Shape Conditions and Phonological Context

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1 Introduction

In discussions of the syntax-phonology interface, lexically-specific allomorphy of the kind illustrated by the *a*/*an* alternation in English has provoked a steady trickle of comment. An early discussion can be found in Bloomfield's (1935, p. 186) definition of *external sandhi*:

> Features of modulation and of phonetic modification play a great part in many syntactic constructions; they are known as *sandhi*. The form of a word or phrase as it is spoken alone is known as its *absolute form*; the forms which appear in included positions are its *sandhi-forms*. Thus, in English, the absolute form of the indefinite article is *a* [ˈej]. . . . If the next word begins with a vowel, we have instead a sandhi-form, *an* [ˈɛn], as in "not *an* uncle, but *her* uncle."

More recently, Spencer (1991, Section 4.6) has provided a useful overview of the problem under the rubric of Arnold Zwicky's (1985a; 1985b; 1988) notion of 'shape conditions'. Spencer comments that such data presents a difficulty for conventional grammar architectures "if we wish to maintain that lexically or morphologically conditioned alternations are limited to the lexicon, for this alternation is certainly lexically conditioned (it only happens to one word!), yet it seems to take place in the syntax". (Spencer, 1991, p.128)

The notion of a shape condition, e.g., that *an* rather than *a* is selected when the determiner is followed by a vowel, is elucidated by Pullum and Zwicky (1988), in the following terms: "It is not part of the lexical entry for the word, because it refers to the following syntactic context. It is not a phonological rule of English, for it applies only to the indefinite article and has no general applicability to phonological domains. It is a condition on shape that overrides the lexical entry for the indefinite article and stipulates that another shape is called for."

It might seem, at first blush, that we can solve the difficulty by simply dropping Pullum and Zwicky's assumption that lexical entries cannot refer to syntactic context; after all, reference to local syntactic domains is one of the tasks that lexicalized theories of grammar were originally designed to accomplish. Pursuing this line of inquiry, one possibility for dealing with the distribution of *an* is to postulate an entry like the following:

(1)
$$\begin{bmatrix} \textit{det-lxm} & \\ \text{PHON} & \textit{an} \\ \text{ARG-ST} & \left\langle \begin{bmatrix} \text{PHON} & \textit{vow-init} \\ \text{SYN} \mid \text{HEAD} & \textit{noun} \end{bmatrix} \right\rangle \end{bmatrix}$$

That is, the form *an* selects for a nominal argument whose phonology is vowel-inital. Yet such an account raises two objections. First, we don't want the account of allomorphy to be so closely bound to the dependency analysis; (1) conflicts with the current HPSG view that the noun syntactically selects the determiner rather than vice versa. Second, even in an approach where determiners did select a nominal argument, (1) runs counter to the view that lexical items don't generally subcategorise for phonological properties of their arguments.

1.1 Hayes' Precompiled Phrasal Phonology

Interestingly, Hayes (1990) also concludes that apparent cases of phonological rules which refer directly to syntax should be dealt with lexically, while maintaining a conventional view of grammatical components. He writes "most of the rules that have in the past been analyzed as [making reference to syntactic representations] should be characterized as 'phrasal allomorphy'; that is, as the selection of the appropriate precompiled allomorph for phonological instantiation"(Hayes, 1990, p. 92).

On Hayes' approach, the lexical entry for the indefinite article would specify its insertion context as follows (where '999' is a unique identifier for the indefinite article):

(2)
$$\begin{bmatrix} \text{999} \\ \text{(syntactic and semantic specifications)} \\ \text{Phonological instantiation:} \\ \quad \text{/ən/ in the context / \_V} \\ \quad \text{/ə/ elsewhere} \end{bmatrix} \text{(= Hayes' example (10))}$$

Hayes also notes that phonological instantiation would be governed by the Elsewhere Condition, in that a more specific insertion context will take precedence over a less specific one.

