1. Introduction

Restrictions on consonant sequencing have been explained in many languages in terms of sonority. Whether these are onset clusters, or sequences at syllable boundaries, sonority is by far the most common way of attempting to account for restrictions on these sequences. However, a large number of these languages permit sequences that defy traditional sonority-based explanations. Onset clusters that begin with [s] or coda clusters that end with [s] are the most common exceptions to sonority-based accounts, and these have been dealt with by treating these cases as operating outside the traditional domain of the syllable which is still sonority-based.

Because of the familiarity of such cases, they are viewed as basically solved, and so the same mechanism is used to account for still rarer cases of consonant clusters that lack sonority distinctions, such as stop-stop or fricative-fricative clusters at syllable boundaries. Moreover, if a language permits some, but not all such sequences, this is generally put down to an accidental property of the lexicon.[1][1] Some languages, however, seem to have a principled mechanism at work to restrict such sequences that can be described and investigated, a mechanism that appeals not to sonority, but rather to place of articulation as the basis of this restriction.

As I will show in this paper, place of articulation sequencing is needed to explain the behaviour of consonant sequencing restrictions in some languages. Place sequencing may operate apparently without regard to sonority, or in combination with it. It may also operate in restricted contexts or freely within words. I will examine the evidence for place-based consonant sequencing, and examine some possible phonetic bases for accounting for such behaviour. I will also examine whether these accounts can explain the kinds of restrictions, and the kinds of environments under which these restrictions seem to operate. Finally, I will discuss the implications of my account for other behaviours common to consonant clusters, and what work still needs to be done.

2. The Problem

The problem of appealing to place-of-articulation as a restriction on the order of consonant sequences arises in four languages that I have uncovered so far. These languages are Ancient/Modern Greek, Deg, Georgian, and English. Each of these languages exhibits slightly different tendencies with regard to the sequence of places that the language allows. They also differ in the environments in which each allows the sequencing restriction to have effect. I will examine each of these languages in turn to describe the evidence for the place-based sequencing effects, and how each of these relates to the others before attempting to account for the various sequences.

2.1. Greek

Perhaps one of the most intriguing aspects of the place-ordering problem in Greek is that we can observe the process of its development and how it changes over time. As I will show below, the place-ordering restriction appears to have arisen in Greek between the time it split off from Indo-European and the period of our first texts. The reconstruction of Indo-European is very well documented, so changes in individual lexical items as well as a synchronic account of the morphology of Ancient Greek is possible. Attested Greek goes on for another 2500 years, so changes in the system can be studied and placed in a phonetic context.

2.1.1. Ancient Greek

Ancient Greek is typical of languages in the Indo-European family, and in some ways was more faithful to its Indo-European roots at that time than even Latin or Sanskrit. Greek preserved the three-way stop distinction from Indo-European, although the phonetic values had changed to voiceless unaspirated, voiceless aspirated, and voiced. Unlike Indo-European, it had lost the labial-velar segments and was left with only three places of articulation: labials, dentals, and velars. Greek also had two nasals, labial and dental, and only one fricative, *s*. The Indo-European glides in onset position had been lost, and were only preserved as off-glides.

Occurring sequences of consonants in Ancient Greek have been noted and observed over the years. All these accounts of occurring consonant sequences observe the same thing: sequences of two stops or two nasals were relatively common. They could occur in single lexical items or at morpheme boundaries, and pairs of them could be articulated as an onset, even when preceded by an open syllable. The occurring stop-stop and nasal-nasal clusters are given in (1) and (2) below.

(1) Single lexeme stop-stop and nasal-nasal clusters

kt, pt kVtV, pVtV gd, bd ŋn, mn

(2) Morpheme generated stop-stop and nasal-nasal clusters

kt, kp, pt, kpt kVtV, kVpV, pVtV gd, gb, bd ŋn, ŋm, mn

With three places of articulation, there should be six possible sequences of stop clusters for each laryngeal or nasal feature. Of these, we see only velar-coronal, velar-labial and labial-coronal. What about coronal-velar, labial-velar and coronal-labial? While we might expect accidental gaps, the systematic absence of half of the possible sequences is intriguing. Why not other such sequences of stop-stop clusters? Indo-European had these in its reconstructed lexical items. What happened to them? Is it an accident of morphology that other clusters can just never be generated?

