Allomorphy, Spirantization, and Palatalization in English:
with or without Geometry[*]
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1. Introduction

The theory of feature geometry (cf. Clements (1985), Sagey (1986), etc.) has succeeded in properly analyzing various phonological processes, such as assimilation and harmony, by attributing them to the internal structure of segments. With the advent of Optimality Theory, however, such a structural account seems to be on the wane. Padgett (1995), for example, assumes that most features are directly linked to the root node without constituting a hierarchical structure, and that constraint ranking for the most part determines phonological processes. In this paper, I will demonstrate the superiority of structural theory to non-structural theory, providing evidence from suffixation, spirantization and palatalization in English.

The facts of suffixation involving -ory, -ive and -al provide evidence for the close relation between place features and continuancy. They can also be accounted for in non-structural theory, by having recourse to another mechanism (cf. Ní Chiosáin and Padgett (1997)). The facts of spirantization, however, can only be accounted for within structural theory, since the facts show [continuant] can spread independently. To capture both of these facts, it is reasonable to assume that Place and [continuant] are organized hierarchically.

This paper is organized as follows. In the next section, we review the essence of non-structural theory. Section 3 provides evidence from English suffixation for the combinatory effect of features, and Sections 4 and 5 discuss several segmental processes regarding the independent nature of the feature [continuant]. Section 6 concludes the paper.

2. Non-structural Theory

As mentioned above, more and more researchers in Optimality Theory are abolishing the idea of feature geometry, proposing instead that properly-ranked constraints alone can account for the data that feature geometry had analyzed in

derivational theory (cf. Pullyblank (1997), Suzuki (1998), Fukazawa (1999), Yip (2003), etc.). Among others, Padgett (1995) clearly proposes that most of the features are organized non-configurationally, as shown below:

(1) [son]

[voice] Lab Phar [hi] [glot] Cor [back] [lo] [nasal] Dors [round] [asp]

[ant] [dist]
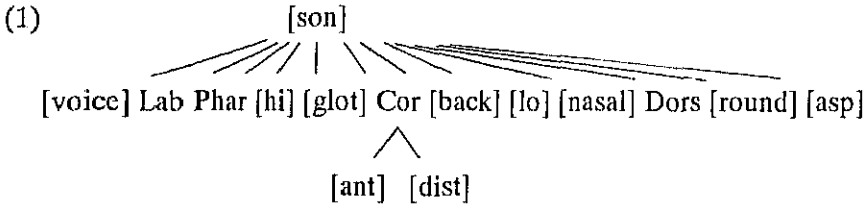
In this structure, very little geometry is left; what remains are, specifically, the relation between Coronal and its two dependent features [anterior] and [distributed], and that between [sonorant] and other features.

Padgett's Feature Class Theory, as he dubs it, also assumes that features form several 'classes' —not a structure —which are independently defined elsewhere in the grammar.

(2) Feature classes

Laryngeal: {voice, asp, glo}

Place: {Lab, Cor, Dors, Phar, ant, dist, hi, lo, back, round...}

Pharyngeal: {Phar, ...}

Oral: {Lab, Cor, Dors, ant, dist, hi, lo, back, round...}

VPlace: {hi, lo, back, round...}

Height: {hi, lo}

Color: {back, round}

This assumption makes it possible to analyze various assimilation processes. By referring to a particular class, it is possible to show how several features of the same class act in tandem. If a constraint requires harmony of the VPlace class, for example, all the features of that class will be harmonized.

