Intrusive *r* in English: A functional approach*

Young-Shik Hwangbo
(Seoul National University)

Hwangbo, Young-Shik. 1998. **Intrusive *r* in English: A functional approach.** *Studies in Phonetics, Phonology and Morphology* 4, 291-314. Whether *r*-intrusion is natural or not has been controversial. In this paper I will argue that *r*-intrusion is phonetically motivated, that is, natural, by showing that *r*-triggering vowels and intrusive *r* have something in common. Specifically, I will treat *r*-intrusion as a kind of glide insertion. I will argue that the neighboring vowels select the nearest glide in the vowel space that, in turn, may be proved the most similar one in vocal tract shape. This implies that the selected glide is the one which can be reached most easily from the preceding vowels. This means that *r*-intrusion (as well as *j*- and *w*-intrusion) can be explained functionally, at least in part. I will show that intrusive *r* can be explained in Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1995) in two ways: by the constraint *Effort (Boersma 1997) that demands the least effort or by the markedness constraints that penalize every occurrence of features (Itô and Mester 1994). (Seoul National University)

Keywords: intrusive r, functional, effort, spreading, Optimality Theory

1. Introduction

The insertion and deletion of *r* in some dialects of English (*r*-less dialects) have been of particular interest in English phonology. The prime examples of these phenomena are presented below (McCarthy 1993: 170):

(1) a. *r*-deletion
The spar seems to be broken.
He put the tuner down.
You're somewhat older.

b. *r*-linking
The spar is broken.
He put the tuner away.
You're a little older.

* I am greatly indebted to Sang-buom Cheun, William J. Idsardi, Jin-Hyung Kim, and Sun-Hoi Kim, as well as two anonymous reviewers, for their valuable comments and suggestions. I wish to acknowledge the financial support of Korea Research Foundation made in the program year of 1997.

(2) a.
The spa seems to be broken.
He put the tuna down.
The boat tends to yaw some.

b. *r*-intrusion
The spar is broken
He put the tunar away.
The boat'll yawr a little.

In *r*-less dialects, *r* is not pronounced before a consonant or a pause, as in (1a). However, it is pronounced before a vowel, as in (1b). In the latter case, *r* is called linking *r*. In some *r*-less dialects, *r* is inserted before a vowel even though there is no *r* in the spelling, as in (2b). This *r* is called intrusive *r*. Intrusive *r* can also occur word-internally:

(3) bananary, Kafkaresque, magentarish, propagandarize, subpoenaring; sawring, Shawrism, thawring, withrawral;
cha-charing
(Wells 1982: 225-6; McMahon 1994: 84)

In this paper, I will just focus on intrusive *r*. Intrusive *r* has brought about contradictory proposals concerning its naturalness. On the one hand, Walmsley (1977), Broadbent (1991), Cheun (1995), and Gnanadesikan (1997) argue that *r*-intrusion (or *r*-insertion) is natural. Contrarily, Vennemann (1927: 216), McMahon (1994), McMahon et al. (1994), and Blevins (1997) deny its naturalness, arguing for its arbitrariness. For example, McMahon (1994: 86) asserts:

> [r]-Insertion process is synchronically arbitrary: it gives us no idea of why [r] is the segment inserted, and why insertion happens in the particular contexts where it does. It is certainly true that, in the rule of [r]-Insertion, the vowels preceding [r] do not form a synchronically principled natural class, since they do not share any feature with [r] or with each other.

In spite of McMahon's assertion, I will argue that *r*-intrusion is natural and will attempt to provide some phonetic supports for the naturalness of *r*-intrusion.

The remainder of the article is organized as follows. In section 2, relevant data will be presented, and the previous approaches to *r*-intrusion will be briefly reviewed. In section 3, I will show that *r*-triggering vowels and the intrusive *r* have something in common, and thus, *r*-intrusion is phonetically motivated. Specifically, I will treat *r*-intrusion as a kind of glide insertion. I will argue that the neighboring vowels select the nearest glide in the vowel space that, in turn, may be proved the most similar one in vocal tract shape. This implies that the selected segment is the one which can be reached most easily from the preceding vowels. In section 4, I will show that intrusive *r* can be explained in Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1995; hereafter OT) in two ways: by the constraint *Effort (Boersma 1997: 28) that demands the least effort or by the markedness constraints that penalize every occurrence of features (Itô and Mester 1994). Section 5 concludes the paper.

2. Related data and previous studies

Some examples of the intrusive *r* have already been illustrated above in (2b) and (3). Additional examples are presented below, covering the range of the *r*-intrusion environment (Brown 1988: 144):

(4) ma and pa	[mɑːr ənd pɑː]
thaw out	[Tɔːr aʊt]
milieu[1] of Dickens	[miːljɜːr əv dɪkɪnz]
China Airlines	[tʃaɪnər eəlaɪnz]
idea of it	[aɪdɪər əv ɪt]
Eritrea in Ethiopia	[erɪtreər ɪn iːTɪəʊpjə]
Nicaragua and Costa Rica	[nɪkərægjʊər ənd kɒstə riːkə]

Assuming that *ɜː* is a long version of *ə*, *r*-intrusion can be taken to occur after *ə*, *ɑ*, and *ɔ*. These *r*-triggering vowels (*ə*, *ɑ*, and *ɔ*) are

---

[1] This has various pronunciations. The pronunciation given by Brown is just one of them.

often said to be the only true vowels that can occur word-finally (McCarthy 1993: 171; Cf. Johansson 1973: 60).

There are some marginal examples. First, *baa* is one of the few English words ending in *æ* (Stockwell and Bowen 1965: 89); Donegan (1993: 118-119) cites *baa* [bæ] as one of the words after which intrusive *r* takes place in RP.[2] Another example is *yeah*, the truncated form of *yes*. Moulton (1990: 130) transcribes this word as [jæː]; Wells (1982: 226) points out that the phonemic representation of *yeah* could be /je/ (=[jɛ]) or /jɛə/.[3] According to Wells, *yeah* triggers *r*-intrusion in England, as in *yeahr it is*. In Cockney, *r* is inserted after *how* as in *How[r] are you?*. Yet, in Cockney, the pronunciation of *how* is not [aw], but [æə] or [æː] (Wells 1982: 227). All of these examples show that *r* is also inserted after *æ* and *ɛ* if these vowels happen to occur at the word-final position as well as before another vowel.