The data in (3) shows that lexical items from Indo-European that survived into Ancient Greek eliminated sequences of the coronal-velar, and labial-velar type. This process was highly systematic in the relatively large number of lexical items that contained sequences of coronal stop followed by velar stop. The example in (3a), unlike the other examples, may represent a possible synchronic alternation. Both the present and the perfect of this verb {tk} 'beget' are reduplicated, and both forms reduplicate with the initial consonant and a vowel. Notice, however, that the present form of this verb has metathesized the consonants of the root that remain adjacent, while the perfect remains unmetathesized because of the intervening ablaut vowel. In both cases the replicated consonant continues to be the coronal.

In addition to motivating metathesis in morpheme-internal sequences that are disallowed, processes that will generate new illegal sequences were blocked. One of the common assimilatory behaviours in Proto-Greek was the leftward nasal feature spreading in sequences of voiced-stop plus nasal, so that both consonants would become nasals. The process occurred regularly both at morpheme boundaries and morpheme-internally. However, as the example in (3f) shows, this process was blocked

when the obstruent stop was a coronal. Carrying this process forward would have created a sequence of nasals that would have violated the sequencing restriction.

(3) Indo-European to Proto-Greek- Morpheme-Internal Sequences (Sihler 1995)

a. *titko: → τίκτω [tikto:] 1s pres.indic. τέτοκα [tetoka] 1s perf. 'beget'

b. *dhghom- → χθών [kVtVo:n] 'earth'

c. *tkey- → κτίζω [ktizdo:] 'found'

d. *H_2rtko- → –ρκτος [arktos] 'bear'

e. *pktens → κτεÃς [kteis] cf. Latin *pecten* 'comb'

f. –δμητος [a.dme:.tos] *[anmetos] 'untamed'

The data in (4) shows that the historical changes could not have been just a random process that eliminated such sequences in individual lexical items, but it also was an active process that operated synchronically at the time of our earliest texts. Sequences that may be generated in the morphology, or as processes of historical change, are eliminated or prevented from occurring, as we saw in (3). In (4a-c), the morphology concatenates straightforwardly as long as no disallowed sequences are generated. In (4d-f), however, the usual place assimilation that we see in many languages eliminates some clusters at morpheme boundaries. (4h) and (4i) show that assimilatory processes are blocked, creating dissimilation, apparently in order to preserve underlying place features in stems, while avoiding disallowed clusters. In (4j-l), deletion may occur to prevent disallowed sequences. Particularly interesting is the alternation in (4k) and (4l). Both of these words have identical meanings, yet the presence or absence of perfect ablaut seems to determine which of the two consonants will be preserved. In neither case, though, can both consonants be preserved, as they would violate the sequencing restriction.

(4) Stop-stop clusters at morpheme boundaries in Ancient Greek (Sihler 1995)

A. Prefix-stem Boundaries

a. /ek/ + /paleia/ → ¦κπαλεια [ek.pa.lei.a] 'dislocation'

b. /ek/ + /tem/ + /n/ + /o:/ → ¦κτεμνω [ek.te.mno:] 'I cut out'

c. /ek/ + /ptyksis/ → ¦κπτυκις [ek.pty.kis] 'spreading'

d. /kat(a)/ + /kei/ + /ontes/ → κακκειοντες [kak.kei.on.tes] 'lie down', pr.pt.

e. /en/ + /gnamp/ +/t/ + /o:/ → ¦γγναμπτω [eŋ.ŋnam.pto:] 'I bend in'

f. /en/ + /mane:s/ → ¦μμανης [em.ma.ne:s] *[enmane:s] 'frantic'

B. Stem-suffix Boundaries

g. /plek/ + /menos/ → πεπλεγμενος [pe.ple.ŋme.nos] 'weaved', ppp.

h. /peitV/ + /menos/ → πεπεισμενος [pe.pei.zme.nos] *[pepeinmenos] 'persuaded', ppp.

