WHAT IS GREAT ABOUT THE GREAT VOWEL SHIFT?
AN OPTIMALITY-THEORETIC VIEW

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This paper argues that Optimality Theory gives a new insight into some aspects of the Great Vowel Shifts circa 1500. In particular, our goal is to show that the structural coherence problem raised by Stockwell and Minkova (1988) is explained in relation to the universal constraint hierarchies and that unlike previous analyses, the simultaneity of high vowel diphthongization and mid vowel raising around the 16th century is synchronically predictable. It will also be demonstrated that an approach with Local Conjunction (Smolensky (1993, 1995)) plays a vital role. As a consequence, our analysis resolves the long-disputed “chain controversy” and captures the typology of vowel shifts in a natural way.*

Keywords: Intrinsic Ranking, Local Conjunction, High Vowel Diphthongization, Mid Vowel Raising

1. Introduction

One of the striking phonological changes from the late Middle English through Modern English is the shifts which affected stressed long vowels in the following way.

* This is a revised version of the paper presented at the workshop ‘The Great Vowel Shift and Phonological Theories’ on the 16th National Conference of the English Linguistic Society of Japan, held at Tohoku University on November 8, 1998. I am deeply indebted to the workshop members, Koichi Tateishi and Yuko Yoshida, who helped me organize my basic idea of the present topic in the framework of OT. The discussions with them were really exciting and stimulating. Comments from the audience, especially from Michinao Matsui and Hideki Zamma, were also very valuable. Special thanks go to Suzy Fukuda, Shosuke Haraguchi, John McCarthy, Shin-ichi Tanaka, Norio Yamada, and two anonymous EL referees for their insightful and detailed comments on an earlier version of this article, which substantially improved its content and style. I would not have completed it without the assistance of all of them. Of course, I alone am to blame for any remaining inadequacies or misconception therein.

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The details of the period may slightly vary depending on each lexical item, but Kiparsky (1995: 665) generalizes that the shifts concerned took place in three stages (i.e. circa 1500, 1650 and 18th century) based on the analysis of the historical records by Dobson (1968).

It is well known that the whole vowel change observed above was named “Great Vowel Shift (henceforth, GVS)” by Otto Jespersen, and the greatness of this change has been investigated so far concerning the systematicity of the change affecting all of the seven long vowels (Chomsky and Halle (1968)), and the widespread geographical influence (Ogura (1987, 1990), Labov (1994), Labov, Yeager and Steiner (1972)), and the seamless chain shift which occurred from 1350 through 1700 (Kiparsky (1995), Kubozono (1980, 1983), Lass (1976), Martinet (1955), Wolfe (1972) and others). This paper focuses on the theoretical aspects concerning the ‘unity’ of two individual phenomena of raising of mid vowels (henceforth, MVR) and diphthongization of high vowels (henceforth, HVD) which completed around 1500 in standard Modern English. The idea of decomposition of the GVS into smaller pieces are not new: Natural Phonology (Stampe (1969, 1972, 1973) and Donegan (1979)) and its subsequent works (e.g. Yamada (1984)) had already emphasized the independence of individual processes due to their own phonetic motivations, and pointed out the possibility that the GVS in fact consists of “no chain,” contrary to the widely held view that it was a “seamless chain.” Johnston (1992) and Lass (1992) also articulated the “broken chain” hypothesis that the GVS should be di-

\[ \text{(1)} \]

<table>
<thead>
<tr>
<th>Examples(^1)</th>
<th>ME</th>
<th>1500</th>
<th>1650</th>
<th>18th c. ~</th>
</tr>
</thead>
<tbody>
<tr>
<td>bite, child; fight; sky</td>
<td>i:</td>
<td>ei</td>
<td>ai</td>
<td></td>
</tr>
<tr>
<td>brown; bound, foul</td>
<td>u:</td>
<td>ou</td>
<td>au</td>
<td></td>
</tr>
<tr>
<td>deep; field; people</td>
<td>e:</td>
<td>i:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>boot, cool, doom</td>
<td>o:</td>
<td>u:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>beat, clean, dream</td>
<td>e:</td>
<td>e:</td>
<td>i:</td>
<td></td>
</tr>
<tr>
<td>choke; foam; know</td>
<td>a:</td>
<td>o:</td>
<td>ou</td>
<td></td>
</tr>
<tr>
<td>bate, cake, date</td>
<td>æ:</td>
<td>e:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) The symbol ‘;’ indicates that the underlined part of the next item is spelled differently from that of the previous one.
vided into two smaller chains, adducing the evidence of a chronological gap around 150 years between the shifts in the upper two heights and those in the lower two heights. Supporting this view, I focus on the changes in the upper two heights, and construct the synchronic grammar around 1500.