Another phrasal allomorphy example cited by Hayes comes from Hausa, where "final long vowels of verbs appear as short when the the verb precedes a full NP direct object" (Hayes, 1990, p.93). For example:

(3) ná: ká:mà: — 'I have caught (it)' — (no object)
vs.
ná: ká:mà kí:fí: — 'I have caught a fish' — (NP object)

Hayes proposes that lexicons for natural languages contain phonological instantiation frames, such as the following for the Hausa case just mentioned:

(4) Frame 1: / [$_{VP}$ _NP . . .], NP non-pronominal

Then we could have the following phonological rule:

(5) Hausa Shortening
$V{:} \rightarrow V \, / \, [\, \ldots \_ \,]_{[Frame1]}$

This shortening rule is a lexical rule which applies in the lexical phonology to create an allomorph of relevant verbs with a short final vowel. Since this is a lexical rule, the phonology never refers to the syntax proper, but only to a lexicalised syntactic frame. However, Hayes' analysis begs the question of how lexicalised syntactic frames fit into the overall grammar framework. Although they could be identified with subcategorization frames, this would make the implicit claim that the relation between a shape condition target and its triggers can be equated with the syntactic relation between a lexical head and its complement. Although this assumption holds good for the Hausa shortening rule he addresses, we do not believe that it holds in general, as noted earlier.

1.2 Phonological Edge Effects

External sandhi between two forms involves the *edges* of one or both of those forms. Thus, the alternation in the form of the English indefinite article is manifested at the right edge of the article, and is conditioned by the left edge of the following context. A broader class of such cases is illustrated by French liaison (cf. Bloomfield, 1935, p. 188):

(6)
a. ce couteau
/sə kuto/
this knife
b. cet homme
/sət ɔm/
this man
c. les femmes
/le fam/
the women
d. les hommes
/lez ɔm/
the men
e. vous faites
/vu fɛt/
you make
f. vous êtes
/vuz ɛt/
you are

(7)
a. ma première étude
/ma prəmjer etyd/
my first lesson
b. mon étude
/mõn etyd/
my lesson
c. un beau garçon
/œ̃ bo garsõ/
a fine lad
d. un bel homme
/œ̃ bɛl ɔm/
a fine man

The first class of liaison forms (6) have been argued by Kaisse (1985) to result from a general rule, regardless of the categorial identity of the liaising expression. The second group of liaison forms (7) are distinguished by the fact that they clearly involve morphological realisation rather than a phonological process.In this respect, they resemble the *a*/*an* alternation in English.

By contrast, mutation in the Celtic languages is manifested on the left edge of the affected form. Thus, consider the case of soft mutation in Welsh:

(8)
a. eu cath /i kaθ/ ‘their cat’ (radical form)
b. ei gath /i gaθ/ ‘his cat’ (soft mutated/lenited form)
c. ei chath /i xaθ/ ‘her cat’ (aspirate mutated/spirantized form)
d. fy nghath /vəŋhaθ/ ‘my cat’ (nasal mutated/nasalized form)

(Ball and Müller, 1992, p. 1)

Ball and Müller (1992, p. 1) list 23 syntactic environments for soft mutation, of which we will consider the following three:

(9) **Feminine, singular noun before adjective/noun**

merch	cath	>	merch	gath
	/kaθ/			/gaθ/
girl	cat			

a girl cat

(10) **Adjective before adjective/noun**

hen	ci	>	hen	gi
	/ki/			/gi/
old	dog			

old dog (Ball and Müller, 1992, p. 17)

(11) **Definite article**

merch	>	y	ferch
/mɛrχ/		/ə	vɛrχ/
girl		the girl	

(Ball and Müller, 1992, p. 95)

gardd	>	yr	ardd
/garð/		/ər	arð/
garden		the garden	

(Ball and Müller, 1992, p. 95)

2 Phonological Context

We assume that objects of type *sign* have the following structure:

(12)
$$sign \rightarrow \begin{bmatrix} \text{PHONOLOGY} & \textit{phonology} \\ \text{SYNSEM} & \textit{synsem} \end{bmatrix}$$

Following the construction theory of (Sag, 1999), signs do not have DAUGHTERS attributes; these instead occur only within *constructions*, which can be regarded as context-free production rules (with signs labelling the nodes) reified as feature terms.