Beside feature classes, in order to accommodate the relation between place and stricture features, Ní Chiosáin and Padgett (1997) introduce a unit called *gesture* —a unitary bundle of articulator and oral stricture features (p.6). By using such gestures, labial segments, for example, can be represented as in (3):

(3)   *u/w*   *β*   *f*   *p/m*

        | | | |

       Lab_V Lab_A Lab_F Lab_S (Ní Chiosáin and Padgett (1997))
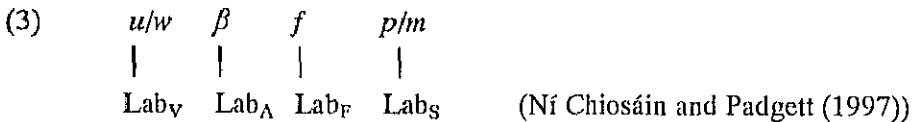
In these representations, V stands for vowel/glide, A for approximant, F for fricative, and S for stop. In other words, gestures are defined elsewhere in the grammar as containing the following values for stricture features:

(4) | | V | A | F | S |
|---|---|---|---|---|
| [cons] | | − | + | + | + |
| [approx] | | + | + | − | − |
| [cont] | | + | + | + | − |

As Ní Chiosáin and Padgett say, "[t]he important result here of adopting gestures...follows when these units spread.... Spreading of major place gestures entails spreading of all of these properties (p.6)." Thus in this theory, the relation between place and stricture features is easily accounted for. Since the continuancy feature is included in the gesture attached to the place feature, for example, they are affected together in phonological processes.

Several theoretical problems may arise in this kind of anti-geometric analysis, however. First, it is not clear where the classes and the gestures are determined in the grammar of OT, where only Generator and constraints are posited. Some may assume that they are determined by Gen, but this does not seem plausible because Gen by definition can only build structures from an input, but not definitions such as class and gesture. Ní Chiosáin and Padgett explain that "feature classes...are understood as set-theoretic postulates" (p.6), but the problem is where they should be set. Moreover, it is not clear why only place and stricture features in combination — rather than other features such as the laryngeal —can be a gesture.

An empirical problem also arises as to the treatment of stricture as a part of the gesture — the problem of how to explain cases where only continuancy spreads. Because stricture and place features are considered to be a bundle within a gesture, it is impossible to predict that [cont] spreads independently of the place features. This problem will be considered in Section 4.

3. Connection between Place and [cont]: The Facts of English Suffixation

Before we discuss the empirical problem of gestural theory, let us first examine the cases where place and stricture features do have some relation. As mentioned, such data constitute an argument for both the geometric and the gestural theories. The data come from English suffixation.

As shown in various studies, affixes put particular restrictions on the bases to which they attach (cf. Aronoff (1976), Fabb (1988), Zamma (1994a, 2003), etc.). These restrictions can be categorized into several types, but what is most relevant

here are the ones exemplified by -ory and -ive. These suffixes are restricted to attaching to bases which end with /s/ or /t/ (cf. Zamma (1994a, 2000)). In (5), the base ends with a segment required by the suffixes, and thus simple suffixation takes place.

(5)　a. -ory: dismiss-ory, vomit-ory, excret-ory, deposit-ory, contribut-ory

　　　b. -ive: reflex-ive, regress-ive, act-ive, effect-ive, prohibit-ive

In (6), on the other hand, the final segment is neither /s/ nor /t/. In these cases, a special suffix -ate is introduced between the base and the suffix, whose final segment clearly satisfies the requirement.[1]

(6)　a. -atory: sign-atory, reform-atory, observ-atory, declar-atory

　　　b. -ative: accus-ative, conserv-ative, provoc-ative, compar-ative

Sporadically, the final segment of the base is changed so that the requirement of the suffixes is satisfied.

(7)　a. /d/ → /s/: expansive (< expand), decisive (< decide)

　　　b. /z/ → /s/: abusive (< abuse), effusive (< effuse)

　　　c. /r/ → /s/: cohesive (< cohere), adhesive (< adhere)

　　　d. /ʃ/ → /t/: admonitory (< admonish), punitory (< punish)

These facts strongly suggest that the relevant restriction is operative in the suffixation of these forms.

A similar phenomenon is observed with -al, which imposes the opposite requirement to -ory/-ive: the base-final segment should not be /s/ or /t/. If it is /s/ or /t/, /i/ and /u/ are respectively inserted before the suffix. Compare (8a) with (8b, c).