Since the advent of Optimality Theory (Prince and Smolensky (1993) (henceforth, PS93), McCarthy and Prince (1995)), various problems on GVS have been tackled in terms of constraint-based analysis (Lee (1996), Miglio (1998), Parkinson (1996), among others). However, the so-called "structural coherence problem" posed by Stockwell and Minkova (1988) (henceforth, SM88) has remained unanswered.

(2) "[I]s it possible, when one takes the dialect evidence into account, that perhaps the putative unity of the vowel shift is the product of hindsight, and that its 'unity' is the linguist's perception, promoted by the simplicity of Jespersen's neat diagram (1909: 231), by the elegance of the Chomsky-Halle rules, and of course by the vested interests of several lifetimes spent trying to establish beyond challenge the internal structure and dependencies within the GVS? (SM88: 356)"

They imply that some dialects have HVD only, and others MVR only, then they doubt that the occurrence of the two changes resulted from a principle such as "gap-filling" claimed by drag-chain theorists and "avoidance of merger" claimed by push-chain theorists. Clearly, they pose a question of the reason for the cooccurrence of both changes. The 'unity,' in their original sense, refers to all of the seven vowels arrayed in four heights, but in a synchronic term, it would refer to four vowels in the upper two heights.

This paper concludes that the greatness of the unity of the GVS follows from the architecture of OT, especially, universal constraint sub-hierarchies built from Local Conjunction, "a general operation in UG (Smolensky (1995: 1))." And the long-standing controversy over the trigger between the push-chain and the drag-chain will be resolved by the ranking difference of phonetically-motivated universal constraints.

2. Raising

We will adopt the following constraints proposed by Kirchner (1996).

(3) a. RAISING: Maximize vowel height.

b. PARSE (f): For all $a \in \{+, -, 0\}$, if feature f is spec-
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ified α in the input, it is specified α in the output.
RAISING, as a member of Markedness constraints, characterizes the
general tendency of vowels to be raised along the height continuum,
and requires that they be raised to the maximum height, that is, to high
vowels. This kind of constraint, when it is violated, checks the degree
of violation along the height scale: its degree corresponds to the
height distance between the output vowel and the high vowel. For ex-
ample, the output of a high vowel will incur no asterisk, a higher mid
vowel one, a lower mid vowel two, and a low vowel three. Thus it en-
ables us to see that lower vowels have more violations of this con-
straint. This is a natural consequence of a constraint which specifies
that high vowels are the least marked.

PARSE (f), or a member in the constraint family of Faithfulness con-
straints, requires that a feature in the input be parsed in the output.
Features relevant to the GVS are [high], [low] and [tense]. If we set
the ranking relation as RAISING >> PARSE (f), all non-high vowels in
the input are raised to be high in the output. But if the ranking is re-
versed as PARSE (f) >> RAISING, all vowels remain unchanged.

We claim that each of the features [high], [low] and [tense] are rel-
vent to the GVS. The Late Middle English (henceforth, late ME) has the four-height vowel system, when the GVS started to occur.

(4) Vowel height features for Late Middle English

<table>
<thead>
<tr>
<th></th>
<th>low</th>
<th>high</th>
<th>tense</th>
</tr>
</thead>
<tbody>
<tr>
<td>iː, uː</td>
<td>−</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>eː, oː</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>eː, oː</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>aː</td>
<td>+</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

(full specification) (cf. Kiparsky (1995))

Then IDENT (f) could be decomposed into the following subconstraints
incorporating these three height features as follows.

(5) a. IDENT (LOW): Correspondent segments in Input and
       Output have identical values for the feature [low]

b. IDENT (HIGH): Correspondent segments in Input and
       Output have identical values for the feature [high].

c. IDENT (TENSE): Correspondent segments in Input and
Output have identical values for the feature [tense]. Although GVS raised all of the non-high vowels diachronically, the GVS around 1500 didn’t affect nontense mid (i.e. /ɛ:, ɔ:/) nor low vowels (i.e. /a:/).² The raising of a nontense mid vowel would change the value of [tense], and the raising of a low vowel would change the value of [low]. It follows then that in the synchronic grammar of late ME, IDENT (TENSE) and IDENT (LOW) should be ranked over RAISING, as illustrated below.

(6) Synchronic raising circa 1500 (raising of mid vowels only, i.e. (iii))

<table>
<thead>
<tr>
<th></th>
<th>IDENT (TENSE)</th>
<th>IDENT (LOW)</th>
<th>RAISING</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>a. ɛɛ aː → aː</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>b. aː → ɛː</td>
<td>*!</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>c. aː → eː</td>
<td>*!</td>
<td>*!</td>
</tr>
<tr>
<td></td>
<td>d. aː → iː</td>
<td>*!</td>
<td>*!</td>
</tr>
<tr>
<td>(ii)</td>
<td>ɛː → aː</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ɛː → ɛː</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ɛː → eː</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ɛː → iː</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>(iii)</td>
<td>eː → aː</td>
<td>*!</td>
<td>*!</td>
</tr>
<tr>
<td></td>
<td>eː → ɛː</td>
<td>*!</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>eː → eː</td>
<td></td>
<td>*!</td>
</tr>
<tr>
<td></td>
<td>ɛɛ eː → iː</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