The type *phonology* introduces the following features:

(13) $$\textit{phonology} \rightarrow \begin{bmatrix} \text{SEGMENTS} & \textit{list(segment)} \\ \text{PROSODY} & \textit{prosody} \\ \text{PHONOLOGICAL-CONTEXT} & \textit{p-ctxt} \end{bmatrix}$$

We will not attempt to delve into the structure of *segment* and *prosody*; for suggestions, see for example (Bird and Klein, 1994) and Klein (2000). We will mainly use IPA symbols for segments in the rest of this paper, supplemented by Chomsky-Halle style distinctive features for some examples.

The attribute PHONOLOGICAL-CONTEXT (P-CTXT for short) will be crucial to the analysis below. It is through this feature that lexical items undergo alternation that is conditioned by immediately adjacent items. We will limit attention to the *right context* of lexical items, though it would be straightforward to incorporate left context as well. As a first approximation, let's define the feature's value as:

(14) $$\textit{p-ctxt} \rightarrow \textit{sign} \vee \textit{nil}$$

We require a *nil* value for items which are on the right-peripherary of an utterance, and thus lack a right context.

We will use the DAUGHTERS list in a construction to provide the information required for specifying the value of P-CTXT, by virtue of the following constraint on constructions:[1]

(15) $$\textit{cx} \rightarrow$$
$$\begin{bmatrix} \text{MOTHER} & \textit{phrase} \\ \text{DTRS} & \left\langle \begin{bmatrix}\text{PHON} \mid \text{P-CTXT} & \boxed{1}\end{bmatrix}, \boxed{1}\begin{bmatrix}\text{PHON} \mid \text{P-CTXT} & \boxed{2}\end{bmatrix}, \ldots, \boxed{n}\begin{bmatrix}\text{PHON} \mid \text{P-CTXT} & \textit{nil}\end{bmatrix} \right\rangle \end{bmatrix}$$

Thus, the value of PHON | P-CTXT for a daughter sign is its immediately following (or preceding) sister, severely constraining the local nature of P-CTXT. The P-CTXT of the rightmost daughter is *nil*, which amounts to a further kind of locality restriction, namely that shape conditions can only refer to triggers which are in syntactic construction with the target expression. We have not yet carried out a systematic attempt to find counter-examples to this strong locality claim; it would be an interesting result if it turns out to be empirically sustainable. Finally, notice that the mother's P-CTXT value is left unspecified until it enters into construction with sisters of its own.

Allowing the value of P-CTXT to be a sign is attractively simple, but allows too much latitude in what can constitute a context. In particular, it fails to express our earlier observation that if phonological properties

[1] We assume that the head daughter is listed amongst the other signs in the value of DTRS. In place of examining the DTRS value, an alternative, possibly superior, approach would be to read the P-CTXT information off from the list of signs in a word-order DOMAIN list (Reape, 1994; Kathol and Pollard, 1995); however, the current analysis is easier to present within our space limitations.

of the trigger are a conditioning factor, then it is only the edge of the trigger which is relevant. In order to capture this restriction, therefore, we introduce a function pctxt which extracts just those components of the sign that play a role in shape conditions, namely the phonological edge and the SYNSEM value.

Definition 1 pctxt: *sign* $\mapsto$ *p-ctxt*

$$\text{p-ctxt}\left(\begin{bmatrix} \textit{sign} & \\ \text{PHON} \mid \text{SEGS} & \langle \boxed{1}, \ldots \rangle \\ \text{SYSEM} & \boxed{3} \end{bmatrix}\right) = \begin{bmatrix} \textit{p-ctxt} & \\ \text{EDGE} & \boxed{1} \\ \text{SYNSEM} & \boxed{3} \end{bmatrix}$$

Since we are confining our attention to right context, it follows that we only need to look at the left edge of the trigger expression. To simplify matters, we have defined left in terms of the initial segment in the trigger's segment string; in a more complete analysis, we would probably want instead to refer to the onset of the initial syllable in the trigger's prosodic dimension. We can now replace (15) by (16), where the value of an expression α's P-CTXT is derived by applying the function pctxt to the sign which occurs as α's right sister.