i. /pVan/ + /menos/ → πεφασμενος [pe.pVa.zme.nos] *[pepVanmenos] 'spoken', ppp.

j. /loip/ + /ka/ → λελοιπα [le.loi.pa] *[leloipka] 'I have left'

k. /poitV/ + /ka/ → πεποιθα [pe.poi.tVa] *[pepoitka] 'I have persuaded'

l. /peitV/ + /ka/ → πεπεικα [pe.pei.ka] *[pepeitka] 'I have persuaded'

2.1.2. Modern Greek

Since the time of the earliest Greek texts, changes have taken place in the Greek stop consonants that effect the behaviour of the sequences I described above. The voiced stops and the voiceless aspirated stops became fricatives, and seem no longer to be restricted in the same way that the remaining stops and nasals still are. There were two changes in the development of Greek since Classical times that generate sequences of fricatives so that they no longer follow the same limitations that stops continue to obey. One of these is the change of the labial off-glides in diphthongs to fricatives. We can see in the data in (5c-e) that this change may create place sequences that are both traditionally allowable, as in (5c), or a new previously disallowed one in (5d) and (5e). The second change is the initial vowel loss in some words triggering metathesis. Examples of this development are given in (5a) and (5b). These two changes created new sequences of fricative-fricative of the type labial-velar. Despite these changes in the stops that became fricatives, the stops and nasals that remained continue to obey the restriction. The data for this is given in (6).

(5) Greek fricative-fricative clusters (Holton, Mackridge & Philippaki-Warburton 1997)

a. βγαζω [vγazo] 'I lead'

b. βγαινω [vγeno] 'I speak' (from ¦κβαινω [egbaino:])

c. ευθετος [efθetos] 'proper'

d. ευγενης [evgenis] 'polite'

e. ευχη [efxi] 'wish'

(6) Modern Greek stop-stop clusters

a. κτηση [ktisi] 'possession'

b. πτηνο [ptino] 'bird'

c. εκπτωση [ekptosi] 'decline'

e. ανεβασμενος [anevazmenos] 'having ascended' from αναβαινει [anebeni]

*[anevanmenos]

What can this data tell us about how we account for these apparent restrictions? One way to begin to address this question is to come at the problem with a descriptive generalization. One possible way of describing the Greek data is that in stop consonants the more marked place feature should precede the less marked. Velar is considered the most marked of the three that Greek allows, and coronal is accepted to be the least, with labial in between. How does this begin to *explain* the restriction, however? What does this "markedness" relationship correspond to in phonetics?

One more interesting complication in the Greek case is that it cannot be solved by traditional appeals to sonority or syllable contact restrictions. In all cases the adjacent segments are of the same sonority when they are permitted. When a dispreferred place sequence is generated the two segments must be of different sonority or manner values. Cases of dissimilation, such as in (4i) where an underlying coronal nasal becomes a fricative before a labial nasal, or the blocking of assimilatory processes in (3f) interact with the restriction. However, syllable shape and contact restrictions do not seem to interact with the Greek restriction, as some clusters in Greek may be in onsets or articulated across syllable boundaries at the morpheme boundaries. Predictions based on sonority that all such clusters must be heterosyllabic are challenged by the facts of Greek poetic meter.[2][2]

The three important properties of the place sequencing restriction in Greek are: 1) the preferred sequence of places is velar, labial, coronal; 2) syllable boundaries and syllable shape do not seem to be factors; and 3) the restriction in Greek operates only over stops that have no laryngeal or manner distinctions. The final point is borne out in the Modern Greek data, where the stops continue to abide by the restriction, but the fricatives do not. What is it about the stops that make them particularly susceptible to this restriction?

2.2. Deg

Deg is a language of the Gur family and is spoken in west-central Ghana. Like Greek, Deg has a very strong restriction on heterorganic consonant clusters, a sequencing restriction strong enough to operate across morpheme boundaries triggering either assimilation or metathesis. However, the similarities end there. While the Greek place sequencing restriction is limited to stop-stop and nasal-nasal clusters, the restriction appears to operate over all consonant clusters in Deg regardless of sonority distinctions. Also unlike Greek, Deg obeys a restriction tied to the airflow of consonant sequences, preferring that velar precede coronal or labial, and coronal precede labial: a downstream order of articulation.

