The role of phonetic knowledge in phonological patterning
Corpus and survey evidence from Tagalog infixation

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0. Introduction

The task of linguistics could be viewed as discovering and explaining cross-linguistic regularities. In the realm of phonology, at least, it has become clear that this task is not as straightforward as it might seem. To take a simple example, it has observed that many languages assimilate a nasal consonant in place to a following obstruent (/an+pa/ → [ampa]), while assimilation to a preceding obstruent (/ap+na/ → [apma]) is less common . (See Steriade 2000, Hura et al. 1992 for discussion.) This typological observation is accompanied by a functional observation, in this case a phonetic one: a nasal's place of articulation is more difficult to perceive in the environment *vowel__obstruent* than in the environment *obstruent__vowel* (for most places of articulation). The problem lies is translating the phonetic observation into an explanation for the typological observation.

One possible mechanism is that humans' cognitive apparatus somehow encodes the undesirability of maintaining place where it is hard to perceive. That is, first, people must be able to learn in what environments nasal place is hard to perceive (or perhaps be endowed innately with this knowledge). And second, people must be biased against maintaining hard-to-perceive place contrasts. Under this approach, the functional motivation—phonetic knowledge plus a bias about how to apply it—is inside the mind. This is the position taken explicitly by Steriade 2000, for example, and is implicit in many other works (see Hayes & Steriade 2004). More generally, the idea that typological tendencies are to be explained by a bias in the mind has pervaded generative phonology since Chomsky and Halle 1968.

A second possible mechanism, however, is diachronic: because nasal place is hard to perceive in the *vowel__obstruent* environment, learners will have a tendency to mis-hear /an+pa/ as [ampa],[1] but to correctly hear /an+i/ as [ani]. If this misperception is widespread enough, it will appear to such a learner that the language has a process of nasal place assimilation to a

[1] See Hura et al. (1992) and discussion in Steriade (2000) however: misperceptions in this environment are mostly non-assimilatory.

following obstruent, and this will be encoded in the learner's grammar. Thus, languages without assimilation will tend to change into languages with assimilation, and this will be more frequent for pre-obstruent assimilation than for post-obstruent assimilation, since misperception is less likely in the *obstruent__vowel* environment. Under this approach, the functional motivation for the typological trend is outside the mind. Humans need not have any knowledge of perceptibility, let alone a bias about how to apply that knowledge. This is the position advanced by Blevins and Garrett (1998, 2004), Blevins (2004) under the name *Evolutionary Phonology*. See also Ohala 1981, 1993, and others; Hale & Reiss 2000; Hyman 2001; Myers 2002; Yu 2003, 2004.

Work in Evolutionary Phonology and in the same spirit has included two strands: diachronic explanations for functionally motivated "natural" typological patterns that seemingly remove the need for positing phonetic knowledge or bias (e.g., the work by Ohala); and examples of "unnatural" patterns (along with diachronic explanations of them) to show that they also are learnable (e.g., Hyman 2001, Yu 2004). For example, standing against the many languages with post-nasal voicing of obstruents (see Pater 1999; see Hayes & Stivers 1995, Hayes 1999 for an aerodynamic motivation), Hyman gives a case of post-nasal de̲voicing of obstruents.

The existence of these unnatural cases is important, because it rules out certain hard-line positions. For example, under the classic Optimality Theory (OT) idea that the constraint set is universal (Prince & Smolensky 1993/2004), we might want to say that only functionally motivated constraints belong to that set, and thus that only "natural" languages are possible. The Evolutionary Phonology program has shown that this position is not tenable, and that if the language faculty does include substantive biases, they are only that—biases—and do not rule out as unlearnable all languages that flout those biases. (Though it may still be true that there are limits on learnability, and that not every conceivable grammar is learnable.) See Wilson (in progress) for a development and implementation of the idea of soft biases within a constraint-based framework.

So we are left with two positions: the language faculty contains either soft substantive biases or no substantive biases at all. The diachronic-explanation aspect of the Evolutionary Phonology program has shown that it is dangerous to make inferences about substantive biases from typology, because typological patterns may result from those biases, or they may result from tendencies in language transmission. One response to this situation is to continue to investigate, in individual cases, whether a purely diachronic account of a typological tendency is constructible, but another is to ask whether we can test hypotheses about mental biases using other types of data.