(16) $\textit{cx} \rightarrow$

$$\begin{bmatrix} \text{MOTHER} & \textit{phrase} \\ \text{DTRS} & \left\langle \left[\text{PHON} \mid \text{P-CTXT} \;\; \text{pctxt}(\boxed{1})\right], \boxed{1}\left[\text{PHON} \mid \text{P-CTXT} \;\; \text{pctxt}(\boxed{2})\right], \ldots, \boxed{n}\left[\text{PHON} \mid \text{P-CTXT} \;\; \textit{nil}\right] \right\rangle \end{bmatrix}$$

3 Formalizing Shape Conditions

3.1 The English Indefinite Article

Let us now return to the problem we started with, namely stating how allomorphs of the lexeme A are distributed. In the following, the type *a* (to the left of the arrow) is to be interpreted as a maximal subtype of *word*, and counts as the identifier for the lexeme A. The phonological realization is expressed as three disjuncts, conditioned by the P-CTXT value:

(17) $$a \rightarrow \begin{bmatrix} \textit{det-lxm} & \\ \text{PHON} & \begin{bmatrix} \text{SEGS} & \langle \text{ən} \rangle \\ \text{P-CTXT} \mid \text{EDGE} & [+\ \text{cont}] \end{bmatrix} \vee \begin{bmatrix} \text{SEGS} & \langle \text{ə} \rangle \\ \text{P-CTXT} \mid \text{EDGE} & [-\ \text{cont}] \end{bmatrix} \vee \begin{bmatrix} \text{SEGS} & \langle \textit{ej} \rangle \\ \text{P-CTXT} & \textit{nil} \end{bmatrix} \\ \text{SYNSEM} \mid \text{HEAD} & \textit{det} \end{bmatrix}$$

So if an occurence of A immediately precedes a sign whose phonological left edge is a vowel (i.e., is a segment with the distinctive feature [+ CONTINUANT]), then the allomorph *ən* is selected.[2] Second, if A's *p-ctxt*'s EDGE is a consonant (i.e., a segment with the feature [− CONTINUANT]), then ə. Last, the 'absolute form' *ej* (Bloomfield, 1935, p. 186) is selected when it occurs in isolation—that is, when the P-CTXT value is *nil*. Notice that (17) crucially differs from (1) in that the phonological context is determined by whatever occurs immediately to the right of *a/an* in the relevant construction, rather than being determined by valency information.

3.2 French Syncretic Liaison Forms

As noted above, (see also Zwicky, 1985b), certain French adjectives and the singular possessive pronouns exhibit phrasal allomorphy very similar to *a/an*. For example, the first-person possessive pronoun has singular forms *mon* (MASC) and *ma* (FEM). However, the feminine has a liaison form *mon* which appears immediately preceding vowel-initial expressions; e.g., *ma première étude* [ma prəmjer etyd] 'my first study', but *mon étude* [mõn etyd] 'my study'.

Taking MON as our lexeme, we might represent the masculine singular form as in (18).

(18)
$$\textsc{mon} \wedge \textit{masc-sg} \rightarrow \begin{bmatrix} \textsc{phon} \mid \textsc{segs} & \langle \textit{mɔ̃n} \rangle \\ \textsc{synsem} \mid \textsc{head} & \begin{bmatrix} \textit{det} & \\ \textsc{agr} & \begin{bmatrix} \textsc{num} & \textit{sg} \\ \textsc{gend} & \textit{masc} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

In fact, all the feminine singular possessives *ma*, *ta* and *sa* have liaison forms *mon*, *ton* and *son* which are identical to the corresponding masculine singular possessive. This syncretism involves what Zwicky (1985b) calls rules of referral, whereby a morpheme is realized by "borrowing" a formative from another morpheme. We capture this by invoking a function refer, which maps from a word to the PHON | SEGS value of that word. That is, instead of directly stipulating the PHON | SEGS value ⟨mɔ̃n⟩ as a liaison form, we provide an indirect reference to this value as refer(MON ∧ *masc-sg*):[3]

