ABSTRACT

This paper addresses the significance of rare patterns in linguistic typology. In the Georgian nominal system, vowel deletion in the context of hiatus targets low vowels regardless of position. This pattern is extremely unusual (possibly unique) both in that it targets low vowels (Gouskova 2003) and in that the position of the vowel does not play a role in determining which vowel is deleted (Casali 1996, 1997). Nevertheless, this is a productive phonological pattern in Georgian. In a comparative pattern learning pilot experiment using English speaking subjects, I show that the pattern found in Georgian is more difficult to learn than an unattested, but theoretically predicted, counterpart. The existence of the less natural pattern in Georgian argues in favor of Hayes et al. (2009)’s assertion that cognitive predispositions act as a bias toward natural patterns but do not prevent the emergence of less natural ones.

1. Introduction

Much recent work in phonology has asked, directly or indirectly, at least one of two questions: What patterns are natural or unnatural in human language? Why do unnatural patterns arise?

Let us turn to the first question. Natural patterns can be identified by examining linguistic typology and patterns seen in acquisition. Under the view that a natural pattern is one which is motivated by cognitive predispositions, unnatural patterns arise from diachronic
misinterpretation or simply by accident. Strong supporters of this view argue that these unnatural patterns are not a part of speakers’ grammars and that they are not truly learnable patterns; that is to say that while such patterns can be learned on a lexical level, they cannot be internalized and extended to new words (Becker, et al. 2007). A more moderate view is taken by those who argue that some cognitive bias exists that makes certain patterns easier to learn, thus making them typologically more prevalent (Kawahara 2008, Hayes et al. 2009). Proponents of the cognitive bias theory expect to find that while unnatural patterns are hard to learn, they will still exist in minority.

Other researchers emphasize the role that phonetic precursors play on the emergence of phonological patterns. Moreton (2008) refers to the effect of phonetic detail on pattern innovation and loss as channel bias. Phonetically natural patterns should be typologically more common because they are more likely to emerge diachronically through systematic transmission errors in the articulatory or perceptual domain. Proponents of this theory fall into a strong and a weak camp. Strong supporters believe that channel bias is the predominant force which causes patterns to emerge across languages (Ohala 1981, Blevins 2004), while moderate supporters believe that channel bias interacts with a cognitive bias (Wilson 2006, Kawahara 2008). Channel bias does not provide an obvious explanation for how phonetically unnatural patterns emerge (if indeed they do). Kawahara (2008) argues that unnatural patterns reflect multiple unrelated phonetically natural sound patterns which, over time, result in the emergence of phonologically unnatural sound patterns.

The viewpoints expressed above are by no means exclusive. One way that researchers have attempted to determine whether a given sound pattern is supported by a cognitive bias is
through comparative pattern-learning experiments (Wilson 2003, Carpenter 2005, Holt et al. 2004, Moreton 2008, Finley & Badecker 2009). In these experiments, participants are taught patterns in miniature artificial languages, and the facility with which given patterns are learned is compared. The basic premise is that if one pattern is easier to learn than another, all else being equal, there must be a cognitive bias favoring the easier pattern.

In this paper I focus on a typologically unusual pattern of vowel deletion in hiatus found in Georgian. I test the learnability of the Georgian pattern with a comparative pattern learning experiment. In section two, there is a brief typological overview of vowel deletion patterns as they relate to Georgian. First, I discuss common hiatus repair strategies involving deletion, based on Casali (1996, 1997), and in section 2.2, I discuss typological norms in syncope. The Georgian data are presented in section 3 where I show that Georgian does not follow the typological norms of hiatus repair or vowel deletion more generally, and in section 4 I argue that the data can be accounted for in Optimality Theory by positing that constraint ranking hierarchies must be re-rankable. Section 5 presents the pattern learning experiment and the findings. Results are discussed in section 6 and I argue that they provide additional evidence that although a cognitive bias may facilitate the learning of natural patterns, the existence of the Georgian pattern shows that unnatural patterns can nevertheless be phonologized in a grammar. This result is expected if we understand the cognitive bias truly as bias and not a rigid template. It must be noted that this study will not address how unnatural patterns emerge in a language; see Blevins 2004, Kawahara 2008, etc. for discussion of this matter.
2. Vowel Hiatus

It is well known that heterosyllabic vowel-vowel sequences, also known as hiatus, are marked structures, not tolerated in many languages. When hiatus is created by the morphology of a language (for example if a vowel-final prefix is combined with a vowel-initial stem) a variety of processes are attested to repair the marked structure. The most common repair strategies are deletion of one of the two vowels and gliding; less common but still attested are consonant epenthesis and coalescence (Casali 1996, 1997, Rosenthal 1997).

In this paper I will be concerned with vowel hiatus in Georgian, which presents an interesting and potentially revealing case study. Hiatus is tolerated in many contexts in Georgian. It is found within morphemes (both lexical and functional) and across the prefix-stem boundary. When vowel hiatus arises at the stem-suffix boundary, however, it is repaired by deletion of the lowest unrounded vowel. This is typologically uncommon in two respects. First, cross-linguistically, when vowel hiatus is repaired by deletion, the deleted vowel is overwhelmingly chosen by position or quantity (Casali 1997). Secondly, height based vowel deletion in non-hiatic contexts tends to target high vowels (Gouskova 2003). I will first discuss the typologically common patterns, before returning to the rare pattern found in Georgian.

2.1 Vowel Hiatus Repair Strategies

In a survey of 92 languages which exhibit either elision or coalescence when two vowels come into contact across a syllable boundary, Casali (1996, 1997) found that languages surveyed showed a preference for preserving phonological material in well-defined prominent positions:

1) a. word initially
   b. in root morphemes
   c. in content (as opposed to function) words
   d. in stressed syllables
Casali found that most repair strategies refer only to the position of the vowel in the word or phrase and to morpheme type. The only non-positional factor found to be relevant was vowel length; phonologically long vowels are less likely to be deleted than short vowels. His findings can be summarized as follows: In V₁ + V₂ sequences, V₁ deletion was found to be significantly more common than V₂ deletion; 92% of languages exhibit V₁ deletion, while only 33% delete V₂, and all but two of those languages also exhibit V₁ deletion. Thus word (and morpheme) initial segments are preferentially preserved. These facts are true for hiatus both at the stem-suffix and prefix-stem boundaries. In addition, at lexical word boundaries, only V₁ is deleted. Lexical words and morphemes are significantly more likely than functional ones to retain their initial vowels.