An approach taken by many researchers has been to probe humans' behavior in situations where it is not directly determined by their native-language experience, so that the history that shapes that experience cannot be an explanation for the behavior (another is to probe processing of "natural" vs. "unnatural" native-language phonology, as in Zhang & Lai (in progress)). This type of research has included artificial language-learning experiments (Guest, Dell & Cole 2000; Pater & Tessier 2003; Pycha & al. 2003; Wilson 2003), including novel language games (Treiman 1983, Derwing & al. 1988, Pierrehumbert & Nair 1995). Less commonly, there has been research on literary invention, such as puns, rhymes, and alliteration, mostly using corpora (Minkova 2001, Fleischhacker 2002b, Steriade 2003). The study of the phonological adaptation of loans also falls into this category, though interpreting the data is made more difficult by the question of perception (see section 4.2). Perhaps least commonly, there has been research on the extension of authentic native-language grammar to unprecedented cases—that is, not just the application of native-language grammar to novel words (the "wug-testing" pioneered by Berko 1958), but its application to novel types of words. The "plural of *Bach* test" proposed by Lise Menn (Halle 1978) would be an example: is it [baxz], [baxs], or [baxɨz]? This article aims to contribute to the debate on substantive biases in the language faculty by presenting evidence from a study of this last type, involving infixation in Tagalog stems with novel initial clusters.

Section 1 reviews previous findings on cluster splittability and explains the relevance of Tagalog infixation. Section 2 presents evidence from a written corpus of Tagalog, and section 3 presents evidence from a survey of Tagalog speakers. It will be argued that both the corpus and the survey evidence follow a predicted cross-linguistic pattern, that a diachronic explanation is unlikely, and that therefore Tagalog speakers do have phonetic knowledge of consonant clusters and a bias about how to apply that knowledge. Section 4 sketches an OT analysis, which includes a proposal about the form of constraints that regulate similarity between related surface forms. Section 5 considers some alternative explanations of the data.

1. Cluster splittability

1.1 Previous findings

There has been considerable previous study of how word-initial consonant clusters behave in various situations where the cluster could potentially be split. The most extensive evidence comes from epenthesis in loanword adaptation or second-language phonology, and the most robust finding there has been that stop-liquid clusters are more splittable than sibilant-stop clusters (Fleischhacker 2002a; Broselow 1983/1987/1992; Singh 1985). The pattern found in Farsi (from Fleischhacker 2002a; see also Shademan 2003) is typical. Foreign words beginning with a sibilant-stop cluster receive an initial prothetic vowel, leaving the cluster intact, as in ***e**sparta* 'Sparta', whereas words beginning with a stop-liquid cluster receive an epenthetic vowel that splits the cluster, as in *p**e**lutus* 'Plutus'. The pattern is repeated in many other languages, and the reverse does not seem to be attested.

This finding is corroborated by results of an artificial language game study by Pierrehumbert & Nair 1995 (see also Fowler, Treiman & Gross 1993), in which English speakers were taught to insert various VC infixes into real words. When participants were tested on words beginning with clusters, where outputs such as *st-əl-ʌb* or *s-əl-tʌb* would be possible for 'stub', and *pl-ək-ænət* or *p-ək-lænət* for 'planet', "[t]he cluster /st/ split the least, and the clusters /sl/ and /pl/ split the most." (p. 101).

Fleischhacker 2002b presents additional evidence for a sibilant-stop vs. stop-liquid difference, such as onset simplification (e.g., Gothic *ge-grot* 'wept' vs. *ste-stald* 'possessed'), imperfect puns (relative frequency of puns like *<u>B</u>onaparte* ~ *<u>bl</u>own apart* vs. *<u>s</u>urgeon* ~ *<u>st</u>urgeon*), and alliteration (see also Minkova 2001).

One problem in interpreting the difference between these two types of C_1C_2 cluster is that they differ in both C_1 (sibilant vs. stop) and C_2 (stop vs. liquid), making it hard to pin down the source of the difference in behavior. Examining sibilant-C clusters permits a more controlled comparison, since we can hold C_1 constant and vary C_2. This is what Fleischhacker 2002a does, looking again at epenthesis in loan adaptation. She discovers an implicational hierarchy, schematized in (1). Within a given language, if one of the clusters in (1) splits, clusters to the right of it must also split. (For full details, including the distribution of prothesis vs. no repair, see Fleischhacker 2002a.)

