>
<td>*</td>
<td>*!</td>
<td>**</td>
</tr>
<tr>
<td>(c) fi[tθ]</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the case of compounds, two adjacent consonants need not agree in voicing. In (24a,c), for instance, a voiceless obstruent is followed by a voiced plosive and in (24b), a voiced plosive is followed by a voiceless fricative. Borowsky (1999) proposes to distinguish between root + affix combinations and stem + affix combinations (or, combinations of two stems) by restricting identity constraints in their domain of application. That is to say, identity constraints may refer to a domain which excludes roots and affixes. In her proposal this domain is “word”, but we might also refer to this domain as “stem”. The data in (24a-c) suggest that the voicing specification of a segment in the stem may not be altered to satisfy AGREE, i.e. AGREE is subordinated to the constraint formulated below:

5 In OT-tableaux, a dotted line indicates that the relevant ranking of the constraints separated by this line cannot be determined.
(26) IDENTSTEM(voice): a segment which is [α voice] in an input stem is [α voice] in the output. 
(Do not change the feature for [voice] of the stem).

This constraint is not violated in candidates (25a–c) above, because we are dealing with a combination of a root and a suffix. The relatively low ranked constraint FINALDEVOICING decides in favour of candidate (25c) rather than (25b).

In (23a–d), a suffix is added to a stem and I here propose that the feature specification of the stem-final obstruent is not altered due to high-ranked IDENTSTEM(voice). The feature specification of the suffix may differ from its input specification to assure that adjacent consonants agree in voicing in the optimal output form (see 27c).

<table>
<thead>
<tr>
<th>(27) Input:</th>
<th>ca[t]stem + /z/</th>
<th>IDENTSTEM (voice)</th>
<th>AGREE</th>
<th>IDENT(voice)</th>
<th>FINALDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>ca[tz]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(b)</td>
<td>ca[dz]</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(c)</td>
<td>ca[tz]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(28) Input:</th>
<th>do[g]stem + /z/</th>
<th>IDENTSTEM (voice)</th>
<th>AGREE</th>
<th>IDENT(voice)</th>
<th>FINALDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>do[kz]</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(b)</td>
<td>do[gz]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c)</td>
<td>do[ks]</td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

In English compounds, adjacent obstruents need not agree in voicing, because the feature specification of obstruents in both members of the stem are not changed in compliance with IDENTSTEM(voice):

<table>
<thead>
<tr>
<th>(29) Input:</th>
<th>do[g]stem + /f/ightstem</th>
<th>IDENTSTEM (voice)</th>
<th>AGREE</th>
<th>IDENT(voice)</th>
<th>FINALDEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>do[g.fight]</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>(b)</td>
<td>do[g.vight]</td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(c)</td>
<td>do[k.fight]</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In summary, it is argued that English voicing assimilation involves a grammar in which AGREE is subordinated to IDENTSTEM(voice) and in which IDENT(voice) is subordinated to AGREE. The effect of the low ranked constraint against voicing in obstruents can be seen in root plus affix combinations like _fifth_ (see the tableau in 25). Essential in this analysis is whether a morpheme is specified as a root or a stem in the input. I assume without discussion that certain affixes select roots, whereas others select stems as their host.

Lombardi (1999) suggests a different OT-analysis for English. The major differences between her approach and the one advocated here are that (i) she assumes that features are privative, (ii) she claims that the constraint FINALDEVOICING does not exist, and (iii) she
does not recognise featural identity to stems. Instead, she assumes only one devoicing constraint, viz. *[voice] and she draws on a generalisation that forbids a sequence of a postvocalic voiceless plus voiced obstruent at the syllable’s right edge (Harm’s Generalisation). To ensure that devoicing of obstruents does not apply to obstruents in onset position, she suggests an additional “positional faithfulness constraint” which says that consonants in onset position of a syllable should be faithful to their underlying voicing specification (see below). Her analysis has three major drawbacks. First, under her account, the data in (22a-d) cannot be explained. For root plus affix combinations like five + th, the output predicted by her analysis is *fi[vθ] rather than fi[fθ]. The analysis suggested by Borowsky (1999) provides an explanation for these examples at the cost of the introduction of a curious constraint that says ‘do not change a morpheme which consists of only one segment’. Furthermore, under Borowsky’s approach, syllable-final devoicing in German and Dutch is problematic and neither Borowsky nor Lombardi can account for the voicing alternations in words like thief- thieves (see section 4).