The analysis of hiatus in Optimality Theory identifies certain vowels as being more faithful to the input than others. Casali proposes two MAX constraints to make the needed positional and morphological distinctions (2).

2) $\text{MAXWI}$ - Every word or morpheme initial segment in the input must have a corresponding segment in the output.
$\text{MAXLEX}$ - Every input segment in a lexical word or morpheme must have a corresponding segment in the output.

Casali illustrates the interaction of these constraints with data from Etsako, a Niger-Congo language. First, looking at the boundary between lexical and functional words, we see that regardless of position, the segments of the lexical word resist deletion.

3) a. /ona aru ɔli/ [onaruli] ‘that louse’
the louse that

b. /ɔna ɛɣi ɔna/ [oneγina] ‘this tortoise’
the tortoise the

(Casali 1997: 493)
These data are consistent with the generalizations made in (1), and can be accounted for by the MaxLex constraint, which would be violated if the vowels in the stems *aru* and *eɣi* were deleted, but not if the vowels in the function words are deleted. MaxWI becomes relevant when two lexical stems are combined, as in (4). MaxLex cannot choose between the vowels, but MaxWI ensures that the stem initial vowel is retained.

4) a. /de akpa/ [dakpa] ‘buy a cup’
   buy cup
b. /owa ɔda/ [owɔda] ‘a different house’
   house different

I will refer to the deletion patterns discussed above as *positional deletion*. Though, as previously mentioned, some languages show faithfulness to vowels on the basis of quantity, none of the 92 languages surveyed in Casali (1996, 1997) chose which vowel to delete on the basis of vowel quality.

Vowel deletion is not the only method used to repair hiatus. In many languages, one of the vowels in a VV sequence is pronounced as a glide or secondary articulation on a neighboring consonant, as detailed extensively in Rosenthall (1994, 1997). Glide formation and secondary articulation, which are both processes of a vowel losing its association with a mora, are closely tied to vowel height; high vowels are more likely to become non-moraic than mid vowels, which are in turn more likely to do so than low vowels. Often, a bipartite pattern emerges in which low prevocalic vowels delete and high prevocalic vowels become non-moraic, as is shown below in examples from Luganda.²

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² Mid vowels can pattern either with low or high vowels, but Rosenthall shows that if mid vowels can be non-moraic in a language, high vowel can be, also.
5) a. /μυ+oyo/ [mʊw:o:yo] 'soul'
b. /κα+oto/ [ko:to] 'fireplace (dim.)' (Rosenthall 1997:139)

The question then arises as to whether this pattern truly reflects more faithfulness to high vowels than to low vowels. Rosenthall’s analysis of this pattern suggests that low vowels are deleted because they cannot appear as glides or secondary articulations. He proposes a constraint \{A\} = V which states that every low vowel (\{A\}) must be associated with a mora. Thus, while languages which use glide formation/secondary articulation to resolve hiatus often look like they retain high vowels in some form more than low vowels, it is not because the grammar is more faithful to high vowels.

2.2 Typological Norms in Vowel Syncope

It has been observed that, cross-linguistically, vowels of higher sonority are preferred as syllable nuclei (Clements 1990, Prince and Smolensky 1993, Rosenthall 1997, Gouskova 2003). I take vowel sonority to correspond to vowel height (lower height = higher sonority). High vowel syncope can be found in a wide range of languages, a sampling of which is shown below.

6) **Lebanese Arabic**

a. /nizil-it/ [nizlit] ‘she descended’
b. /saahib-it-na/ [saahbitna] ‘our friend’
c. /ʔakal-it/ [ʔakalit] ‘she ate’
d. /saḥab-it/ [saḥabit] ‘she withdrew (tr.)’ (Gouskova 2003: 221)

7) **Thao (Austronesian)**

a. /fuˈʔup-an/ [fʊup-an] ‘heal, of a wound’
b. /faˈðik-in/ [faðik-in] ‘smell’
c. /baˈɾiz-an/ [bariz-an] ‘level, flat-LV (Locative Voice)’
d. /faˈzaq-in/ [faqaq-in] ‘be known-PV (Patient Voice)’ (Lu 2009: 8)
8) **Modern Greek**

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<tr>
<td>a. /fegi/</td>
<td>[feği]</td>
<td>‘he beams/shines’</td>
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<tr>
<td>b. /toki/</td>
<td>[toki]</td>
<td>‘(bank) interests’</td>
<td></td>
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<tr>
<td>c. /kima/</td>
<td>[kima]</td>
<td>‘wave’</td>
<td></td>
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<tr>
<td>d. /γena/</td>
<td>[γena]</td>
<td>‘birth’</td>
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(Topintzi & van Oostendorp 2008)

Lebanese Arabic deletes high vowels in specific metrical positions (6a-b), while low vowels survive in the same position (6c-d). Similar patterns appear in Thao (7), and Modern Greek (8), where unstressed high vowels are deleted word finally (8a-b) but low vowels survive in the same position (8c-d). Low vowel syncope, however, is a much more unusual pattern. In some languages, like the Salish language Lushootseed, low vowels are dispreferred, but only in mandatorily unstressed positions (Gouskova 2003).

Based on the overwhelming tendency for languages to prefer low vowels as syllable nuclei, it has commonly been assumed that height-based constraint hierarchies should be universally favorable towards low vowels as syllable nuclei. One such hierarchy, discussed in Gouskova (2003), is the scalar constraint *Nuc, which bans specific elements from being syllable nuclei. Gouskova argues that *Nuc/a is an impossible constraint since /a/ is the least marked nucleus (cf. Rosenthall (1994) {A} = V). Similarly, both Hartkemeyer (2000) and Tranel (1999) argue for a fixed ranking of constraints favoring low vowels in all contexts:

9) **MAX-A>>MAX-E,O>>MAX-I,U**

Languages such as Lushootseed, which deletes low vowels but not high ones, are not necessarily counterexamples to the above ranking. Gouskova argues that low vowel deletion patterns like that found in Lushootseed can be accounted for by constraints on the sonority of vowels in foot peaks and margins.