(8)　a. verb-al, physic-al, economic-al, prim-al, origin-al, person-al

　　　b. fac-ial, rac-ial, offic-ial, sacrific-ial

　　　c. act-ual, intellect-ual, habit-ual, spirit-ual

What is interesting here is that the base behaves differently when it ends with /nt/, although the final segment itself apparently satisfies the restriction. Observe the words in (9):

(9)　a. argument-ative, present-ative, frequent-ative, augument-ative

　　　b. accident-al, parent-al, rent-al, segment-al, experiment-al, orient-al

Because the base argument ends with /t/, a form like *argumentive would be predicted. Contrary to our prediction, -ate is introduced before the suffix. Similarly, even though accident ends with /t/, /u/ is not inserted before -al. It is obvious from

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[1] As discussed in Zamma (1994b), the -at- in -atory/-ative should be regarded as the suffix -ate in order to account for stress behavior and vowel length in the words containing them.

the examples above that the /t/ in the /nt/ cluster is regarded as different from a single /t/.

This difference can be reduced to the linked structure of /nt/. Note that both /n/ and /t/ have the same place of articulation, and thus the cluster /nt/ is assumed to have the structure in (10a).

(10) a.   n   t   b. t

      ＼| |
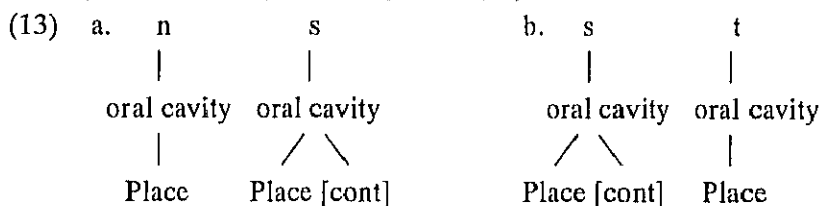
          Place   Place
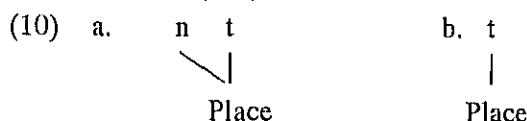
The /t/ in this cluster cannot be regarded as a 'genuine' /t/, which contains a single association line as in (10b). Therefore, the bases in (9a) must be regarded as violating the suffixal restrictions, resulting in the introduction of -ate. Similarly in (9b), the restriction of -al is regarded as satisfied.

When the base ends with /ns/ or /st/, the case is again different from that of /nt/; that is, the /s/ and /t/ in these clusters behave as single.[2]

(11) a. offens-ive, expens-ive, recompens-ive, sens-ory, respons-ory

      b. financ-ial, provinc-ial, essent-ial, evident-ial, sugstant-ial, referent-ial

(12) a. suggest-ive, digest-ive, arrest-ive, resist-ive, exhaust-ive, combust-ive

      b. text-ual, context-ual, best-ial, celest-ial

Although -ate is added to bases which end with /nt/, -ory or -ive is attached directly to the base in (11a) and (12a). Similarly, an epenthetic vowel does appear in (11b) and (12b), although not in (9b). These facts suggest that the /s/ and /t/ in the clusters /ns/ and /st/ are regarded as 'genuine' /s/ and /t/. In other words, the sequences /ns/ and /st/ are not considered to have a linked structure as in (10a).

This fact can be accounted for either with geometry in which Place and [continuant] are linked (13), or with gesture (14).[3]

(13) a.   n   s   b. s   t

          | | | |

      oral cavity oral cavity   oral cavity oral cavity

          | ／ ＼   ／ ＼ |

      Place   Place [cont]   Place [cont]   Place

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[2] Note that words ending with -nsatory/-nsative are derived from -ate-ending bases; e.g. compensat-ory (that is, not from *compense).

[3] I tentatively assume the geometry proposed by Clements and Hume (1995), although different theories of geometry will suffice as long as they guarantee a connection between Place and [continuant] (e.g. Padgett (1991)). In Clements and Hume's theory, then, it is actually the oral cavity node that is linked in (10a).

