Open Linguistics 2016; 2: 471–499

Research Article

Peter Staroverov*

Washo Onsets and the Revised Sonority Theory

DOI 10.1515/opli-2016-0025
Received May 18, 2016; accepted September 7, 2016

Abstract: This article presents an argument for the idea that consonants of high sonority are preferred over low-sonority consonants between vowels (Uffmann 2007). The argument is based on a detailed description and analysis of the phonological patterns which ensure that a syllable starts with a consonant in Washo. Washo inserts [j], which is of high sonority, between any two vowels. Word-initially however a glottal stop is inserted. It is argued that the Washo insertion patterns show influence of the sonority requirements, and these patterns are not subject to an analysis in terms of autosegmental spreading. Thus although feature spreading is a useful tool for capturing similarity requirements on neighboring segments, it is not sufficient to account for cases like Washo epenthesis.

Keywords: phonology, Washo, consonant insertion, glide, glottal stop, autosegmental spreading, floating features, sonority, optimality theory

1 Introduction

The concept of sonority has played an important role in explaining the patterning and sequencing of sounds since the advent of linguistic analysis. The first known sound scale similar to sonority goes back to Pāṇini (Parker 2002), and sonority continues to be intensely debated in the phonetic and phonological literature (see e.g. Ohala 1990, Parker 2012). The introduction of Optimality Theory by Prince and Smolensky (2004) has also brought a concrete implementation of the sonority requirements. According to Prince and Smolensky, the sonority hierarchy translates into two kinds of scalar requirements on sounds within a syllable. Syllable peaks are required to be of a relatively high sonority by the Peak hierarchy of violable constraints, whereas the preferred syllable margins are of low sonority. The Margin hierarchy is thus a reversal of the peak hierarchy.

Uffmann (2007) proposes a significant modification of Prince and Smolensky’s proposal, motivated by an analysis of [ɹ/ɻ] insertion in dialects of English as well as by additional considerations such as the typology of consonant lenition. In Uffmann’s theory, to which I refer as revised sonority theory, intervocalic consonants obey the Peak hierarchy (just like syllable nuclei), whereas the consonants in other positions tend to be of low sonority.

One of the arguments for the revised sonority theory comes from the fact that the consonants inserted between vowels are very often highly sonorous, e.g. glides or rhotics, whereas the consonants inserted at word edges tend to be of low sonority (Lombardi 2002, Blevins 2008, Staroverov 2014). However the cross-linguistic abundance of epenthetic rhotics is controversial (Hall 2013, Morley 2015). Furthermore, it is hard to interpret the frequent attestation of intervocalic glide insertion as an argument for revised sonority, since there is an alternative explanation for word-medial glide insertion. The epenthetic intervocalic glides are
overwhelmingly homorganic to a neighboring vowel (Blevins 2008, de Lacy 2002, 2006, Staroverov 2014, Morley 2015). The insertion of a homorganic consonant is arguably a preferred operation, since we can assume that only a minimally specified segment is inserted, while the exact features of a glide are dictated by feature spreading from a neighboring vowel (Kawahara 2003, Rubach 2000, Uffmann 2007, Naderi, van Oostendorp 2011 a.o.).

This paper argues that the patterns of consonant insertion in Washo support the revised sonority theory, and are not subject to the confound mentioned above. In Washo, the glide [j] is inserted between any two vowels word-medially but a glottal stop appears before vowels word-initially. This pattern matches the predictions of the revised sonority theory, but it is unexplained on the spreading view.

Washo [j] epenthesis suggests that not all intervocalic inserted glides result from spreading. A consideration of additional apparent hiatus alternations in Washo reveals that feature spreading is allowed in this language, but only as a last resort to integrate a floating feature. Thus feature spreading is useful in accounting for similarity requirements on neighboring segments, but it is not sufficient to capture all cases of emergent similarity.

An additional contribution of this paper is in considering a full system of hiatus alternations in Washo. Among these alternations, word-initial glottal stop insertion has been controversial. This paper assembles an array of phonological evidence from alternations, showing that Washo has a general process of word-initial [ʔ]-insertion, and unambiguously describing the domain of this process.

The rest of this paper is structured as follows. Section 2 presents a general overview of Washo phonology. Section 3 presents the data on [j]-insertion, followed by an analysis in Section 4. Section 5 provides a detailed argument for word-initial glottal stop insertion in Washo, and this process is analyzed in Section 6. Sections 7 and 8 deal with other apparent hiatus repairs in Washo, and Section 9 concludes.

2 Overview of Washo phonology and onset satisfaction

Washo is a severely moribund Hockan language spoken around Lake Tahoe on the border of California and Nevada. The Washo examples in this article come from several grammatical descriptions (Jacobsen 1964, 1980, 1996, Kroeber 1907) as well as from the dictionary available from the Washo Project,1 see Yu (2008b) for details on the Washo Project data. Unless otherwise noted, the page numbers in examples refer to Jacobsen (1964), and ‘WP’ refers to the Washo Project dictionary. All examples in this article appear in IPA, which is only a slight deviation from the traditional transcription adopted in most Washo sources since Jacobsen (1964). The rest of this section outlines some general properties of the Washo phonology, paying particular attention to the syllable structure, hiatus resolution, sonority, and the consonants serving to provide an onset – the glide [j] and the glottal stop.

The vowel phoneme inventory of Washo is /i ɨ e a o u/, with contrastive length for each vowel. The consonant inventory is given in (1), glottalization is marked with an apostrophe <'>.

(1) Washo consonants

<table>
<thead>
<tr>
<th>plaintext</th>
<th>IPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>p b b’</td>
<td>p b’</td>
</tr>
<tr>
<td>t d t’</td>
<td>d t’</td>
</tr>
<tr>
<td>dz ts’</td>
<td>dz ts’</td>
</tr>
<tr>
<td>k g k’</td>
<td>k g’</td>
</tr>
<tr>
<td>s</td>
<td>s</td>
</tr>
<tr>
<td>f</td>
<td>f</td>
</tr>
<tr>
<td>h</td>
<td>h</td>
</tr>
<tr>
<td>m m’ n n’</td>
<td>m m’</td>
</tr>
<tr>
<td>ŋ ŋ ŋ’</td>
<td>ŋ ŋ’</td>
</tr>
<tr>
<td>w w’ j j’</td>
<td>w w’</td>
</tr>
</tbody>
</table>

The series of voiceless and voiced stops differ phonetically in aspiration (Yu 2011), and hence can be more properly referred to as ‘aspirated’ and ‘plain’. However, since aspiration is not marked in my main sources (Jacobsen 1964, WP) I will not mark it in the examples.

The Washo glides /j w/ differ from underlying vowels (see Jacobsen 1964: 1.74). First, there are near-minimal pairs demonstrating a contrast between surface [iw] and [ju] which cannot both stem from

underlying /iu/, e.g. [ˈtaniw] ‘Miwok’ vs. [ˈbanjulaʔ] ‘Mexican’ (Jacobsen 1964: 62). It should be noted that [wl] is a possible consonant sequence in Washo, and therefore there is nothing preventing a hypothetical underlying form /banjulaʔ/ from being realized *[banjulaʔ]. Second, Washo glides also pattern with consonants in that they occur modal voiced, voiceless, and glottalized, while no vowels occur voiceless or glottalized (see also Yu 2016). If surface [j w] always stemmed from underlying /i u/, the consonantal inventory would lack underlying modally voiced glides and only have /w̥ w’ j̥ j’/, whereas all other sonorants would have modally voiced counterparts. Finally, coda sequences of a consonant + glide trigger vowel insertion, rather than vocalizing the glide. Thus the word ‘lake’ /daʔw/ surfaces as [ˈdaʔaw] rather than *[daʔu] (see Yu 2016 for a more detailed discussion of this alternation). On the other hand, Washo has no phonological processes where glides alternate with vowels. Within the same syllable, the sequences [ij] and [uw] are prohibited, but it is not clear that this restriction bears on the underlying glide-vowel difference. I conclude that Washo glides are distinct from vowels, and in terms of Levi (2004, 2008) they belong to the class of phonemic glides. The exact theoretical implementation of the glide-vowel distinction will be discussed in further detail in Section 4.2.

Washo laryngeals are also relevant to our purposes. The revised sonority theory treats the glottal stop as a low-sonority segment, and the proposed account will be based on this assumption. In Section 6, I will discuss some potential independent motivation for assuming that Washo glottal stop patterns with obstruents. This evidence comes from the fact that of all consonants, only laryngeals and plain obstruents have not been reported to undergo lengthening after a stressed short vowel in Washo. This could be interpreted to suggest that laryngeals resist bearing a mora, just like plain obstruent stops do.


The default stress is assigned to the penultimate syllable of the stem (Yu 2005a, 2005b, 2008b), and it will not be marked in underlying representations. Long vowels and certain suffixes with short vowels are stress-attracting, and for these cases stress or length marks will be used in the underlying forms. Stressed syllables must be minimally bimoraic in Washo, i.e. CVː(C) or CVC (Yu 2005a, b, 2008b).

Washo syllables fit the template CV(C). A limited number of otherwise unattested clusters occurs in loanwords where up to three consonants may form a syllable margin as in [ˈmampʃ] ‘mumps’. See Yu (2008a) and Jacobsen (1964) for a complete inventory of possible word-medial consonant sequences.

Washo requires all syllables to begin with a consonant. The effects of this requirement are the main focus of this article. Input onsetless syllables are repaired differently depending on the phonological and morphological environment, as summarized in (2).

(2) Washo onset satisfaction

<table>
<thead>
<tr>
<th>Process</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glottal stop insertion</td>
<td>#.V</td>
</tr>
<tr>
<td>vowel deletion and quality alternations</td>
<td>V_V (limited morphologically)</td>
</tr>
<tr>
<td>[j] insertion</td>
<td>V_V (elsewhere)</td>
</tr>
</tbody>
</table>

Initial onsetless syllables receive an epenthetic glottal stop. Word-medially at a suffix boundary vowel sequences are always resolved via [j]-insertion. Several prefixes exhibit suppletive allomorphy that puts a consonant-final allomorph before vowel-initial stems. Two other prefixes exhibit apparent vowel deletion accompanied by vowel quality alternations. Finally, the alternations in Washo compounds also appear to involve vowel deletion, quality changes, and [j]-insertion although it is not clear to what extent compound formation is productive.
3 Word-medial [j]-insertion

[j] is inserted word-medially when two vowels come together, usually at a root-suffix or suffix-suffix boundary. [j]-insertion is illustrated in (3a). The underlying representation of the relevant stems and suffixes is supported by alternations. (3b) shows the relevant stems/suffixes that have a vowel at a right edge before a consonant or word-finally. (3c) shows the relevant vowel-initial suffixes after a consonant-final stem.