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*See Gouskova (2003) for a description of the environment for syncope.*
10) a. /RED-caq’/ [cácq’] ‘to spear big game on salt water’
b. /RED-walis/ [wáwlis] ‘little frog’
c. /s-RED-tiqiw/ [stitiqiw] ‘pony, foal’
d. /RED-hiqəb/ [hihiʔəb] ‘too, excessively’ (Gouskova 2002: 264)

In Lushootseed stress defaults to the leftmost syllable, which in the examples in (10) is the reduplicated syllable. In a binary foot system the following syllable, the root syllable, is mandatorily unstressed. If the unstressed vowel is high, as in (10c-d), the output is faithful; no syncope occurs. If the unstressed vowel is low, however, that low vowel is deleted (10a-b). This pattern reflects a general preference for highly sonorous vowels to be stressed (a reflex of the Stress to Weight Principle). Within a five vowel system like Georgian’s, sonority corresponds to height, in that the lower a vowel is, the higher its sonority. Gouskova (2003) uses fixed constraint rankings based on de Lacy (2002) and Kenstowicz (1997) to capture the generalization that languages prefer to have highly sonorous (low vowel) foot peaks (11) and less sonorous (high vowel) foot margins (12).

11) *PKFT/ə >> *PKFT/i,u >> *PKFT/e,ə

12) *MARFT/a >> *MARFT/e,ə >> *MARFT/i,u

The proposed universal constraint ranking in (11) ensures that languages universally prefer more sonorous foot peaks to less sonorous ones. The ranking in (12) ensures that less sonorous foot margins will be universally preferred to more sonorous ones. In Lushootseed, syncope of unstressed ə is achieved by ranking *MARFT/a above MaxV. For example, in a word like /RED-caq’/, a faithful output would be [*cá.caq’]. In this hypothetical form the reduplicant is the foot peak and the stem [a] is the foot margin, which violates *MARFT/a. Thus, the output with the syncopated foot margin is the optimal output.
In this section I have given an overview of the typological norms of hiatus repair and vowel syncope. For the following discussion, two generalizations about vowel deletion will be most relevant: 1) When hiatus is repaired by vowel deletion, the deleted vowel is chosen by position, not quality; 2) High vowel syncope is more common than low vowel syncope, and when low vowel syncope occurs it is for metrical purposes.

3. Hiatus in Georgian

Georgian, a Kartvelian language spoken in the Republic of Georgia, is well known for its large consonant inventory and complex consonant clusters (Chitoran 1998, Butskhrikidze 2002) but very little has been said about its vowels. In this section I will describe the hiatus resolution pattern before proposing an analysis in section 4.

Modern Georgian has a five vowel system, with no attested diphthongs or contrastive vowel length, although geminate\(^4\) vowels occur. The exact quality of the vowel phonemes is disputed; Butskhrikidze (2002) claims that all vowels in Georgian are lax, while Shusted and Chikovani (2006), in an acoustic study of one male speaker, found that only the mid vowels are lax. As the exact quality of the vowels will not affect this discussion, I will simply transcribe them as \(\langle u \rangle, \langle e \rangle, \langle i \rangle, \langle o \rangle, \) and \(\langle a \rangle\). In this paper I will restrict discussion of hiatus to the nominal system. Verbal morphology has been excluded because it is highly irregular and it is difficult to determine which patterns are productive. In most morphological contexts vowel hiatus is tolerated; heterosyllabic adjacent vowels can be found stem- and affix-internally, as well

\(^4\) By *geminate*, I refer to identical, adjacent, heterosyllabic vowels, such as in the word *saarmio* ‘army encampment.’
as across the prefix-stem boundary (13). At the stem-suffix boundary, on the other hand, hiatus regularly results in vowel deletion (14).¹

13) *Hiatus tolerated*

Stem internal

/ʻbebi-/ [bebia]  ‘grandmother’
/
/dei/- [deida]  ‘maternal aunt’

Affix internal

/-ian-/ [ian]  ‘HAVING’
/-eul-/ [eul]  ‘OF’

Prefix-stem boundary

/sa-armi-o/ [saarmio]  ‘army encampment’
/sa-int’eres-o/ [saintereso]  ‘interesting’
/u-axal-es-i/ [uaxalesi]  ‘newest’

14) *No hiatus tolerated*

Stem-suffix boundary

/dedi-t/ [dedit]  ‘mom-INST’
/
/mze-eb-i/ [mzebi]  ‘sun-PL-NOM’
/sa-sk’ola-o/ [sask’olo]  ‘FOR-school-FOR’

Deletion at the stem-suffix boundary is a highly productive process; it applies to all common, vowel-final nominal stems and all vowel-initial suffixes which have minimally a VC

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¹ I use the following symbols in transliteration:

/c/ voiceless alveolar affricate
/
/ȝ/ voiced alveolar affricate
/š/ voiceless alveo-palatal fricative
/ʃ/ voiceless alveo-palatal affricate
/x/ voiceless post-velar fricative
/ɣ/ voiceless post-velar fricative
/q/ voiceless uvular stop
‘ indicates glottalization of the preceding consonant
structure. Deletion always occurs at the boundary between stems and inflectional markers, and is productive with loan words (15).

15) a. /salat-i-s/ [salatisch] ‘salad-GEN’
   b. /masa-it/ [masit] ‘mass-INST’
   c. /radio--ad/ [radioed] ‘radio-ADV’

Deletion at the boundary between the stem and derivational suffixes is a slightly less regular process. While it is attested with all derivational suffixes of the appropriate shape, it does not apply consistently to all stem-suffix combinations. Despite the fact that it does not apply uniformly, it still appears to be a productive process, as evidenced by its application to loan words (16).