The data given in (7) below illustrates the kinds of occurring heterorganic consonant sequences permitted word-internally. Each consonant cluster in Hume (1997) is separated with a short transitional vowel. Since the restriction on consonant sequencing is not obeyed across nontransitional vowels, the vowel does not seem to be truly epenthetic. This would indicate that

the consonants are fully released in such sequences. In (7) we see that of the allowable consonant sequences, the velar-labial, and velar-coronal are similar to the sequences permitted in Greek. Dɛg differs from Greek in allowing coronals to precede labials, as well as including cluster with changes in manner of articulation to participate in the restriction.

(7) Word Internal Heterorganic Consonant Clusters in Dɛg (data from Hume 1997)

A. Velar-Labial

a. lugbɔɔ 'armhole'

b. tɛgfi 'a medicine'

c. nwhaŋma 'waves'

B. Coronal-Labial

d. wɔrbi 'to be hot'

e. marfa 'gun'

f. bilalbie 'orphan'

g. solmwn 'yellow'

h. kʊnfalw 'something new'

C. Velar-Coronal

i. bɔgtɔ 'pocket, bag'

j. tugre 'mortar'

k. yaglw 'to rinse'

l. soŋni 'to be seated'

This sequencing restriction seen in monomorphs also shows its effects at morpheme boundaries. Shown in (8) below are the effects of phonological processes on clusters which underlyingly violate the previously described restrictions. As with the Greek example, the sequences are repaired using more than one mechanism, including assimilation, but also metathesis when assimilation is not preferred.

(8) Repair Strategies for Dɛg

a. […aŋ] + / rI / → […aŋrw] 'backs' (no repair)

b. [nɔm] + / rI / → [nɔrmw] 'scorpions' (metathesis)

c. [dem] + / rI / → [dermi] 'houses' (metathesis)

d. [vʊgɛ] + / rI / → [vʊgrw] 'to divine' (no repair)

e. [swwɛ] + / rI / → [swrww] 'to die' (metathesis)

f. [dam] + [dɛɛge] → [dandɛɛge] 'good friend' (assimilation)

The Dɛg data represents special problems of its own for determining the motivating factors behind the sequencing restriction. The Greek data was clear in that a sequence of oral stops with identical laryngeal and nasal features was necessary to trigger the restriction, and there seems to be some question about the issue of syllabification. Dɛg, however, requires its place sequencing restriction to operate over all consonant clusters, and has a much simpler syllabic structure than Greek. These differences make comparisons between the two languages difficult at best. They point tend to point to unrelated motivations behind the sequencing problem. The correlation with the airstream is telling in the Dɛg case, and I will return to this correlation later on.

2.3 Georgian

Georgian is a Kartvelian language spoken in the Republic of Georgia in the southern Caucasus. Georgian is a language characterized by abundant consonant clusters that violate traditional concepts of syllable structure requirements. Georgian also has many sequences of two stops that are individually articulated. These cases are of interest because of the strong tendency to restrict these stop-stop clusters within morphemes. As outlined in Chitoran (1998), when stop-stop sequences have the same laryngeal specification, they are generally limited to a place sequence opposite to that of Dɛg: opposite the airflow rather than with it. When the laryngeal specification differs, the consonant sequences tend to violate the sequencing restriction obeyed elsewhere. The data in (9) gives examples of these stop-stop sequences. Also included here are sequences of three stops, which also obey these restrictions.

(9) Georgian Stop-Stop Clusters (data from Chitoran 1998).