² Miglio (1998) assumes that the initiator of the GVS is the raising of the marked segments of low mid vowels (/ɛ:, ɔ:/). However, her assumption that raising of /ɛ:, ɔ:/ triggers the raising of /ɛ:, ɔ:/ in the GVS conflicts with the synchronic view, because of the chronological gap around “perhaps a century and a half or more” (Lass (1989: 88)). I thus maintain the position that the GVS started with the shifts in the top two heights, independently of the raising of low mid vowels.
As expected, raising affects only the tense mid vowel, while the others remain unchanged. Raising of tense mid vowels changes the value of [high], which means that IDENT (HIGH) is violable, thus ranked below RAISING as follows.

Combining constraint rankings in (6) and (7), the raising phenomena in the GVS around 1500 can be captured as the grammar in (8).

The synchronic grammar of raising around 1500 is represented with the conflict between markedness and faithfulness constraints. Three featural faithfulness constraints and a phonetically-motivated markedness constraint correctly outputted the raising of mid tense vowels only.

3. High Vowel Diphthongization

In this section, we adopt the device of Local Conjunction (henceforth, LC) proposed by Smolensky (1993, 1995). It is a device which makes the two constraints interact with each other in a certain local domain, developed on the idea that “two constraint violations are worse when they occur in the same location: constraint interactions can be stronger locally than non-locally (Smolensky (1995: 4)).” LC can thus be defined as follows (Smolensky (1995: 4)).

9. a. The Local Conjunction of C1 and C2 in domain D, C1 & C2, is violated when there is some domain of type D in which both C1 and C2 are violated.
b. Universally, C1 &1 C2 >> C1, C2
It is worth noting that the conjoined constraint C1 &1 C2 incurs one asterisk if and only if both (not either of) C1 and C2 are violated locally, i.e. in the same domain. It is also the significance of LC that allows us to see the reason why candidates bearing two marked elements have to be ruled out as the case of “banning the worst of the worst” (PS93: sec.9), Smolensky (1995: 4)): “each constraint is individually violable, but no form is admitted which violates both of them at once (PS93: 180)).”

Although what kinds of constraints can be conjoined is a matter of debate (cf. Fukazawa (1999), Fukazawa and Miglio (1998)), we adopt a limited version of LC, “self-conjunction” (Smolensky (1993)), where a constraint can be conjoined with itself.

(10) Self-conjunction: when C1 = C2 = C, C1 &1 C2 = C2 is violated when there is some domain of type D in which both C is violated twice. (Smolensky (1995: 4))
The self-conjoined constraints governing the GVS are two types: a markedness version (henceforth, M2), which prohibits the output from having a certain property, and a faithfulness version (henceforth, F2), which requires that the output be identical to the input. Following (9), M2 and F2 are intrinsically ranked above M and F respectively.

(11) Intrinsic Ranking on Local Conjunction (IRLC)
<table>
<thead>
<tr>
<th>a. Markedness constraints</th>
<th>b. Faithfulness constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>[M2]L</td>
<td>[F2]L</td>
</tr>
<tr>
<td>[M]L</td>
<td>[F]L</td>
</tr>
</tbody>
</table>

I will refer to this strict dominance relation as the IRLC (i.e. Intrinsic Ranking on Local Conjunction). Emphasis should be placed once again on the following point: based on the idea that all constraints are universal and that LC subhierarchies are “built from a general operation in UG (Smolensky (1995: 1),” the IRLC is universally fixed.

HVD is a process of dissimilation, which occurred as a result of the Obligatory Contour Principle (henceforth, OCP: cf. Leben (1973), McCarthy (1986)) defined as follows.

(12) OCP: Adjacent identical elements are prohibited. The OCP prohibits identical elements such as segmental features and prosodic properties. In the previous works based on derivational theories, it has been interpreted as a morpheme structure constraint, a rule blocker, or a rule trigger. Since the advent of OT, OCP effects
have been explored as a response to markedness, which has been widely applied to the analyses of dissimilation of world languages (Alderete (1997), Fukazawa (1999), Itô and Mester (1996, 1998), Myers (1997a, b), Suzuki (1997, 1998), among others).

As a first approximation, I will explain the general dissimilation schema (cf. Alderete (1997)).