16) a. /amerik’a-el-i/ [amerik’eli] america-NAT-NOM ‘an American’
   b. /kimia-ur-i/ [kimiiuri] chemistry-ADJ-NOM ‘chemical’

We have just seen two ways in which hiatus resolution in Georgian is sensitive to morphology: 1) Resolution occurs only at the stem-suffix boundary; 2) The boundary between

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6 The final vowel of proper names does not delete, though it can still trigger deletion of the suffix vowel. Likewise, the vowel of the plural marker, -eb, does not delete, though it can still trigger deletion of the stem vowel.

7 The nominative case marker is /-i/, however it does not appear with any vowel final stems:
   i. kac-i         ii. deda             iii. sak’me         iv. gogo         v. ru
   man-NOM mother-NOM task-NOM girl-NOM stream-NOM

   Many linguists (e.g. Aronson 1990, Butskhrikidze 2002) have argued that the /-i/ suffix deletes after V-final stems. While the alternation may have been phonological historically, I take the /-i ~ -∅/ alternation to be purely morphological in the synchronic grammar.

8 Derivational morphology offers many possible vowel combinations, however in many cases no deletion occurs with derivational morphology.
   i. proza-uli ‘prosaic’
   ii. tito-euli ‘each’
   iii. sa-armi-o ‘army encampment’

   I entertain three possible reasons that deletion does not occur in some words with derivational morphology. First, low frequency words might resist deletion, since more segmental information might be necessary for lexical retrieval (i). Secondly, some high frequency words may have been reanalyzed over time as monomorphemic, so hiatus wouldn’t be expected to be resolved (ii). Lastly, mono-segmental morphemes do not undergo deletion, and may trigger deletion of vowels higher in the hierarchy. I believe this is due to a highly ranked constraint MAXMS which requires that all mono-segmental morphemes in the input be in the output (Casali 1996).
stems and inflectional suffixes is more likely to exhibit hiatus resolution than the boundary
between stems and derivational affixes. Given these facts and the trend seen in Casali (1996,
1997) towards positional deletion in hiatus (which is usually sensitive to morphology), we would
expect to find that either the stem-final vowel or the suffix-initial vowel is consistently deleted.
This, however, is not the case.

In Georgian it is vowel quality rather than position that determines which vowel is
deleted at the stem-suffix boundary. Given a stem, either the stem final vowel (V₁) or the suffix
initial vowel (V₂) can delete, depending on the quality of the suffix initial vowel.

17) a. /mze-ad/ [mzed] ‘sun-ADV’ V₁ + V₂ → V₁
    b. /mze-it/ [mzit] ‘sun-INST’ V₁ + V₂ → V₂

18) a. /medukne-ad/ [medukned] ‘shop-owner-ADV’ V₁ + V₂ → V₁
    b. /medukne-is/ [meduknis] ‘shop-owner-GEN’ V₁ + V₂ → V₂

In (17a, 18a) the suffix vowel is deleted, while in (17b, 18b) the stem vowel is deleted.

The choice of which vowel is deleted reveals a vowel hierarchy based on roundness and
sonority, outlined in (19) and illustrated in (20). Round vowels are the “strongest” vowels,
meaning the least likely to delete, followed by unrounded vowels in decreasing height. I have
noted whether the suffix is a derivational or inflectional morpheme to show that the phenomenon
is productive in both sets.

19) Georgian Vowel Hierarchy
   u, o (> ) > i > e > a

9 The gloss ‘ADV’ refers to an inflectional case called ‘adverbial’, not derivational morphology.

10 Some scholars have argued that what I am calling vowel deletion in (17a, 18a) is actually a reflection of
allomorphy of the case marker (-ad ~ -d). This is a natural conclusion since /a/ deletes in the presence of any other
adjacent vowel. This account, however, misses the more general fact that /a/ deletes readily in Georgian, both stem
finally (20a-d) and in the context of pre-sonorant syncope (see page 15). -ad/ is the only multi-segmental /a/-initial
suffix in Georgian, however the postposition /-amde/ ‘up to, until’ also undergoes /a/ deletion when attached to
vowel final stems. This fact is considered an independent instance of allomorphy by traditional Georgian scholars,
but it is predicted if we consider both instances of quality-dependent hiatus resolution.
The hierarchy proposed in (19) is illustrated by the examples in (20). (20a-d) illustrate that all other vowels dominate /a/, (20e) shows that /i/ dominates /e/. (20f-g) shows that /o/ and /u/ dominate /i/, but there is high degree of variation when round vowels are adjacent to /i/ at the stem-suffix boundary, as is shown in (21).

21) **Inflectional suffixes**

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<td>a. /gogo-is/</td>
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<td>girl-GEN</td>
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<td>b. /gogo-it/</td>
<td>[gogoti]</td>
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<td></td>
<td>girl-INST</td>
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<td>c. /ru-is/</td>
<td>[rus]</td>
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<td>stream-GEN</td>
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<td>d. /ru-it/</td>
<td>[ruti]</td>
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<td>stream-INST</td>
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21) **Derivational suffixes**

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<tr>
<td>e. /gogo-ian-i/</td>
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<td>girl-FUL-NOM</td>
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<td>f. /c’q’aro-ian-i/</td>
<td>[ts’q’aroiani]</td>
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<td>spring-FUL-NOM</td>
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21) **Postposition**

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<td>g. /dro-idan/</td>
<td>[drodan]</td>
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<td></td>
<td>time-FROM</td>
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<td>‘since then’</td>
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In examples (21a, c) we see that the genitive suffix /-is/ allows deletion of /i/ when attached to round vowels (cf. 20f-g). The same pattern is seen in (21g) with the postposition /-idan/, but the /i/ in /-idan/ derives from the instrumental case /-it/, the postposition once attached to inflected noun forms. Thus, the vowel deletion in (21g) may come from the same morpheme as (21a, c). (21b, d-f) do not show any vowel deletion.\footnote{11} Deletion in the genitive suffix alone is not sufficient evidence for showing that round vowels dominate /i/ in the hierarchy in (19). Regardless of whether any clear distinction can be made between round vowels and /i/, we can at least assert that Georgian exhibits a higher degree of faithfulness to \{i, o, u\} than to \{e, a\}.