The *r*-triggering vowels, including marginal ones, are usually characterized by the feature [−high] (Cf. Wells 1982: 226):

(5) $\varnothing \rightarrow r \;/\; \begin{bmatrix} V \\ -\text{high} \end{bmatrix}$ ___ V

However, this kind of rule raises some problems. First, the rule in (5) does not reveal why *r* should be inserted between vowels and more specifically, why only after nonhigh vowels. In other words, it does not show how *r*-intrusion and its triggering vowels are related. The above rule is therefore "arbitrary and non-explanatory," to use Broadbent's (1991: 281) terms.

Secondly, the rule cannot account for the lack of *r*-intrusion after nonhigh monophthongs *eː* and *oː* in some dialects where these vowels occur word-finally, as in (6a, b) below. In such dialects, these monophthongs do not attract *r*, even though they are [−high] and true vowels (Cf. Harris 1994: 296, note 41).

---

[2] Note that *baa* is also pronounced as [bɑ]. In that case, *baaing* will be [bɑrɪŋ].

[3] Gutch (1992: 567) rhymes *yeah* with *bare*. Brown (1988: 149) seems to think of *yeah* as ending in *ə*.

(6) **the West Yorkshire dialect** (Broadbent 1991)[4]

a. see a [si: jə]
   be on [bi: jɒn]
   pay as [pe: jəz]

b. Sue on [su: wɒn]
   do it [du: wɪt]
   go in [go: wɪn]

c. idea of [aɪdɪə ɹəv]
   Shah of Persia [ʃa: ɹəv pə:ʒə]
   law and order [lɒ: ɹən ɒ:də]
   was it [wɒ ɹɪt]
   yes it is [jɛ ɹɪt ɪz]

Thirdly, as can be seen above in (6), the segment inserted between vowels is not restricted to *r*.[5] In this dialect, if the first vowel of two consecutive vowels is *i:* or *e:*, then *j* is inserted. If the first vowel is *u:* or *o:*, then *w* is inserted. Elsewhere, *r* is inserted. This suggests that the environments for *r*, *j*, and *w* insertion are complementary. It is therefore plausible to treat all these insertions as one and the same phenomenon. This means that they should be explained by one rule or principle. In what follows, some proposals along this line will be reviewed.

Walmsley (1977) and Broadbent (1991) treat *r*-intrusion as a kind of glide insertion. Such an approach will not be problematic because *r* is usually treated as one of three glides in English in the phonetic literature. For example, Bronstein (1960: 61) states as follows:

> For glides, the breath stream is altered during the formation of the sounds by the motion of the articulators from one position to another.

---

[4] A few comments should be made concerning these examples. According to Broadbent, the West Yorkshire dialect has *a:* for RP's *ɑ:*, and *ɒ:* for RP's *ɔ:*. Furthermore, *e:* and *o:* are monophthongs in this dialect unlike in RP where the counterparts of these vowels are diphthongs ending in high glides *j* and *w* respectively. Note that *r* is inserted after *ɛ*, as in *yes it is* [jɛ ɹɪt ɪz].

[5] For more examples, see Harris (1994: 104) and Gimson (1994: 193, 195, 264).

The second position of the glide is the position of the following sound. There are three such sounds in English: /w/, /r/, and /j/.

All of these glides have their own vocalic counterparts; for example, "In the same way as [w] may be said to be a nonsyllabic counterpart of [u], so [ɹ] as in 'red' may be said to be a nonsyllabic version of the vowel in 'fur'" (Ladefoged 1982: 209-210). The three glides also show acoustic similarity: "/r/, /w/ and /j/ do not exhibit formant discontinuities in their transition from the previous consonants and to the formant of the following vowels" (Olive et al. 1993: 99).[6] Thus, viewing *r* as a glide is unproblematic.

Next, Walmsley and Broadbent argue that glide insertion occurs to avoid hiatus. In this case, it is important to elucidate the relation between inserted segments and their contexts. Walmsley (p. 74) proposes that features *spread/rounded* can capture the environments of glide insertion. His proposal can be summarized as follows: inserted glides have the same values with the triggering vowels in the features *spread/rounded*. However, his proposal predicts that *w* will be inserted after ɔ as in *law and order* [lɔw ən ɔdə]. As far as I know, however, all the authors but Walmsley provide [lɔr ən ɔdə] as its pronunciation.[7]

Broadbent (pp. 281-2) adopts Government Phonology (or Element Phonology, to use her terminology) and explains glide formation as a spreading of the head element into an empty onset position of the next syllable. If this account is to be proved right, it would be non-arbitrary and explanatory because it shows the relationship between a phonological process and its context in a principled way, that is, by the head element's spreading. However, this analysis faces some critical

[6] *l* is sometimes treated as a glide (e.g., Potter et al. 1947: 202). However, *l* is distinguished from *j*, *w*, and *r* in that it shows a slight formant discontinuity (Olive et al. 1993: 99, Ladefoged 1982: 188).

[7] It might be the case that some people insert *w* after ɔ. Nevertheless, there are many other people who insert *r* after ɔ. This must be explained. The ɔ in RP is rather higher or closer than American ɔ (Gimson 1989: 117). Consequently, the person who has a lower ɔ might use an intrusive *r*. The one who has a higher ɔ might use *w* because, in this case, *w* would be the nearest glide from ɔ. See section 3 for the distance in the vowel space.

problems. Most of all, her analysis predicts empirically wrong results, as admitted by Broadbent herself (footnote 20): her proposal cannot account for why *r* is inserted after ɛ, ə, and ɔ. For the other problems, see McMahon et al. (1994: 307).

I will assume, with Walmsley (1977) and Broadbent (1991), that *r*-intrusion is a kind of glide insertion, which takes place to resolve hiatus. However, unlike Walmsley and Broadbent, I will explain the relationship between inserted glides and their environments in a functional way.

3. Minimization of articulatory effort

In this section, *r*-intrusion will be re-examined in two respects: vicinity in the vowel space and similarity in the vocal tract shape.