(14) a. n   s   b. s   t

       | | | |

    Cor$_S$ Cor$_F$ Cor$_F$ Cor$_S$
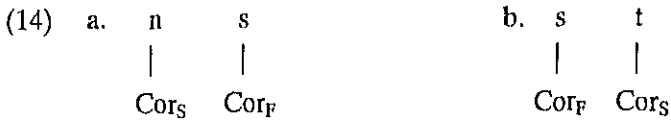
In both theories it is impossible to make a linked structure for /ns/ and /st/, because the content of the oral cavity node in (13) or the place feature with gesture in (14) is different. Hence, the final segments in /ns/ and /st/ must be singly linked, which forces them to be regarded as having a single /s/ or /t/.

In sum, both theories can properly account for the facts of English suffixation, provided that the relation between place and continuancy features is guaranteed. When we consider facts in which only [cont] spreads, it becomes evident that the structural account is superior to the non-structural one. English spirantization is an example of such a case.

4. Independence of [cont]: English Spirantization and Palatalization

As documented in the literature (cf. Chomsky and Halle (1968), Halle and Mohanan (1985), Rubach (1984), etc.), English has rules of palatalization and spirantization that act upon suffixation. Examples of words which undergo palatalization are as follows:

(15) a. impress   profess   confuse   diffuse   supervise

      b. impression   profession   confusion   diffusion   supervision

(16) a. race   commerce   malice   space   Mars   Paris

      b. racial   commercial   malicious   spacious   Martian   Parisian

Because of palatalization, the base-final /s/ and /z/ in (15a) and (16a) change to [ʃ] and [ʒ] in (15b) and (16b), respectively.[4]

Cases in which only spirantization applies are scarce in English, although they are abundant in other languages, e.g. French.[5] Spirantization in English is most commonly observed in words which also undergo palatalization.

(17) a. react   invent   extinct   delete   invade   expand

      b. reaction   invention   extinction   deletion   invasion   expansion

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[4] In *Martian* and *Parisian*, the value of the voicing feature is reversed; i.e. /z/ and /s/ in the base change to [ʃ] and [ʒ] respectively.

[5] Chomsky and Halle (1968) and Rubach (1984) say that the suffixation of noun-forming -y represents such a case (e.g., *private/privacy*). As Halle and Mohanan (1985) point out, however, it is not true of adjective-forming -y (e.g., *trend/trendy*), and thus the application of the rule seems lexically-determined. I will therefore assume that spirantization normally applies in the same environment as palatalization.

(18)   a. part   delight   Egypt   Scot

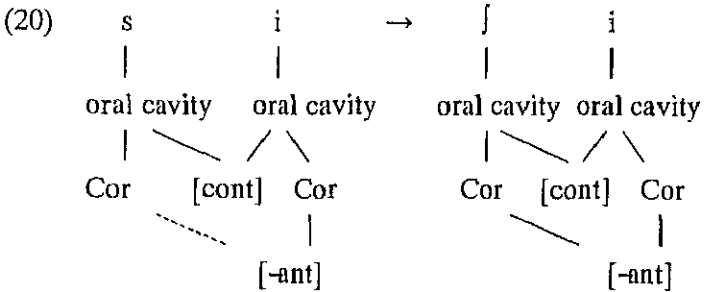   b. partial   delicious Egyptian   Scotia

In terms of derivational theory, spirantization changes the base-final /t/ and /d/ to /s/ and /z/; palatalization then changes them to [ʃ] and [ʒ]; e.g. *reac[t]* → *reac[s]-ion* → *reac[ʃ]-ion.*

In addition to these examples, there are words which undergo palatalization only, even when at a first glance spirantization could also apply.

(19)   a. Christ   beast   digest   congest

       b. Christian   bestial   digestion   congestion

Contrary to the words in (17) and (18), the application of spirantization is blocked in these words, with palatalization producing [tʃ] from /t/.