A. Obeys restriction

a. voiced: bg, gd, $d^{z}g$, ®g

b. aspirated: $p^{h}k^{h}$, $p^{h}t^{h}$, $t^{h}k^{h}$. $t^{sh}k^{h}$, $\pm^{h}k^{h}$

c. ejective: p'k', p'q', $p't^{s'}$, t'k', t'q', $t^{s'}k'$, $t^{s'}q'$, ±'k', ±'q'

B. Violates restriction

d. $t^{h}b$, $t^{sh}b$, q'b, k'b, t'b, q'd

C. Three stops

e. identical laryngeal specification: $p^{h}t^{sh}k^{h}$, $p't^{s'}k'$

f. change in laryngeal specification: t'k'b'

While the restriction in Georgian is manifested as a strong tendency rather than the kind of absolute or near-absolute restrictions seen in Greek and Dɛg, the sequencing restriction is quite strong in monomorphemic words, with well-defined exceptions. Also unlike the examples given for Greek and Dɛg, the sequencing restriction does not apply across morpheme boundaries. Clearly, because the Dɛg restriction and the Georgian restriction are diametrically opposed to each other, this is something that will have to be accounted for in any analysis.

2.4 English

Unlike the previous cases described above where the sequencing restrictions applied on consonant sequences regardless of syllable affiliation, the English case is tied directly to syllable structure. The English restriction operates only in codas and so may be violated both at morpheme boundaries and monomorphemically so long as the consonants can be resyllabified. The data in (10) gives examples of the application of the sequencing restriction in English. It is similar to Greek in that both velar and labial stops must precede coronal stops in stop-stop clusters. Also like Greek, these are the only sequences possible in native, monomorphemic words. However, Greek has these sequences in onsets, and morphology may produce velar-labial sequences with bound morphemes, while English cannot.

(10) English Codas

a. monomorphs: except, direct, act, apt

b. polymorphs: kept, slept, dragged, walked, jerked, jabbed

c. violations across syllables: Atkin, outcome, pickpocket, topcoat

This situation in English has been previously accounted for by appealing to the sonority of the consonant cluster. The previous analysis would simply relegate the coronal in these stop-stop clusters to an adjunct status directly attached to the syllable, rather than being incorporated into the rhyme as the labial or velar stop would be. This kind of account can correctly account for the English case where only coronals may be attached outside the syllable in this manner. It may be that this is still the correct way to analyze the English coda restriction. However, this kind of account alone does present certain problem for the Greek analysis, since the consonants that may be attached outside the syllable in the onset clusters would be everything but the coronals. This is the analysis adopted by Steriade (1982). This analysis, however, does not agree with Greek syllable structure, which under most circumstances does not resyllabify onset stop-stop clusters into a preceding open syllable, something which is characteristic of English when these coda clusters are followed by onsetless syllables, such as in

'directed'. This difference between the Greek case and the English case will hopefully shed some light on the solution to these sequencing restrictions.

3. Comparing Environments

Besides the actual place sequencing patterns themselves, of interest to us in finding the solution will also be environments over which these restrictions operate. I have discussed some of these factors already, but I will summarize them again here.

In Greek, we saw that the sequencing restriction, both in Ancient Greek and Modern Greek, is velar-coronal, velar-labial and labial-coronal. I also found one instance of a string of three stops, velar-coronal-labial. This data is given in (2) - (4). These sequencing restrictions are obeyed completely both within morphemes and across morphemes, but only in consonants with an oral-stop closure: obstruent stops and nasals. As we saw in Modern Greek, fricative-fricative sequences, whether generated from historical stop-stop sequences or from other sources, are not obliged to follow the restriction obeyed by stops and nasals. We also saw that sequences which differ by manner of articulation may preserve place sequences that would not be permitted if phonological processes present in other environments were allowed to proceed.

The Dɛg restriction differs from the Greek case in place sequencing by the coronal-labial preference. This difference aligns Dɛg with the direction of the airstream. Like Greek, the Dɛg restriction is a powerful one, operating both within morphemes as well as across morpheme boundaries. The repair strategies employed are somewhat less complicated than the Greek case. Greek permits metathesis only within a morpheme, and permits place assimilation only in prefixes, forcing it to use additional repair strategies. Dɛg also requires that its sequencing restriction be obeyed for all manners of articulation and in all consonant clusters.