3.1. Vicinity in the vowel space

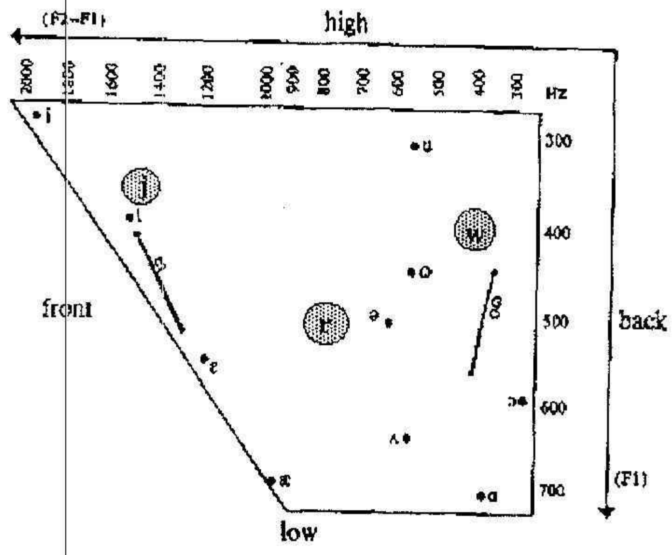


Figure 1. A combined acoustic and auditory representation of some of the vowels of American English (adapted from Ladefoged 1982: 198).

We find in Cheun (1995: 201) an interesting explanation of *r*-intrusion:

> ... we might say that intrusive *r* occurs between vowels to avoid hiatus, only when the first vowel [of the two consecutive vowels] is /ə/. However, it also occurs after ɔ and ɑ, as in *law and order*, *saw a man*, *Utah and Wyoming*, and *Shah of Persia*. Note that, in these examples, either the next vowel is /ə/, or the tongue must pass through the /ə/-area during the transition from the first vowel to the next. Since the area of /ə/ articulation is the same as that of /r/ articulation, it is not likely that intrusive *r* is an analogue to linking *r*. [translated by HBYS]

Cheun's observation provides a new way of tackling *r*-intrusion since he treats it in terms of tongue movement in the vowel space. His observation can be restated like this: *r* is the first glide encountered when our tongue moves from the first vowel to the next. See Figure 1, which is adapted from Ladefoged (1982: 198), assuming for the moment that it can also represent the articulatory vowel space. Postvocalic *r* is articulated near the area where schwa is articulated (F1=500, F2=1200-1400; Delattre and Freeman 1968: 48-9). Postvocalic *j* and *w* are located roughly near the regions of ɪ and ʊ, respectively (Ladefoged 1982: 76-7; Giegerich 1992: 74-75; Gimson 1994: 119-24). The approximate locations of these glides are indicated in Figure 1.

We can generalize Cheun's observation in terms of the relative distance in the vowel space:

(9) *r* is the nearest glide from the preceding vowel.

If a segment should be inserted after ə, ɑ, and ɔ in order to resolve hiatus, or for any reason, *r* is the strongest candidate because it is the nearest glide from these vowels. This definition correctly predicts that *r* will be inserted in the following examples:

(10) baaing [bæːrɪŋ] (Donegan 1993: 118)

bourgeois ideas [bʊəzwɑːr ajdɪəz] (Gutch 1992: 568)
bourgeois aspect [bʊəzwɑːr æspekt] (Hall 1976/77: 172)
thaw out [θɔːr aʊt] (Wells 1990: 578)
raw oyster [rɔːr ɔɪstə] (Grandgent 1920: 42)
raw apple [rɔːr æpl] (Wells 1982: 225)

Note that, in the above examples, the tongue does not have to pass through the ə-area during the transition from the first vowel to the next. Nevertheless, r is selected because two consecutive vowels are not allowed, and because r is the nearest glide from the preceding vowels æ, ɑ, and ɔ.

This account of r-intrusion can be extended straightforwardly to the glide insertion in general:

(11) The glide that is inserted between vowels is the *nearest* glide from the preceding vowel.

According to (11), *iː* will attract *j*; and *uː* will attract *w*. The vowels *ɑ*, *ɔ*, and *ə* (*æ* and *ɛ* if they happen to come in a word-final position for any reason) will attract *r*. In such dialects as the West Yorkshire in (6), monophthongs *eː* and *oː* also attract *j* and *w*, not *r*, because they are nearer to *j* and *w* than to *r*. However, if we define the *r*-triggering vowels as true or nonhigh vowels, then it will be difficult to account for the fact that nonhigh monophthongs *ɛ* and *eː* attract different glides, *r* and *j* respectively.

As shown in section 2, the previous studies have not been able to explain the relationship between triggering vowels and inserted glides in terms of features or elements. Now we have an apparatus at hand to treat this relationship: the 'relative distance' from the preceding vowels. Therefore, it is important to define 'distance in the vowel space' more precisely. As is well known, the vowel space can be defined in three ways: auditorily, acoustically, and articulatorily. The traditional vowel diagram reflects just an auditory arrangement of vowels, despite the traditional labeling of the axes in terms of tongue positions (Ladefoged et al. 1978: 1030). The acoustic vowel space can be obtained by plotting the first and second formants on the graph, as in Figure 1.[8] Articulatorily, a vowel space can be defined, for example, in terms of the highest point of the tongue. As Ladefoged (1982: 72-3) indicated, the problem in this case is that it is very hard to describe the tongue position of a vowel and to say exactly how our tongue is moving. It has also been noted that speakers differ in their vowel production and that even different articulatory gestures can produce the same acoustic result (See Lindblom and Sundberg 1971; Johnson et al. 1993). Thus, the articulatory vowel space seems to be unreliable.

Lindau (1978: 541-5), nevertheless, holds a different view. She normalized the tongue height, acoustic, and auditory plots so that the points in each of the three maps had the same mean and standard deviation. Then she compared the correlation between auditory and articulatory maps with the correlation between auditory and acoustic maps. She concluded that both correlations are very high, even though they are not identical.