All of these facts can be analyzed easily within geometric theory. The only assumption we need is that the vowel /i/ has the feature [cont] because of its potential of being a glide. First, Palatalization can be analyzed in the following way:

(20)
```
        s           i       →        ʃ           i
        |           |                |           |
   oral cavity  oral cavity     oral cavity  oral cavity
      |    \    /  \              |    \    /  \
     Cor  [cont] Cor            Cor  [cont] Cor
       ‥‥‥‥       |               \          |
           [-ant]                    [-ant]
```

Condition: another vowel follows [i].[6]

Because [+ant] is underspecified —hence absent —in /s/ and /z/, the [-ant] feature of the following /i/ spreads onto an empty position, changing /s/ and /z/ into [ʃ] and [ʒ]. In other words, palatalization can be defined as the spreading of [-ant] in this theory.
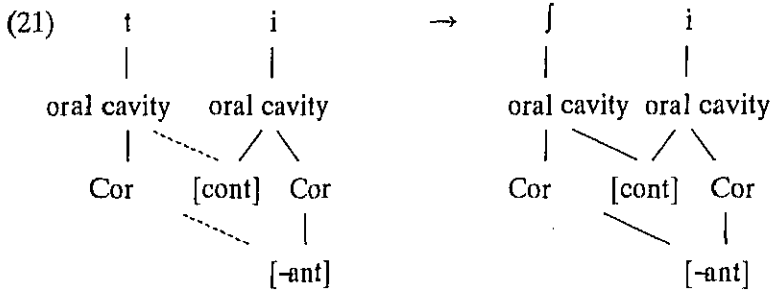
It is also possible to analyze this process as merger rather than spreading, since the vowel /i/ itself disappears after the rule applies (cf. fn. 6). In any case, it is the [-

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[6] This condition itself needs to be explained, of course. My impression is that the following vowel is necessary for the sake of syllabification, since the triggering vowel /i/ disappears after palatalization (and spirantization); e.g. *impre[ʃən]*, but not **impre[ʃiən]*.

What is interesting is that the environment of palatalization (and spirantization) is quite similar to that of CiV-lengthening. I also have the impression that these rules must be connected to each other. The disappearance of the palatalizing vowel /i/ consequently leads to a loss of moraicity. In order to make up for this lost mora, the preceding vowel is lengthened. This 'rule' applies to other forms in which palatalization does not apply. In other words, CiV-lengthening might have been a kind of compensatory lengthening. Of course, the validity of this analysis must be confirmed by investigating the historical development of CiV-lengthening. If the rule first applied to the forms in

ant] feature of /i/ which triggers palatalization, and geometry adequately captures this fact. Note that the underlying vowel status of /i/ is justified in stress assignment; e.g. *ma(líci)<ous>*. If it were not present at the stage of stress assignment, stress would fall on the preceding syllable; e.g. **(máli)<cious>*.
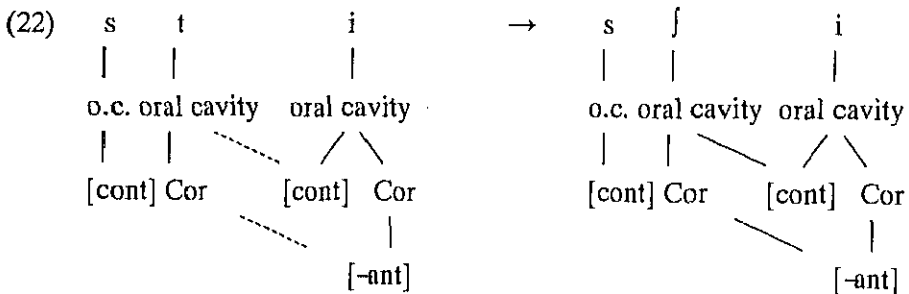
The alternation in the words of (17) and (18), where both palatalization and spirantization apply, can be analyzed as the spreading of [-ant] and [cont]. The spreading of the latter is the essence of spirantization, while that of the former expresses palatalization as we saw in (20).