A second problem for Lombardi’s proposal is that English and German children do not faithfully realise voicelessness in initial obstruents, whereas they never voice final voiceless obstruents (see Menn 1971 and Grijzenhout & Joppen 1999, respectively). This implies that the positional faithfulness constraint proposed by Lombardi can be violated in early child speech (or, alternatively, that this constraint has not been “recognised” yet by children at the earliest acquisition stage), whereas the constraint FINALDEVOICING is present in the grammar of children. Both English and German child speech is often characterised by devoicing of final obstruents (e.g., some English children realise the words chee[z]e and egg as [is] and [ek], respectively, see Menn 1971 and Smith 1973). The occurrence of initial voicing and final devoicing at the same stage in child language, cannot be explained when we assume Lombardi’s analysis. Grijzenhout & Joppen (1999) propose that FINALDEVOICING is a relevant constraint in early child speech and English children have to learn that it is ranked low in their language.

A third drawback of Lombardi’s analysis is that it fails to account for Dutch progressive voicing assimilation in stems plus an obstruent initial inflectional suffix. An alternative OT-analysis that makes use of positional faithfulness as well as FINALDEVOICING is proposed in section 3.3. Before we turn to this analysis, we will first consider voicing alternations in German.

3.2 German final devoicing in Correspondence Theory

German differs from English in that syllable-final obstruents are invariably voiceless. In OT-terms, this means that FINALDEVOICING outranks IDENT[voice].
(30) a. Diebe - Die[p] ‘thieves’ - thief
b. Räder - Ra[t] ‘wheels’ – ‘wheel’
c. jagen - Ja[kt] ‘to hunt’ – ‘hunting’

In stem plus affix combinations and in compounds, adjacent obstruents need not agree in voicing. The syllable final obstruent is always voiceless and the following obstruent is faithful to its input specification. It may thus be concluded that in German, IDENT[voice] is ranked higher than AGREE.

(31) a. Ra[t.z]am ‘advisable’
b. bewei[s.b]ar ‘provable’

Féry (1998 and references cited there) points out that German has a number of words with an intervocalic obstruent which is ambisyllabic. In the examples below, the voiced obstruents belong simultaneously to the coda of the first syllable and to onset of the second syllable:

(32) a. Flagge [fla'gə] ‘flag’
b. Krabbe [krəbə] ‘crab(-fish)’

Even though there are not many examples of words with ambisyllabic voiced obstruents in German, no stipulations about their occurrence - such as additional lexical strata (see Féry 1998) - need to be made in the analysis that I propose here.

To ensure that devoicing of obstruents does not apply to all obstruents, Lombardi (1996, 1999) suggests so-called “positional faithfulness constraints” which require that segments in certain positions are faithful to their input representations. She points out that it is usually more important to be faithful to onset laryngeal specifications than to coda - or elsewhere - specifications (e.g., the allophonic alternation /b/ak – [p]ak is not attested in the languages of the world, whereas the alternation /b/ – /p/ is). She therefore suggests a version of the identity constraint in (18) that is restricted to the syllable onset. The constraint formulated in (33) says that consonants in onset position of a syllable should be faithful to their underlying voicing specification:

(33) IDENTONS(voice): Obstruents in the syllable onset should have the same value for the feature [voice] as in the input.

The output forms in (32a-c) suggests that IDENTONS(voice) outranks FINAL-DEVOICING. The following tableaux illustrate the constraint ranking suggested in this paper:
In Correspondence Theory, it is assumed that constraints are universal and that languages differ in the ranking of constraints. To account for voicing alternations, I suggest that the grammars of English and German involve the following universal constraints that are ranked as below:

(37) English: $\text{IDENTSTEM}[\text{voice}] \gg \text{AGREE} \gg \text{IDENT}[\text{voice}] \gg \text{FINALDEV}, *[^{+\text{voice}}]$

German: $\text{IDENTONS}[\text{voice}] \gg \text{FINALDEV} \gg \text{IDENT}[\text{voice}] \gg \text{AGREE}, *[^{+\text{voice}}]$

The next section presents an analysis of final devoicing and voicing assimilation in Dutch.

### 3.3 Dutch voicing assimilation and final devoicing in Correspondence Theory

Dutch exhibits devoicing of syllable-final obstruents (38a,b) and this suggests that FINALDEVOICING is ranked higher than IDENT[voice]. In some contexts (e.g., 38c), the effect of syllable-final devoicing is overruled by the requirement that adjacent consonants should agree in voicing, i.e. AGREE outranks FINALDEVOICING.