Assuming that the three types of vowel space are highly correlated, any type of vowel space will be satisfactory for our purpose since what we need is just the relative distance between sounds, not the exact distance. For example, *ɪ* and *ʊ* are sometimes lower than *e* and *o*, as shown in some x-ray photos (Ladefoged et al. 1978: 1030, Fischer-Jørgensen 1985: 81). Yet this evidence does not challenge my proposal as long as the distance from *ɪ* and *ʊ* to *j* and *w* is shorter than that to *r*.

Now consider what the distance implies in each vowel space. If the vowel space is defined articulatorily in terms of the highest tongue positions, the distance will be a physical one, and it will be proportional to the effort used to move the highest point of the tongue. If the vowel space is defined acoustically or auditorily, then the distance on the acoustic/auditory map may indicate the acoustic/auditory similarity between sounds. It may also indicate the amount of articulatory effort used to move any relevant articulators in order to make a desired acoustic/auditory change.[9] Therefore, selection of the nearest or most

[8] In Figure 1, the vertical axis represents F_1, and the horizontal axis represents the difference between F_2 and F_1.

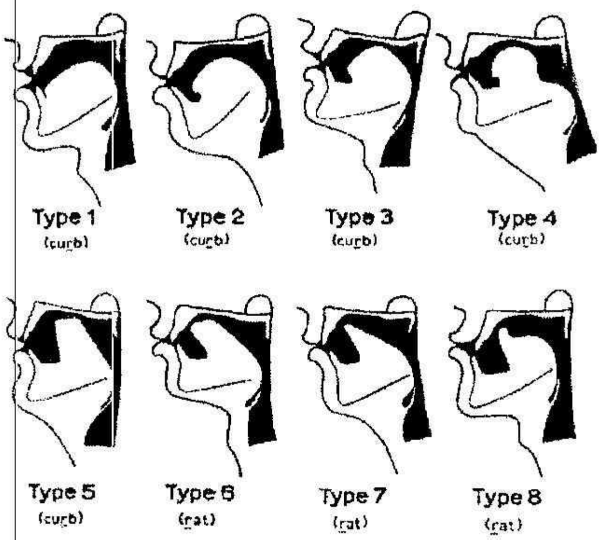


Figure 2. Major types of tongue shapes found for the British r's (1 and 8) and for the American r's (2 to 7) in X-ray motion pictures of 46 English speakers from England and all areas of the U.S. (from Delattre and Freeman: 1968: 41)

similar glide enables the speaker to use the least effort.

3.2. Similarity in vocal tract shape

In this section, vowels and glides will be considered from the viewpoint of vocal tract shape or constriction.[10] Traditionally, *r* is said to be articulated in two ways: it can be formed either with tongue tip up (*retroflexed r*) or with tongue tip down and tongue body bunched high (*bunched r*), as in Potter et al. (1947: 218), Ladefoged (1982: 78),

---

[9] For this purpose, three dimensional vowel space might be more appropriate because it incorporates the third formant frequency which is said to reflect lip rounding. For three dimensional vowel space, see Broad and Wakita (1977) and Lindblom (1986). For the effect of lip rounding to formants, see Ladefoged (1982: 179). For the overall relationship between articulatory and acoustic properties, see Lindblom and Sundberg (1971). For a convenient summary of them, see Clark and Yallop (1990: 294).

[10] Because some vowels like æ in English are said to be constrictionless, the term vocal tract shape will be more appropriate here (Johnson et al. 1993: 702).

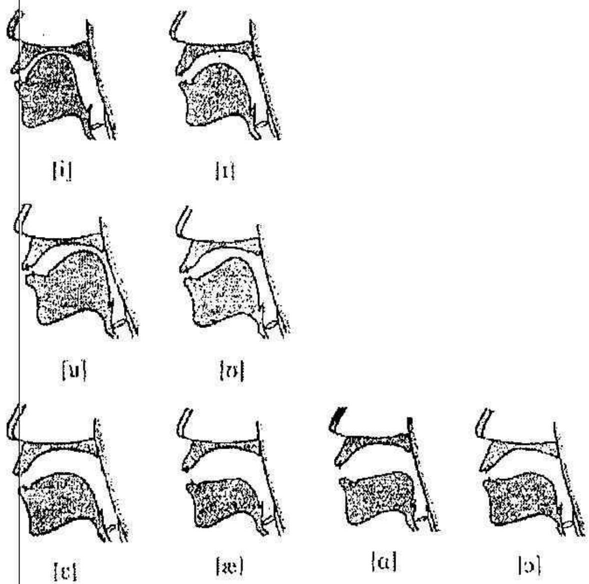


Figure 3. Vocal tract shapes of some of English vowels (adapted and rearranged from Ladefoged 1996: 100-101)

etc. Delattre and Freeman (1968), however, found that there are 8 types of *r* articulation in English (See Figure 2). Articulatorily, American *r*s have two constrictions, one at the palate and another at the pharynx.[11] British *r*s have only one constriction: the postvocalic one has a constriction in the pharynx and the prevocalic one in the palate. Acoustically all *r*s have low F3.[12] Delattre and Freeman also found that *r*s can be classified into two groups by the position they occupy in the syllable: strong *r* and weak *r*. Strong *r* occurs prevocalically and is articulated with the tongue tip up and with the lips rounded (Types 6-8 in Figure 2). Weak *r* occurs elsewhere and is bunched (Types 1-5). We are interested in the weak *r*, especially Types 1 and 2, because they are found in *r*-less dialects. Type 1 is British weak *r* and Type 2 is

[11] The pharyngeal constrictions of postvocalic *r* as well as palatal constrictions are also confirmed by Ladefoged (1982: 78) and Lindau (1978: 554-6; 1985: 164).

[12] Lindau (1978; 1985: 163) also suggests a lowered third formant as a common acoustic factor of *r*s. This low F3 is nicely explained by the perturbation theory (Johnson 1997: 101-2).

American weak *r* (Eastern New England and the Coastal South).