The Georgian restriction, compared to the two previous examples, is considerably weaker. However, except for a relatively small number of non-systematic exceptions, the sequencing restriction does operate over a well-defined set of cases. These cases are principally stop-stop clusters with identical laryngeal specifications. This environment is similar to the Greek case since Greek requires laryngeal assimilation in stop-stop clusters. Georgian permits exceptions with voicing differences and manner differences, the second of which is also found in Greek. And like Modern Greek, the restriction appears to be irrelevant in fricative-fricative sequences. Chitoran (1998) gives only one example of an occurring heterorganic nasal-nasal sequence. While this nasal-nasal sequence appears to follow the restriction, the labial nasal and the coronal nasal are the only nasals found in Georgian, but the absence of 'nm' clusters in Georgian may not be accidental.

The English case is similar to the Greek and the Georgian case because the restriction is English likewise operates between stops. However, unlike both of these languages, the English restriction is tied closely to syllable structure, and may only play a role in syllable codas. Because of the consistency of the syllable-structure factors, this particular case may best be analyzed by traditional models, particularly with the resyllabification across syllable boundaries. However, it does provide a sharp contrast to the Greek case, which must operate both within and across syllable boundaries.

What are the relationships between the place ordering restrictions and the syllable structure? How do the release properties of the consonants relate to the sequencing restrictions, and how are the

different repair strategies selected? These may not be answerable questions in this paper, but they will have to be addressed in the following discussion.

4. Possible Orders and Boundary Relationships

One of the things we need to consider is the possible sequences of consonants that may occur. With three places of articulation, a two-stop consonant cluster may take six possible shapes: velar-labial, velar-coronal, labial-velar, labial-coronal, coronal-velar and coronal-labial. In each of the first three languages given above, only three of these sequences are permitted. Another way of summarizing this, is that there is only possible (hypothetical) three-stop sequence. For Greek this sequence does occur, and is kpt. Dɛg does not allow three-stop sequences, but would be ktp. Georgian has five places of articulation, but would be ptk, or with all the places, pt±kq. English would be similar to the Greek order, though, like Dɛg, English does actually allow three-stop sequences. One possible way of deriving the English case would be by adding an additional restriction to the Greek restriction. However, given the six stop-stop sequences given above, there are three other possible ordering patterns: pkt, tkp, and tpk. The last is the opposite of the sequence permitted in Greek, though I have yet to find a language that permits this sequence.

All of these sequences permitted above assume that no stop-stop sequence may be the inverse of another. Many Slavic languages, such as Czech (Harkin 1953), permit both kt, and tk sequences word-initially. Czech also permits pt word-initially, but not tp, nor kp and pk. Any account that can be made for Greek, Dɛg or Georgian, may not be able to account for languages such as Czech. The differences between the Greek case and the Slavic case will be discussed more below.

Another factor that affects these ordering restrictions is the kind of boundary relationship the consonants in question have with each other. Sequences of place of articulation features may relate to each other on a spectrum that ranges from complex segments with nearly complete overlap, to consonant sequences at word boundaries that may have little or no interaction with each other. One of the questions that will need to be addressed is the difference between complex segments, clusters and sequences of consonants. What is the functional difference? How do these differences play out in the phonology? The other boundary question to be addressed, is the morphological status of these clusters or sequences. How are morpheme-internal clusters different that heteromorphemic clusters? How are sequences that cross morpheme boundaries, but are in a single word different than consonant sequences that span words? How does syllable structure effect these considerations? As we've seen from the data given in §2, some of the place-sequencing restrictions are effected by these morphological factors. Greek still requires the restriction be obeyed, but selects different repair strategies under different morphological conditions. While Georgian, does require the restriction be obeyed at all at morpheme boundaries. As I have mentioned previously, the English case is sensitive to syllable structure.

To account for the restrictions described above, the role of articulatory phonetics and the role of phonology in these ordering accounts will have to be established. How much can phonetic considerations really account for, and how much is grammaticalized beyond what is required of phonetics? What role do the boundary relationships play in the sequencing restrictions described above? What light does the phonetic literature shed on these questions?

5. Complex Segments

Because this paper is still incomplete, what follows below is an outline of the remainder of the paper. To help flesh-out what I intend to do, I have included additional notes and comments about the kinds of things I am planning to include. For the sake of brevity, I have tended to use tags which I myself place on things for convenience' sake. I hope this does not make it too difficult to follow.

A. Complex Segments

By this I want to restrict myself to doubly-articulated consonants, and exclude ones with secondary articulation.