(13) OCP as Markedness approach

\[
\begin{array}{|c|c|c|c|}
\hline
\alpha & \beta & *P^2L & \text{PARSE (P)} & *P \\
\hline
P & P & * & * \\
\hline
a. & [ \alpha & \beta ] & *! \\
| & P & ** \\
\hline
\end{array}
\]

Given that the sequence \( \alpha \beta \) is marked because of feature P, its ill-formedness can be captured by the violation of \(*P\), where the number of violations corresponds to that of the emergence of P. Moreover, the deletion of one of the Ps as in candidate (13a) can be captured as a response to \(*P^2L\). The advantage of this analysis is that the locally-conjoined constraint is able to mirror the correlation between the activity of dissimilation and the markedness of the feature involved in it.

The feature involved in the dissimilation in the GVS is the sequence of [+high], since it is only long high vowels that take part in the diphthongization processes in this period. The substitution of [+high] for P would result in the following constraints.

(14) a. \(*\text{Hi}\): Segments specified as [+high] are prohibited.

b. \(*\text{Hi}^2\): The sequence of two segments specified as [+high] are prohibited in stressed syllables.

\(*\text{Hi}^2\) militates against long high vowels, since their representation includes [+high] twice. But when long vowels are diphthongized, they avoid the violation, since the relevant feature is revealed only once. In this way, the LC-based approach allows us to capture HVD as a consequence of the \(*\text{Hi}^2\) violation. The relevant local domain here is, of course, specified as the stressed syllable.
Once P is designated as [+high], we can see that Parse (P) shows up as IDENT (HIGH), which was previously introduced in (5). DHV, then, can be induced by the three constraints, as in the following tableau.

(15) OCP effect in diphthongization

<table>
<thead>
<tr>
<th></th>
<th>i</th>
<th>y</th>
<th>*Hi(^2)</th>
<th>IDENT (HIGH)</th>
<th>*Hi</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>[i]</td>
<td>y</td>
<td>![]</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>[+hi]</td>
<td>[+hi]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>[e]</td>
<td>y</td>
<td>![]</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>[-hi]</td>
<td>[+hi]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(L\): stressed syllable

As expected, candidate (15a) violates \(*Hi^2\), while candidate (15b) does not, so that (15b) becomes a winner.\(^3\) In view of the fact that candi-

\(^3\) An anonymous reviewer suggests another possibility, as an output candidate, that the second element of \(/iy/\) would be either turned into \([-\text{high}]\) or deleted, and the constraints in tableau (15) alone might appear to be unable to preclude these candidates from winning out. To obtain the correct result, we need some dominant constraints by which the glide feature and position of the second element should be preserved throughout their input-output relation. For example, if we assume that IDENT (VOC) as defined in (i) is in dominant position, then changes from ‘outgliding’ to ‘ingliding’ diphthongs, such as \(/iy/ \rightarrow [i\alpha]\) and \(/uw/ \rightarrow [u\alpha]\) (i.e. \([-\text{vocalic}] \rightarrow [+\text{vocalic}]\), are banned (putting aside the question of whether ingliding diphthongs are phonemes in ME (Stockwell (1985)). Also, assuming MAX-IO in (ii) in dominant position will be sufficient to prohibit the \(/y/\) of \(/iy/\) from being deleted:

(i) IDENT (VOC): Correspondent segments in Input and Output have identical values for the feature [vocalic] in stressed syllables.

(ii) MAX-IO: Input segments must have output correspondents (i.e. No deletion).

The following tableau shows how these dominant constraints work well to obtain the correct output \(/ey/\):
date (15b) abides by the dominant markedness constraint, diphthongization may well be interpreted as an unmarked process.

Let us now turn to another essential question: why diphthongization occurred as it did. That is, the problem is the landing site to which high vowels descend, since the system in (15), as it stands, does nothing to prohibit /ɛy/ or /æy/ from emerging as an optimal output. The important observation is that diphthongization proceeded in a similar way to raising, in that both processes did not change the height value by more than one degree at a time. This kind of step-wise procession can be captured by means of F². F² is decomposed into the following constraints.

(16) a. IDENT (LOW) & IDENT (TENSE): Correspondent segments in Input and Output have identical values for both of the feature [low] and [tense] in stressed syllables.

b. IDENT (HI) & IDENT (TENSE): Correspondent segments in Input and Output have identical values for both of the feature [hi] and [tense] in stressed syllables.

Candidates violating both of the two features at once incur the violation of those constraints, but candidates violating only one of them do not. These constraints play a vital role in prohibiting vowels from changing more than one degree of the vocalic height. This point is clearly substantiated in the tableau below.
(17) Step-wise diphthongization by means of F2

<table>
<thead>
<tr>
<th></th>
<th>/iy/</th>
<th>*HI2</th>
<th>IDENT (LOW) &amp; IDENT (TENSE)</th>
<th>IDENT (HI) &amp; IDENT (TENSE)</th>
<th>IDENT (HI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>iy</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>ey</td>
<td></td>
<td>(only high)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>ey</td>
<td></td>
<td>(only tense)</td>
<td>*!</td>
<td>*</td>
</tr>
<tr>
<td>d.</td>
<td>ay</td>
<td>*!</td>
<td>*!</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

*HI2 and the set of F2s are unranked with respect to one another, because any ranking of the constraints would produce the same optimal output. This indicates that F2, in any form, is dominant and inviolable in the activation of diphthongization. Expectedly, candidates (17b–d) avoid a violation of *HI2, but candidates (17c, d) do violate F2, so that candidate (17b) wins out. F2 thus plays an indispensable role in answering the problem of the landing site of high vowels.