In the previous paragraph, the phonetic properties of *r* have been reviewed. Now it will be useful to consider vowels in terms of vocal tract shape. Look at Figure 3, which is adapted and reclassified from Ladefoged (1996: 100-101). Vowels *i* and *ɪ* have constriction in the palatal region, and vowels *u* and *ʊ* have constriction in the velar region. The other vowels have more or less constriction in the pharynx. Negatively, they do not have any apparent constriction in the palatal or velar region. Thus it can be safely said that these vowels (*ɛ*, *æ*, *ɑ*, and *ɔ*) have a relatively similar vocal tract shape with the postvocalic *r* (Type 1 and 2).

The classification of vowels in Figure 3 is supported by Harshman et al.'s (1977) findings. They analyzed the shapes of the tongue in English vowels, applying a factor analysis (PARAFAC). They found two factors: one factor (factor 1) generates a forward movement of the root of the tongue accompanied by an upward movement of the front tongue; the other factor (factor 2) determines an upward and backward movement of the tongue. Ladefoged (1980) calls factor 1 the front-raising parameter and factor 2 the back-raising parameter. Factor 1 specifies a movement from approximately *o* to *i*. Factor 2 determines a movement from approximately *ɑ* to *u*. The table in (12) shows the values of factor 1 and factor 2 (Harshman et al. 1977: 702). These values are presented graphically in Figure 4 (Ladefoged 1980: 481).

(12)

Vowel	Factor 1	Factor 2
i	1.5220	0.6931
ɪ	0.9730	0.3293
e	1.0430	0.4910
ɛ	0.7739	−0.1704
æ	0.3306	−0.5261
ɑ	−0.3107	−2.0370
ɔ	−1.0720	−1.2360
o	−1.3780	0.2591
ʊ	−1.0490	0.5826
u	−0.8333	1.6870

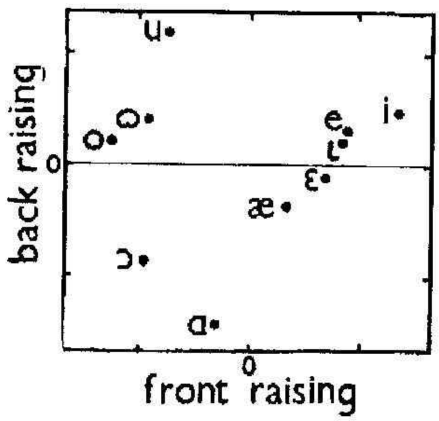


Figure 4. The values of factor 1 and factor 2. (adapted from Ladefoged 1980: 489)

Ladefoged claims that factor 1 enables us to account for the phonological phenomena by clearly separating front vowels and back vowels. But he argues that "... the back-raising component ... is not very useful in explaining observed vowel patterns, or in writing phonological rules for alternations of vowels (although it does help explain articulatory similarities such as that between low back vowels and pharyngeals)" (Ladefoged 1980: 490; See also Fisher-Jørgensen 1985: 90-1).

As it happens, however, the vowels *ɛ*, *æ*, *ɑ*, and *ɔ* which have negative values of factor 2 are the very vowels which attract *r* before other vowels. The negative value in factor 2 implies some degree of constriction in the pharynx, as verified by the fact that *ɑ* has the greatest negative value of factor 2. As mentioned before, all types of postvocalic *r* in Figure 2 also have a pharyngeal constriction. Moreover, as noted by McMahon et al. (1994: 303), schwa also has a pharyngeal constriction.[13] Again, the above observations suggest that vowels *ə*, *ɛ*, *æ*, *ɑ*, and *ɔ* share some degree of pharyngeal constriction with postvocalic *r*. Apart from these vowels (*ə*, *ɛ*, *æ*, *ɑ*, and *ɔ*), the vowels

[13] They remark that "the pharyngeal constriction component of the /r/ is articulatorily rather similar to the constriction for schwa."

which attract *j* have positive values of factor 1, and the vowels which attract *w* have negative values of factor 1. This classification exactly matches that of Figure 3. Roughly speaking, the vowels with a palatal constriction attract a palatal glide *j*, those with a velar constriction attract a velar glide *w*, and those with a pharyngeal constriction attract pharyngeal glide *r* (Cf. Gnanadesikan 1997: 161-2).[14] In other words, the inserted glides have a vocal tract shape similar to that of the triggering vowels.[15] Again, the transition to the sound with a similar vocal tract shape or constriction entails less effort.

3.3. Summary

It follows from the preceding observations that the vicinity in the vowel space implies less tongue movement between the relevant sounds, or similarity in the vocal tract shape, or similarity in the acoustic and auditory effect. Thus, it can be argued that vowels form glides which can be articulated with the least effort. Another way to say this is that vowels select glides which can be reached in the easiest way. A caveat is necessary here. Logically, the selected segment does not need to be a glide. Any segment which is a phoneme or an allophone in English will be permitted only if it can be reached most easily from the preceding vowel.

In section 3, I have shown why *r* is inserted after ə, ɑ, and ɔ, even after ɛ and æ. In section 4, I will show how this fact can be accommodated within the OT framework.

---

[14] It should be noted, however, that some authors classify vowels differently. For example, Wood (1975, 1979) classifies vowels into four categories based on the degree of vocal tract constriction: palatals ([i-ɛ]-like vowels), velars ([u-ʊ]-like vowels), upper pharyngeals ([o-ɔ]-like vowels), and low pharyngeals ([ɑ-a-æ]-like vowels). Basically, how vowels are classified does not matter for this paper, because what is important here is the relative distance in the vowel space.

[15] The historical lowering of vowels before *r* may be attributed to the assimilation of vowels to the pharyngeal consonant *r* (Cf. Fischer-Jørgensen 1985: 90). In other words, the vowels before *r* were assimilated to the pharyngeal constriction of *r* and became pharyngeal vowels. Conversely, *r* is inserted after pharyngeal vowels if the environment requires a consonant for any reason, because *r* is more similar to these vowels than any other consonants.