(3) Washo [j]-insertion

<table>
<thead>
<tr>
<th>UR, gloss</th>
<th>SR, transl, source</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. /wat’a-a/ river-LOC</td>
<td>[ˈwat’aja] ‘in the river’ (261)</td>
</tr>
<tr>
<td>/di-dok’o-a/ 1P-heel-LOC</td>
<td>[di’dok’oja] ‘at my heel’ (261)</td>
</tr>
<tr>
<td>/Ø-k’eje-es-i/ 3P-be.alive-NEG-IPF</td>
<td>[k’eje’jesi] ‘he’s dead’ (263)</td>
</tr>
<tr>
<td>/laːdu-a/ 1P-hand-LOC</td>
<td>[la’duda] ‘in my hand’ (260)</td>
</tr>
<tr>
<td>/lanalʃi-a/ 1P-house-DU.INCL-LOC</td>
<td>[lanalʃijja] ‘on our house’ (262)</td>
</tr>
<tr>
<td>/lemts’ti-i/ 1P-awake-IPF</td>
<td>[lemts’ti] ‘I’m awake’ (261)</td>
</tr>
<tr>
<td>/Ø-p’il’i-i/</td>
<td>[p’il’i] ‘he’s fishing with hook and line’ (262)</td>
</tr>
<tr>
<td>3P-fish_with_hook_and_line-IPF</td>
<td></td>
</tr>
<tr>
<td>b. /wat’a/ river</td>
<td>[ˈwat’a] ‘river’ (261)</td>
</tr>
<tr>
<td>/ge-emts’i-ha/ IMP-awake-CAUS</td>
<td>[ˈgeemts’i-ha] ‘wake him up!’ (262)</td>
</tr>
<tr>
<td>/di-dok’o/ 1P-heel</td>
<td>[di’dok’o] ‘my heel’ (261)</td>
</tr>
<tr>
<td>/ge-k’ehe-ha/ IMP-be.alive-CAUS</td>
<td>[gek’ehe] ‘save his life!’ (304)</td>
</tr>
<tr>
<td>/laːdu/ 1P-hand</td>
<td>[la’duda] ‘my hand’ (260)</td>
</tr>
<tr>
<td>/lanalʃi/ 1P-house-DU.INCL</td>
<td>[lanalʃi] ‘our (du.incl) house’ (262)</td>
</tr>
<tr>
<td>/ge-p’il’i/</td>
<td>[gep’il’i]</td>
</tr>
<tr>
<td>IMP-fish_with_hook_and_line</td>
<td>‘fish with hook and line!’ (262)</td>
</tr>
<tr>
<td>c. /lanal-a/ 1P-house-LOC</td>
<td>[lanala] ‘on/at my house’ (502)</td>
</tr>
<tr>
<td>/Ø-iʃm-i/ 3P-sing-IPF</td>
<td>[ʔiʃmi] ‘he is singing’ (104)</td>
</tr>
<tr>
<td>/Ø-iʃm-i/ 3P-sing-IPF</td>
<td>[ʔiʃmi] ‘he is singing’ (104)</td>
</tr>
</tbody>
</table>

The quality of the neighboring vowels does not influence the choice of epenthetic glide. Indeed, [j] is inserted after any vowel and before /a, e, i, u/, which are the only suffixal vowels. Interestingly, even sequences of identical vowels and sequences which do not contain a front vowel trigger [j]-insertion.

Washo alternations between [j] and zero cannot be analyzed as deletion. The deletion account would hold that [j] is underlyingly present between vowels in examples in (3a), but it is deleted in other environments. However surface [j] occurs both word-finally and next to a consonant, as illustrated in (4).

(4) Washo has final [j] and medial clusters with [j]

| [dam’u:k’aj’aj] | ‘mosquito’ (90) |
| [ʔit’jewsiw] | ‘ski’ (99) |
| [ge’bejdi] | ‘he’s combing him’ (113) |

2 The list of abbreviations appears at the end of the article.

3 This form exhibits effects of vowel assimilation across /h/: stem-final /e/ assimilates in quality to the suffix vowel and surfaces as /a/. This alternation is limited to /e/ and is “somewhat sporadic” according to Jacobsen (1964: 303-304).

4 A reviewer asks if the coda glides in (4) could be analyzed as being part of the nucleus. This diphthong analysis would complicate the Washo vowel inventory, and it is hardly compatible with what we know about the quantity system of the language. As argued by Yu (2005a; 2008b) Washo allows long vowels only in stressed syllables, but codas are also allowed in unstressed syllables. The examples in (4) demonstrate that syllables ending in [aj] and [iw] may be unstressed, and hence the coda [j w] pattern with consonants, not with vowels with respect to weight. This patterning presents a challenge for the diphthong analysis. See Sections 2 and 4.2 for additional evidence that Washo glides pattern with consonants.
These examples demonstrate that there is no final or preconsonantal [j]-deletion in Washo (see also Hall 2013 for a discussion of this criterion to distinguish between deletion and insertion).

[j] epenthesis is also not restricted morphologically. It is recorded before all vowel-initial suffixes and with nominal, verbal and demonstrative stems. Some of the examples in (3) show that [j]-insertion happens between two suffixes, not just after roots. Thus, it occurs after the suffixes /-ha/ ‘causative’ and /-ʃi/ ‘dual inclusive’. Finally, [j]-insertion is also applicable in compounds, although the productivity of compound formation is questionable, see Section 7.2. To summarize, Washo inserts [j] between two vowels at a morpheme boundary, regardless of vowel quality.

4 Analysis of Washo [j]-insertion

On the proposed analysis, [j] is inserted because it is highly sonorous, and hence preferred between vowels according to the revised sonority theory (Uffmann 2007). Furthermore, [j] is selected over the other glide [w] due to a preference to insert coronal consonants over labials.

This section also shows that Washo [j] insertion cannot be analyzed with autosegmental spreading. I therefore conclude that the Washo pattern is consistent with the revised sonority theory but not with the spreading theory of glide insertion.

The analysis is spelled out within the framework of Optimality Theory (OT) (Prince, Smolensky 2004), where the phonological input-output mapping is conceived of as competition between various output candidates, and regulated by formal constraints on the output and on the faithfulness of the input-output mapping. The proposed analysis relies on the fact that OT is particularly well-suited to capture the phonological patterns where multiple alternations serve the same goal – the so-called conspiracies (Kisseberth 1970, Casali 1997, 1998, 2011). Thus the diverse processes summarized in Section 2 are all caused by the pressure to avoid onsetless syllables. The basic architecture of OT is reviewed and exemplified in Section 4.1. The featural specification of Washo glides is addressed in Section 4.2. The main argument is formalized in Sections 4.3 - 4.4. Section 4.5 summarizes the theoretical implications of Washo [j]-insertion.

4.1 Motivating epenthesis in Optimality Theory

Within OT, the phonological mapping between input and output proceeds as simultaneous evaluation of candidates for the output. The function Gen generates all possible outputs for a given input to yield a set of output candidates. Gen is thought to be maximally inclusive (McCarthy 2002), it may apply any phonological changes any number of times. The set of output candidates is filtered by the function Eval which assesses the violations for the ranked constraints, and determines the winning candidate – the candidate which receives the least violations on highest ranked constraints. The set of constraints used by Eval is often thought of as universal, although the ranking of constraints is language-specific (Prince, Smolensky 2004).

The operation of OT can be illustrated with an analysis of [j] insertion in Washo. The ban on onsetless syllables is formalized in the constraint ONSET, as defined in (5) (adapted from Prince, Smolensky 2004).

(5) ONSET: assign a violation for each syllable beginning with a nucleus

In order for [j]-insertion to be optimal, this constraint must dominate any constraints which require preservation of onsetless syllables in the input. Thus the faithfulness constraint DEP-C (6) militates against consonant epenthesis (McCarthy, Prince 1995, 1999).

(6) DEP-C: assign a violation for each output consonant without an input correspondent

The tableau in (7) illustrates the ranking relation between the two constraints which obtains in Washo. This tableau considers the competition of two candidates for the mapping /lemts’i-/ → [lemts’iji] ‘I’m awake’.
The format of the tableau in (7), and all following tableaux in this paper, is based on Prince (2002). Violation profiles are shown with numbers in each cell. The first row shows the winner. Each non-first row indicates the violations of losing candidates, and in addition notates for each constraint whether it favors the winner (‘W’), the loser (‘L’), or has no preference (blank). Dots within candidates are used to show syllable boundaries.

(7) **ONSET motivates epenthesis in Washo**

<table>
<thead>
<tr>
<th>/lemts'i-i/</th>
<th>ONSET</th>
<th>DEP-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ˈlem.ts'i.ji</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>b. ˈlem.ts'i.i</td>
<td>W1</td>
<td>L</td>
</tr>
</tbody>
</table>

The first candidate in (7) has [j]-insertion, and therefore it incurs one violation of DEP-C. The second candidate (7b) does not violate DEP-C, but instead violates ONSET. Given that ONSET is ranked over DEP-C, it is worse to have a vowel-initial syllable than to insert a consonant and hence (7a) wins over (7b).

The tableau in (7) provides a somewhat simplified illustration since it compares only two candidates. In the actual OT evaluation, these candidates compete with other possible output forms, among them the candidates that fill an onset by deleting one of the vowels or by long vowel formation. Throughout the paper, I will be abstracting away from such candidates and assuming that they are penalized by additional faithfulness constraints. For example the constraint against deletion Max is ranked above DEP-C thus ruling out deletion in vowel sequences.

While the ranking in (7) makes epenthesis optimal, it does not derive the quality of the inserted segment. The next sections discuss the additional constraints and rankings responsible for the fact that [j] is inserted.

### 4.2 The representation and sonority of Washo glides

This section sets the stage for a more detailed analysis of Washo insertion by discussing the phonological features which distinguish glides from vowels. Recall that Section 2 presented several arguments that underlying glides /j w/ are distinct from vowels /i u/ in Washo.

One possible analysis of the glide-vowel difference assumes that [j w] and [i u] differ only in the underlying pre-specification for their syllabic status, whereas their featural specification is the same (Clements, Keyser 1983, Levin 1985, Harris, Kaise 1999, Rubach 2000). However, Levi (2004, 2008) has argued that this approach is typologically untenable. Furthermore, a detailed implementation of this account in OT would imply the existence of contrastive syllable structure, which is highly controversial (see e.g. McCarthy 2007, Köhnlein 2011, 2016, Iosad 2016 for some discussion).

For these reasons I conclude that glides differ from vowels in Washo in their featural specification. The distinction between [j w] and [i u] can be accounted for by appealing to the major class feature [consonantal] (Hyman 1985, Hayes 1989, Rosenthal 1997, Waksler 1990), although other featural implementations (e.g. Hume 1995, Levi 2004, 2008, Padgett 2008, Nevins, Chitoran 2008) are also compatible with the present proposal.

Importantly, I will assume that the phonemic glides have high sonority (see also Miller 2012). This assumption seems to be present, at least implicitly, in most accounts of the phonemic glides, and it is also compatible with the phonetic properties of phonemic glides discussed by Cohn (1990, 1993). There is also no clear evidence of a sonority difference between phonemic glides and vocalic margins.

Finally, within OT no restrictions on the input are assumed and therefore we need to explain why vocalic margins are prohibited in Washo, which constraints exclude them. I will only briefly address this question since a detailed answer would require us to consider a typology of glide and vowel inventories. Levi (2004, 2008) found that there are many languages that have only vocalic/derived glides in syllable margins. However there are also languages where only phonemic/consonantal glides occur in margins and high vowels do not (e.g. Turkish, see Levi 2004: ch. 4). Finally, there are languages where both high vowels and phonemic glides occur in margins (e.g. Karuk, Pulaar).
Thus there are no implicational relations between languages with respect to phonemic glides vs. high vowels occurring in margins. Therefore there must be constraints which penalize vocalic margins to the exclusion of phonemic glide margins and vice versa. Furthermore, since the picture is symmetric the relevant constraints probably do not have to do with sonority. In fact, there is little evidence of a sonority difference between phonemic and derived glides. I will thus assume that vowels are prohibited in Washo margins by the high-ranked constraint VOWEL-MORA which requires vowels to be moraic (Rosenthal 1997). Crucially, this constraint is not part of a larger universal hierarchy. I will not consider the candidates containing margin vowels in what follows.