(19)
$$\textsc{mon} \wedge \textit{fem-sg} \rightarrow$$
$$\begin{bmatrix} \textsc{phon} & \begin{bmatrix} \textsc{segs} & \mathsf{refer}(\textsc{mon} \wedge \textit{masc-sg}\,) \\ \textsc{p-ctxt} \mid \textsc{edge} & [+\ \text{cont}] \end{bmatrix} \vee \begin{bmatrix} \textsc{segs} & \langle \textit{ma} \rangle \\ \textsc{p-ctxt} \mid \textsc{edge} & [-\ \text{cont}] \end{bmatrix} \\ \textsc{syn} \mid \textsc{head} & \begin{bmatrix} \textit{det} & \\ \textsc{agr} & \begin{bmatrix} \textsc{num} & \textit{sg} \\ \textsc{gend} & \textit{fem} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

[2] Harris (1994) suggests that what is crucial is a prosodic constraint, namely whether the *n* in *an* can occupy the onset of the following syllable, since *y* and *w* in *yacht* and *willow* are vocalic and don't allow *an*. This is similar to the phenomenon of *enchaînement* in French liaison. However, we ignore this subtlety here.

[3] An obvious failing of this proposal is that it does not constrain the referral to another form of *the same paradigm*. We leave open at this stage exactly how to incorporate such a constraint.

3.3 Hausa Final Vowel Shortening

Hayes (1990, p. 87) gives the following informal characterization of final vowel shortening (HFVS):

(20) HFVS:
A verb-final long vowel is shortened immediately before an object NP.

Although Hayes does not mention this point, all the Hausa so-called 'variable vowel verbs' (i.e., verbs which participate in HFVS) are transitive and end in long *a*. According to Parsons' (1960) widely adopted system of Hausa verb classification, such verbs were classified as Grade 2. In order to capture this generalisation, we introduce a type *grade-2* as a subtype of *verb-lexeme*, and treat the final vowel as comparable to a suffix.

(21)
$$\begin{bmatrix} \textit{grade-2} & \\ \text{PHON} & \begin{array}{l} \begin{bmatrix} \text{SEGS} & \boxed{1} \oplus \langle a \rangle \\ \text{P-CTXT} \mid \text{SYNSEM} & \boxed{2} \end{bmatrix} \vee \\ \begin{bmatrix} \text{SEGS} & \boxed{1} \oplus \langle a{:} \rangle \\ \text{P-CTXT} \mid \text{SYNSEM} & \neg\, \boxed{2} \end{bmatrix} \end{array} \\ \text{MORPH} \mid \text{ROOT} \mid \text{PHON} \mid \text{SEGS} & \boxed{1} \\ \text{SYNSEM} \mid \text{HEAD} & \textit{verb} \\ \text{ARG-ST} & \langle [\ ], \boxed{2}\,\text{NP}[\textit{npro}] \rangle \end{bmatrix}$$

This example is similar to the preceding ones, except that the P-CTXT information which conditions the short *a* allomorph is not of type *segment*, but of type *synsem*, and is coindexed with the (non-prominal) NP object on the verb's ARG-ST list.

3.4 Welsh Soft Mutation

Our treatment of Soft Mutation in Welsh closely parallels our other analyses in this paper, except that the alternation is conditioned by the left context. Thus, consider the following constraint:

(22) *noun-lxm* $\rightarrow$
$$\begin{bmatrix} \text{PHON} & \begin{array}{l} \begin{bmatrix} \text{L-EDGE} & [-\ \text{cont}] \end{bmatrix} \vee \\ \begin{bmatrix} \text{L-EDGE} & [+\ \text{voice}] \\ \text{P-LEFT-CTXT} \mid \text{SYNSEM} \mid \text{HEAD} & \textit{det}[\text{def}] \vee \textit{adj} \vee \textit{noun}[\text{fem, sg}] \end{bmatrix} \end{array} \end{bmatrix}$$

The left edge of a noun lexeme is either [− cont] (i.e., not a consonant) or else it is [+ voice]. The latter, however, holds only if the left sister of the lexeme has a syntactic head of type *det*[def] (definite article), *adj* or *noun*[fem, sg] (feminine, singular noun).