4. Constraints and constraint interaction

The facts we have discovered above may be implemented into OT in two ways. One way is to use constraints such as Save (Jun 1995), *Effort (Boersma 1997), and Lazy (Kirchner 1998), all of which demand minimization of articulatory effort.[16] The other way is to treat glide selection as determined by feature spreading. It is to say that the relationship between triggering vowels and inserted segments can be viewed as assimilation. Consider the first possibility. The relevant constraints and their ranking are as follows:

(13) a. *Cod/r: No *r* should be wholly within a syllable coda (Halle and Idsardi 1997: 337; Cf. McCarthy 1993).[17]
b. Dep: Every output segment has a correspondent in the input.
c. Max: Every input segment has a correspondent in the output.
d. Ons: Every syllable has an onset.
e. Final-C: Every word must end with (part of) a consonant (Halle and Idsardi 1997: 337; Cf. McCarthy 1993: 176).
f. *Effort: We are too lazy to spend any positive amount of effort (Boersma 1997: 28).

(14) *Cod/r≫Max, Dep(C^{tr})≫Ons≫Dep(G)≫Final-C≫*Effort
(C^{tr}=True Consonant, G=Glide)

*Cod/r is the very constraint that makes a dialect *r*-less. Dep is usually divided into Dep(C) and Dep(V). In this paper, Dep(C) is further divided into Dep(C^{tr}) and Dep(G).[18] Ons forces glides to be inserted between

[16] For more references of this approach, see Kirchner (1998: 2).
[17] *Cod/r and Final-C are defined in a non-crisp manner (Itô and Mester 1994). Ons must be interpreted in the same manner. See Halle and Idsardi (1997) for the criticism of such use of constraints.
[18] I assume that Dep is encapsulating all individual dependency constraints: Dep(p), Dep(t), Dep(k), ..., Dep(r), Dep(w), Dep(j), Dep(i), Dep(u), ..., Dep(a). This implies that they can be grouped in different ways and that other constraints can intervene into these constraints. Ons can be dominated by all the consonant dependency constraints, as in ... Dep(r), Dep(w), Dep(j)≫Ons (= Dep(C)≫Ons).

vowels. To avoid hiatus, however, we cannot insert a true consonant between two vowels, because Dep(C^{tr}) is ranked higher than Ons.[19] As a result, only the insertion of a glide is allowed. Now it is very important to determine which glide is inserted. This is done in a way in which the effort is minimized, that is, by the functional constraint *Effort. The role of Final-C here is illustrated by the following fact. Linking and intrusive *r*s are of the same quality and distinct from true word-initial *r*s (McCarthy1993: 178-9). For example, the *r* in *saw eels* [sɔr ijlz] is considerably more vocalic than the *r* in *saw reels* [sɔ rijlz].[20] Thus, in order to retain this distinction, intrusive or linking *r*s cannot be completely resyllabified into the onset position of the next syllable. Final-C serves to prevent these *r*s from being wholly resyllabified. Thus, only ambisyllabification of *r* is allowed.[21] Note that Final-C, as well as *Cod/r, is satisfied by ambisyllabic *r*s by definition.

In the following tableaux, the space between segments represents a syllable boundary, and the sequences such as *rr* or *rr* represent an ambisyllabic segment. First, consider the intrusive *r*:

This ranking will come up with a dialect that does not insert anything between vowels. If Ons dominates Dep(j) and Dep(w), as in ... Dep(r)≫Ons≫Dep(w), Dep(j), then only *j* and *w* will be inserted to avoid hiatus. If Ons dominates Dep(r), Dep(w), and Dep(j), as in ... ≫Ons≫Dep(r), Dep(w), Dep(j), then *j*, *w*, and *r* will be inserted to resolve hiatus. If a language inserts *t* like French, Dep(t) will be ranked below Ons, as in ...≫Ons≫Dep(t).

19) We cannot delete one of the two vowels in sequence, either. Thus Max(V) must be high ranked.

20) This matches Delattre and Freeman's (1968) observation and is also supported by Gimson (1994: 193, 195, 264). Gimson (1994: 264) argues that the inserted glides must close the syllable rather than being initial in the next syllable, based on the differences that the underlying glides and inserted glides make in the pronunciation.

21) In this article, following Itô and Mester (1994: 39), the ranking Ons≫CrispEdge(PrWd)≫Final-C is assumed for English ambisyllabicity. This ranking forces a word-final or inserted consonant to be ambisyllabified but prohibits a word-initial consonant from being ambisyllabified.

(15)

	Wanda is	Dep(C^{tr})	Ons	Dep(G)	Final-C	*Effort
	a. Wandat tis	*!				***
	b. Wanda is		*!		*	
	c. Wandaj jis			*		**!
	d. Wandaw wis			*		**!
☞	e. Wandar ris			*		*

Here some explanation of the *Effort column is required. The marks in the *Effort column denote the additional effort needed to insert a segment after a given vowel. The difference in the number of marks just means the relative difference in effort. In other words, when a candidate has two marks and another has one, it does not mean that the former requires twice as much effort as the latter. It just means that the former requires more effort than the latter. The effort distinction between ambisyllabic and non-ambisyllabic consonants will be neglected, because this does not make any significant difference. Keeping these in mind, let us consider each candidate. Candidate (b) does not use any additional articulator (i.e. effort). Candidate (e) uses additional effort to insert a glide *r*, but the effort is less than that used to insert *j* or *w* because *r* is the nearest from *ə*, as illustrated in Figure 1. It is not obvious which of *j* and *w* is farther from *ə*. Thus the same marks are assigned in candidates (c) and (d). In candidate (a) *t* is inserted to avoid hiatus. In this case, much more effort is required because the tongue tip must move farther to make a complete constriction against the gum ridge.

Now we will consider the overall interaction of the constraints in (15). Candidate (a) inserts a true consonant and violates Dep(C^{tr}). Candidate (b) violates Ons and is ruled out. The remaining candidates tie on Dep(G).[22] At this point, the functional constraint *Effort plays a crucial role. Candidate (e), of the remaining candidates, uses the least effort and is optimal.

[22] Unlisted candidate *Wanda ris*, which ties with candidates (c)-(e), is ruled out by Final-C.

