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NO SPREADING IN CHUMASH SIBILANT HARMONY*

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Ever since Poser (1982) first described it within an non-linear framework, Chumash sibilant harmony has stood as one of the most stubborn obstacles to simplifying phonological theory.

Much recent work in phonology has been devoted to finding straightforward definitions of locality, based on the observation that phonological process can affect items that are adjacent at some level but not items that are separated by arbitrarily large distances. Against these attempts, Chumash seems to require the ability to perform action-at-a-distance, skipping over all sorts of intervening material in an apparently unconstrained way.

At the same time, phonologists have managed to analyze almost every other harmony system using only feature-adding rules, rather than feature-changing rules. For example, while McCarthy (1984) argued that feature changing rules were needed to deal with Pasiego Montañes, Vago (1988) showed how Pasiego could be handled using only feature-adding rules within a underspecification framework. Against this trend, Chumash has seemed to be an insurmountable obstacle, apparently requiring feature-changing. This has been assumed by Steriade (1987) and Lieber (1987). Although Chumash is the only language Lieber is aware of that requires such power, she still believes that it deserves its own category in the typology of possible harmony systems.

The purpose of this paper is to question the status of Chumash sibilant harmony as a phonological rule, and hence as a potential counterexample to otherwise desirable simplifications of phonological theory. Examining Harrington's (1974) description of Ventureño Chumash reveals a process that is poorly explained by phonological rules but which could receive a natu-

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ral explanation in a model of phonetic implementation such as Keating's Windows model.

In the first section, I lay out some of the data that has been taken as evidence of Chumash's status as a feature-changing action-at-a-distance rule. I then discuss Harrington's description and its implications for the phonological explanation. In the third section, I suggest a way in which the behaviour of Chumash could be analyzed in a principled fashion as a phonetic effect of fast speech. Finally, I briefly discuss some of the other reported cases of consonant harmony and the implications for phonological theory if long-distance feature-changing assimilations such as Chumash are systematically excluded from the inventory of possible phonological rules.

1 The facts — a first look

The standard presentation of the facts of Chumash sibilant harmony is that all sibilants within a word will agree in anteriority with the final sibilant, regardless of whatever their own underlying specifications may have been.

For example, the initial *s* in the stem whose underlying form is *sunon* will surface as *s* if the final sibilant is *s*, as in (1a), and as *š* if the final sibilant is *š*, as in (1b).

(1) a. ksunonus 'I obey him' /k + sunon + us/
b. kšunotš 'I am obedient' /k + sunon + š/

In the absence of any following sibilant, an underlying *s* will surface as *s*, as in (2a):

(2) a. saxtun 'to pay'
b. šaxtun-itš 'to be paid'

Just like *ss* in verb stems, those in prefixes will also harmonize with following sibiliants. (3) shows the alternation of the causative prefix *su-*. (4) and (5) show the third person singular prefix *s-*.

(3) suwayan 'cause to hang' /su + wayan/
kšušoyin 'I darken it' /k + su + šoyin/

(4) saqunimak 'he hides' /s + aqunimak/
sixut 'it burns' /s + ixut/

(5) šilakš 'it is soft' /s + ilakš/
šammotš 'they paint it' /s + am + motš/

So far we have only seen *s*→*š* assimilations, which could easily be the result of a feature-adding harmony that spreads [anterior] onto a position that is underlyingly unspecified for it. The following examples show that the opposite change, *š*→*s*, also occurs. The dual subject marker, which has the underlying representation of *-iš-*, will surface with the *š* if there is no following sibilant in the word, as in (6), but will harmonize to a following *s*, as in (7).

(6) pišanan' 'don't you two go' /p + iš + al + nan'/
pišikimin 'you two are young' /p + iš + ʔikimin/

(7) sis^{h}iluleqpeyus 'they two want to follow it'
/s + iš + sili + uluaqpey + us/
sistisiyepus 'they two show him'
/s + iš + tišiyep + us/

Similarly, the stem *tš^{h}o* 'good' will harmonize to a following *s*, as in (8b).