(1) ST Sm Sn[2] Sl SR SW

(*S* = sibilant; *T* = stop; *R* = rhotic; *W* = glide)

Partial reduplication (Fleischhacker 2002b) provides some support for this hierarchy, distinguishing *ST* from the rest.

Fleischhacker's explanation for this hierarchy is perceptual. She proposes that in all the cases above, there is a preference to keep the two related forms (foreign word and loan, uninfixed and infixed, etc.) perceptually similar. Noting that all the types of splitting above share the property that if C_1C_2 is split, C_1 becomes vowel-adjacent (C_1V…), as summarized in (2), Fleischhacker focuses on the similarity between the C_1-to-C_2 transition in the unsplit form and the C_1-to-V transition in the split form. She proposes the scale of perceptual distance (Δ) shown in (3).

(2)	unsplit		split	
epenthesis	C_1C_2V...	(foreign word)	$C_1\mathit{V}C_2V$...	(adapted)
VC infixation	C_1C_2V...	(uninfixed)	C_1-*VC*-C_2V...	(infixed)
reduplication	C_1C_2V...	(base)	C_1V...	(reduplicant)
pun	C_1C_2V...	(one member of pun pair)	C_1V...	(other member of pun pair)
alliteration	C_1C_2V...	(one member of allit. pair)	C_1V...	(other member of allit. pair)

(3) $\Delta(C_1T, C_1V) > \Delta(C_1m,C_1V) > \Delta(C_1n,C_1V) > \Delta(C_1l,C_1V) > \Delta(C_1R,C_1V) > \Delta(C_1W,C_1V)$

The underlying idea is that the transition from C_1 into C_2 is more vowel-like the more sonorous C_2 is. Thus, the difference $\Delta(C_1W,C_1V)$ between C_1W, a consonant-glide sequence, and C_1V is small, whereas $\Delta(C_1T, C_1V)$ is large. Under the assumption that there is a preference to preserve similarity between the two related forms, splitting should be most likely when the difference $\Delta(C_1C_2, C_1V)$ is small:

(4) *least splittable* CT Cm Cn Cl CR CW *most splittable*

(holding C constant)

[2] Why a difference between *m* and *n* in this apparently sonority-based scale? It can be argued that [n] is more vowel-like than [m] because nasal-antiformants that might interfere with vowel-like formant structure are higher (and thus interfere less) for [n] than for [m]. See Zuraw (2005) for a discussion of this, based on an idea of Daniel Silverman.

(The influence of the first C is unclear. Fleischhacker 2000a finds evidence, from Farsi and Wolof, that stop-liquid clusters pattern as more splittable than sibilant-liquid clusters. In Farsi, all stop-liquid clusters split, but not all sibilant-liquid clusters do (*sl* undergoes prothesis, and *sr* splits). Broselow (1992) reports that one Wolof speaker treats *sm*, *sn*, and *sl* the same as stop-liquid (all split), but the speaker consulted by Fleischhacker shows lexical variation in *sm*, *sn*, and *sl* clusters (some split, some do not), whereas stop-liquid always splits. On the basis of these data, Fleischhacker incorporates *TR* into the *SC* scale: ST < Sm < Sn < Sl < Sr < SW < TR, but we could also characterize the facts with a two-dimensional scale: [3]

(5) ST < Sm < Sn < Sl < Sr < SW
∧ ∧
Tl Tr

If this perceptual phonetic account is correct, there remains, however, a problem in translating it into an explanation for the cross-linguistic pattern. As in the nasal-assimilation example above, one possible explanation is that the phonetics are inside the mind of the speaker: speakers are able to determine how similar a C_1C_2-C_1V pair is, and are biased to keep pairs such as foreign word and loan, or base and reduplicant, similar. This would follow Steriade's (2000, 2001) proposals concerning the "P-map". But another possible explanation lies in language transmission. Taking the loanword/L2 epenthesis examples, perhaps speakers are more likely to misperceive a C_1C_2-initial foreign word as having a vowel between the two Cs if C_2 is more sonorous; under this account the grammar plays no role in determining where to insert vowels, and no phonetic knowledge is required of speakers. It is less obvious how this explanation would extend to the other cases (reduplication, infixation, puns, alliteration), but if such an extension is possible, it would mean that the phonetics are outside the mind of the speaker.