(21)
```
    t            i         →      ∫            i
    |            |                |            |
oral cavity  oral cavity     oral cavity  oral cavity
    |     ⟍  ╱ ╲                 |    ⟍  ╱ ╲
   Cor  [cont] Cor              Cor  [cont] Cor
      ⟍       |                    ⟍        |
        [-ant]                       [-ant]
```
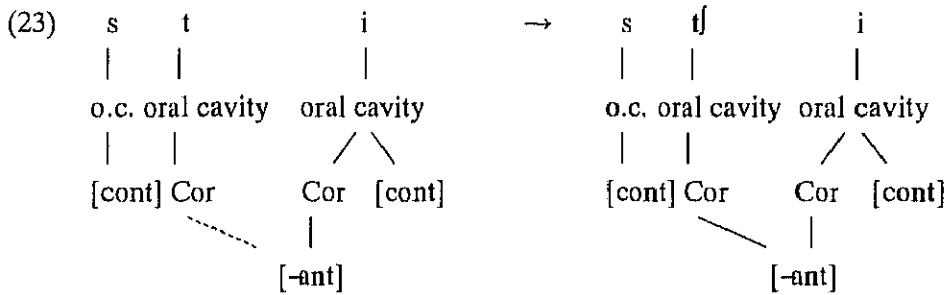
Condition: another vowel follows [i].

Because both [+ant] and [cont] are underspecified in these cases, the features of the following /i/ spread to /t/ and /d/, turning them into [∫] and [ʒ]. Recall that [cont] is specified to /s/ and /z/ and thus considered to form a linked structure as in (20).

In the case where /s/ precedes /ti/, only palatalization applies as we saw in (19). This is because the OCP blocks a sequence which has consecutive independent features. If palatalization and spirantization both applied to these words, the following illegal structure would be created.

(22)
```
  s    t            i       →    s    ∫            i
  |    |            |            |    |            |
 o.c. oral cavity oral cavity   o.c. oral cavity oral cavity
  |    |    ⟍  ╱ ╲               |    |    ⟍  ╱ ╲
[cont] Cor  [cont] Cor         [cont] Cor  [cont] Cor
         ⟍       |                     ⟍        |
           [-ant]                        [-ant]
```

As (22) shows, the resulting sequence of [s∫] would involve two consecutive [cont] features, violating the OCP. In order to avoid this situation, the spreading of [cont] is suppressed, allowing only [-ant] to spread (i.e. palatalization).
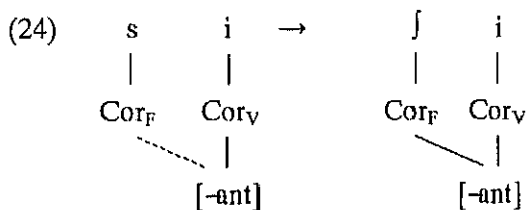
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which palatalization had applied, then to those in which palatalization had not applied, the analysis would be verified.

(23)

```
        s       t            i          →        s      tʃ          i
        |       |            |                   |      |           |
      o.c. oral cavity   oral cavity           o.c. oral cavity  oral cavity
        |       |          / \                   |      |          / \
      [cont]  Cor        Cor  [cont]           [cont] Cor       Cor  [cont]
           `·····,        |                          `·,         |
                [-ant]                                  [-ant]
```

Note again that in the case of /si/ —to which only palatalization applies as we saw in (20) —the OCP is not violated because both segments already have [cont], which is thus linked.

To summarize, the geometric theory succeeds in accounting for English palatalization and spirantization in a reasonable way. Although I have analyzed it above within classical derivational terms, the analysis is valid within a non-derivational theory such as OT: all of the correct distributions can be predicted if the output form has a featural structure. Moreover, from the derivational point of view, my analysis is advantageous in that it can do away with the ordering of the two rules involved: geometry correctly predicts that the features in question spread only when a landing site is available (i.e., the features of the target are underspecified or unspecified). Recall that previous derivational studies without geometry had to assume that spirantization preceded palatalization, which inevitably produces a dubious intermediate structure: e.g. *ac[t] → ac[s]-ion → ac[ʃ]-ion*.