Taking constraint hierarchies (15) and (17) into account, we now see that the diphthongization grammar around 1500 can be summarized as in the following way.

(18) Diphthongization ranking summary ((15)+(17)): *HI2 IDENT (LOW) & IDENT (TENSE) IDENT (HIGH) & IDENT (TENSE) IDENT (HIGH) & *HI

We can see that if diphthongization is a dissimilation, M2 is necessary by all means. Alderete's model indeed enables us to see why diphthongization occurred, as an unmarked process. Furthermore, F2 is necessary in order to capture the nature of the step-wise diphthongization.

4. The Structural Unity of Raising and Diphthongization

This section presents an answer to the "structural coherence problem," which has been a long-standing puzzle in historical phonology. It will be shown by the demonstration that the IRLC plays a crucial role in the structural unity of MVR and HVD.

The following are the constraint rankings for MVR and HVD.
The constraint-based model outlined here allows us to capture both diphthongization and raising as unmarked processes. They are unmarked, not only because they abide by universal markedness constraints, but also because the universal constraints are phonetically grounded, in that RAISING minimizes the effort of the articulation, and *Hi₂ maximizes the perceptual distinctiveness between the first and the second elements of long vowels. Therefore this implies that the two changes in question do not necessarily cooccur, in accordance with the no-chain assumption that Natural Phonologists made.

Then, is the “unity” of the two changes a product of “hindsight”? As introduced at the outset, this question is closely connected to the “structural coherence problem” posed by SM88. The answer from the analysis in OT here is the following: the unity of the two changes is not a product of hindsight, but the simultaneous production of the two changes is entirely predictable from the architecture of OT. Later, I will discuss in more detail why such a conclusion can be drawn.

Given that all of the universal constraints presented in (19a, b) were possessed by all human beings, one must subsequently consider how speakers of English around 16th century permute all the constraints. To put it another way, we must integrate all of the constraints presented in (19a, b) into a single constraint hierarchy.

Looking for a clue to achieve the integration of those constraints, one might pay attention first to IDENT (HIGH), because it is a common constraint to the structures in (19a, b). But unfortunately, that constraint alone would not provide us with any clue for the procedure. What we must do here is to turn our attention to the IRLC. Its GVS
version can be rephrased in the way below.

(20) Intrinsic Ranking relevant to GVS (following IRLC)
   a. Markedness Constraints  b. Faithfulness Constraints
   \[\text{[Hi}^2\text{]} \ L \quad \text{[IDENT (LOW) \& IDENT (TENSE)]} \ L\]
   \[\quad \text{[IDENT (TENSE)]} \ L \quad \text{[IDENT (LOW)]} \ L\]
   \[\quad \text{(L: stressed syllable)}\]

The reason we must do so is that the IRLC is universally fixed. This fixed hierarchies will surely be helpful to determine the ranking of all of the constraints. Thanks to the effects of the IRLC, the two separate constraint structures in (19a, b) can successfully be integrated into the following single hierarchy.

(21) Synchronic grammar of GVS circa 1500; MVR (19a)+HVD

(19b)

\[\text{*Hi}^2 \]
\[\quad \text{IDENT (LOW) \& IDENT (TENSE), IDENT (HI) \& IDENT (TENSE)} \]
\[\quad \text{IDENT (TENSE)} \quad \text{IDENT (LOW)} \quad \text{RAISING} \]
\[\quad \text{IDENT (HI)} \quad \text{*Hi} \]

The effects of the IRLC given in (20a) and (20b) is perfectly reflected as the above schema shows. Thus, the unified ranking in (21) is a synchronic grammar of the GVS around 1500.

Let us go on to confirm whether or not this system can produce the outputs of HVD and MVR simultaneously and correctly.
Simultaneous output of MVR and HVD

<table>
<thead>
<tr>
<th></th>
<th>IDENT (LOW) &amp; IDENT (TENSE)</th>
<th>IDENT (TEN) &amp; IDENT (TENSE)</th>
<th>IDENT (LOW)</th>
<th>IDENT (TEN)</th>
<th>RAISING</th>
<th>IDENT (HI)</th>
<th>*H1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) /i:/</td>
<td>a. iy</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td></td>
<td>b. ə# ey</td>
<td>(only high)</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(ii) /e:/</td>
<td>a. ə# i:</td>
<td>(only high)</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. e:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. e:</td>
<td>(only tense)</td>
<td>(only tense)</td>
<td></td>
<td></td>
<td>*!</td>
<td>**</td>
</tr>
</tbody>
</table>

Two processes, HVD in (22i) and MVR in (22ii), are correctly outputted under this permuted hierarchy. Thus the synchronic grammar of the English GVS around 1500 is successfully constructed thanks to universally fixed hierarchies composed of universal constraints.