Next, consider the word *seeing* in which glides need not be inserted:

(16)

sij+iŋ	Dep(C^{tr})	Ons	Dep(G)	Final-C	*Effort
a. sijɹ iŋ		*!	*		*
b. sij iŋ		*!			
c. sij ɹiŋ			*!		*
d. sijɹ ɹiŋ			*!		*
e. si jiŋ				*!	
☞ f. sij jiŋ					

Candidates (a) and (b) have a violation of Ons. Candidates (c) and (d) incur Dep(G) violations. In candidate (e), the glide is wholly resyllabified into the onset position of the next syllable, violating Final-C. In candidate (f), the glide is just ambisyllabified into the onset position of the next syllable. Therefore, candidate (f) does not incur any crucial violation In this case, *Effort does not play an active role because higher ranking constraints have already decided the optimal form. If the vowel in *see* is a monophthong, however, a glide will have to be inserted. Then *Effort will be active and select *j*.

Tableau (15) shows that whenever hiatus appears, a glide is inserted to satisfy both Ons and Final-C. Thus the inserted glide must be ambisyllabic.[23] Yet, as in (16), if the preceding word ends in a glide, the glide is ambisyllabified into the empty onset position of the next syllable to satisfy Ons. In this case, no new glides are inserted because the insertion of glide incurs a gratuitous violation of Dep(G).

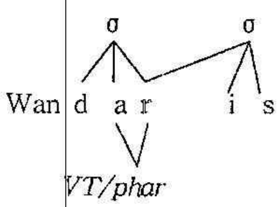
It has been shown in the last section that the inserted glide is also the most similar one to the preceding vowel. This fact can be regarded as a kind of feature spreading from vowels to inserted glides since feature spreading is one way of minimizing the articulatory effort. For this, we need constraints penalizing every vocal tract (VT) features,

---

[23] The ranking Ons≫Final-C does not entail that a glide is first inserted into the onset position and then ambisyllabified into the coda position of the preceding syllable. What matters is that both constraints must be met, irrespective of which position is first filled.

following Itô and Mester (1994: 41): *VT/pal(atal), *VT/vel(ar), and *VT/phar(yngeal). Spreading of a feature is illustrated in (17):

(17)



Look at the following tableau, where *Effort is replaced by constraints *VT/pal, *VT/vel, and *VT/phar, which I assume are not ranked with each other (In the following tableau the single vertical line indicates that relevant constraints are not ranked):

(18)

Wanda is	Dep (C^{tr})	Ons	Dep(G)	Final-C	*VT/pal	*VT/vel	*VT/phar
a. Wandat tis	*!				*		**
b. Wanda is		*!		*	*		**
c. Wandaj jis			*		**!		**
d. Wandaw wis			*		*	*!	**
☞ e. Wandar ris			*		*		**

Candidate (a) violates Dep(C^{tr}). Candidate (b) violates Ons and Final-C. The remaining candidates tie on Dep(G). All candidates have two pharyngeal vowels and one palatal vowel, and are penalized as such by the constraint family *VT/artic(culator). Candidates (c) and (d) use one more vocal tract feature, *VT/pal* and *VT/vel* respectively, to insert a glide. Candidate (e) does not use any additional vocal tract feature because it spreads feature *VT/phar* of the preceding vowel to the epenthetic glide, as in (17). Thus candidate (e) is optimal.

5. Concluding remarks

I have tried to prove that *r*-intrusion is not arbitrary and can be treated as a kind of glide insertion, conditioned by the preceding vowels. Intrusive *r* occurs after *ɑ*, *ɔ*, and *ə* (or marginally after *æ* and *ɛ*). These vowels have something in common with the glide *r*. The common factor may be pharyngeal constriction, or similar vocal tract shape, or crucially the negative values of factor 2 proposed by Harshman et al. (1977). From a different perspective, *r* is the nearest glide from these vowels in the vowel space. I have also shown that the selection of the proper glide among three possible glides can be done either by the constraints such as *Effort demanding the least effort, or by the markedness constraints such as *VT/artic penalizing every articulatory feature that force feature spreading to be preferred. This means that *r*-intrusion must be explained functionally, at least in part.

It should be admitted that it is difficult to account for the details of *r*-intrusion since this phenomenon is very complicated and varies greatly from dialect to dialect and from person to person. Thus, I leave many questions and problems to be investigated in future studies.

References

Blevins, J. 1997. "Rules in Optimality Theory: Two case studies," in Iggy Roca ed., *Derivations and Constraints in Phonology*, 227-260. Oxford: Oxford University Press.

Boersma, P. 1997. "The elements of functional phonology," ms., University of Amsterdam, The Netherlands. ROA-173.

Borden, G., K. Harris and L. Raphael. 1994. *Speech Science Primer*. 3rd edition. Baltimore: Williams and Wilkins.

Broad, D. and H. Wakita. 1977. "Piecewise-planar representation of vowel formant." *Journal of the Acoustical Society of America* 62, 1467-1473.

Broadbent, J. 1991. "Linking and intrusive r in English," *UCL Working Papers in Linguistics* 3, 281-302.

Bronstein A. 1960. *The pronunciation of American English: An Introduction to Phonetics*. New York: Appleton-Century-Crofts, Inc.

Brown, A. 1988. "Linking, intrusive, and rhotic /r/ in pronunciation models," *Journal of the International Phonetic Association* 18, 144-151.

Cheun, S.-B. 1995. *Yeongeo Eumseonghak Gaeron (Introduction to English*

Phonetics). Seoul: Eulyumunhwasa.

Clark, J. and C. Yallop. 1990. *An Introduction to Phonetics and Phonology*. 2nd edition. Oxford: Blackwell.

Delattre, P. and D. Freeman. 1968. "A dialect study of American *R*'s by X-ray motion picture." *Linguistics* 44, 29-68.

Donegan, P. 1993. "On the phonetic basis of phonological change," in C. Jones ed., *Historical Linguistics: Problems and Perspectives*, 98-130. London: Longman.

Fischer-Jørgensen, E. 1985. "Some basic vowel features, their articulatory correlates, and their explanatory power in phonology," in V. Fromkin ed., *Phonetic Linguistics: Essays in Honor of Peter Ladefoged*, 79-99. New York: Academic Press.

Giegerich, H. 1992. *English Phonology*. Cambridge: Cambridge University Press.

Gimson, A. C. 1989. *An Introduction to the Pronunciation of English*, 4th edition. London: Edward Arnold

Gimson, A. C.1994. *Gimson's Pronunciation of English*, 5th edition. London: Edward Arnold.