4 Conclusion

At the heart of HPSG lies the notion of the Saussurian sign: linguistic elements are bundles of form and meaning. Syntax provides the combinatorics for composing smaller linguistic elements into larger ones. The version of HPSG that we have been assuming separates the type *sign* into PHONOLOGY and SYNSEM, handling the combinatorics through the use of constructions (Donohue and Sag, 1999; Ginzburg and Sag, 2000), rather than by the use of the DAUGHTERS attribute of Pollard and Sag (1994). Given this architecture and the theory of shape conditions that we have been developing, we can next consider the dimensions of selection for shape. We would expect that selectors can select for the following kinds of information in their phonological contexts:

1. Phonological edge information only.
2. Syntactic/semantic (i.e., SYNSEM) information only.
3. A mixture of phonological and syntactic/semantic information.

The cases we have been considering provide examples of all three options. In what follows, we will refer to the element that undergoes some change in shape relative to its environment as the shape target and to the phonological context that conditions the change as the shape trigger.

The alternation of the English indefinite article (*a/an*), the French possessive determiners,[4] and the Welsh definite article provide examples of the first kind of shape condition. In each case, the alternation is essentially phonologically-conditioned morpheme selection. The thing that makes it slightly unusual is that the phonological conditioning is provided outside the word that is itself the locus of the alternation. In our theory, this means that the English indefinite has to place certain restrictions on its PHONOLOGICAL-CONTEXT, but these restrictions are purely phonological in nature (that the following element must begin with a vowel or not), and make no reference to any syntactic properties of the shape trigger. Referring back to (17), only PHONOLOGY is mentioned in the P-CTXT of the lexeme A.

The Welsh soft mutation alternation gives us the second type of information selection. The soft mutation triggers do not share any synchronic phonological traits and are not a uniform syntactic class. However, both the triggers and targets in this case are identified by syntactic criteria. The targets are adjectives or nouns, and the triggers are feminine singular nouns (9), adjectives (10), and the definite article (11).

The Hausa final vowel shortening illustrates the final, mixed case. On the one hand, we have morpheme selection as in the first case (the form of the stem), but the trigger is identified syntactically (it must be an adjacent direct object). The analysis of Hausa uses phonological context for adjacency and also uses the re-entrancy between P-CTXT and ARG-ST to capture the syntactic requirement, in particular the constraint that the trigger is a governed argument of the verb. Unlike our approach, Hayes's "subcategorization frame" approach cannot separate out these distinct phenomena.

In this paper we have taken a first step towards an HPSG account of syntactically-conditioned allomorphy. Contrary to Zwicky's own suggestions about the nature of shape conditions, we have included a reference

[4]The French determiners have an added complication, in that they involve rules of referral, which we modeled with the relation refer. However, the fact that the vowel-final and nasal-final feminine alternants are related systematically to their masculine counterparts is orthogonal to the fact that the alternation is conditioned only phonologically by its phonological context.

to the syntactic environment within lexical entries, in part as a means of formalizing Hayes' theory of precompiled phrasal phonology. The formalization depends on a strongly localized notion of phonological context, which is determined from linearization information contained the syntactic construction in which a given expression occurs. By 'strongly localized', we mean that a the triggers referred to by a shape condition on a lexeme *w* must be (i) immediately adjacent to *w*, and (ii) must be in construction with *w*.

The formalization allowed us to account for four problematic cases: the indefinite article alternation in English, syncretic liaison forms for possessive pronouns in French, Hausa verb-final vowel shortening, and soft mutation in Welsh nouns. However, we have completely omitted any discussion of the Elsewhere Principle; we suspect this would require a thoroughgoing reformulation of our rules in a more expressive logical setting, such as that proposed in (Richter et al., 1998). In future, we also hope to give a fuller account of two aspects of our analysis: (i) the encoding of rules of referral within a better articulated notion of morphological paradigm, (ii) the relation between phrasal allomorphy and a wider class of external sandhi phenomena.

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