It is true that the analysis outlined here leads to the simultaneous output of both changes, but one may wonder how it is superior to the previous analyses. Traditionally assumed principles or constraints such as 'avoidance of merger' and 'gap-filling' are able to lead to the same result. So do other assumptions such as 'exchange rule' proposed by generative phonologists and 'particle exchange' proposed by Particle Phonology. Then we explain the problems in those theories in turn.

Avoidance-of-merger is assumed by push-chain theorists, who believe that MVR started earlier than HVD. In contrast, gap-filling is assumed by drag-chain theorists, who believe that HVD triggers MVR. Although the two of the principles are set up respectively in order to support each claim, it is evident that both principles presuppose a close affinity of trigger-reaction between MVR and HVD. But some dialectal evidence does not show such an affinity between them, so it seems dubious that those principles are universal. Moreover, the choice of reaction is arbitrary. It is not clear why HVD has to be selected as a strategy of avoidance of merger, among other processes (e.g. backing of /i:/ and fronting of /u:/). Similarly, it is not clear why MVR is selected as a gap-filling among other processes (e.g. low vowel raising). Lastly, both theories do not provide us with sufficient account for why
the trigger change occurred. Push-chain theorists have to answer to why MVR has to occur. Similarly a Drag-chain account has to answer to why HVD has to occur.

Chomsky and Halle assume that an exchange rule or $\alpha$-switching rule (23a) was added to the grammar of English in the fifteenth century (SPE: 256).

(23) a. \[\alpha\text{high,} -\text{low} \rightarrow [-\alpha\text{high}] / [+\text{tense,} +\text{stress,} __]\]
b. \[-\text{high,} -\text{low} \rightarrow [+\text{high}] / [+\text{tense,} +\text{stress,} __]\]
c. \[+\text{high,} -\text{low} \rightarrow [-\text{high}] / [+\text{tense,} +\text{stress,} __]\]

Rule (23a) turns the feature value of [high] into the opposite, thus changing mid tense vowels into high, and high tense vowels into mid. It is clearly able to produce the simultaneous output. But since this framework hypothesizes that rules are entirely language-specific, rule (23a) alone does not explain the dialectal difference. Dialectal difference is explained by other rules: Rule (23b) is added to the grammar of dialects showing MVR only, and rule (23c) is added to that of dialects showing diphthongization only. Thus rules differ from dialects to dialects. Moreover, rule (23a) is set up as a collapsed rule based on the abbreviatory conventions, which reduces two rules (23b, c) into one, with $\alpha$ as coefficients of feature [high]. Although this “notation-al transformations” (SPE: 392) succeeds in equalizing the number of rules among the three types of dialects, rule (23a) still remains to be more marked than the other two, due to the use of an auxiliary expression $\alpha$. However, as they admit, markedness of phonological changes should be considered in relation to the universal principle concerning the intrinsic content of features (SPE: 400), rather than the simplicity of rules.

Schane (1984), in Particle Phonology, proposed the particle notation, which “contains a built-in ‘markedness’ system, where the number of particles relates to the degree of markedness (Schane (1984: 39)).” Instead of binary height features such as [high] and [low], a monovalent aperture particle “a” was introduced. MVR and HVD are represented, respectively, as (24a) and (24b).

(24) a. \[\text{[e:]} \rightarrow \text{[i:]}\quad \text{ai} \quad \text{i} \quad \text{i} \quad \text{“a” deletion (\rightarrow less marked)}\]
b. \[\text{[i:]} \rightarrow \text{[ei]}\quad \text{i} \quad \text{i} \quad \text{ai} \quad \text{“a” addition (\rightarrow more marked)}\]

(‘i’ designates a palatal glide) In the process of (24a) the aperture particle “a” is deleted, while it is added in (24b). Under the assumption that fewer particles in the same (front or back) series correspond to less marked structure, it is reason-
able to see why mid vowels undergo raising. By decreasing a particle, less marked structure was attained. Thus the particle analysis seems to succeed in giving a natural answer as to the motivation of MVR. However, a question arises when our attention is shifted to HVD. This change, represented by particle addition, suggests that it creates more marked structure. Schane takes up these two contradictory changes, and characterizes English GVS as undergoing “reciprocal exchange of particles,” but such a characterization makes the problem even more serious, for it must face another question as to why particles have to be exchanged with each other in the first place.

In summarizing, traditional chain-theorists and classic generative phonologists have tried to give a principled account for English GVS, where MVR and HVD seem to be structurally dependent. Although each principle is able to produce the English vowel shift, what is not clear is how the principle is extended toward the explanation for the dialectal variation of vowel shifts and the motivation of both MVR and HVD.