(8) a. šapitš^{h}olit 'I have a stroke of good luck' /s + api + tš^{h}o + it/
b. sapits^{h}olus 'He has a stroke of good luck' /s +api + tš^{h}o + us/

Because it is unpredictable whether a given stem or affix will surface with an *s* or an *š* in the absence of any following sibilants, this information must be part of the underlying representation of the morpheme, that is, each sibilant will underlyingly have an [anterior] feature. The harmony process must be feature-changing because this underlying information is destroyed and replaced by the [anterior] of the trigger.

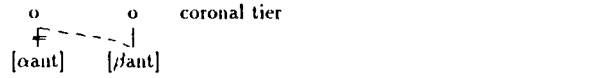
Sibilant harmony also seems to be performing action-at-a-distance. In all of the above examples, we can see that the distance between the final sibilant that triggers the harmony and the sibilant that undergoes it can be arbitrarily large. The two can be separated by any number of vowels and by any number of consonants, coronals as well as non-coronals.

Assuming that this characterization of the facts is correct, the only obvious alternative to accepting feature changing would be a peculiar situation of massive allomorphy. Every single stem and affix with a sibilant (and coincidentally only those with a sibilant) would coincidentally have two allomorphs, one with *s* and one with *š*. The allomorph selection principles

would have to be sensitive to the presence and identity of the rightmost sibilant in the word. While such a situation might conceivably be possible, most phonologists would rather have a less coincidental account, even at the expense of admitting feature-changing rules into the grammar.

Poser (1982) argued for a feature-changing harmony rule that operated over unrestricted distances. Some of the uneasiness over action-at-a-distance can be dispelled in a formulation such as that of Shaw (1991):

(9)



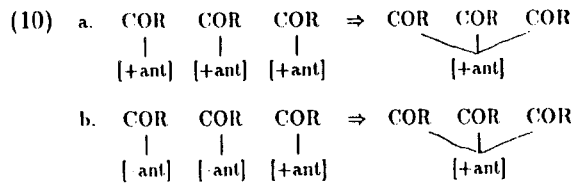
Here, [anterior] spreads leftward iteratively, delinking whatever [anterior] feature may originally have been on the target. Shaw argues that the trigger and the target are in fact adjacent on the coronal tier. Since *s* and *š* are the only two segments of the language that contrast in a feature dependent on COR, all other coronals can be underspecified for COR and they (like non-coronal segments) will be transparent for the purposes of the harmony rule.

2 The facts — a second look

The feature-changing analysis makes a rather strong prediction about the phonetic implementation of forms that have undergone sibilant harmony. Because of the feature-changing rule, each sibilant of the word ends up with exactly the same feature for [anterior]. Under any reasonable model of phonetics, this makes the prediction that all the sibilants of the word should be, if not phonetically identical, then at least extremely similar.

Specifically, consider a case where we have two underlying forms, each with three sibilants in comparable syllabic positions and segmental environments. The first has three [+ant]s, the second two [-ant]s followed by a [+ant]. Under the harmony rule, both end up with identical surface representations:

(10)



If the formalisms of autosegmental phonology are to have any meaning at all, the phonetic interpretations of (10a) and (10b) should be indistinguishable.

It appears that this prediction does not in fact hold for Chumash.

While there are no longer any Chumash speakers on whom we can run phonetic tests, we do have Harrington's meticulous description of the sibilant harmony process in the Ventureño dialect of Chumash. A passage from his 1928 paper, published posthumously in 1974, is worth quoting at length:

> But in actual practice the raising or lowering [to *s* or *š*] is largely only partial and frequently does not occur at all. Intermediate sounds between s and š, here written ş, arise by such imperfect assimilation or by a lowering of sounds before t, l, n... The assimilation is moreover less thorough with some speakers than with others. Especially in slow speech and when detached words are furnished it is apt to be absent.
>
> The assimilation is as a rule retrogressive. Progressive assimilation is rare and never extends far. The probable reason for this backward direction is that the phonetically strongest sibilants of Chumashan are the final sibilants....
>
> It is interesting in the light of general phonetics that š is much more thorough and far-reaching in its working of assimilation than is s. Just as in language growth in general it is supposed that s more often becomes š than vice versa, just as a drunken man may allow his s's to lapse into š's but does not s-ize his š's, so also here in Chumashan it seems that š has more power to pull s down than s to raise š up.
>
> It should be noted that the harmony rarely extends further back than through a single word and that the article si-, when it has this form, seems especially resistant to assimilation.