4.3 The need for revised sonority: [j] vs. other epenthetic consonants

This section addresses the question of how [j] is selected among all the possible epenthetic consonants that could resolve hiatus. The proposed account relies on three main premises. First, Washo prohibits spreading, and therefore there is no homorganic glide insertion. Second, the highly sonorous glides are preferred to other segments in the intervocalic context – this assumption follows from the revised sonority theory (Uffmann 2007). Finally, the default inserted glide is [j] and not [w] due to a language-specific ranking of faithfulness constraints for consonants bearing particular place features.

To resolve intervocalic hiatus, many languages insert homorganic glides such as [j] next to front vowels and [w] next to back or rounded vowels. Such homorganic glide insertion is commonly analyzed by assuming that the inserted segment is not specified for place features, and instead the place features are spread from neighboring vowels, yielding homorganicity (Rubach 2000, 2002, Kawahara 2003, Naderi, van Oostendorp 2011). This analysis relies on the constraint in (8), penalizing insertion of place features, and thus enforcing place spreading. This constraint can in fact be thought of as a whole constraint family, as we will see further on.

(8) \text{Dep(place): assign a violation for each output place node without an input correspondent}

However in Washo the quality of the inserted glide does not depend on neighboring vowels. Following Rubach (2000), I assume that this follows from an anti-spreading constraint, penalizing a situation where two neighboring segments are linked to the same feature or featural node (see also Davidson, Erker 2014). I will refer to this constraint as *\text{MULT-LINK}, defined in (9).

(9) \text{*MULT-LINK (*ML): assign a violation for each feature or node which is dominated by more than one segmental root node}

*\text{MULT-LINK} ensures that Washo glides do not spread from neighboring vowels, but instead are separate segments with their own featural content (see also Section 4.2). The effects of *\text{MULT-LINK} are illustrated in (10) with the analysis of the mapping /laːdu-a/ [ˈlaːduja] ‘in my hand’. The winning candidate is compared here to the candidate (10b) which inserts a placeless root node and spreads place features from /u/ to give *[ˈlaːduwa] (feature sharing is indicated by underlining).

(10) Washo [j]-insertion: multiple-linking is not allowed

\[
\begin{array}{|c|c|c|c|}
\hline
\text{/laːdu-a/} & \text{ONSET} & *\text{ML} & \text{DEP-C} & \text{DEP(PL)} \\
\hline
\text{a. ‘laː.du.ja} & & 1 & 1 & \\
\hline
\text{b. ‘laː.du.wa} & \text{W1} & 1 & \text{L} & \\
\hline
\text{c. ‘laː.du.a} & \text{W1} & \text{L} & \text{L} & \\
\hline
\end{array}
\]
As can be seen in this tableau, *MULT-LINK favoring (10a) outranks the constraints from DEP(place) family that favor unspecified glide insertion plus spreading (10b). Reranking *MULT-LINK and DEP(PL) would give a common pattern of homorganic glide insertion. The candidate (10c) illustrates an additional ranking condition within the Washo grammar: the constraint ONSET motivating epenthesis must dominate the DEP(place) constraints.

The high ranking of *MULT-LINK also rules out spreading in the cases where it would produce an inserted [j] such as /lɛmts'i-i/ → [ˈlɛmts'iji] ‘I’m awake’, analyzed in (11). This tableau compares two candidates which are phonetically identical but structurally different: (11b) involves insertion of a bare root node and spreading of place features (symbolized by underlining), resulting in a doubly-linked structure that violates *MULT-LINK. On the other hand, the winning candidate (11a) inserts the glide as a full segment and does not involve multiple linking. The failure of the candidate (11c) is entirely parallel to (10c).

(11) Washo [j]-insertion: multiple-linking is not allowed

<table>
<thead>
<tr>
<th>/lɛmts'i-i/</th>
<th>ONSET</th>
<th>*ML</th>
<th>DEP-C</th>
<th>DEP(PL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. lɛm.ts'i.ji</td>
<td>W1</td>
<td>1</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>b. lɛm.ts'j.ji</td>
<td>W1</td>
<td>1</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>c. lɛm.ts'j.i</td>
<td>W1</td>
<td>1</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

To summarize, all inserted palatal glides in Washo are fully epenthetic, and they never borrow features via spreading.

Next, let us consider the selection of epenthetic [j] over other consonants that are often assumed to be less marked such as laryngeals or [t] (Lombardi 2002, de Lacy 2006). On my account, the selection of a glide over obstruents in the intervocalic environment follows from the revised sonority theory, proposed by Uffmann (2007). In this theory, intervocalic consonants are required to be as sonorous as possible, and thus glides are preferred in this environment. On the other hand, Uffmann assumes that both obstruents and laryngeals are of low sonority, and hence they are dispreferred intervocalically. See section 6.2 for some additional discussion of the sonority of Washo laryngeals.

The revised sonority theory is implemented by a fixed hierarchy of constraints relating consonantal articulations to the intervocalic position. This peak hierarchy was originally proposed by Prince and Smolensky (2004) for syllable nuclei, and Uffmann (2007) extends this hierarchy to intervocalic consonants and proposes a distinction between oral obstruents and laryngeals.

(12) Peak hierarchy for intervocalic consonants (Uffmann 2007)

\[ \ast V_\_V/Lar \gg \ast V_\_V/OrObs \gg \ast V_\_V/Nas \gg \ast V_\_V/l \gg \ast V_\_V/r \gg \ast V_\_V/Gld \]

Formally speaking, the proposed hierarchy is a fixed ranking of constraints such that each constraint penalizes a consonant of a particular class in the intervocalic position. For example, the constraint against intervocalic oral obstruents (\(\ast V_\_V/OrObs\)) is ranked above the constraint against intervocalic glides (\(\ast V_\_V/Gld\)). Additional motivation for the application of this hierarchy comes from lenition and fortition processes as well as from distributional gaps (Uffmann 2007). Furthermore, as we shall see in Section 6, the revised sonority theory also offers a principled account of Washo word-initial glottal stop insertion.

The role of sonority requirements on intervocalic consonants is illustrated in (13). This tableau considers additional candidates for the mapping /ladr-\(\hat{a}\)-/ → [ˈlaːduja] ‘in my hand’. Inserting an obstruct between two vowels (13b) violates a relatively high-ranked constraint \(\ast V_\_V/OrObs\), and this candidate is worse than the winner, which inserts a glide. Avoiding insertion is also not an option, since ONSET dominates \(\ast V_\_V/Gld\).
Washo Onsets and the Revised Sonority Theory

(13) Washo [j]-insertion: only glides can be inserted

<table>
<thead>
<tr>
<th>/laːdu-a/</th>
<th>ONSET</th>
<th>*V__V/OrObs</th>
<th>DEP-C</th>
<th>DEP(PL)</th>
<th>*V__V/GLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 'laːdu.ja</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>b. 'laːdu.ta</td>
<td>W2</td>
<td>1</td>
<td>1</td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>c. 'laːdu.a</td>
<td>W1</td>
<td>1</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>

Of course, the constraint *V__V/OrObs applies to intervocalic obstruents regardless of whether they are epenthetic. Each candidate in (13) receives one violation on this constraint, for intervocalic [d]. However, underlying intervocalic obstruents do not change into glides since their underlying specification is protected by the constraints against featural changes between input and output – the IDENT-IO constraint family (McCarthy, Prince 1995, 1999). Crucially, the IDENT constraints are ranked higher than the sonority requirements in Washo – this ranking results in a situation where highly sonorous segments are preferred intervocally, but only if no input specification is present. This ranking pattern is known as the emergence of the unmarked (McCarthy, Prince 1994).

The ranking presented so far selects glides as the optimal epenthetic consonants intervocally. However, Washo has two glides, and therefore we need to address the question of why [j] is inserted between any two vowels, rather than [w]. I will assume here that the insertion of coronal place is less costly than that of labial, due to a language-specific ranking of DEP-feature constraints. Thus the constraint DEP(place) should be thought of more precisely as a hierarchy of constraints against inserting particular place features. While for all the tableaux considered so far these constraints are ranked together, their ranking is crucial for selecting between labial and coronal inserted glides. The crucial rankings obtaining in Washo are stated in (14).

(14) Washo hierarchy of DEP(place) constraints

DEP(Labial), DEP(Dorsal) >> DEP(Coronal)

This ranking is consistent with the view that labial place is universally more marked than coronal (Lombardi 2002, de Lacy 2002, 2006, de Lacy, Kingston 2013). However the universal unmarked status of coronals is debated (Hume, Tserdanelis 2004, Morley 2015). It is therefore assumed here that in principle the constraints from DEP(place) family could be reranked in other languages, although the learner may have inherent expectations about their ranking.

The selection of epenthetic [j] over [w] is illustrated in (15) for the mapping /laːdu-a/ → [ˈlaːduja] ‘in my hand’. The losing candidate in this tableau is phonetically equivalent to a candidate which spreads place from a neighboring vowel, [ˈlaːduwa] considered in (10). However the representation of this candidate is different: instead of resulting from place spreading, the segment [w] has been inserted here as whole, together with its place features. Both candidates in (15) thus satisfy the constraint *MULT-LINK, and they also tie on the sonority constraints in (12).

(15) Washo [j] insertion: [j] is preferred over [w]

<table>
<thead>
<tr>
<th>/laːdu-a/</th>
<th>*V__V/GLD</th>
<th>*ML</th>
<th>DEP(LAB)</th>
<th>DEP(COR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 'laːdu.ja</td>
<td>1</td>
<td></td>
<td>W1</td>
<td>L</td>
</tr>
<tr>
<td>b. 'laːdu.wa</td>
<td>1</td>
<td></td>
<td>W1</td>
<td>L</td>
</tr>
</tbody>
</table>

5 A terminological note is relevant at this point. We can distinguish between abstract markedness hierarchies, and markedness constraints which are formal objects of OT. Despite the name difference, the faithfulness constraints can be used to implement hierarchical statements just as well as the markedness constraints, as demonstrated by Howe and Pulleyblank (2004) and de Lacy (2002, 2006), among others. The present proposal similarly uses DEP constraints to encode a hierarchy.
The choice between the two candidates is made by the ranking \( \text{Dep}(\text{lab}) >> \text{Dep}(\text{cor}) \). This ranking is only relevant for epenthetic glides, since otherwise the \( \text{Dep}(\text{place}) \) constraints are relatively low-ranked. However, in Section 8 we will see that the same ranking regulates the insertion of place features for vowels.

### 4.4 Alternative accounts

This section briefly considers the alternative approaches to the question of why \([j]\) is selected as an epenthetic consonant in Washo. As discussed throughout Section 4, the Washo pattern is not amenable to a spreading-based analysis, as the features of epenthetic \([j]\) do not depend on neighboring vowels.

A possible alternative has been suggested to me by an anonymous reviewer. On this story, the Washo epenthetic consonants \([j \, ʔ]\) are both specified \([-\text{consonantal}]\). This account would presumably assume some constraint that selects \([-\text{consonantal}]\) segments as epenthetic while ruling out other consonants. Word-medial \([j]\)-epenthesis follows from the fact that intervocalic consonants prefer to have the feature \([\text{voice}]\) which glottal stop lacks. However, such an account has to rely on an implausible feature specification for \([j]\). Cross-linguistically sonorants very rarely have phonologically active feature \([\text{voice}]\), and Washo is no exception to this. In fact, Yu (2011, 2016) presents independent evidence that feature \([\text{voice}]\) is irrelevant for Washo sonorants, as well as obstruents.