There is additional support for asserting that round vowels are privy to some special status in Georgian phonology. This comes from a process called pre-sonorant syncope, which is outlined in (22) and illustrated in (23). We find that non-high vowels delete in the last syllable of a root when followed by a sonorant and a suffix of the minimal shape -VC.

1) Pre-sonorant syncope

\[
CV_{[-hi]}C_{[+son]}+VC \rightarrow CC_{[+son]}+VC
\]

2) a. /bal-ad/ [blad] ‘cherry-ADV’
b. /mezo-bel-is/ [mezoblis] ‘neighbor-GEN’
c. /mego-bar-eb-i/ [megobrebi] ‘friend-PL-NOM’

When this process applies to roots with /o/ in the final syllable, the /o/ does not delete entirely, but instead can be realized as /v/.\footnote{12}

3) /mindor-is/ [mindvr-is] ‘field-GEN’

\footnote{11}{It appears that the instrumental case suffix /-it/ undergoes metathesis when attached to stems ending in round vowels (18b, d).}

\footnote{12}{If /o/ is adjacent to a labial consonant it may delete entirely.}

i. /di\chi om-is/ [di\chi mis] ‘toponym-GEN’
ii. /sa\p' on-is/ [sap'nis] ‘soap-GEN’
Though the vowel is deleted, the labiality is retained. Syncope does not apply to /i/ or /u/.

13

1) a. /p’ur-is/ [p’uris] ‘bread-GEN’
   b. /k’art-opil-ad/ [k’art’opilad] ‘potato-ADV’

Faithfulness to high vowels must outrank whatever constraint drives pre-sonorant syncope, making deletion of high vowels impossible. If we compare examples (25) and (24) we see that /i/ is retained in a context in which /o/ is not, which is the exact opposite pattern than we saw in (21). These examples reflect two independent forces in Georgian phonology: a preference for high vowels and a preference for roundness/labiality. Examples (20a-e) show that Georgian prefers higher vowels, and the resistance of round vowel deletion in hiatus, coupled with the fact that /o/ survives as /v/ in pre-sonorant syncope, shows that Georgian also exhibits strong faithfulness to labiality.14 From the data given we can postulate two hierarchies of faithfulness to vowels in Georgian based on height and labiality, revealed through hiatus repair and pre-sonorant syncope.

2) Georgian Vowel Hierarchy: Height
   High > Mid > Low

3) Georgian Vowel Hierarchy: Labiality
   Round > Non-round

We now can see two ways that Georgian vowel deletion defies typological norms: 1) Vowel deletion in hiatus is based on quality, rather than position; 2) Georgian displays greater

13 It is not clear that pre-sonorant syncope is a productive process. It applies to words on a lexical basis, as seen in the minimal pair below. Nevertheless, it either is or was conditioned by a specific phonological environment (described in (19)), and we can still gain from it valuable phonological insight.

i. saxel-i ‘house.NOM’ saxl-is ‘house.GEN’
ii. saxel-i ‘name.NOM’ saxel-is ‘name.GEN’

14 Labiality plays an important role in Georgian phonology in many ways. For a discussion of the status of /v/ and the role of OCP[labial] in Georgian, see Butskhrikidze (2002).
faithfulness to high vowels than to low vowels. In the next section I propose an analysis of the Georgian pattern which accounts for the data presented, although it does not address why such a pattern should be so rare.

4. Analysis

In this section I argue for an analysis of Georgian hiatus in Optimality Theory (Prince & Smolensky 1993) which contradicts the proposed universal constraint ranking proposed in Tranel (1999) and Hartkemeyer (2000). The grammar of Georgian appears to require the ranking of height-based MAX constraints as shown in (28), an unnatural constraint ranking in terms of vowel height with respect to syncope. The tableaux in (29-30) show how this grammar works in Georgian.

1) \( \text{MAX-I,U} \gg \text{MAX-E,O} \gg \text{MAX-A} \)

2)

<table>
<thead>
<tr>
<th></th>
<th>*VV</th>
<th>MAX-I,U</th>
<th>MAX-E,O</th>
<th>MAX-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>/mze+ad/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. mze.ad</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. mzed</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. mzad</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

3)

<table>
<thead>
<tr>
<th></th>
<th>*VV</th>
<th>MAX-I,U</th>
<th>MAX-E,O</th>
<th>MAX-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>/mze+it/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. mze.it</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. mzit</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>c. mzet</td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

In the tableaux above, the most faithful candidates, (a), are immediately ruled out by violating *VV, a constraint which is violated by the presence of adjacent heterosyllabic vowels.
In both figures, candidates (b) are chosen over candidates (c) because they violate lower ranked MAX constraints. The candidates missing from these tableaux are ones in which the vowels in contact are coalesced into a form identical to the highest vowel. For figure 1, that candidate might look like this:

1) /mze₁₂d/ → [mze₁₂d]

The coalescence analysis fails to make any different predictions from the deletion analysis. Since there is no overt evidence for coalescence (i.e. the output vowel always has an identical correspondent in the input) I will continue to assume the process is deletion.

The ranking thus far predicts that all high vowels will be preferred over all mid vowels, but as we saw in section 3, roundness also must be taken into account. In order for labiality to be preserved in all situations, FAITH-lab must be highly ranked in this system. This is supported both by the preference for preserving round vowels at the root-suffix boundary and also by the /o/ - /v/ alternation seen in pre-sonorant syncope (section 3). The revised ranking is shown in tableau (32) for /gogo+is/ ‘girls’.