It is useful to compare this situation with ones where phonological spreading has undeniably taken place, such as many examples of vowel harmony. No matter how slowly one speaks Hungarian, otherwise harmonic vowels will not become disharmonic. In fact, this passage casts doubt on almost every aspect of a formal feature changing analysis of Chumash, represented by rules such as (9).

The rule predicts that the targets of assimilation should be pronounced identically to the trigger — instead, we usually find intermediate articulations. The rule predicts a symmetry between the *s* to *š* and the *š* to *s* directions — in reality, the *s* to *š* direction is greatly preferred. The rule should only work right to left — in reality, there is a limited tendency to for left to right spreading as well.[1] The rule predicts that the domain of harmony should be the word — in reality, the domain is frequently smaller, and occasionally larger. Instead of applying everywhere where its structural description is met, it applies more often in fast speech and can be suppressed entirely in slow speech.

In short, Chumash sibilant harmony has all the characteristics of a phonetic effect of fast speech, and none of the characteristics of a regular rule of the lexical phonology. Put another way, it seems to have more to do with the reason why I can't pronounce "She sells seashells by the seashore" quickly, than with the reason why I can't pluralize the word *cat* by adding a voiced *-z*.

Suspicion is justified when phonetics is invoked in a hazy way to explain phenomena that phonologists don't want to deal with. There is some burden on anyone who wants to claim something as a phonetic effect to show that there is some reason to believe that theories of phonetics can actually deal with it. Although it is too late to obtain clear instrumental data, such as palatograms, from Chumash speakers, Harrington's unusually careful description of the language allows us to build a reasonable picture of what that data would probably have looked like. In the next section I shall argue that a reasonable model of phonetics and the phonology-phonetics interface, along the lines of the Windows model of Keating, can deal perspicuously with what seem to be the phonetic facts of Chumash sibilant harmony.

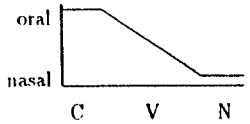
[1]Problems with directionality are especially acute for a spreading analysis of Chumash. Since the results of progressive assimilation seem not to be clearly distinguishable from those of regressive assimilation in terms of the segmental identity of the targets after spreading, there is no reason why we should expect progressive assimilation to be accomplished by a fundamentally different mechanism than regressive assimilation. We would need a second rule like (9), identical to (9) in all respects except its directionality and in its "strength" (however that is to be encoded), or else endow (9) with some kind of mirror-image ability that is almost never realized to its full potential. A phonetic-effect analysis, such as the one to be presented in the next section, has no such problems.

3 A phonetic model

An idea common to much recent work in phonetics (e.g., Keating 1988ab, Beckman and Pierrehumbert 1989) is that phonological specifications correspond in the phonetics to articulatory targets. These targets are temporally coordinated with each other. Articulators will move around in an attempt to realize each target at the appropriate point in time — all else being equal, they generally succeed.

Furthermore, articulators try to make as smooth as possible a transition from one target to another, resulting in a phenomenon Keating (1988b) refers to as "interpolation". For example, in English, where nasality is not distinctive for vowels, the amount of nasalization in the phonetic implentation of a syllable like *tan* will look like:

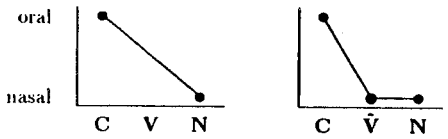
(11)



Here, the initial consonant has a definite target demanding that the velum be completely raised, and the final nasal consonant has a target demanding that the velum be lowered. The intervening vowel has no target of its own for nasality, so during the production of the vowel the velum will be making as smooth a transition as possible from its initial target to its final target, resulting in an intermediate and increasing level of nasalization throughout the vowel.