In Yu’s account of the Washo laryngeal alternations, the phonological difference between plain consonants (traditionally called ‘voiced’ for obstruents), aspirates, and ejectives follows from the fact that the latter two classes are specified for \([\text{spread glottis}]\) and \([\text{constricted glottis}]\) respectively, while plain obstruents and modally voiced sonorants do not bear any laryngeal features. Indeed the voicing of ‘plain’ obstruents and sonorants seems to be best explained by their context and by surface phonetic effects such as passive voicing (Westbury, Keating 1986, Jessen, Ringen 2002). Sonorants are modally voiced by default, while obstruents are modally voiced only when they are surrounded by sonorant sounds. The laryngeal underspecification of plain obstruents and modally voiced sonorants also shows itself in that they are the outcome of laryngeal neutralization, and they coalesce with laryngeals to form aspirates and ejectives. Based on Yu’s (2011, 2016) laryngeal realism analysis we may thus conclude that neither Washo obstruents nor \([j]\) should have a phonologically active specification for the feature \([\text{voice}]\). The evidence in Section 4.2 also suggests that Washo glides do not pattern with vowels, and hence there is no evidence that they are specified \([-\text{consonantal}]\). Thus the alternative account which would rely on \([j]\) being \([-\text{consonantal}, \text{+voice}]\) goes against the featural representations that are motivated by the rest of Washo phonology.

Finally, a few existing approaches to \([j]\)-insertion are close in spirit to the present proposal since they assume some mechanism enforcing similarity between vowels and consonants in major class features. Thus de Lacy (2002, 2006) argues that consonants are subject to the AGREE constraints requiring them to match major class features of neighboring vowels. Staroverov (2014) proposes that inserted consonants split off of underlying vowels, thus reproducing their features via simple preservation of the input. Both of these theories rely on features rather than sonority, and both have to appeal to additional constraints in order to rule out \([j]\)-insertion in word-initial position. Within the revised sonority theory, initial laryngeal insertion follows from the general assumptions about sonority as much as medial \([j]\)-insertion (see Section 6). Thus only the revised sonority account derives both Washo insertion patterns from the same set of theoretical assumptions. In addition, the revised sonority theory can potentially be generalized to cover cases of consonant lenition (Uffmann 2007).

### 4.5 Summary

To summarize the main argument, Washo \([j]\)-insertion supports the predictions of the revised sonority theory, since the most sonorous segment is selected for insertion intervocally. The Washo case is particularly interesting because the selection of intervocical epenthetic consonants cannot be attributed to
autosegmental spreading from neighboring vowels: \([j]\) is inserted regardless of the surrounding segments.

I have implemented the analysis of Washo \([j]\)-insertion in Optimality Theory. As an intermediate summary of the analysis, the diagram in (16) gives the partial constraint rankings established so far for Washo. This diagram only shows the lower part of the sonority-based ranking scale in (12), which is assumed to be universal. This ranking should also be thought of as integrated within the bigger system of Washo alternations. Thus there are additional faithfulness constraints selecting epenthesis (as opposed to say vowel deletion) as a hiatus resolution strategy, and additional \textbf{Ident} constraints which prevent intervocalic lenition in accordance with the revised sonority hierarchy.

(16) Washo ranking: \([j]\)-insertion (universal sonority ranking not shown)

```
*ML          Onset     *V__V/r
Dep(lab)  Dep-C     *V__V/Gld
    Dep(cor)
```

Feature spreading is prohibited in Washo, due to the ranking \(*\text{MULT-LINK} \gg \text{Dep(Lab)}, \text{Dep(Cor)}\). The selection of the epenthetic consonant is then handled by the sonority constraints in (12). Only \(*V__V/Gld\) is crucially dominated by \textbf{Onset}, and all other sonority constraints dominate \(*V__V/Gld\), in accordance with the universal hierarchy in (12). As a result, the most sonorous consonant is inserted in the intervocalic context.

\section{5 Word-initial glottal stop insertion: the data}

Within the revised sonority theory, the word-initial position is different from the word-medial intervocalic environment in that this position prefers low-sonority segments rather than highly sonorous ones (Uffmann 2007). This section shows that Washo has word-initial glottal stop insertion, and argues that Washo thus supports the predictions of the revised sonority theory. Since Washo glottal stop insertion is variably reported in the literature, this section makes an additional descriptive contribution by assembling the relevant evidence, and considering the domain of the alternation in detail.

There seems to be general agreement that Washo words must start with a consonant, but only a few sources connect this generalization with a general word-initial glottal stop insertion process (Yu 2008a: fn3). The \textit{phonological analysis} postulating initial epenthesis will be contrasted here with an account that I will somewhat loosely call \textit{morphological} (Jacobsen, 1964). The morphological approach derives initial glottal stop from a number of independent allomorphy patterns that are postulated separately for particular prefixes.\textsuperscript{6} I argue that the morphological approach does not straightforwardly extend to the citation forms of nominal stems, and that it leads to an overall loss of generalization. The rest of this section looks in detail at the alternations of stems (5.1), prefixes (5.2), and suffixes (5.3). The domain of glottal stop insertion is analyzed in 5.4, the application in loanwords is discussed in 5.5, and Section 5.6 provides a summary.

\textsuperscript{6} Some analyses of the Washo plural postulate initial vowel deletion (Broselow & McCarthy 1983; Urbanczyk 1993). So far as I can see, there is no motivation for this process outside of the domain of plurals. The application of vowel deletion in the plural has been reanalyzed in Yu (2005a).
5.1 Alternations of vowel-initial stems

While Washo nominal stems may appear without a prefix, verbal stems will always have at least a person marker prefixed on their left. Therefore it makes sense to consider the two classes of stems separately.

Based on their initial underlying segment, Washo nominal stems can be broken down in two classes, illustrated in (17): vowel-initial stems (17a) and consonant-initial stems (17b). The two stem classes take different allomorphs of the personal prefixes, for example the 2nd person prefix is [m-] before vowel-initial stems and [ʔum-] before consonant-initial stems (second column in (17)). When nominal stems occur unprefixed, vowel-initial stems show an initial glottal stop (first column in (17)).

(17) Washo stems with glottal stop insertion (all examples but one from WP)

<table>
<thead>
<tr>
<th>Stem</th>
<th>UR</th>
<th>Unprefixed</th>
<th>2sg: /m-/</th>
<th>/ʔum-/ ‘your’</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. /aŋal/</td>
<td>[ʔaŋal]</td>
<td>‘house’</td>
<td>[maŋal]</td>
<td>‘your house’</td>
</tr>
<tr>
<td>/emlu/</td>
<td>[ʔemlu]</td>
<td>‘food’</td>
<td>[memlu]</td>
<td>‘your food’ (415)</td>
</tr>
<tr>
<td>b. /ʃuː/</td>
<td>[ʔuː]</td>
<td>‘chest’</td>
<td>[ʔumʔuː]</td>
<td>‘your chest’</td>
</tr>
<tr>
<td>/ʔaːt’u/</td>
<td>[ʔaːt’u]</td>
<td>‘older brother’</td>
<td>[ʔumʔaːt’u]</td>
<td>‘your older brother’</td>
</tr>
</tbody>
</table>

On the phonological approach, the initial [ʔ] appearing with the unprefixed nouns in (17a) results from a general epenthesis process whereas the stems in (17b) start in an underlying consonant. The consonant-initial stems may start in an underlying glottal, thus [ʔaːt’u] ‘older brother’ contrasts with say [ʔaŋal] ‘house’ in selecting the preconsonantal allomorph of the second person prefix, witness [ʔumʔaːt’u] ‘your older brother’. Because of this contrast it is not possible to assume that ‘house’ is underlyingly [ʔaŋal], since this would predict ‘my house’ to appear as *[ʔumʔaŋal]. Within the morphological approach, there is no obvious reason why vowel-initial nominal stems would begin in a glottal stop when they appear unprefixed.

Unlike the nominal stems, verb stems always occur with a personal prefix in Washo. One verbal prefix, namely the 3rd person singular, can be analyzed as phonologically null, although the morphological account postulates that ‘3sg’ may be marked by a glottal stop. The shape of the 3rd person marker has a very direct relation to the initial glottal stop alternations, and therefore it will be considered here in detail. The simple 3rd person forms of verbs are illustrated in (18), where all verbs appear with the imperfective suffix /i/ which in turn triggers regular [j]-insertion after vowels.

(18) 3rd person subject marking in Washo verbs (pp. 455-456)

<table>
<thead>
<tr>
<th>Stem</th>
<th>3rd person imperfective</th>
<th>Translation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. /emlu/</td>
<td>[ʔemluji]</td>
<td>‘eat’</td>
</tr>
<tr>
<td>/iːgi/</td>
<td>[ʔiːgiji]</td>
<td>‘see, sense’</td>
</tr>
<tr>
<td>b. /leʔʃ/</td>
<td>[ʔeʔʃi]</td>
<td>‘chase’</td>
</tr>
<tr>
<td>/damalɨ/</td>
<td>[daˈmalɨji]</td>
<td>‘change’</td>
</tr>
</tbody>
</table>

On the phonological analysis, the 3rd person subject prefix is always null. Vowel-initial verb stems surface with a glottal stop in (18a) due to the general epenthesis process, which we also saw in (17a). On the other hand, the morphological account postulates that the 3rd person prefix has two allomorphs: /ʔ/ before consonants and /ʔ-/ before vowels (Jacobsen, 1964).

Although the phonological account is more parsimonious (it avoids postulating allomorphy and relates the data in (17) and (18)), the morphological account captures the simple verbal alternations in (18) equally well. However, the two accounts make different predictions for several other contexts. Thus if the initial glottal stop in (18a) is the 3rd person marker, then it should be absent in the cases where there is no 3rd
person meaning. One case at hand involves person marking on locative expressions. In general, the locative expressions can appear with personal prefixes to express location with respect to the interlocutors (19a). However, in (19b) the location expression appears with an initial glottal stop, even though the reference point is not a third person nominal.

(19) Person marking with Washo locative expressions (pp 439-440)
   a. /m-iwiʔ/ 2p-on/over [ˈmiwiʔ] ‘on/over you’
   b. /lewhu iwiʔ/ [ˈlewhu ˈʔiwiʔ] ‘concerning us (incl.)’ (lit. ‘on/over us’)

The initial glottal stop in [ʔiwiʔ] in (19b) thus cannot be the 3rd person marker, and its appearance is mysterious on the morphological account.

On the phonological account, no person agreement morpheme needs to be postulated in (19b). In fact, Washo location expressions never appear with a personal prefix when the reference point is expressed by an overt NP. The initial glottal stop in [ʔiwiʔ] in (19b) follows from the general word-initial epenthesis process.

Assuming multiple allomorphs of the 3rd person prefix also predicts that the overt allomorph [ʔ] will appear in cases where the 3rd person marker is not word-initial. Yet, glottal stop is absent in these cases. Thus transitive verbs mark both subject and object person. As shown in (20a), the object prefix precedes the subject prefix. All the examples in (20) bear the 2nd person objective prefix, which generally appears as [m’] before vowels and as /mV-/ with an alternating vowel before consonants (Jacobsen 1964: 349, 478). In (20b) the subject is in the third person, and on the morphological account we would expect to see the 3rd person subjective marker [ʔ] here. This however would lead to the selection of a preconsonantal allomorph of the 2nd person objective, predicting something like *[maʔaʃdɨm-i] for ‘he’s hiding you’.