(38) a. dieven - die[f] ‘thieves’ – ‘thief’
    b. handen - han[t] ‘hands’ – ‘hand’
    c. bewij[z.b]aar ‘provable’
For some speakers, a stem-final consonant that is voiceless in underlying representations may be voiced if followed by a voiced obstruent (39a). In these cases, the stem-final obstruent does not have the same specification for voicing as its underlying (Input) representation and the following initial consonant remains voiced.

(39) \( \text{dek} + \text{bed} \rightarrow \text{de[g.b]ed} */\text{de[k.p]et} \) ‘eiderdown quilt, duvet’

To ensure that devoicing does not affect syllable-initial obstruents Lombardi (1996, 1999) calls on the constraint IDENTONS(voice) formulated in (33) above. The output form in (39) suggests that IDENTONS(voice) outranks FINALDEVOICING. However, there are other words (e.g. 40b,d) which suggest the opposite ranking. The question that remains unanswered in Lombardí’s analysis is why the stem-final consonant is voiced in (40a) and voiceless in (40b) and why initial /d/ remains voiced in (40a), whereas it is voiceless in (40b):

(40) a. \( \text{za/k/ + /d/oe} \rightarrow \text{za[g.d]oek} \) ‘handkerchief’
   b. \( \text{za/k/ + -/d/e} \rightarrow \text{za[k.t]e} \) ‘to sink’ – ‘sank’
   c. \( \text{to/b/ + -/d/e} \rightarrow \text{to[b.d]e} */\text[to[p.t]e} \) ‘to worry’ – ‘worried’
   d. \( \text{of} + \text{die} \rightarrow \text{o[f t]ie} */\text{o[v d]ie} \) ‘whether he’

The answer proposed in Grijzenhout & Krämer (1998) is based on the observation that these forms differ in their prosodic structure. In compounds and combinations of stems plus certain derivational suffixes, there are two prosodic words (see 41a). Inflectional suffixes consist of one consonant or a syllable containing Schwa and they cannot form a prosodic word of their own. These suffixes are part of the same prosodic word as the stem (see 41b,c). Clitics resemble the latter suffixes in that they can neither form a prosodic word of their own. They differ from these suffixes in that they do not become a part of the preceding prosodic word. Instead, it is argued in Grijzenhout (1998) and Grijzenhout & Krämer (1998) that they are adjuncts within the phonological phrase (41d):

(41) Prosodic structure of stems, suffixes, and clitics:
   a. stem + stem: \( (\text{za[g]}_{\text{PrWd}} (\text{d[oe]}_{\text{PrWd}} \)
   b. stem + suffix: \( (\text{za[k.t]}_{\text{PrWd}} \)
   c. stem + suffix: \( (\text{to[b.d]}_{\text{PrWd}} \)
   d. stem + clitic: \( ((\text{o[f]}_{\text{PrWd}} \text{tie})_{\text{PPhrase}} \)

Apparently, it is more important to preserve the voicing of a plosive in onset position of a prosodic word than the voicing of a plosive that is not in onset position of a prosodic word (see 40a vs. 40b,d). Moreover, in Dutch it is more important to be faithful to the voicing specification of a plosive in onset position than to the voicing specification of a fricative in onset position (see 39 vs. 42):
(42) raa/d/ + /z/aam \rightarrow (raa[t])_{PWd} ([s]aam)_{PWd}

The following constraint captures these observations:\(^6\)

(43) IDENTONSPWSTOP(voice): Plosives in onsets of prosodic words should have the same value for the feature [voice] as in the input.

Furthermore, obstruents in final position of prosodic words are more likely to get devoiced than obstruents in syllable final position within prosodic words. The obstruent /d/, for instance, is realised as [t] at the end of a prosodic word in (42) whereas syllable-final /b/ in (40c) is realised as [b] within the prosodic word. This implies that PROSODIC-WORD-FINALDEVOICING (see 19b, repeated below as 44) is ranked higher than IDENT(voice) which, in turn, is ranked higher than SYLLABLE-FINALDEVOICING.

(44) PWFINALDEVOICING: Prosodic word final obstruents are voiceless.