Keating (1988b) and Cohn (1990) use this effect to distinguish between phonological assimilation and phonetic assimilation. Phonetic assimilation is the result of interpolation – it is the intermediate level of some parameter that is a side effect of the articulator making a smooth transition from one target to another. Phonological spreading actually results in a new target for the phonetics. For example, English vowel nasalization is a phonetic assimilation involving two targets, as in (11), reformulated in (12a). If it had been a phonological spreading, it would have involved three targets, as in (12b):

(12)



While I shall not ultimately claim that Chumash involves phonetic spreading in the sense of interpolation, I will maintain that any analysis using a phonological feature changing rule will necessarily entail that the sibilants' articulatory targets in the phonetics should be more or less identical. While the Chumash behaviour Harrington observed may not be caused directly by interpolation, I believe it involves a phenomenon of which interpolation is an aspect, namely, the desire for ease of articulation.

Specifically, I argue that actual phonetic events are subject to two pressures, or, put another way, there are two measures of goodness that actual phonetic events will attempt to maximize.

(13) Two measures of phonetic goodness:
Goodness of fit
Articulatory goodness

Goodness-of-fit measures how closely the phonetic event meets the articulatory targets established by the phonology-phonetics interface.[2] Articulatory goodness measures how appropriate the phonetic event is as a sequence of actions that must be performed by pieces of anatomy that are subject to limitations (i.e., articulatory goodness measures what is traditionally referred to as ease of articulation).

The two measures are often in conflict with each other. For example, a phonetic event that involves an abrupt and difficult-to-coordinate transition from one gesture to another might score high on goodness-of-fit, but performs abysmally on the articulatory goodness measure. Both measures

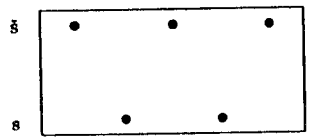
[2] Targets are pictured as points in (12). Keating (1988a) argues that these targets are better seen as "windows" — not exact points in the parameter space which the articulator must reach, but as bands of of allowable parameter values which are all acceptable. The difference is probably best seen as involving goodness-of-fit. In the most general formulation, a target can be seen as a function that maps points in a parameter space (e.g., anteriority, velum position) to the goodness-of-fit value the event would have if the articulator reached that point. A prototypical point-like target would have a graph with a narrow peak and steep sides. The graph of a prototypical "window" target would have a wide plateau.

cannot be maximized at the same time. To determine the overall goodness of a phonetic event, different weights are given to the two measures depending on such factors as rate of speech and formality — slow speech and formality tend to favour goodness-of-fit at the expense of articulatory goodness, faster speech and informality tend to favour articulatory goodness at the expense of goodness-of-fit.

Segments can have different goodness-of-fit properties. For example, it seems to be the case universally that targets for *š* are fussier than targets for *s*, that is, a deviation from the target for an *s* will incur a lesser penalty on goodness-of-fit than an equally large deviation from the target for a *š*.[3]

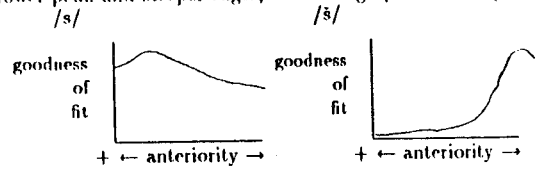
Applying these ideas to Chumash sibilant harmony, we see that the best explanation is obtained if we assume that there has been no phonological spreading at all and that all underlying values for [anterior] survive to the surface form and receive corresponding targets in the phonetic representation. The set of sibilant targets for a Chumash word might look something like:

(14)



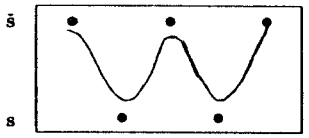
Rapid alternation between sibilants with opposing values for [anterior] is a very difficult task for the coronal articulator, as demonstrated by the seashells tongue-twister. Closely approaching all the targets in (14) will result in a phonetic event that scores very poorly on the articulatory goodness measure. In slower and more formal speech, where articulatory goodness tends to be sacrificed in favour of goodness-of-fit, a Chumash speaker might