1. Typological facts

What are the typological facts? describe conditions on this definition.

Complex segments are defined by Ladefoged & Maddieson as a doubly articulated consonant, of roughly the duration of a single consonant. Ignores cases where there is overlap, but as long as two. All cases with their definition are of the kp-type. Phonological complex segments may also contain coronals, but seem to be phonetically non-complex by L&M's def.

2. Why order here?

Describe the articulatory facts underlying complex segments. The overlap and its effect on release bursts. Why do typology facts reflect basic physical and auditory necessity? Given a possible range of overlap in two segments such as k and p, with pk on one end with completely separate articulations, and kp on the other, also with completely separate articulations, and the complex segment kp in the middle. On either end of the spectrum, where there is no overlap, one sequence should have no advantage over the other. Approaching the center of this spectrum, both sides go through a phase where these levels of overlap are dispreferred because one consonant will open into another closure. Toward the center, however, there is a slight bias toward the kp order because the k burst can produce an airflow that flows into the downstream p burst. The same level of overlap with the p burst slightly ahead of k, produces a p release with no airflow at all. The kp ordering allows more cues from both releases when the overlap is not precise.

3. What orders are predicted based on complex segment behaviour?

One strict interpretation of these facts would eliminate all the sequences that exclude pk orders, because of the typological facts of degree of overlap. Another would be to generate only the downstream airflow order, as seen in Dɛg. The Dɛg case does not show any overlap of this type in consonant sequences, though it does have complex segments in its inventory. Generalization?

4. What does this say about orders that do not comply?

Can the order be generalized? does it help with generating any of the above? (Georgian & Dɛg) Dɛg seems to have generalized this airflow mechanism. Georgian is the opposite. Both fall on the ends of the spectrum with no overlap, so while Dɛg seems to have phonologized a process needed in its complex segments, Georgian, while not incompatible, does not seem to be relying these facts alone. Can contrast maintenance play a role here? Does Georgian use this order to prevent overlap? What do these facts say about a case like Greek?

B. Overlap

1. refresh A2 facts

   ~ definition of complex segments by overlaps ~ typology, too

2. describe Byrd's 'gd' data

   ~ pay attention to overlap in Byrd's data and differences in order

   Her study shows overlapping articulation in sequences of consonants in English, both in coda clusters and across word boundaries. She shows that the overlap among stops is actually greater across words than in coda clusters. Is this because the d in these gd clusters is morphological? More overlap in dg than gd. English dg sequences can only be in separate words. Overlap consists of percentage of closure, describe in detail.

3. How do this and complex segments work together?

   do they agree, disagree, or are indifferent? Preference for gd would be consistent with airflow, like kp. Consistent with Dɛg. Also consistent so far with Greek (odd cluster pt). What effect does the percentage of overlap have to do the overall ordering problem? What else needs to be known? More data. More consonant sequences. Information on a language like Modern Greek or Slavic with onset stop-stop clusters. How do levels of overlap change in different contexts?

4. What possible orders can be generated with these 2 facts?

   What does this say about the facts in I? Do we have enough information to make a generalization? What is consistent? What does the percentage overlap data have to do with complex segment behaviour? Why the overlap in these ways? Raises more questions than it answers perhaps. Because the overlap is incomplete, should not effect the release bursts?

C. Jaw height

describe Lindbolm's data. what are the logical possible relationships from this data? Lindbolm's data details with jaw height. It seems that the jaw motion needed to produce k is less than p, which is less than t. From a preceding vowel, this would generate a sequence

of kpt, with t the peak of the upward jaw motion. Linked to preceding vowel based on what's his name. Does jaw height link to markedness?

1. What is order if linked to following vowel? attested?

   If linked to following vowel, would generate tpk sequence. Not attested in any of these languages, but... what about Greek with initial vowel loss cases? Metathesis.

2. What if linked to preceding vowel? phonetic justification

   for generally linking to preceding vowel. How does this link up with attested cases now. where would additional places of articulation fit?

   a. English codas ~ seems sensible, no following vowel, but why no kp?

   b. Greek onsets

      how does this work initially? empty vowel? Sequence generated is exactly what is needed. why limited monomorphemically? separate question. relationship to initial vowel loss.

   c. does it matter?