(20) Washo verbal inflection for subject and object person
   a. [mi-ˈle-ʃɨl-hi]: 2ob-1p-give-opt    ‘let me give you this’ (452)
      [mi-ˈl-iːgi-ji]: 2ob-1p-see-ipf      ‘I/we see you’ (451)
   b. [m’-Ø-ˈiːgi-ji], *[mi-ʔ-ˈiːgi-ji]: 2ob-3p-see-ipf       ‘he sees you’ (460)
      [m’-Ø-ˈaʃdɨm-i], *[ma-ʔ-ˈašdɨm-i]: 2ob-3p-hide-ipf    ‘he’s hiding you’ (460)

Within the phonological account, the 3rd person subjective marker is always null, and hence we derive the correct forms in (20b). No glottal stop appears in front of the stem, since word-initial insertion is inapplicable here, and hence the prevocalic allomorph of 2nd person objective is selected. While the phonological account straightforwardly captures the forms of Washo verbs under object agreement, the morphological account thus has to stipulate a special exceptional rule to the effect that 2nd person objective appears as /m/ (an otherwise non-existing allomorph), just before the 3rd person subjective prefix.

To summarize, we have seen that Washo vowel-initial nouns appear with a glottal stop, when they are not preceded by a prefix. I have also argued that Washo verbs show up with a null prefix, when they only agree with a 3rd person subject. The surface forms of both nouns and verbs are in full conformity with word-initial glottal stop insertion.

5.2 Vowel-initial prefix /it-/ ‘attributive-instrumental’

Only one vowel-initial prefix of Washo occurs both word-initially and after consonants.7 This prefix – the attributive-instrumental /it-/ – alternates in conformity with word-initial glottal stop insertion.

7 One other prefix is reported to undergo similar alternations: the intransitivizer /ʔum/ (Jacobsen 1964: 350). However the following example from the Washo Project suggests an underlying /ʔ/ in this prefix: [deʔumˈbiʔits'iʔ] ‘expensive’. More data is needed on the behavior of this morpheme.
When attributive-instrumental is word-initial, it appears as [ʔit] (21a). The fact that attributive-instrumental is underlyingly vowel-initial is illustrated in (21b) where it is preceded by the prevocalic allomorph of the 2nd person possessive prefix [m] (the alternations of the 2nd person possessive prefix were illustrated in (17)).

(21) Washo attributive-instrumental /it-/  
a. /it-dij’u/ ATIN-fire [ʔit’dij’u] ‘stove’ (468)  
   /it-mafu/ ATIN-wash [ʔit’mafu] ‘soap’ (488)  
b. /m-it-dij’u/ 2P-ATIN-fire [mit’dij’u] ‘your stove’ (415)  

The examples in (21a) also show that glottal stop insertion is not limited to stressed syllables (see also Section 5.4). Stress in these forms falls on the first syllables of the stem, as predicted by the Washo stress rule, but the initial syllable still receives an inserted [ʔ].

The morphological account has to stipulate the glottal-zero alternation as specific to attributive-instrumental, whereas on the phonological account it follows from the general prosodic requirements of the language: the glottal-initial allomorph appears precisely when the vowel-initial prefix is word-initial and hence an onset is missing.8

5.3 Prosodically separable suffixes

The fact that glottal stop is inserted for prosodic reasons manifests itself perhaps most clearly when a suffix becomes a separate prosodic word. This happens only to a subset of suffixes which can be referred to as prosodically separable. Suffixes form separate prosodic words when “the speaker belatedly decides he should have added a certain suffix”, or when the suffix is added anaphorically to the preceding sentence (Jacobsen 1964: 397).

The examples in (22) illustrate the dual behavior of prosodically separable suffixes (the relevant morphemes are underlined, dots show syllable boundaries). When occurring as a separate prosodic word, prosodically separable suffixes receive stress (unless followed by a stress-attracting morpheme), and vowel-initial suffixes get an initial glottal stop (22a). On the other hand, the same morphemes may act as proper suffixes and attach to verb stems forming a single prosodic word with the stem – in this case no glottal stop or glottalization appears after consonant-final stems (22b).

(22) Washo prosodically separable suffixes /-ˈaʃaʔ/ ‘near future’ and /-enun/ ‘usitative’  
a. Appearing as a separate prosodic word  
   [ˈbak.ba gi.#.ʔa.ʃaʔ] ‘he’s smoking -- he’s going to.’ (597)  
   [ˈt’a nu.#.ʔenun.ɡe.duŋ ˈwaʔaʔ] ‘people always did it’ (624)  
b. Attaching to verb stems  
   [ˈʔi.p’a.ˈma.ʃa.ʔi] ‘he will arrive there, he’s just getting there’ (593)  
   [ˈbaŋ.ku.ʃe.nu.ɡe.duk] ‘smoked as usual’ (622, part of a larger phrase)

When attaching regularly to a verbal stem, some prosodically separable suffixes also attract stress (e.g. /-ˈaʃaʔ/ ‘near future’), while others do not seem to do so (e.g. /-enun/ ‘usitative’). Crucially, when prosodified separately both kinds of suffixes end up receiving stress on their first syllable.

The phonological account of Washo glottal stop insertion explains the distribution of initial glottal stop in prosodically separable suffixes. When these appear as separate words and are preceded by a pause, they

8 No data is available on the fate of attributive-instrumental /it-/ after vowel-final prefixes. Jacobsen (1964: 350) states that the prefix loses its initial vowel in this environment, i.e. we expect it to show up as [t], although no examples are given.
cannot be syllabified together with the preceding word, and hence they need an onset, which is provided by glottal stop insertion. Similarly, the obligatory presence of stress also follows from prosodic requirements on Washo words. Thus prosodification of suffixes provides additional evidence that glottal stop insertion is a general phonological process.

5.4 The domain of glottal stop insertion

Most examples of epenthetic glottal stop considered so far involved simple words in isolation, and since the default stress is stem initial, glottal stop insertion in these cases happened phrase-initially, and always in a stressed syllable. In fact, glottal stop insertion is not limited to these positions. Thus the attributive-instrumental prefix, discussed in Section 5.2, often appears unstressed but still receives an epenthetic glottal stop. The examples in (23) serve to further illustrate glottal stop insertion in a phrase-medial, unstressed syllable. In these examples the vowel-initial verb stems appear with stress-attracting suffixes /ˈəʃaʔ/ ‘near future’ and /eːs-/ ‘negative’.

(23) Sentence-medial glottal stop insertion

\[∅-iʃl-ˈaʃaʔ-i/\] 3p-give-NFT-IPF  \[ʔiʃˈlaʃaʔi\] ‘he will give it (to him)’

\[t’anu-ŋa ∅-emlu-eːs-i/\] person-NP 3P-eat-NEG-IPF  \[ˈt’anuŋa ʔemluˈjeːsi\] ‘nobody ate’ (WP)

5.5 Glottal stop insertion in loanwords

If initial glottal stop insertion is a general phonological process, we might also expect that this alternation will apply in loanword adaptation. The available examples of loanwords from English support this prediction. Thus (24a) lists the Washo counterparts of English vowel-initial words, while (24b) shows the application of glottal stop insertion in simplification of initial foreign clusters. No other repairs for foreign vowel-initial words are found in my corpus, although the dataset is somewhat limited.

(24) Glottal stop insertion in loanwords

a. \[ˈʔutsiʃ\] ‘oats’ (65)  b. \[ʔiʃdɨˈliŋ\] ‘string’ (90)

\[ʔelku\] ‘Elko’ (109)  \[ʔiʃˈgwaʃ\] ‘squash’ (116)

\[ʔaˈteljan\] ‘Italian’ (110)  \[ʔiʃˈluːn\] ‘saloon’ (168)

\[ʔelkoˈhoːl\] ‘alcohol’ (245)

5.6 Summary

This section has argued that Washo has a general phonological process of word-initial glottal stop insertion. This view is supported by converging evidence from citation forms of nominal stems, from the allomorphy of 3rd person singular verbs and of the attributive-instrumental prefix, and from suffix prosodification. In sum, all vowel-initial native morphemes add a glottal stop when they appear word-initially. The productivity of glottal stop insertion is supported by preliminary evidence from loanwords. Thus glottal stop insertion is best analyzed as a general phonological alternation. This alternation targets the beginnings of words,
not phrases, and it applies independently of stress. The next section spells out the analysis of word-initial glottal stop insertion, and shows that this process presents an additional argument for the revised sonority theory.

6 Analysis of Washo word-initial glottal stop insertion

The account of [j] insertion sketched in Section 4 makes several predictions. First, we expect that Washo may enforce the requirement for syllables to have onsets in other environments. The properties of the environment will influence the choice of a strategy used to provide onsets, although we have seen that epenthesis is preferred word-medially. Finally, we expect that the sonority requirements will be relevant to Washo consonants in other environments as well.

Word-initial glottal stop insertion in Washo substantiates all of these predictions. Indeed, we see that the ONSET violations in word-initial position are repaired by consonant insertion. Furthermore, the predictions of the revised sonority theory are borne out as well: in this theory, word-initial consonants of low sonority are preferred. The Margin hierarchy of Prince and Smolensky (2004) is operative here. The Margin hierarchy assumed by Uffmann (2007) is reproduced in (25) and it is essentially a reversal of the sonority requirements in the intervocalic context. Observe that the laryngeal consonants are assumed to be the least sonorous and hence best possible margins (Uffmann 2007). I follow Uffmann’s assumptions here while noting that the sonority of laryngeals may be controversial (Parker 2002, 2011, Miller 2012). Section 6.1 spells out the analysis of Washo glottal stop insertion and section 6.2 discusses some additional evidence suggesting that glottal stop patterns with low-sonority consonants in Washo.

6.1 The account of glottal insertion


(25) Margin sonority hierarchy, applicable to word-initial consonants


To illustrate, consider the analysis of the mapping /emlu/ → [ʔemlu] ‘food’ in (26). The ranking of ONSET over DEP-C, which was already established in 4.1, guarantees that the candidate without epenthesis is suboptimal (26c). Furthermore, only the lowest sonority consonants are allowed to be inserted word-initially. Only *Mar/Lar is crucially dominated by ONSET, and inserting a more sonorous oral obstruent is prohibited by *Mar/OrObs (26b).

(26) Washo word-initial glottal stop insertion

<table>
<thead>
<tr>
<th>/emlu/</th>
<th>ONSET</th>
<th>*Mar/OrObs</th>
<th>DEP-C</th>
<th>*Mar/Lar</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ʔemlu</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>b. temlu</td>
<td></td>
<td>W1</td>
<td>1</td>
<td>L</td>
</tr>
<tr>
<td>c. ʔemlu</td>
<td>W1</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

As discussed in Section 4, I assume here that input-output IDENT constraints are high-ranked, and thus they prevent underlying word-initial consonants from becoming less sonorant. Furthermore, the additional faithfulness constraints which militate against deletion are ranked above DEP, to ensure that insertion is used to provide onsets.
Finally, let us consider why Washo inserts a laryngeal stop [ʔ] rather than a laryngeal fricative [h] word-
initially. I propose here that this fact, just like the choice between two possible epenthetic glides, follows
from a language-specific ranking of Dep constraints. More specifically Dep(+continuant) is ranked above
Dep(–continuant) and thus a stop rather than a fricative is inserted. This analysis is similar in spirit to
de Lacy’s (2006: 86-87) analysis of glottal stop insertion in Mabalay Atayal which relies on a markedness
constraint specifically targeting [+continuant] segments and hence ruling out [h]-insertion. However the
proposed account remains agnostic as to whether the dispreference for [+continuant] segments is universal,
thus abstracting away from the issue of universal markedness (see also Section 4.3).