<table>
<thead>
<tr>
<th>/gogo+is/</th>
<th>MAX-lab</th>
<th>*VV</th>
<th>MAX-I,U</th>
<th>MAX-E,O</th>
<th>MAX-A</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. gogo.is</td>
<td></td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≡b. gogos</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. gogis</td>
<td>*!</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Thus far the analysis is able to derive Georgian’s faithfulness to high vowels, but Georgian’s hiatus resolution is typologically rare in that the quality of the vowels has an effect on the vowel choice. As discussed in section 2, Casali (1996, 1997) argues that hiatus resolution via
vowel deletion is a result of the interaction between three constraints, MAXWI, MAXLEX, and MAXV. Because the data I have shown displays no evidence that Georgian is more faithful to morpheme initial segments or lexical segments, MAXWI and MAXLEX must be ranked below MAXV (and all instantiations thereof). The final constraint ranking driving hiatus resolution in Georgian is shown in (33).\footnote{MAXWI - Every word or morpheme initial segment in the input must have a corresponding segment in the output. MAXLEX - Every input segment in a lexical word or morpheme must have a corresponding segment in the output.}

1) \textsc{Faith}-lab >> *VV >> MAX-I,U >> MAX-E,O >> MAX-A >> MAXWI, MAXLEX

A solution along the lines of Gouskova (2003)’s analysis of low vowel deletion in Lushootseed (see section 2.2), which results from universal well-formedness constraints on the foot domain, is not able to account for the Georgian pattern. I will explore the possibility of such an approach, but show that it falls short. Stress in Georgian is highly debated and accounts of it give divergent predictions (cf. Butskhrikidze 2002 and Aronson 1990). Gouskova (2003)’s analysis of Lushootseed depends on the underlying low vowel being in a position which cannot receive stress. Under any analysis of Georgian stress, the first syllable of a two syllable word receives stress. Looking again at example (17), repeated here as (34), we see a pair of underlyingly two syllable words are reduced to one syllable through vowel deletion.

\footnote{I will provide a brief account of why hiatus is not always resolved in Georgian. Recall that hiatus is tolerated within both lexical and functional roots:

i. Stem internal Affix internal
   a. bebia ‘grandmother’ b. -ian- ‘HAVING’
   c. deida ‘aunt’ d. -eul- ‘OF’
   This indicates that a faithfulness constraint protecting morpheme internal segments (such as CONTIGUITY) must be ranked above *VV. Similarly, hiatus is not repaired at the prefix-suffix boundary:
   ii. a. sa-armi-o ‘army encampment’
      b. sa-interes-o ‘interesting’
      c. u-axal-es-i ‘newest’
      I propose that the alignment constraint ALIGN-L(stem, $\sigma$ edge) is ranked above *VV. This constraint requires that the left edge of the stem be aligned to the left edge of a syllable.}
A metrical analysis of vowel deletion favors low vowel deletion in unstressed positions. (34) shows that Georgian exhibits a preference for high vowels even when the resulting form is monosyllabic, and thus necessarily stressed.

In this section I have argued for an Optimality Theoretic account of hiatus resolution in Georgian. I have shown that there is a need to be able to re-rank a set of constraints (MAX [height]) that has been considered to be a fixed hierarchy. This analysis leaves two questions. First, why is low-vowel deletion so rare typologically? In section 2.2 I showed that both Hartkemeyer (2000) and Tranel (1999) argue that height specific maximality constraints are in a fixed ranking with greatest faithfulness to low vowels. In this section I have argued that the opposite ranking exists in Georgian. If Hartkemeyer (2000) and Tranel (1999) are wrong and this hierarchy is not fixed, why should the Georgian pattern be so unusual? Second, if quality-based vowel deletion is possible, as I have shown above, why should it not be employed by more languages? One possibility is that some cognitive bias exists which impedes the acquisition of the Georgian pattern to some extent. This hypothesis is tested in the following small pilot experiment.

5. The Experiment

The preceding discussion established the two ways in which the Georgian hiatus repair strategy is typologically and theoretically unusual. The experiment was designed to address two questions: Is a quality-based deletion pattern in hiatus learnable in artificial language learning? Is it easier to learn a pattern in which low vowels or high vowels are deleted?
The first question addresses Casali’s (1996, 1997) generalization that all vowel deletion in hiatus is positional (which we have seen to not hold for Georgian). If quality based deletion is not learnable in an artificial language-learning context, we will have new evidence to support Casali’s generalization from language acquisition. We will also then have to ask how it is that Georgians are able to learn this pattern. If quality-based deletion is learnable, we must ask why Georgian is the only language to employ such a strategy to repair hiatus.

The second question addresses the typological norms in vowel syncope. We saw in section 2.2 that there is good typological evidence for positing a universal hierarchy of *Nuc constraints which bans high vowels from syllable nuclei in favor of mid vowels. If languages other than Georgian used quality-based deletion to repair hiatus, we can predict that they would delete high vowels. The pattern might look like this: both /CVCi + aC/ and /CVCa + iC/ would have the output form [CVCaC], the exact opposite of the Georgian pattern (whose output for both would be [CVCiC]). A pattern such as this which deletes high vowels in hiatus is unattested in natural language, but nevertheless is predicted to be more learnable than the Georgian pattern because it is based on high vowel deletion, which we have seen to be common in other contexts (section 2.2). This experiment tests whether this unattested pattern is easier to learn than the Georgian pattern which deletes low vowels. Based on the cross-linguistic evidence from syncope presented in section 2.2, we predict that a pattern which deletes high vowels should be easier to learn.

I have framed this research question on the basis of the theoretical assumption that typological frequency, learnability and cognitive bias are all related. Cognitive bias towards a
certain pattern makes that pattern learnable, and highly learnable patterns should be typologically common.

5.1 Method

This pilot experiment uses artificial grammar learning to test the learnability of height-based vowel deletion patterns in hiatus resolution. Two groups of subjects were each taught to delete vowels in hiatus on the basis of vowel height. Group 1 was taught to delete the higher of the two vowels, a pattern which is unattested as a hiatus resolution strategy, and group 2 was taught to delete the lower of the two vowels; the Georgian pattern. Though group 1’s pattern is unattested for hiatus resolution, it is predicted to be easier to learn because high vowel syncope is better attested in other contexts.

Participants. Twelve native English speakers, 8 women and 4 men, from 23-38 years old (mean age 26.6), participated in the experiment.