LC is a general operation in Universal Grammar, and gives internal structure in the constraint component CON or the universal set of constraints. Dialectal variation is explained by the ranking difference of those constraints. Moreover, IRLC is fixed crosslinguistically. This nature is crucially different from other principles or rules proposed exclusively for the purpose of explaining the unity of the GVS.

Keeping this distinction in mind, we can now understand that “hind-sight” may be true only of the assumption of traditional principles and rules we have just seen, whose applicability is language-specific. It cannot hold true of the IRLC, because it is universal, and it takes effects whether or not we assume the structural unity between the two changes. (This point will be discussed in the next section.)

To conclude, theoretical consequences of this analysis are summarized as follows. First, this account of the GVS in OT renders the

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4 Other components assumed in OT are the language-particular constraint hierarchy H, the universal function for evaluating optimality EVAL, and the universal candidate generator GEN (see McCarthy (2002)). Smolensky (1995) claims that CON is richly structured, including at least Parametrized Families, Harmony Scales by Constraint Subhierarchies and LC.
principles of avoidance-of-merger and gap-filling unnecessary. The only principle that captures the unity of the upper two height changes is the IRLC. Furthermore, this analysis resolves the controversy between the no-chain hypothesis and the broken-chain hypothesis. In OT, individual phonetic motivations, which the no-chain hypothesis insists, are reflected in the proposed constraints themselves. The broken-chain hypothesis is also seen in the ranking in (22) in that the simultaneous production of MVR and HVD is entirely predictable from the integrated ranking drawn from the IRLC. The no-chain and the broken-chain hypotheses are not mutually exclusive, but compatible with each other in OT. Finally, this analysis leads us to draw a conclusion that the “hindsight” view of structural coherence posed by SM88 does not make any sense in our framework, because IRLC is a general operation in UG.

5. The Typology of the Four Possible Grammars of Vowel Shift

This section further confirms the present analysis, by presenting two advantages of this account.

First, this OT analysis captures the typology of vowel shifts as given below.

(25) Typology of Vowel Shifts

<table>
<thead>
<tr>
<th>a. HVD and MVR</th>
<th>b. HVD only</th>
<th>c. MVR only</th>
<th>d. None of them</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Hi²</td>
<td>*Hi²</td>
<td>RAISING</td>
<td>IDENT (HI)</td>
</tr>
<tr>
<td>RAISING</td>
<td>IDENT (HI)</td>
<td>IDENT (HI)</td>
<td>*Hi²</td>
</tr>
<tr>
<td>IDENT (HI)</td>
<td>RAISING</td>
<td>*Hi²</td>
<td>RAISING</td>
</tr>
<tr>
<td>*Hi</td>
<td>*Hi</td>
<td>*Hi</td>
<td>*Hi</td>
</tr>
</tbody>
</table>

Languages that caused both HVD and MVR, such as English and Common Czech, have the constraint ranking in (25a). The HVD-only type, of Swedish (the Malmo dialects) and Standard German is captured by (25b). The MVR-only type, such as Dutch (the Brabant dialects), is represented in (25c). Languages without HVD or MVR, such as Japanese, have the ranking in (25d).

Notice that the four types are all accounted for by the same set of
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constraints with some variation in their constraint hierarchy. Type (25b) ranks *Hi2 high and RAISING rather low, while type (25c) ranks RAISING high and *Hi2 rather low. Type (25d) ranks IDENT (HI) high and both *Hi2 and RAISING rather low. What is common to the four types is that only constraints above IDENT (HI) are active, whereas those below it are inactive. It is clear that F marks the cut-off point in the activation of a set of constraints. This analysis systematically illustrates that the English GVS is just one of the four possible grammars, and its activation is caused by the ranking of constraints, not by the constraints themselves.

The factorial typology outlined here depends on the existence of the four constraints above. Among them, RAISING and *Hi2 are contradictory to each other in that Raising demands less aperture while *Hi2 demands more aperture. Their relation is ‘antagonistic,’ and this is contrastive with the ‘demanding-and-default’ relation between RAISING or *Hi2 on one hand and IDENT (HI) on the other. Now readers may well wonder if it is a natural assumption that such antagonistic constraints play a crucial role in human grammar. In phonology, the antagonism in question stems from the conflicting tension between speakers and hearers: the minimization of articulatory effort leads to desired results for speakers whereas the maximization of perceptual contrast brings benefits to hearers. Such a functionalistic view has tra-