Gnanadesikan, A. 1997. *Phonology with Ternary Scales*. PhD dissertation, University of Massachusetts, Amherst.

Grandgent, C. 1920. *Old and New*. Cambridge: Harvard University Press.

Gutch, D. 1992. "Linking and intrusive r in English and Bavarian," in C. Blank ed., *Language and Civilization*, 555-611. Frankfurt: Peter Lang.

Hall, R. 1976/77. "'Linking r' and close juncture," *Forum Linguisticum* 1, 172.

Halle, M and W. Idsardi. 1997. "r, Hypercorrection, and the Elsewhere Condition," in I. Roca ed., *Derivations and Constraints in Phonology*, 331-348. Oxford: Oxford University Press.

Harris, J. 1994. *English Sound Structure*. Oxford: Blackwell.

Harshman, R., P. Ladefoged and L. Goldstein. 1977. "Factor analysis of tongue shapes," *Journal of the Acoustical Society of America* 62, 693-707.

Itô, J. and A. Mester. 1994. "Reflections on CodaCond and Alignment," ms., University of California, Santa Cruz. ROA-141.

Johansson S. 1973. "Linking and intrusive /r/ in English: A case for a more concrete phonology," *Studia Linguistica* 27, 53-68.

Johnson, K. 1997. *Acoustic and Auditory Phonetics*. Oxford: Blackwell.

Johnson, K., P. Ladefoged, and M. Lindau. 1993. "Individual differences in vowel production," *Journal of the Acoustical Society of America* 94, 701-14.

Jun, J.-H. 1995. *Perceptual and Articulatory Factors in Place Assimilation: An Optimality Theoretic Approach*. PhD Dissertation, UCLA.

Kirchner, R. 1998. "Some new generalizations concerning geminate inalterability," ms., UCLA. ROA-240.

Ladefoged, P. 1980. "What are linguistic sounds made of?" *Language* 56, 485-502.

Ladefoged, P. 1982. *A Course in Phonetics*, 2nd edition. New York: Harcourt Brace Jovanovich.

Ladefoged, P. 1996. *Elements of Acoustic Phonetics*, 2nd edition. Chicago: The University of Chicago Press.

Ladefoged P., R. Harshman, L. Goldstein and L. Rice. 1978. Generating vocal tract shapes from formant frequencies. *Journal of the Acoustical Society of America* 64, 1027-1035.

Lass, R. 1987. *The Shape of English: Structure and History*. London: J. M. Dent and Sons Ltd.

Lindau, M. 1978. "Vowel features," *Language* 54, 541-563.

Lindau, M. 1985. "The story of /r/," in V. Fromkin ed., *Phonetic Linguistics: Essay in Honor of Peter Ladefoged*, 157-168. New York: Academic Press.

Lindblom, B. and J. Sundberg. 1971. "Acoustical consequences of lip, tongue, jaw, and larynx movement," *Journal of the Acoustical Society of America* 50, 1166-1179.

Lindblom, B. 1986. "Phonetic Universals in Vowel Systems," in J. Ohala and J. Jaeger ed., *Experimental Phonology*, 13-44. Orlando: Academic Press.

McCarthy, J. and A. Prince. 1993. "Prosodic Morphology I: constraint interaction and satisfaction," ms., University of Massachusetts, Amherst and Rutgers University. To appear, MIT Press.

McCarthy, J. and A. Prince. 1995." Faithfulness and reduplicative identity,"in J. Beckman, L. Dickey, and S. Urbanczyk, eds., *University of Massachusetts Occasional Papers in Linguistics* 18: Papers in Optimality Theory, 249-384. Amherst, Massachusetts: Graduate Linguistic Student Association. Also in R. Kager, H. van der Hulst, and W. Zonneveld eds., *The Prosody Morphology Interface*. ROA-60.

McCarthy, J. 1991. "Synchronic rule inversion," *BLS* 17, 192-207.

McCarthy, J. 1993. "A case of surface constraint violation," *Canadian Journal of Linguistics* 38, 169-95.

McMahon, A. 1994. "On the use of the past to explain the present: The history of /r/ in English and Scots," in D. Britton ed., *English Historical Linguistics 1994*, 73-89. Amsterdam: John Benjamins.

McMahon, A., P. Foulkes and L. Tolfree. 1994. "Gestural representation and Lexical Phonology," *Phonology* 11, 277-316.

Moulton, W. 1990. "Some vowel systems in American English," in S. Ramsaran ed., *Studies in the Pronunciation of English: A commemorative volume* in honour of A. C. Gimson, 119-136. London: Routledge.

Olive, J., A. Greenwood and J. Coleman. 1993. *Acoustics of American English Speech*. New York: Springer.

Potter, R., G. Kopp and H. Green. 1947. *Visible Speech*. New York: D. Van Nostrand Company, Inc.

Prince, A and P. Smolensky. 1993." Optimality Theory: constraint interaction in generative grammar," ms., Rutgers University and University of Colorado, Boulder. To appear, MIT Press.

Stockwell, R. and J. D. Bowen. 1965. *The Sounds of English and Spanish*. Chicago: The University of Chicago Press.

Vennemann, T. 1972. "Rule Inversion," *Lingua* 29, 209-242.

Walmsley, J. 1977. "The phonology of English V+V juncture," *Studia Linguistica* 31, 71-82.

Wells, J. 1982). *Accents of English*, 3 vols. Cambridge: Cambridge University Press.

Wells, J. 1990. *Pronunciation Dictionary*. Harlow: Longman.

Wise, C. 1957. *Applied Phonetics*. Englewood Cliffs, New Jersey: Prentice-Hall.

Wood, S. 1975. "Tense and lax vowels – Degree of constriction or pharyngeal volume?" *Working Papers* 11, 109-134. Department of Linguistics, Lund University.

Wood, S. 1979. "A radiographic analysis of constriction locations for vowels," *Journal of phonetics* 7, 25-43.

Hyangchon APT. 308-204, Dongan-gu
Anyang-si, Gyunggi-do 431-070, ROK
E-mail: hwangbo@plaza.snu.ac.kr