3. How does this jive with previous expectations?

   expectations such as markedness? Fit to data? Phonetically linked to preceding vowel. implications?

4. Why should jaw movement matter? Speculations?

   The principal speculation has to do with the general idea of contrast. Alternating sequences of consonant and vowel are the least marked syllable structures. If coronals have the highest jaw height, they would have the most contrast with vowels. There is a certain logic to their default status. But where is this going? What could this tell us about assimilation? Why would a change in voicing in or manner matter?

III. Conclusion

Summary. Have we made any progress? How has any of this suggested ways to deal with the problem of consonant ordering? Contrast maintenance? Airflow? Jaw height?

A. What hypothetical orders cannot be generated based on what is given above? At least 2 can't be apparently. How can we justify orders the reverse of what is expected? ~ relationship between Deg and Georgian? Metathesis in Greek?

B. What orders are so far unattested? predicted(-able), not predicted?

C. What kinds of interactions might be possible?

How might they complement each other? two or three? or further limit sequences? Assimilation? And what about the manner problem?

D. How do they interact with manner?

All, some, one, etc.? Are there any possible accounts of the various solutions? such as assimilation, metathesis, etc.?

E. What still needs done?

What is unaccounted for? What questions need answered? Have we made any progress? Where is this going?

From here, the plan is to finish this this summer. One possible follow-up to this is to look at the historical and typological factors at work in these cases more closely. One could look at related languages to the ones mentioned in this paper and compare stop-stop clusters in these other languages. How must their analyses differ? How does one get from point A to point B? Indo-European is the most natural place to being since it is the language family of two of the languages under discussion here. Why does Slavic allow tk clusters but not Greek? Why does English allow kt in codas, and Greek in onsets? Indo-European has been reconstructed with stop-stop clusters. What principles does it follow, if any? What was the outcome of these clusters in other branches? This would also be interesting for the Gur family and Kartvelian family, however, these language families present several problems. They are less well-studied, and more difficult to access. An areal typological study would likewise present similar problems. One of the drawbacks generally to addressing stop-stop clusters is the relatively few languages that permit them, so any study that can expand the range of data for the kinds of questions I want to ask is a plus.

A second possible follow-up is to address these questions phonetically. I have laid out a large number of questions that need to be answered regarding stop-stop clusters. One place to begin would be by addressing the phonetic issues of such clusters in English, to expand upon Byrd's work and consider other stop consonant sequences besides gd and dg, as well as other environments than word-final codas and word boundaries. Factors such as morpheme boundaries, stress placement and such may also place a role in questions of overlap or auditory/ articulatory distinguishability. This kind of phonetic analysis can then be readily expanded to address Greek and Slavic stop clusters. Do the languages behave phonetically differently? This kind of study can perhaps help determine the degree to which the restriction is phonetically motivated or if the process is simply phonologized and is not reflected in the phonetic facts.

Questions to be addressed in the future also include the relevance of manner differences: nasal-obstruent interactions, voicing, the role fricatives play in these accounts. Also, what features are being preserved in various repair strategies, and which ones are sacrificed? Greek uses at least four different repair strategies. Why? What pressure is each strategy responding to? This is more than I can answer all at once, but it is something to look forward to.

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[1][1] I say "generally" for two reasons. The first is that this is the reaction I most-commonly encounter in conversations about the data I will present below. Second, because I believe we can sometimes determine as much about what an author thinks from what they do *not* say as what they do. In his account of Ancient Greek phonology, Bubenik (1983) lists the occurring stop-stop clusters among his lists of all occurring consonant clusters. However, he makes no attempt to account for why only certain stop-stop sequences occur, while other consonant pairs occur in any order. Nor does he even mention the possibility that this may be anything other than accidental. A common variation of the "accidental" theme is to put the absence of certain clusters down to historical factors. And while the absence of some sequences may be attributable to either of these factors, broad systematic gaps are also ignored.

[2][2] Steriade (1982), because of her sonority-based account, requires that these stop-stop sequences be heterosyllabic. A final draft will include a discussion of her account here.