Let us now move on to an analysis within gestural theory. Padgett's geometry in (1) successfully accounts for palatalization, allowing [-ant] to spread to the adjacent Coronal feature. Recall that in (1) the structure between Coronal and [ant] is one of the few dominance relations that remain.

(24)

```
        s       i      →        ʃ       i
        |       |                |       |
      Cor_F   Cor_V           Cor_F   Cor_V
         `····, |               `·, |
            [-ant]                 [-ant]
```

In the case of spirantization, however, the theory encounters serious problems. In analyzing this phenomenon, it is necessary to assume that a gesture must be changed completely.

(25)   t   i   →   ʃ   i
        | | | |
      Cor_S Cor_V   Cor_F Cor_V
        ⟍ | ⟍ |
      [-ant]   [-ant]
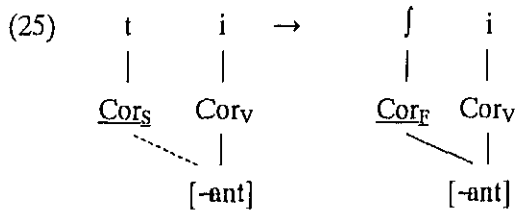
In (25), it remains unexplained why Cor_S must be changed into Cor_F: there is no clear triggering factor in the following vowel. Recall that this is easily accounted for in geometric theory by reducing the alternation to the spreading of [cont] into an empty position. In this approach, on the other hand, [cont] cannot play the same role because it is hidden in the gesture, i.e. it does not appear in the representation.

Moreover, it is not necessarily implied in gestural theory that only gestures are changed in a process, while leaving the place feature intact. Why must Cor_S be changed to Cor_F rather than any other feature, say, Lab_S? Gestural theory does not seem to be able to answer this question, as features with different gestures can be regarded as distinct, even when the place feature is itself the same. Note that Ní Chiosáin and Padgett say:

> "By hypothesis, entities like [coronal]_F and [labial]_S form <u>indissolutable units</u> (i.e., 'feature bundles') of major place ... and oral stricture... (Ní Chiosáin and Padgett (1997:6)) [emphasis mine]."

In other words, a place feature is identified by the feature and the gesture as a whole, because they are indissolutable. Then, changing Cor_S to Cor_F differs no less than changing Cor_S to Lab_S. It is not explained why the two features happen to have the same place before and after the alternation.

Let us summarize here the problems of gestural theory. First, we cannot account for cases in which only [cont] spreads or delinks: it is necessary to change the whole feature bundle, for example, from Cor_S to Cor_F. This weakens the predictability of the theory regarding what feature would change to what and when.

## 5. Additional Arguments against Gesture Theory

One might oppose the analysis of spirantization in the previous section by arguing that such an alternation is less productive in current English. There are, however, several pieces of evidence which suggest that [cont] does act independently. Grimm's Law and Verner's Law, which were very productive in Germanic languages, illustrate the point:

(26) a. Grimm's Law: p, t, k → f, θ, x
      b. Verner's Law:[7]   p, t, k → f, s, x

Both of these historical processes are analyzed quite simply as the addition of [cont], or spirantization.

(27)   C   →   C
         | |
      oral cavity   oral cavity
        | ‾‾‾‾‾   ╱ ╲
      place [cont]   place [cont]
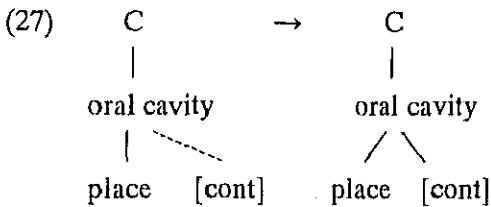
For some reason [cont] is added to a stop, producing a fricative at the same place. On the other hand, this analysis would be highly unnatural in gestural theory.