In (45a-c) IDENTONSPWSTOP(voice) is vacuous, because there is no plosive in onset position of a prosodic word and the candidate that does not violate the constraints AGREE and PWFINALDEV is selected as the winner. In (46), IDENTONSPWSTOP(voice) is violated in candidate (c), but not in (b), so that the latter candidate is optimal.\(^7\)

<table>
<thead>
<tr>
<th>(45) Input: raa/d/ + /z/aam</th>
<th>AGREE</th>
<th>IDENTONSPWSTOP (voice)</th>
<th>PWFINALDEV</th>
<th>IDENTSTEM (voice)</th>
</tr>
</thead>
</table>
| (a) (raa[t](z)aam) | *! | | | *
| (b) (raa[d](z)aam) | | *! | | *
| (c) (raa[t](s)aam) | | | | *

<table>
<thead>
<tr>
<th>(46) Input: za/k/ + /d/oek</th>
<th>AGREE</th>
<th>IDENTONSPWSTOP (voice)</th>
<th>PWFINALDEV</th>
<th>IDENTSTEM (voice)</th>
</tr>
</thead>
</table>
| (a) (za[k](d)oek) | *! | | | *
| (b) (za[g](d)oek) | | * | * | *
| (c) (za[k](t)oek) | *! | | | *

In (47a-c) and (48a-c), both IDENTONSPWSTOP(voice) and PWFINALDEV are vacuous and IDENTSTEM(voice) decides between the candidates which do not violate AGREE.

\(^6\) This constraint may be considered a conjunction of the constraints IDENTPROSODICWORD-ONSET(voice) & IDENTSTOP(voice).

\(^7\) Below, an opening round bracket indicates the left edge, i.e. the beginning, of a prosodic word and a closing round bracket indicates the right edge, i.e. the end, of a prosodic word.
In Randstad Dutch (roughly, the version of modern Dutch spoken in western cities, e.g., Rotterdam, Den Haag, Leiden, Gouda, Delft), there is no regressive voicing assimilation in clusters of a prosodic word final voiceless obstruent plus prosodic word-initial voiced plosive (see 49a,b). This implies that the constraints IDENTONS_PWSTOP(voice) and PWFINALDEV are not violated in Randstad Dutch outputs, i.e. these constraints are ranked higher than AGREE in the grammar of Randstad Dutch:

So far, we have established the following constraint rankings for English, German, the dialect of Dutch described by Berendesen (1983), Booij (1995) and others, and Randstad Dutch, respectively:

Under the assumption that constraints are universal and that languages differ in constraint ranking only, it follows that learning the grammar of a language involves learning the ranking of constraints. In Tesar & Smolensky (1993, 1998) it is argued that the learning process involves that, on the basis of positive evidence, constraints which are violated in optimal
outputs are gradually demoted below constraints which are not violated. I pointed out in section 3.1 that there is evidence for the constraint \textit{FINALEVOICING} in early child speech. The pronunciation [ek] for \textit{egg} in English child speech suggests that \textit{FINALEVOICING} has not been demoted yet in the grammar of the child. English children encounter evidence to demote this constraint below \textit{IDENT(voice)}, but German, Dutch, and Polish children are never prompted to do so. The prediction is that someone in whose native language there is no evidence to demote \textit{FINALEVOICING} will devoice final obstruents in a second language. This prediction is born out (see Van Rooij & Grijzenhout 2000). Similarly, I predict that in the speech of speakers of a language in which \textit{AGREE} is not demoted to a position subordinate to \textit{IDENT(voice)}, we will see effects of voicing assimilation in the second language. Muß-Gorazd (1999) demonstrates that this is indeed the case for Polish speakers who learn German as a second language. These speakers often exhibit regressive voicing assimilation when they speak German.

The next section discusses Inkelas’ (1994) proposal that within one language, a segment may have different specifications for voicing. I will demonstrate that in English, most obstruents are fully specified for voicing, but segments that alternate between being voiceless in word-final position and being voiced in other contexts are underspecified.

4. Constraints and feature specifications

In Turkish, voicing alternations in obstruents are observed as well (e.g. Inkelas 1994, Inkelas & Orgun 1994). Some root-final plosives alternate between being voiceless in coda position (51a) and voiced in onset position (51b). Other plosives are consistently voiceless (52a,b):

\begin{tabular}{ll}
(51) & a. kanat  ‘wing’ & b. kana.d-ı ‘wing-acc’  \\
    & kanat-lar ‘wing-pl.’ & kana.d-ım ‘wing-1.sg.poss’  \\
(52) & a. sanat  ‘art’ & b. sana.t-ı ‘art-acc’  \\
    & sanat-lar ‘art-pl.’ & sana.t-ım ‘art-1.sg.poss’  \\
\end{tabular}

The alternation between voiced /d/ in \textit{ka.na.di} and its voiceless counterpart in \textit{ka.na.t}, suggests that \textit{FINALEVOICING} plays the same role in Turkish as in, e.g., German. However, in some words, voiced plosives do not alternate and they may remain voiced in syllable-final positions:

\begin{tabular}{ll}
(53) & a. etüd  ‘study’ & b. etüd-ü ‘study-acc’  \\
    & etüd-ler ‘study-pl.’ & etüd-üm ‘study-1.sg.poss’  \\
\end{tabular}

Inkelas (1994) claims that this three-way contrast requires the use of under-specification, as illustrated in (54). The root-final obstruent in (51) is unspecified for the feature [voice] in
the input, while the one in (52) is specified as [-voice] and the one in (53) is specified as [+voice].