Stimuli. Stimuli were synthesized using the MBROLA diphone concatenative synthesizer (Dutoit, Pagel, Pierret, Bataille, & van der Vrecken 1996), using the "US 1" voice (a female speaker of American English). The stimuli consisted of a CVCV stem, a VC suffix and the CVCVC word which the stem and suffix formed when joined. Four voiceless obstruents were used in the stems, /t k f ʃ/, and three front vowels, /i e æ/. Three suffixes were used, /-is, -es, -æs/. All had /s/ as their final consonant, which was selected for its strong perceptual cues in coda position. The stimuli consisted of nonce forms with the exception of the suffix /-æs/, which could have been interpreted as the English word ‘ass.’ There were no consonants with strong perceptual cues which could be added to /i e æ/ without forming a real word. I do not believe that
the presence of /-æs/ caused any problems, though in the future it would be better if all real words could be avoided.

The first syllable of the stem was selected randomly from the above-listed phonemes. The second syllable was controlled: each vowel appeared with each consonant the same number of times. All vowels were 200 ms. in duration. V₁ of the stem had two pitch targets, 222 and 235 Hz. V₂ and the vowel of the suffix both had 166 and 173 Hz pitch targets. The higher pitch on the first syllable gave the impression that the first syllable was stressed (though, as is noted, no durational stress cues were present). It was important that the second vowel of the stem and the suffix vowel be unstressed, as stressed vowels have been shown to be resistant to deletion (Casali 1996, 1997, Gouskova 2003). The stem and suffix, when presented together, were separated by a 400ms pause. The artificial language was presented only auditorily, not visually.

**Procedure.** The experiment was conducted in a sound-attenuated booth in the Linguistics Department at Stony Brook University. All stimuli were presented using E-Prime (Schneider, et al. 2009). Participants were randomly divided into two groups, each of which was tested in a different condition. Participants in each condition were taught a height-based vowel deletion pattern. These are schematized in Figures 1 and 2.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Delete lowest vowel: i &gt; e &gt; æ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>stem + suffix</td>
<td>word</td>
</tr>
<tr>
<td>i + e → i</td>
<td>feʃi + es</td>
</tr>
<tr>
<td>i + æ → i</td>
<td>fæti + æs</td>
</tr>
<tr>
<td>e + æ → e</td>
<td>fete + æs</td>
</tr>
</tbody>
</table>

**FIGURE 1**

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Delete highest vowel: æ &gt; e &gt; i</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>stem + suffix</td>
<td>word</td>
</tr>
<tr>
<td>i + e → e</td>
<td>feʃi + es</td>
</tr>
<tr>
<td>i + æ → æ</td>
<td>fæti + æs</td>
</tr>
<tr>
<td>e + æ → æ</td>
<td>fete + æs</td>
</tr>
</tbody>
</table>

**FIGURE 2**
In group 1, participants were taught a pattern similar to that found in Georgian, where high vowels are preserved and low vowels are deleted. In group 2, participants were taught to preserve low vowels and delete high vowels.

Each condition consisted of a training phase and a test phase. In the training phase, participants were told that they would be taught a sound pattern of a “fake foreign language.” Instructions were presented as a slideshow while the experimenter was present. At the end of the instructions the participant was allowed to ask the experimenter for clarification. The experimenter then left the room and the training phase began.

In the training phase, participants were shown a screen with the text “When I say” followed by an audio file of the stem and suffix (e.g. “fete æs”). This was immediately followed by a screen with the text “You say” and then an audio file of the word (e.g. “fetæs”). The stem and suffix were then repeated, after which a microphone appeared on the screen, indicating that the participant should respond with the word. The stem and suffix combinations were constant for both groups, but the word varied. All participants were presented with 28 training sets, composed of a stem + suffix and the resulting word. Each stem was combined with both appropriate suffixes (whichever suffixes had non-identical vowels to the stem final vowel), presented consecutively. After the participant was presented with the set [fete æs, fetæs] they would next be presented with the complementary set [fete is, fetes]. This design reinforced that they were not being asked to follow a lexical pattern (e.g. some words allow deletion and others don’t). The stimuli were also controlled for position. Both groups were exposed to the same amount of V₁ deletion as V₂ deletion. Participants did not have the opportunity to listen to stimuli more than once in either the test or training phase.
After the training phase, the participants were asked to call the experimenter back into the room. Instructions were presented as a slideshow while the experimenter was present. At the end of the instructions the participant was allowed to ask the experimenter for clarification. The experimenter then left the room and the test phase began.

In the test phase, the participants heard an audio file with a stem + suffix set, which was followed by a screen with a picture of a microphone, indicating that they should respond with the word. Each stem was presented twice, consecutively, with both appropriate suffixes. Both groups were presented with the identical 28 test items.

5.2 Results

Data from two subjects (one from each group) were discarded because they consistently failed to delete vowels. For the remaining participants, the results suggest that there may have been some learnability advantage for the more common high vowel deletion pattern. Participants who were trained to delete low vowels (group 1) in the training session were not sensitive to vowel quality in the test phase, but instead deleted on the basis of position. Group 1 had a 58% accuracy rate. In an unpaired t-test, this was found to be no better than chance ($P > 0.1$). Group 2 had a 70% accuracy rate, which was greater than chance to an extremely significant degree ($P < 0.0007$). The individual participants’ accuracy rates are shown in figure 3, while the groups’ average accuracy rates are shown in figure 4. However, in a one way ANOVA with accuracy and group as factors, group 2 was not found to have performed significantly better than group 1 ($P > 0.1$), though it is possible given a larger number of participants the difference between the groups would become significant.
While the two groups did not differ significantly in terms of accuracy, a second factor provides stronger evidence that the two patterns may vary in learnability. Instead of deleting vowels on the basis of quality, many more participants in group 1 than in group 2 appear to have arrived at a system in which deletion is determined by the cross-linguistically common factor of...
position. Four out of five participants in group 1 preserved either $V_1$ (the *stem* vowel) or $V_2$ (the *suffix* vowel) with 80-96% consistency within their session. In a post hoc one way ANOVA with group and position as factors, participants in group 1 were found to depend on position more than group 2. This effect only approaches significance ($P = 0.052$), but it is possible that given a greater number of participants, this effect would be found to be significant. This pattern is particularly interesting given that the training session provided no evidence for position to be a factor in choosing which vowel to delete.