5 Constraint reranking may not be selected at random. For instance, the ranking in (a) may diachronically have stepped through the process of (d)→(b)→(a), where only IDENT (HI) is minimally demoted. This is compatible with a theoretical claim that the unmarked diachronic reranking is done by the minimal demotion of F (Yamane and Tanaka (2002)). In this theory, it is also predictable that system (a) can alternate with system (b) synchronically, which is empirically attested in “the diphthong shift” (e.g. [iː] → [ai] (fleece)) in Cockney (Wells (1982:308)). Moreover, the ranking difference may also involve the structural status of the vowel phoneme inventory as an internal factor. Kiparsky (1995) argues that tenseness triggers vowel shifts if it is present in the language’s phonological representations, which explains the recurrent character of vowel shifts in languages such as English, in contrast to its rarity in other languages such as Japanese where tenseness is non-distinctive. Based on this assumption, system (a) would have tense contrast in the vocalic system, and system (d) would not. It holds true for the two examples which are at the extreme end of the ranking continuum, but this line of explanation needs closer investigation into each vocalic system.

6 Thanks to an anonymous reviewer for addressing this question.
ditionally been supported in various ways. For example, Natural Phonology captured the idea of the conflicting tension in terms of 'natural processes' and 'phonological intention' and suggested that the former unmarked processes are suppressed during the course of language acquisition (Stampe (1969, 1973)). In OT, some functionalists proposed articulatory-based and auditory-based constraints and demonstrated that the grammar of a particular language is characterized by how these constraints are interleaved (Kirchner (1998) and Flemming (1995), among others). Here, RAISING is one of the articulatory constraints reducing force and effort in production, while *HI^2 is one of the auditory constraints enhancing contrast and salience in perception. Thus these functionalistic constraints, interacting with IDENT (HI), bring us a natural account in phonology.

Second, concerning the first advantage, the IRLC contributes to the restrictiveness of the ranking possibilities. The following diagram indicates that only the four ways of rankings in (25) are possible cross-linguistically, according to the IRLC.

(26) Possible Ranking Permutations

If the system allowed the relevant four constraints to be reranked randomly, the overall permutations would be twenty four ways (4×3×2×1
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(=24), as indicated on the top of the tree. Among them, twelve types make $^*\text{Hi}^2$ ranked above $^*\text{Hi}$ (as illustrated in the left branch of the top node), but the other twelve have the reversed ranking (as illustrated in the right branch of the top node), which should be ruled out, since the IRLC permits only the former ranking. Therefore, the possible types here may well be decreased to half, namely twelve. In the same way, according to the IRLC, these twelve types are decreased to eight, and they are finally reduced to four. This is because the reversed rankings, implying the activation of $^*\text{Hi}$, would wrongly predict that there exists a language which lacks a high vowel, but such a language is not attested and even impossible. As is clear from this observation, random reranking is strictly prohibited by the IRLC, which thus plays a crucial role in making the choice of possible grammars correctly.

In sum, the analysis based on LC not only gives us a valid account for the GVS around 1500, but also has two advantages. First, it can capture the typology of vowel shifts, which enables us to see that the unity of MVR and HVD is a product of one of the possible permutations of universal constraints. Second, the IRLC not only presents an alternative view to the "structural coherence problem," but also provides us with a reasonable account for the restrictiveness of the possible phonological grammars.

6. Conclusion

This OT-based analysis of the upper two height changes of the GVS offers novel answers to the problems that have so far remained unresolved in previous studies.

The unanswered questions were attributed to the motivations of MVR and HVD, and their markedness. But in this analysis MVR is seen as the response to the constraint RAISING, and HVD as the response to the constraint $^*\text{Hi}^2$. This system successfully captures both phenomena as unmarked processes.

Another question was what kind of principle caused MVR and HVD to occur simultaneously in the GVS. Based on the observation that MVR and HVD do not necessarily cooccur in other languages, it should be concluded that the principles of avoidance-of-merger, gap-filling, and "reciprocal exchange of particles," are invalid at least as synchronically effective universal principles. In addition it was alterna-
tively proposed that the simultaneous outputs of MVR and HVD should be attributed to the IRLC, which is built from a general operation of UG.

Relevant to this problem was the chain controversy. It has been demonstrated that the no-chain and broken-chain hypotheses are not mutually exclusive, but are both able to be unified in a single grammar of OT. The no-chain hypothesis is supported in the sense that phonetically motivated constraints are independently assumed for MVR and HVD, which leads to the idea that the two changes do not necessarily cooccur. On the other hand, the broken-chain hypothesis is supported in the sense that the simultaneous outputs of the two changes concerned are predictable from a universal phonological system.

As for the “structural coherence problem” posed by SM88, we have argued against the “hindsight” view of unity in the framework of OT. As far as the upper height changes are concerned, the simultaneous occurrence is one of the possible grammars. To echo Lass (1992: 153), “these [MVR and HVD - N.Y.] are both massive and system-transforming enough to be called ‘Great,’ and coherent enough to merit both the definite article and the term ‘Vowel Shift’ (p. 153).” But what led them to be called ‘Great’? The findings in the present analysis will say that it was nothing but the IRLC.

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