The ranking relations necessary to derive the Washo insertion patterns are summarized in (27). On my
account, the high-ranked Onset triggers epenthesis both word-medially and word-initially. The sonority
requirements account for the quality of epenthetic segments. Intervocalically, the high-sonority segments
are preferred, and the glide [j] is inserted. Word-initially, the preference is reversed, and hence the least
sonorous laryngeal is epenthesized.

(27) Washo ranking: medial [j]-insertion and initial [ʔ]-insertion

The revised sonority theory thus provides an account of both word-medial [j]-insertion and word-initial
glottal stop epenthesis in Washo. It is interesting to note that while [j]-insertion could be analyzed with
Agree constraints (de Lacy 2002, 2006) or Splitting (Staroverov 2014), these theories require additional
constraints to rule out [j]-insertion word-initially (see also Section 4.4). Thus the combination of medial [j]
insertion and initial laryngeal insertion in Washo supports the revised sonority theory.

More generally, the revised sonority theory offers a formal explanation for the cross-linguistically
common patterns of edge glottalization and aspiration (Blevins 2008). This explanation should be thought
of as complementing the potential phonetic sources of edge laryngealization. Thus a recent detailed
acoustic and articulatory study by Garellek (2013) found that the articulatory and perceptual motivation
for glottalization only extends to stressed (or prominent) syllables and syllables at phrasal edges. However,
in Washo (among other languages) initial glottal stop insertion is associated with all words, regardless of
stress or phrasing. This pattern then has to result from grammatical generalization, and this generalization
process can be facilitated by the tacit knowledge that low-sonority laryngeals are preferred at all word
edges. In other words, the revised sonority theory provides a synchronic explanation of word-initial
laryngeal insertion in Washo (de Lacy, Kingston 2013) thus complementing a potential diachronic phonetically-based
explanation (Blevins 2008).

6.2 Additional evidence for low-sonority glottal stop in Washo

The revised sonority theory assumes that laryngeals are low-sonority segments (Uffmann 2007), although
this assumption is controversial (for instance, Chomsky, Halle (1968) group laryngeals with glides). In
some languages laryngeals appear to pattern with sonorants, although most relevant evidence comes from
transparency in assimilation processes, and this could also stem from laryngeals lacking oral constriction
(Miller 2012). Furthermore, the patterning with sonorants is attested much more robustly for laryngeal
fricatives [h f] than for glottal stop (Miller 2012). In this section, I review some Washo phonological processes which may be relevant to the sonority of glottal stop.

The Washo prosodic system exhibits pervasive effects of the Stress-to-Weight principle (Prince 1990), as argued at length by Yu (2005a, 2008b). Stressed syllables must be heavy (bimoraic), i.e. minimally CVː or CVC. Following an open stressed syllable with a short vowel, most consonants are long while only short consonants appear after a long stressed vowel (28). Note that consonant length is non-contrastive and it is only marked in the examples in this section.

(28) Types of stressed syllables in Washo (Yu 2005a: 455)

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. CVː</td>
<td>[ˈjaːsaʔ] ‘again’</td>
</tr>
<tr>
<td></td>
<td>[ˈjasːaŋi] ‘it’s hot’</td>
</tr>
<tr>
<td></td>
<td>[ˈwaːʃiw] ‘Washo’</td>
</tr>
<tr>
<td></td>
<td>[ˈdaʃːaŋ] ‘blood’</td>
</tr>
<tr>
<td>b. CVCː</td>
<td>[ˈbaːmuʃ] ‘musk-rat’</td>
</tr>
<tr>
<td></td>
<td>[ˈdamːuʔ] ‘skirt’</td>
</tr>
<tr>
<td></td>
<td>[ˈʔaːni] ‘red ant’</td>
</tr>
<tr>
<td></td>
<td>[ˈtanːiw] ‘Miwok’</td>
</tr>
<tr>
<td></td>
<td>[ˈk’aːŋi] ‘it’s roaring’</td>
</tr>
<tr>
<td></td>
<td>[ˈkaŋːa] ‘cave’</td>
</tr>
<tr>
<td></td>
<td>[ˈwaːlaʃ] ‘bread’</td>
</tr>
<tr>
<td></td>
<td>[ˈʃalːaʔ] ‘pitch’</td>
</tr>
<tr>
<td></td>
<td>[ˈp’aːwa] ‘in the valley’</td>
</tr>
<tr>
<td></td>
<td>[ˈdawːal] ‘buckberry’</td>
</tr>
<tr>
<td></td>
<td>[dimˈlaːjaʔ] ‘my wife’</td>
</tr>
<tr>
<td></td>
<td>[ˈʔajːɨs] ‘antelope’</td>
</tr>
</tbody>
</table>

Yu (2005a) thus suggests that geminate consonants after a short stressed vowel bear a mora. However, only long stressed vowels occur before intervocalic plain stops, which are typically voiced in this position. In other words, plain stops resist being moraic.

(29) Only long stressed vowels occur before heterosyllabic voiced stops (309)

<table>
<thead>
<tr>
<th>Example</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ˈleːduŋ]</td>
<td>‘like me’</td>
</tr>
<tr>
<td>[ˈʔiːdaʔ]</td>
<td>‘he said...’</td>
</tr>
<tr>
<td>[ˈwiːdiw]</td>
<td>‘these (pl)’</td>
</tr>
</tbody>
</table>

Interestingly, vowel length distinction is also reported to be neutralized before the glottal stop. Thus Jacobsen (1964: 119) writes: “It seems possible also that some informants may allow only long vowels in open syllables before /ʔ/” and Yu (2016: fn. 9) reports that “vowel length is never contrastive before a glottal stop”. Based on these statements, it seems plausible that glottal stops pattern with plain unaspirated obstruents in inducing stressed vowel lengthening as in (29) rather than undergoing gemination as in (28b). This interpretation is consistent with both glottal stops and plain stops having low sonority, and thereby being unsuitable to bear a mora (Zec 1995, Morén 2001). However, there is little data on the actual duration of the pre-glottal stressed vowels in open syllables, and therefore this suggestion remains to be investigated.

7 Vowel coloring in word-medial hiatus

This section completes the discussion of Washo hiatus resolution by addressing additional alternations that occur at the left edge of a root. These alternations are traditionally dubbed vowel coloring (Jacobsen 1964). I will argue that only one of these alternations is clearly general enough to warrant a phonological account. While there is a number of other apparent alternations, most of them occur only in a relatively small number of words. Therefore we do not have sufficient evidence as to which of these additional alternations are part...
of the productive grammar. Although a phonological analysis of these alternations is fully compatible with the present proposal, it is not clear that such an analysis is warranted – the ‘alternations’ in question could well be non-productive generalizations about lexically stored forms. In what follows, Section 7.1 considers the relatively productive alternations arising with two inflectional prefixes. Section 7.2 deals with the other alternations, whose productivity is harder to ascertain. Section 7.3 provides a summary.

### 7.1 Root-initial \[i\] ~ [e] alternation after inflectional prefixes

Most Washo stems that appear with an initial [i] in isolation and after a consonant-final prefix change their initial vowel to [e] after two inflectional prefixes: ‘1st person’ and ‘imperative’. The underlying form of these prefixes is assumed to contain some element inducing the alternation, symbolized by /E/ here. The exact nature of this element will be discussed in detail in Section 8. The [i] ~ [e] alternation is illustrated in the following examples. (30) shows alternating roots appearing with an initial [i]. The underlying /I/ stands for [i] alternating with [e].

(30) Stem-initial /I/ is realized after a consonant and word-initially

/m-e-/heb/ 2p-head ['mhep] ‘your head’ (WP)
/Ø-e-ʃm-i/ 3p-sing-IPF ['ʔiʃmi] ‘he is singing’ (104)

The examples in (31) show the same roots appearing with initial [e] in the 1st person and in the imperative. The verb stem meaning ‘to sing’ shows the effect of a general [i]-insertion process here.

(31) Stem-initial [i] ~ [e] alternation

/l-e-heb/ 1p-head ['lhep] ‘my head’ (411)
/l-e-ʃm-i/ 1p-sing-IPF ['lʃmi] ‘I am singing’ (WP)
/g-e-ʃm/ IMP-sing ['gʃmi] ‘sing!’ (WP)

Note that at least one exceptional verb stem does not undergo the [i] ~ [e] alternation. Thus /igi/ ‘see, sense’ shows up as /ɪɡi-/ in the first person (Jacobsen 1964: 293) and as /ɡtiɡi-/ in the imperative (Jacobsen 1964: 286).

Finally, (32) illustrates the allomorphy of the 1st person and of the imperative. The imperative prefix appears as [ɡe] before consonants and as [ɡ] before vowels (except alternating /I/). The 1st person prefix shows up as [di] before consonants and [l] before vowels.

(32) 1st person and imperative in other contexts

/g-e-beju/ IMP-pay ['gbejʊ] ‘pay him!’ (WP)
/g-e-ajad/ IMP-spend_night ['gajat] ‘spend the night!’ (269)
/g-e-emlu/ IMP-eat ['gemlu] ‘eat!’ (WP)
/IE-e-mlu-i/ 1p-eat-IPF ['lemlui] ‘I am eating’ (WP)
/di-ʃm/ ‘1p-face’ [diʃm] ‘my face’ (WP)

For all we know, the [i] ~ [e] alternation occurs as in (30)-(31) for a large number of Washo stems, and it is unlikely that the 1st person and the imperative forms of these stems are lexically stored without establishing a generalization, even though the preconsonantal allomorph of the 1st person prefix is clearly suppletive.
In Section 8, I provide an analysis of the Washo [i] ~ [e] alternation in terms of underlying floating features and partially specified segmental root nodes. This analysis also accounts for the fact that an apparent /ei/ combination does not surface with [j] epenthesis. Before turning to the analysis however, I will briefly review a few other apparent stem-initial alternations, whose productivity is still to be explored.

7.2 Vowel alternations in other contexts

This section considers the apparent stem alternations arising between the two elements of a bipartite stem (Jacobsen 1964, 1980, de Haas 1988, Midtlyng 2005, Bochnak, Rhomieux 2013) and reported in other contexts. Bipartite verb stems are formatives that combine two apparent morphemes of a relatively concrete meaning to form a verb. The first element in bipartite stems is traditionally referred to as a lexical prefix while the second element is a dependent stem. Many elements of a bipartite stem do not occur independently (Jacobsen 1980). This aspect of bipartite stems makes them different from typical compounds, which combine otherwise occurring stems.

The formation of bipartite stems can be illustrated with the following example. The lexical prefix /hU/ ‘wind’ is combined with the dependent stem /Ibiʔ/ ‘to have come’ to form a verb stem /huːbiʔ/ ‘to have come (of wind)’. This latter stem behaves as a regular verb yielding, for instance, the imperfective third singular /ˈhuːbiʔi/ ‘wind has come’ (Jacobsen 1964: 290). In addition to vowel quality changes, bipartite stem formation may also involve [j]-insertion. Thus the lexical prefix /moːk'oE/ ‘knee’ induces two alternations when combined with a following stem /iweʔ/ ‘on the ground’, yielding a verb stem /moːk'ojeweʔ/ (the inserted glide and the changed vowel are underlined), attested in [diˈmoːk'ojeweʔi] ‘I am kneeling’ (Jacobsen 1964: 263).