6. Discussion

While the results discussed above are inconclusive with respect to which pattern was more learnable, they nonetheless raise interesting questions for future study. High vowel deletion in a hiatic context (a theoretically expected but unattested pattern) was learned with greater than chance accuracy, while participants apparently failed to learn the attested, but unexpected, pattern deleting low vowels and instead seemed to depend on position to determine which vowel to delete. If further research affirms the trend in the data that high vowel deletion is more learnable than low vowel deletion as a hiatus repair strategy, we will have greater insight into possible and existing vowel deletion patterns, and a myriad of new questions.

We know that high vowels are frequent targets of syncope (section 2.2) and that vowel hiatus is not tolerated in many languages (section 2.1). Why is it that high vowel syncope is not an attested method of hiatus repair? One possibility is that there is a cognitive bias which ranks positional constraints like $\text{MAXWI}$ and $\text{MAXLEX}$ over $\text{MAX-V}$ as a default ranking, as suggested, but not explicitly argued for, in Casali (1996, 1997). If positional $\text{MAX}$ constraints by default
dominate height-specific maximality constraints, repair of hiatus across morphological boundaries will never be repaired by height-based deletion.

Additionally, if a greater contrast in learnability between groups 1 and 2 were found, it would suggest that Hartkemeyer (2000) and Tranel (1999)’s proposal of a fixed ranking of height-specific MAX constraints (as first stated in (9) and repeated here in (34)), has some support from learnability.

1) \( \text{MAX-A} \gg \text{MAX-E,O} \gg \text{MAX-I,U} \)

The participants who were explicitly taught to reverse the ranking in (34), group 1, failed at doing so. There is no evidence that these constraints are active in the participants’ native language, English. English does not have any regular patterns of vowel deletion, though some dialects exhibit schwa deletion (Patterson et al. 2003). Even so, this vowel deletion is specific to schwa, which did not appear in the stimuli. There is little reason to believe that schwa deletion reflects a larger vowel hierarchy, and therefore it is unlikely that the effect is a result of L1 transfer. Instead, the participants may have some implicit knowledge of the hierarchy in (34), which made learning a contradictory pattern difficult.

If the trends in the data are indicative of a stronger pattern, then we have new evidence to support a universal bias toward the following (default) ranking:

2) \( \{ \text{MAXWI, MAXLEX} \} \gg \{ \text{MAX-A} \gg \text{MAX-E,O} \gg \text{MAX-I,U} \} \)

This ranking predicts that all participants should have chosen to repair hiatus positionally. Group 2, however, did not delete by position. If any pattern can be found in their responses, it would be that they learnt to demote the positional MAX constraints and delete by vowel height. On the other hand, participants in group 1 were unable to both demote the positional MAX
constraints and reverse the order of the height-specific MAX constraints. The constraint rankings taught in the two conditions are illustrated below in (36).

3) Group 1
\{MAX-I,U>>MAX-E,O>>MAX-A\} >> \{MAXI, MAXLEX\}

Group 2
\{MAX-A>>MAX-E,O>>MAX-I,U\} >> \{MAXI, MAXLEX\}

Assuming the default ranking proposed in (35), group 1 was exposed to a pattern which changed nine ranking relationships, while group 2 learned a pattern which changed six ranking relationships. The difference in the groups’ accuracy rates could be attributed to the total number of constraints the pattern asked them to re-rank. Another possibility is that group 1’s pattern was more difficult to learn because it re-ranked constraints of the same type (height-specific MAX constraints) relative to each other, while while group 2’s pattern re-ranked constraints of different types (height-specific vs. positional MAX constraints). This is to say that while it is difficult to learn to switch two types of constraints (height-based vs. positional), as the participants in group 2 were asked to do, it is more difficult to learn to re-rank a set of constraints which are inherently related to each other, as the height-based MAX constraints are.

Another interesting, though unexpected, trend in the data (should further research find it to be significant) could lend support for the existence of a cognitive bias through poverty-of-the-stimulus. There was a tendency for participants in group 1 to repair hiatus through positional deletion. This is neither a pattern that they were taught, nor one which could have been transferred from their native language, since English does not repair hiatus through deletion. If this trend is shown to reflect a stronger pattern in a follow-up experiment, a possible explanation would be that the default ranking proposed in (35) emerged to create the optimal output.
Although this experiment gives some additional evidence for the existence of a cognitive bias, the study as a whole shows that this bias must be lenient, and not a rigid template. While there may be a cognitive bias toward a default hierarchy of the MAX constraints discussed in this section, it cannot be a fixed ranking. The ranking in (35) correctly predicts that the majority of the world’s languages should prefer lower vowels to higher vowels as syllable nuclei. The experiment showed that although the pattern is not attested in natural language, the ranking still holds for hiatus resolution through height-based vowel deletion. However, the existence of a strong and productive counterexample to this generalization, as is found in Georgian, provides evidence that the cognitive bias is lenient, biasing the world’s languages toward a preference for lower vowels, but not eliminating the possibility of a language developing the opposite pattern.

7. Conclusion

Using both typological and experimental evidence, this paper provides new insight into the nature of typologically rare phenomena. I have presented a hiatus repair pattern in Georgian which violates typological norms in hiatus repair (it deletes vowels based on quality, not position) and typological norms of syncope (it favors high vowels). I have also provided experimental evidence suggesting that this pattern is more difficult to learn than a theoretically expected (though unattested) hiatus repair pattern favoring low vowels. The existence of the unusual Georgian pattern despite the evidence shown that it is difficult to learn provides new evidence that cognitively unnatural patterns exist in natural language as productive patterns, contra Becker, et al. (2007), which suggests that the vowel deletion patterns discussed in this paper are not governed by an absolute cognitive limit.
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