[3] Using the idea of targets as functions from footnote 2, the graph for *š*'s target has a narrower peak and steeper edges, while the graph for *s*s target is relatively flatter:



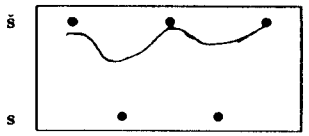
nonetheless decide to try to realize all the targets as closely as possible, resulting in a phonetic event like:

(15)



In faster speech, where goodness-of-fit tends to be sacrificed in favour of articulatory goodness, targets will be approached less closely[4] and the phonetic event would look more like:

(16)

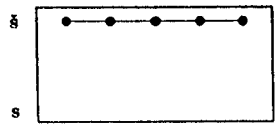


Through the interaction of purely phonetic principles, we have ended up with a phonetic event in (15) that looks very much like it may have been the result of a phonological assimilation process. But no phonological assimilation has taken place. All underlying values for [anterior] continue to survive. Their targets remain in the phonetic representation and continue to exert an influence (albeit a weakened influence) on the overall contour of the phonetic event. This is consistent with Harrington's description of the phenomenon, particularly with his emphasis on the frequency of intermediate articulations.

The predictions of the phonological feature-changing analysis for the phonetics are quite different. Since underlying values of [anterior] have been destroyed and replaced before the phonological surface level, they can have no influence on the shape of the phonetic event. The feature-changing analysis for (15) would end up with five identical [anterior] features at the surface level and five identical articulatory targets in the phonetic representation, and predicts a phonetic event like:

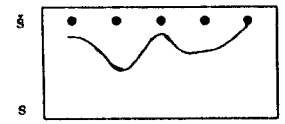
[4]particularly targets for *s*, where the penalty for non-realization is less severe.

(17)



This phonetic event is ideal under both measures of goodness. The articulator stays close to its targets, scoring high on goodness-of-fit. Producing a sequence of identical sibilants is quite easy (especially compared to producing a sequence of unlike sibilants), so the phonetic event would score high on articulatory goodness. Given this doubly ideal phonetic event, it is exceptionally puzzling why a Chumash speaker would ever (let alone usually) decide to produce a doubly sub-optimal event like:

(18)



In the normal course of events, one of the measures of goodness is usually sacrificed in order to improve the other measure. Here, for no apparent reason, *both* measures of goodness have been sacrificed and nothing has been gained in return.

The conclusion is that the analysis of sibilant harmony where no phonological spreading has taken place is consistent with what seems to be the actual phonetic behaviour of Chumash speakers, as observed by Harrington. On the other hand, the feature-changing analysis fails spectacularly to predict this behaviour, or even to be consistent with it.

I cannot claim to have definitively proven that Chumash sibilant harmony did not involve feature-changing action-at-a-distance, but I have at least demonstrated the prima facie plausibility of the belief that it did not and the prima facie implausibility of the belief that it did. Furthermore, the phonetic effect analysis is compatible with the restrictive phonological theories that phonologists have been trying to develop and that apply without problems to the vast majority of other harmony systems. While I may not be comfortable making claims about the phonetics a dead language, given these facts I would argue that the burden of proof is on those

who want to use Chumash as a counterexample to restrictive theories of phonology. At the very least, they should be able to provide some plausible story (consistent with at least one reasonable model of phonetics) for why underlying [anterior] features that have been deleted in the phonology remain around in the phonetics to cause intermediate articulations. Of course, finding a living language that behaves as Chumash was supposed to have would provide even firmer evidence and would help allay suspicions that the disproportionate number of dead languages on the list of supposed feature-changing action-at-a-distance rules is not just a convenient coincidence.

4 Further implications

The strongest possible claim would be that neither feature-changing operations nor action-at-a-distance as Chumash seemed to require are possible parts of a phonological theory. Unfortunately, this strongest claim may not be able to be maintained.