The apparent vowel changes and epenthesis occurring in bipartite stems may have potential bearing on hiatus resolution, and these alternations are thus considered here. The table in (33) gives a summary of Washo vowel alternations occurring in bipartite stems. Although this table is similar to the summaries given in Jacobsen (1964) and Midtlyng (2005), it focuses only on one morphological context. The rows in (33) are organized by the last element of a lexical prefix, and the columns show the first elements of the dependent stem. Three kinds of lexical prefixes appear with a vowel [u] or [e] before a consonant-initial dependent stem, while apparently losing that vowel before vowel-initial stems. In addition, some lexical prefixes show no vowel before consonants, but change a following /I/ into [e] – this alternation is symbolized by /E₂/ in (33). Finally, the lexical prefixes ending in /E₃/ induce a quantity alternation in addition to the [i] ~ [e] alternation.

(33) Summary of Washo vowel coloring patterns

<table>
<thead>
<tr>
<th>V₁</th>
<th>V₂</th>
<th>_a</th>
<th>_e</th>
<th>_i</th>
<th>_C</th>
</tr>
</thead>
<tbody>
<tr>
<td>E₁</td>
<td>e</td>
<td>a</td>
<td>e</td>
<td>i</td>
<td>eC</td>
</tr>
<tr>
<td>E₂</td>
<td>e</td>
<td>a</td>
<td>e</td>
<td>i</td>
<td>C</td>
</tr>
<tr>
<td>U</td>
<td>u</td>
<td>o</td>
<td>i</td>
<td>uC</td>
<td></td>
</tr>
<tr>
<td>E₃</td>
<td>e∶</td>
<td>a∶</td>
<td>e∶</td>
<td>e∶C</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>a</td>
<td>a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>i</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The alternations schematized in (33) apply between a defective V₁ and a following V₂. These alternations would seem to suggest a pattern which almost always amounts to vowel deletion, and which in some cases parallels the [i] ~ [e] alternation discussed in Section 7.1. However if V₁ is preceded by another vowel, both [j]-insertion and vowel quality alternations seem to apply.
It is not entirely clear if the ‘alternations’ in (33) really represent productive generalizations about Washo grammar. Although the overall number of recorded bipartite stems is reasonably large, at least some of these stems are clearly lexically stored since they have an idiomatic meaning. For instance, the combination of the lexical prefix /metgE1/ ‘to be blown’ with the stem /ˈleleg/ ‘red’ is attested only with the nominalizing prefix /de-/ as [demetgeˈlelek] meaning ‘flag’ (Jacobsen 1980: 94). The question then is which bipartite stems are productively formed via morphological concatenation and which others are simply lexically stored as a whole.

The available Washo data do not suffice to characterize the productivity of the phonological changes occurring in bipartite stem formation. Thus many quality alternations happening within bipartite stems are only supported by less than twenty stems. Similarly, [j]-insertion in bipartite stems only occurs in less than a dozen examples. These alternations could in principle simply be non-productive generalizations over lexically stored forms.

It is not claimed here that all bipartite stem formation is lexicalized. The claim is simply that without additional data it is hard to determine which formations are stored as a whole and which are productive. However answering this question would be crucial to an eventual phonological account of bipartite stem alternations, since only the productive generalizations form part of the mental grammar of Washo speakers.

Since it is not clear which alternations in (33) are productive, I will not aim to offer a grammatical account here. It should be pointed out however, that the account presented in Section 8 for [i] ~ [e] alternation could in principle be generalized to those cases as well. Many dependent stems start with an alternating /I/, which I analyze as an empty root node, and many lexical prefixes end in floating features, which color the following empty root node, but remain vacuous before most vowels. Similarly, the analysis of [j]-insertion in Section 4 could be used to capture [j] epenthesis in bipartite stems.

Finally, an additional morphological context where vowel coloring has been reported to apply involves plural and reduplicated forms where on some of the existing analyses a reduplicant ending in a defective vowel meets a vowel-initial stem (Jacobsen 1964, Winter 1970, Broselow, McCarthy 1983). However, Yu (2005a) argues at length that the shape and position of the Washo plural reduplicant is prosodically predictable. On this analysis (see also Urbanczyk 1993), Washo plural reduplication never involves hiatus or vowel coloring (Midtlyng 2005). Similarly, Yu (2008a) describes an additional pattern of full reduplication in Washo. Some of the examples of purported vowel coloring occur with fully reduplicated stems, and are reanalyzed by Yu (2008a) as stemming from analogical backformation. In line with these approaches, I assume that Washo reduplication patterns are irrelevant to hiatus resolution.

7.3 Summary

This section has considered the apparent hiatus alternations arising at the left edge of the stem and traditionally referred to as vowel coloring (Jacobsen 1964). I have argued that the [i] ~ [e] alternation needs a phonological treatment, but for other apparent patterns we lack sufficient evidence to determine whether they are represented as productive phonological processes. Most of these other patterns occur in bipartite stem formation, and the problem is that we cannot determine which bipartite stems are formed by morphological concatenation, and which others are simply lexically stored as a whole.

8 Analysis of Washo [i] ~ [e] alternation

This section proposes that the Washo stem-initial [i] ~ [e] alternation can be viewed as a combination of a defective stem-initial root node with floating features. The proposed account is particularly interesting in light of the assumptions that we already made to account for [j] and glottal stop insertion. While we have seen that Washo prohibits spreading via a high-ranked constraint *MULTLINK, the next section will show that feature spreading is nonetheless possible, precisely in the cases where it does not violate *MULTLINK. The account thus supports the general tenets of OT, and illustrates a pattern of blocking where a process...
applies only if it satisfies some overarching constraint. Section 8.1 spells out the analysis of the [i] ~ [e] alternation, and Section 8.2 combines this analysis with the overall Washo ranking.

### 8.1 Analysis

Unlike the intervocalic and word-initial epenthesis, the Washo [i] ~ [e] alternation is clearly limited in its application: the alternation is robustly recorded only with two prefixes, and there is at least one exceptional stem escaping the alternation. In the proposed account, the application or non-application of the [i] ~ [e] alternation follows from the underlying form of the relevant morphemes, which contain floating features or a defective unspecified root node. [j] insertion does not apply in contexts of the [i] ~ [e] alternation simply because this process applies between two full vowels, and in the case at hand we have a vocalic root node preceded by floating features. This account is thus similar in spirit to other existing optimality-theoretic autosegmental approaches to exceptionality and featural affixation (Akinlabi 1996, Trommer 2011, Bermúdez-Otero 2012).

The table in (34) provides an overview of the assumed representations and the proposed analysis. I will assume that the stems which start in an alternating /I/ in Washo, in fact start out with an unspecified segmental root node in the underlying form, symbolized as /•/. The features of this root node are typically filled in by default to yield [i], as in (34a). However, when this root node comes together with floating features from the prefix, its output specification can be different. Thus, I will assume that the imperative prefix in Washo contains an underlying /g/ and a floating feature {–high} (curly brackets are used to show floating material). The 1st person prefix has a slightly more complex representation: it has a suppletive allomorph /di/ which occurs before consonants, and another allomorph – /l/ with a floating {–high} – occurring before vowels. Particularly relevant to our purposes will be the docking of the floating feature {–high} onto the stem-initial empty root node to yield [e], as in (34b). Not all stems starting with a surface [i] have an empty root node in the underlying form. The stem /iːgi/ 'see, sense' starts in a fully specified segment /i/, and this stem thus escapes the [i] ~ [e] alternation since in general, the floating {–high} is vacuous before full vowels (34c).

(34) Schematic summary of the analysis

<table>
<thead>
<tr>
<th>Context</th>
<th>SR</th>
<th>Example</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. #•, C•</td>
<td>i</td>
<td>/m•-heb/ ['mihep] ‘your head’</td>
<td>Empty root node realized as [i] by default</td>
</tr>
<tr>
<td>b. {–high}+•</td>
<td>e</td>
<td>/l{–high}-•-heb/ ['lehep] ‘my head’</td>
<td>Floating {–high} docks onto the stem-initial empty root node</td>
</tr>
<tr>
<td>c. {–high}+V</td>
<td>V</td>
<td>/l{–high}-iːgi-i/ [‘liɡii] ‘I see it’</td>
<td>Floating {–high} is vacuous before a full vowel</td>
</tr>
<tr>
<td>d. {–high}+C</td>
<td>eC</td>
<td>/g{–high}-beju/ [geˈbeju] ‘pay him!’</td>
<td>Floating {–high} realized as [e] before consonants</td>
</tr>
</tbody>
</table>

Finally, the floating feature {–high} surfaces as [e] in front of consonants, see (34d).

I now consider the formal account of the stem-initial defective root node. The unspecified root node cannot be deleted due to the high-ranked constraint Max (35). Recall that a high ranking of this constraint also explains why in other contexts hiatus is not resolved via vowel deletion.

(35) MAX: assign a violation for each input root node without an output correspondent
The defective root node receives an [i]-quality via the insertion of features [+high], and of the place features responsible for frontness. I will assume the feature geometry of Clements, Hume (1995) where front vowels bear the place feature CORONAL. The insertion of the CORONAL feature for stem-initial [i] is parallel to the insertion of [j] in word-medial hiatus. Filling in the empty root node via feature insertion crucially violates the constraints of the family Dep(F), defined in (36).

(36) Dep(F) (constraint family): assign a violation mark for every instance of feature [αF] which is not present underlyingly

The ranking of Dep constraints on particular features determines which features can be inserted more readily than others. The realization of a stem-initial empty root node is illustrated in (37) with the analysis of the form /m-•heb/ [ˈmihep] ‘your head’. This and the following tableaux abstract away from two additional aspects of this form: the suppletive allomorph selection for the prefix, and the final laryngeal neutralization.

(37) Empty vocalic root node /•/ is realized as a high front vowel

<table>
<thead>
<tr>
<th>/m-•hep/</th>
<th>MAX</th>
<th>Dep(–high)</th>
<th>Dep(+high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. mihep</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>b. mhep</td>
<td>W1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. mehep</td>
<td>W1</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

High-ranked MAX rules out the deletion of an unspecified root node, hence the failure of (37b). The ranking of Dep constraints on particular features determines that it is better to insert [+high] than [–high], hence the empty root node is not realized as [e] (37c). The selection of front, and not back vowel features follows from the ranking Dep(Labial), Dep(Dorsal) >> Dep(Coronal), which was already established in Section 4.2 based on [j]-insertion data.

Next, let us turn to the behavior of the floating feature {–high}, which occurs in the imperative and in the 1st person. In Washo, there are two ways of phonetically realizing the floating feature. First, the floating {–high} can be realized by linking to a defective stem-initial root node. In this case an association line is established between the floating feature and the stem-initial root node. Such an operation incurs a violation of a relatively low-ranked constraint *Spread (38).

(38) *Spread: assign a violation mark for each pair of associated nodes whose correspondents are not connected by an association line underlyingly

When docking on an existing root node is not possible, Washo sometimes chooses to insert a root node to host the floating {–high}. Insertion of a vowel root node violates the constraint Dep-V, which is defined in a way parallel to Dep-C in (6).