(28)   C   →   C
 | |
      Place$_S$ Place$_F$
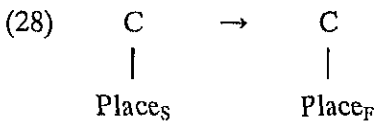
Again a place feature must be replaced by another feature without obvious reason.

In addition, stopping processes in language acquisition are observed cross-linguistically (cf. Locke (1983)). By these processes, infants incorrectly substitute fricatives with stops, as the name suggests. Below are examples from English and Japanese:

(29) a. English (from O'Grady and Dobrovolsky (1992)):

      sing → tiŋ   thing → tiŋ   shoes → tuːd
      sea → tiː   this → dit   zebra → diːbrə

      b. Japanese:

      soo → tʃoo   'so'   suru → tʃuru 'do (indicative)'
      samui → tʃamui 'cold' ʃite → tʃite 'do (gerundive)'

These are clearly cases of anti-spirantization, by which [cont] is delinked.[8]

(30)   C   →   C
         | |
      oral cavity   oral cavity
        ╱ ╲ |
      place [cont]   place

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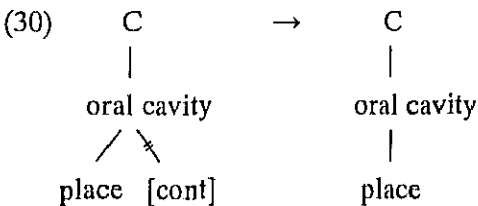
[7] /p/ and /t/ have variants in the output; i.e. [pf] and [ts], respectively. These can be seen as the addition of the entire oral cavity node, resulting in complex segments.

[8] It is not clear why the substituted segment is palatalized in Japanese —in other words, why [-ant] is added. This may result from the fact that palatal fricatives are easier to pronounce than alveolars for Japanese infants, since at the next stage they substitute /s/ with [ʃ]; e.g. *ʃuru* for *suru*. Note that this addition of [-ant] must also be explained in gestural theory.

Though the geometric theory can account for the substitution quite reasonably as in (30), it is not the case of gestural theory, where the place feature must be entirely replaced.

(31)   C   →   C
         | |
       Place$_F$ Place$_S$

This fact, together with the historic alternations in (26), illustrates the obvious superiority of geometric theory over gestural theory: only in the former can the independent addition and deletion of [cont] both be easily accommodated.

6. Conclusion

As Padgett (1991) has argued with extensive data, Place and [continuant] have a close relationship. The data in Section 2 confirm this view, in which *-ory, -ive* and *-al* crucially determine their allomorphy depending on the difference between /nt/ and /ns/. Both geometric theory and gestural theory successfully account for this difference, by reducing it to the possibility of linked structure of a place feature. In both theories only /nt/ can create such a structure, because (i) geometrically, the sequence shares [-cont] which is dependent to the place feature, or (ii) gesturally, the place feature has the same gesture S (for stop).

In spirantization, as well as in stopping processes in language acquisition, it is obvious that [cont] has an independent status. Changing /t/ to [s] —and conversely − − necessarily changes the value of [cont], which is unnatural in gestural theory: a place feature with one gesture must be entirely replaced in the process by the same feature with another gesture. Moreover, the cause of spirantization remains unexplained in gestural theory.

In geometric theory, on the other hand, these problems do not arise. Spirantization and the stopping process are analyzed respectively as addition and deletion of [cont], which is dependent on a place feature. The cause of the process is the vowel /i/ following /t/, which has [cont] because of its consonantal nature. Considering that the geometric theory can capture both of the facts in which Place and [cont] have a close relationship, and that [cont] spreads independently, we conclude that geometric theory is superior to gestural theory, which can capture only the former.

Note that this is a theory-neutral conclusion. Whatever causes the process in question — phonological rules or constraint hierarchy — it is the geometry of the features that makes the correct prediction. In other words, to predict the correct pattern, the output necessarily has a hierarchical structure of features.

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