Of the small number of living languages in Shaw's (1990) list of potential coronal harmony systems, Navaho and Kinyarwanda do seem to provide some sort of evidence for action-at-a-distance, with Navaho also giving some weaker evidence for feature changing.[5]

Compared to the claims made for Chumash, Kinyarwanda sibilant harmony is almost well-behaved. As described by Kimenyi (1979), this process palatalizes an *s* to *š* before another *š*, provided that the two are separated by no more than a single syllabic nucleus. According to Maria Polinsky (p.c.), this process is categorical, and not gradient as in Chumash. The corresponding process in the closely related language Kirundi also appears to be categorical and non-gradient (Jeanine Ntihirageza, p.c.). The processes would thus seem to be the result of true phonological spreading in Keating's sense. But the phonological rules that would be necessary to accomplish the spreading would be nowhere as threatening to theoretical restrictiveness as the putative Chumash rule: they are arguably feature-adding rather than feature-changing (the harmony only applies in the *s* to *š* direction), and

[5] I am not aware of the phonetic details of the other two surviving harmony systems, Tahltan and Harari. Harari dental palatalization may involve action-at-a-distance, but will probably not require feature-changing. If Tahltan is significantly like Navaho, it too may prove problematic for eliminating feature-changing and action-at-a-distance altogether.

they are what we may call, for want of a better term, "semi-local", that is, they do not skip over any intervening consonants, even coronals.

Navaho is somewhat more problematic. Kari (1976: 84) indicates that the application of Navaho sibilant harmony is variable, but McDonough (1991) argues that many aspects of it are, like Kinyarwanda and Kirundi, categorical and non-gradient. Furthermore, they are less local and probably feature-changing.

McDonough divides Navaho sibilant harmony into three domains[6]. Within the Verb domain (consisting of the verb stem and the classifier prefix), any sibilants (including sibilant affricates) are required to share [anterior] values. Because of the structure of Athapaskan verb stems, this requirement is semi-local in the sense discussed for Kinyarwanda and Kirundi. Within the Infl domain (consisting of most of the remaining conjunct prefixes), two Infl stems exhibit a similar semi-local morpheme structure condition: *shish* 's-imperfective/1sg' and *sis* 's-perfective/1sg'. In addition, one aspectual morpheme obligatorily and two agreement morphemes optionally alternate to agree in [anterior] with the following Infl stem.[7] To complicate matters, there is one aspectual morpheme, *s* 'destruct', which causes the following Infl stem to agree with *it* in [anterior]. Finally, there is obligatory agreement in [anterior] between the Infl domain and the Verb domain, in which the feature of the Verb domain overrides that of the Infl domain.

If this harmony involves phonological spreading, it would have to be feature-changing. Each of the alternating prefixes has a default form of unpredictable anteriority which will surface in the absence of any surrounding [anterior]. When discussing the apparently analogous aspect of Chumash harmony, we briefly considered and rejected an analysis that relied on allomorphy. While we may eventually want to do so for Navaho as well, the reasons for rejecting allomorphy as a solution no longer seem quite so overwhelming. For Chumash, we would have had to accept that every morpheme in the lexicon containing a sibilant just happened to have two allomorphs, and the allomorphy selection principles just happened to be

[6] leaving aside the possibility of harmony among the disjunct clitics. McDonough (1990) provides evidence from other phonological rules that these domains are independently necessary.

[7] McDonough does not mention whether the optional assimilation of the agreement morphemes is an all-or-nothing choice between two categorical alternatives, or whether it is a gradient phenomenon along the lines of Chumash.

identical for every allomorph pair. In Navaho, on the other hand, the effects of an allomorphy analysis are limited to seven prefixes.[8] Furthermore, the seven prefixes show distinct lexical differences in their susceptibility to and triggering of sibilant harmony, which will somehow need to be encoded anyway.

While it is not self-evident that an allomorphy analysis is the most appropriate for Navaho, it is also not obviously inappropriate. If the only clear cases of feature-changing harmonies turn out to come from Navaho and similar related languages, then the limited price of allomorphy in these cases may be worth paying in order to allow our phonological theories to be as restrictive as possible.

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