To illustrate floating feature association, consider the analysis of the form /l{-high}-•heb/ [ˈlehep] ‘my head’, shown in (39). The winning candidate simply establishes an association line between the floating feature and the empty root node, thus incurring only a violation of *Spread. Since the feature {–high} is present underlyingly the winner does not violate Dep(–high). Interestingly, the winning candidate also

---

9 I nevertheless encode vowel height in terms of the binary feature [high] rather than privative [open] since [–high] is active in Washo.
10 Washo also has [i]-insertion in consonant clusters, and the inserted vowel is subject to some assimilation requirements in that case (Jacobsen 1964: 305). This process can be assumed to apply at a relatively late, i.e. postlexical, level in Washo phonology, since it applies to fully prosodified words, and is sensitive to the presence of a pause. I leave a full account of consonant cluster resolution for future research, while noting provisionally that postlexical phonology may choose a different epenthetic vowel from the earlier strata.
does not violate the constraint *MUlt-LINK, established earlier. The floating feature had no underlying association, and thus it can spread without creating a multiply-linked structure.

(39) Floating features dock on the empty vocalic root node

<table>
<thead>
<tr>
<th>/l{–high}-•heb/</th>
<th>*ML</th>
<th>Dep{–high}</th>
<th>Dep-V</th>
<th>Dep(+high)</th>
<th>*SPREAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 'lehep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 'l{–high}ihep</td>
<td></td>
<td></td>
<td>W1</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>c. 'lejihep</td>
<td></td>
<td></td>
<td>W1</td>
<td></td>
<td>L</td>
</tr>
</tbody>
</table>

In contrast to the winner, candidate (39b) leaves the feature {–high} floating and realizes the empty root node as [i] by feature insertion, thus violating Dep(+high). Finally, the candidate (39c) inserts a new root node to host the floating feature, fills in the stem-initial empty root node with default features, and has [j]-insertion to avoid hiatus. This candidate fatally violates both Dep-V and Dep(+high).

Next, let us consider the realization of the floating {–high} in front of consonants. In this case, a vocalic root node is inserted to host the floating feature, as in /g{–high}-beju/ [geˈbeju] ‘pay him!’ (32). If a root node was not inserted, the feature {–high} would remain floating, and thus a surface word-initial consonant cluster would result. Washo phonotactics does not allow CC-initial words, and this can be attributed to a constraint ruling out complex syllable margins, formulated in (40), after Prince and Smolensky (2004).

(40) *COMPLEX: assign a violation for each syllable margin consisting of more than one segment.

The analysis of the mapping /g{–high}-beju/ → [geˈbeju] ‘pay him!’ is illustrated in (41).

(41) Floating feature realization before a consonant

<table>
<thead>
<tr>
<th>/g{–high}-beju/</th>
<th>*COMPLEX</th>
<th>Dep-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ge.ˈbe.ju</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>b. ˈg{-high}be.ju</td>
<td>W1</td>
<td>L</td>
</tr>
</tbody>
</table>

The winning candidate inserts a root node to host the floating {–high}, in violation of Dep-V. The losing candidate (41b) creates an illicit syllable margin, thus fatally violating *COMPLEX.

Finally, let us consider what happens when the floating feature {–high} occurs in front of a full vowel. In this case the floater is not phonetically realized, hence e.g. /g{–high}-ajad/ ‘spend the night!’ surfaces as [ˈgajat]. This situation can be analyzed in two ways, which are largely equivalent for current purposes. First, we could assume that the floating feature remains unassociated. Second, we can say that the floating feature vacuously docks onto the first vowel of the stem, and changes the value if that vowel is high. This second scenario results in a vowel which dominates two of the same height features, and phonetically the feature is realized only once. For concreteness, I will spell out this second account below.

The fact that the floater cannot change the stem-initial vowel can be attributed to the positional faithfulness constraints (Casali 1997, 1998, Beckman 1998). The stem material is protected by the family of constraints Ident(F),Stem in (42).

(42) Ident(F),Stem (constraint family): assign a violation mark when feature F of a stem-internal segment is modified in the output.

Given that the positional Ident constraints are present in the grammar, the features of an affix can never overwrite those of the stem (Casali (1997, 1998) makes a similar observation with respect to vowel elision).
The reason for this is that it is always better to change the features of an affix. In the case of Washo, the features of a prefix are changed to match the specification of a following stem vowel.

To illustrate, let us consider an example where the floating {–high} occurs next to a high vowel. This happens with the exceptional /i/-initial stem /igi/ ‘see, sense’, and (43) presents the analysis of the form /l{–high}-igi-i/ [ˈliːgijɪ] ‘I see it’ (analysis of [j]-insertion before the suffix is omitted, see Section 4). The winning candidate in this tableau changes the floating {–high} of the prefix to match the [+high] specification of the stem-initial vowel. The modified feature then vacuously docks onto the stem-initial root node without an observable surface effect. The losing candidate (43b) changes the features of the stem vowel. However this candidate can never win because it incurs a superset of the violations of (43a). Any ranking of the constraints in (43) would select the first candidate as the winner. Thus the non-realization of the floating material in front of a fully specified stem vowel follows from the sheer existence of positional faithfulness constraints. The candidate (43c) attempts to realize the floating feature by inserting a root node. However, this is impossible because DEP-V is ranked too high.

(43) Floating features do not dock on a fully specified root node

<table>
<thead>
<tr>
<th></th>
<th>DEP-V</th>
<th>IDENT(high)</th>
<th>*SPREAD</th>
<th>IDENT(high)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ’ligiji</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ’leːgiji</td>
<td>1</td>
<td>1</td>
<td>W1</td>
<td></td>
</tr>
<tr>
<td>c. leˈjiːgiji</td>
<td>W1</td>
<td>L</td>
<td>L</td>
<td></td>
</tr>
</tbody>
</table>

To summarize, I have presented an account of the Washo stem-initial [i]~[e] alternation that restricts the alternation to only two prefixes, namely those which have a floating feature. This account explains why the otherwise general hiatus resolution processes are inapplicable with the 1st person and imperative prefixes, and also shows that autosegmental spreading is allowed in Washo, precisely in a context where it does not create multiply-linked structures.

In conclusion, I would like to point out an additional welcome consequence of the proposed account. The analysis developed in this section can be easily generalized to capture the alternations found in bipartite stems, should these alternations prove to be truly grammatical. In particular, the vocalic alternations arising between a lexical prefix and a dependent stem could be viewed as resulting from a small number of linking vowel morphemes, each of which contains a floating feature (or features). The docking of floating features in bipartite stems would then largely obey the principles established in this section for the floating {–high}. As can be seen in (33), all floating features surface intact before a stem-initial /i/, which I have analyzed as an empty root node. On the other hand the floating features typically fail to surface before dependent stems beginning in full vowels. In sum it seems very tempting to treat the vowel alternations in bipartite stems on a par with the [i] ~ [e] alternation, since many aspects are parallel. However, we have no clear evidence as to which instances of bipartite stem formation are lexicalized, and therefore it is premature to propose a phonological account here.

8.2 The Washo ranking

The aim of this section is to tie the analysis of the [i] ~ [e] alternation together with the grammar of Washo hiatus summarized in Section 6. The final ranking for Washo is given in (44). The relatively high ranking of segmental MAX ensures that segment epenthesis resolves hiatus, and feature epenthesis serves to fill in the empty root node. Similarly, the ranking of DEP(lab) over DEP(cor) is relevant both in selecting [j]-insertion over [w]-insertion and in preferring to realize the stem-initial empty root node as a Coronal, rather than a Labial or a Dorsal vowel.
The ranking in (44) ensures that Washo resolves hiatus via consonant insertion, and that the quality of the inserted consonant is regulated by the constraints employing the revised sonority hierarchy: a glide is inserted word-medially but a laryngeal appears word-initially. The realization of floating features is governed by the general principles of Washo phonotactics, such as *COMPLEX. Another constraint relevant to floating feature realization is IDENT(high)\textsubscript{stem}; this constraint can be ranked anywhere (hence it is absent in (44), but as long as it is present in the system, modification of stem vowels is disallowed.

9 Conclusion

This paper has provided a detailed analysis of the ways in which Washo enforces the requirement that syllables must start with a consonant, or in other words have an onset. I have shown that the onset requirement motivates word-medial [j] insertion between two vowels and word-initial prevocalic glottal stop insertion. The apparent deletion of stem-initial [i] after 1\textsuperscript{st} person and imperative prefix has been analyzed here as resulting from defective root node realization.

I argued that the patterning of Washo onsets supports the revised sonority theory proposed by Uffmann (2007). This theory assumes that highly sonorous segments, such as glides, are preferred intervocally whereas segments of low sonority, as assumed for laryngeal stops, are preferred word-initially. Washo insertion matches the predictions of this theory since a glide [j] is inserted between vowels while a laryngeal stop appears word-initially.

Washo [j] insertion is also not subject to an alternative spreading-based explanation. Thus the inserted glide is [j] between any two vowels and this is incompatible with an account in terms of spreading from neighboring segments (Kawahara 2003, Rubach 2000, Naderi, van Oostendorp 2011).

Interestingly, although spreading is not allowed to affect epenthetic segments in Washo, it does occur with the floating features. This pattern supports the existence of a constraint against multiply-linked autosegmental structures (Rubach 2000). Thus although spreading is useful in analyzing local feature sharing requirements, an additional similarity-inducing mechanism is necessary. The revised sonority theory provides just such a mechanism since it requires the intervocalic consonants to be similar to the surrounding vowels in their sonority (Uffmann 2007). In this way, the revised sonority theory employed here is similar to other phonological proposals employing local similarity through AGREE constraints (Lombardi 1999, de Lacy 2002, 2006) or through segmental splitting (Staroverov 2014).

The proposed analysis unifies various Washo processes caused by the onset requirement, and thus illustrates that Optimality Theory is particularly well-suited for the analysis of conspiring processes (Kisseberth 1970, Casali 1998, 2011). Finally, an additional contribution of the paper is in collecting the phonological evidence for pervasive word-initial glottal stop insertion, and establishing the domain of this alternation. Indeed, glottal stop insertion has been reported only variably (see e.g. Jacobsen (1964) and Yu (2008a: fn. 3) for opposing views).

I have argued that the revised sonority theory offers an insightful way of looking at Washo epenthesis. A challenge for future research on the revised sonority theory lies in establishing the constraints which
differentiate between word-medial syllable heads and word-medial margins in terms of sonority requirements. Thus syllable heads typically tend to be of even higher sonority than word-medial margins, as demonstrated perhaps most convincingly in the analysis of Imdlawn Tashliyiṭ Berber (Dell, Elmedlaoui 1985, Prince, Smolensky 2004, Pater 2012 a.o.).

Acknowledgements: This project would not have been possible without the documentation efforts of William H. Jacobsen and of the members of the Washo Project. I am grateful to Alan Yu for his comments on Washo and to Marc Garellek, Paul de Lacy, Alan Prince, Jochen Trommer, and Eva Zimmermann for a useful discussion of the previous versions. I also thank Shigeto Kawahara and two anonymous reviewers for their very insightful comments. All errors and imprecisions are my own.

The author received support under the German Research Foundation (DFG) Research Training Group grant GRK 2011.

Abbreviations

The following abbreviations are used in the text and examples: 1/2/3 – person marking; ATIN - attributive-instrumental; CAUS - causative; DU - dual; IMP - imperative; INCL - inclusive; IPF - imperfective; LOC - locative; NC – negative concord; NEG - negative; NFT - near future; OB - object; OPT - optative; OT – Optimality Theory; P – person of subject or possessor; SU - subject.

References