(54) a. kana/D/ final obstruent unspecified for [voice]
    b. sana/t/ final obstruent [-voice]
    c. etü/d/ final obstruent [+voice]

The forms in (53a) with a voiced final obstruent suggest that in Turkish, IDENT(voice) is ranked higher than FINALDEVOICING.

<table>
<thead>
<tr>
<th>(55) Input: etü/d/ IDENT (voice)</th>
<th>FINALDEVOICING</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) etüt</td>
<td>*!</td>
</tr>
<tr>
<td>(b) etüd</td>
<td>*</td>
</tr>
</tbody>
</table>

Since the final obstruent in (54a) is unspecified for voicing in the input, the corresponding obstruent in the output does not have a voicing specification to be identical to and thus never violates the constraint IDENT(voice).

<table>
<thead>
<tr>
<th>(56) Input: kana/D/ IDENT (voice)</th>
<th>FINALDEVOICING</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) kanad</td>
<td>*!</td>
</tr>
<tr>
<td>(b) kanat</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(57) Input: sana/t/ IDENT (voice)</th>
<th>FINALDEVOICING</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) sanad</td>
<td>*!</td>
</tr>
<tr>
<td>(b) sanat</td>
<td></td>
</tr>
</tbody>
</table>

Krämer (1999) shows that this use of underspecification enables us to account for the fact that some obstruents in Breton never alter in their voicing specifications while others assimilate in voicing to neighbouring obstruents. English exhibits similar alternations. Some obstruents alternate between being voiceless in word-final position and being voiced before the plural suffix /z/ (58a). Other obstruents are consistently voiced in word-final position and before the plural suffix /z/ (58b). Still others are voiceless in word-final position and cause devoicing of the plural suffix (58c):

    b. sie[v] - sie[vz]        do[g] - do[gs]

Presumably, this obstruent gets its voicing specification in forms like kanad by “intervocalic voicing”.

---

8 Presumably, this obstruent gets its voicing specification in forms like kanad by “intervocalic voicing”.
I here propose that the stem-final obstruents in (58a) are unspecified for the feature [voice], the ones in (58b) are prespecified as voiced and the ones in (58c) are specified as voiceless in the input:

(59) a. thie/F/ final obstruent unspecified for [voice]
    b. sie/v/ final obstruent [+voice]
    c. ree/f/ final obstruent [-voice]

In section 3.1, I suggested a constraint ranking for English that accounts for the alternations in (58b) and (58c), see (27) and (28). The tableaux below show that under the same constraint ranking, the alternations in (58a) can be explained if we assume that the stem-final obstruent in question is not specified for [voice] in the input:

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Input: thie/F/} & \text{IDENTSTEM} (\text{voice}) & \text{AGREE} & \text{IDENT(voice)} & \text{FINALDEV} \\
\hline
\text{(a)} & \text{thie[f]} & & & \\
\text{(b)} & \text{thie[v]} & & & \star! \\
\hline
\end{array}
\]

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Input: thie/F/ + /z/} & \text{IDENTSTEM} (\text{voice}) & \text{AGREE} & \text{IDENT(voice)} & \text{FINALDEV} \\
\hline
\text{(a)} & \text{thie[fz]} & \star! & & \star \\
\text{(b)} & \text{thie[vz]} & \star! & & \star \\
\text{(c)} & \text{thie[fs]} & \star! & & \star \\
\hline
\end{array}
\]

5. Conclusion

In this paper, I argue that voicing alternations in different languages can be accounted for by a set of universal constraints. Languages differ in the rankings of the constraints. An advantage of a constraint-based approach like OT is that it captures certain generalisations that are missed in a generative rule-based approach. The analysis proposed in this paper employs markedness constraints (e.g. AGREE, FINALDEV), constraints that refer to prosodic structure (e.g. IDENTONS [voice]), constraints that refer to morphological structure (e.g. IDENTSTEM [voice]), and language-specific feature specifications. The use of domain-specific constraints such as IDENTSTEM [voice] enables us to account for data which are problematic (and often ignored) in recent OT-literature (e.g. Lombardi 1996, 1999) without the use of different constraints or constraint-rankings at different lexical levels (e.g. Kiparsky 1998).

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