[3] Gouskova (2001) gives new data from Kirgiz (loans from Russian) that vary the sonority of C_1. Gouskova proposes that sonority difference between C_1 and C_2 is crucial: if the sonority is flat or falling, prothesis occurs (Vst, Vlb, Vzv, etc.), but if sonority is rising, anaptyxis occurs (kVv, pVn, mVr, etc.). Gouskova accounts for this with markedness constraints on syllable contact, but a Fleischhackerian account could also be imagined, which would require the assumption that the similarity of the C_1-C_2 transition to a C_1-V transition is sensitive not only to the sonority of C_2, but also to the sonority difference between C_1 and C_2.

The pun, alliteration, and language-game findings do seem to suggest implicit knowledge, since they involve on-the-spot invention and not merely application of a learned pattern whose origin may be the result of historical transmission. The Tagalog data to be presented here, it will be argued, provide further evidence against a purely historical or misperception-based account.

Certain Tagalog verbs take the infixes *um* and *in* (*um* is used for actor-focus forms, *in* for others) to mark realis aspect (*um* also marks infinitives), as shown in (6). (Schachter & Otanes 1972, French 1988, Prince & Smolensky 1993/2004, McCarthy & Prince 1993)

(6) bago 'new' b-um-ago 'to change'

Native words in Tagalog do not have initial consonant clusters (except for some stop-glide clusters created by optional syncope; see section 5.1 below). Tagalog has many loans from Spanish and English that do begin with clusters, however, and these words may be infixed. Two main patterns result, as illustrated in (7): the infix may be placed inside the cluster or after it (Ross 1996, Maclachlan & Donohue 1999, Orgun & Sprouse 1999). (There is also a rarer pattern, *g**um**aradwet*, *p**in**orotekta-han*; see section 5.2 for some discussion of epenthetic vowels.)

(7) 'graduate' g**um**radwet ~ gr**um**adwet
'protect' p**in**rotekta-han ~ pr**in**otekta-han

(The pronunciation of orthographic *r* varies: in native words and loans from Spanish, it represents a tap, [ɾ]. But in loans from English it varies between [ɾ] and an English-like [ɹ]. Since the data discussed here are from a written corpus and a written survey, the exact pronunciation for each token is unknown, so I will use *r*.)

The situation when these loans first entered the language is similar, then, to the Pierrehumbert & Nair 1995 language game: speakers who had learned how to insert a VC infix into words beginning with a single consonant extended the pattern to words beginning with consonant clusters. This required making a decision, in each case, about whether to split the cluster. As in all the cases above, when the C_1C_2 cluster is split, C_1 becomes vowel-adjacent (followed by *u* or *i*). Thus, if Fleischhacker's perceptual explanation is correct, the sonority of C_2 should determine the cluster's splittability.

The empirical question to be addressed here is what differences might exist in splittability among clusters in Tagalog infixation, and whether these follow the cross-linguistically based predictions above. The data to be discussed in section 2 come from established loan clusters, and those in section 3 come from poorly attested clusters. In both cases, speakers' treatment of clusters does follow the cross-linguistic pattern.

2. Corpus

The first set of data comes from a written corpus of Tagalog. The corpus is made of text from the Web. The method for constructing it was as follows. First, a smaller corpus, generously supplied by Rosie Jones (derived from Ghani, Jones & Mladenic 2004, whose idea inspired the procedure used here), was used to estimate Tagalog word frequencies. A Perl program generated strings composed of frequent Tagalog words, such as those shown in (8).

(8)	string	gloss of each word
	kami pangulo	we(excl.) president/chief
	lalo parang	more/much for-*linker*
	+*at salita oo*	and language/declaration/word yes
	tagalog pagiging	Tagalog being
	noong akin aklat	then-*linker* mine book

A program written by Ivan Tam sent these strings as queries to Google (www.google.com), using the Google Web APIs service. This explains the "+" in the third string above: Google ignores common function words such as English *at* unless preceded by "+" (*at* happens to be the frequent word 'and' in Tagalog). The Google web APIs allow a maximum of 1,000 queries per day, with each query returning a maximum of 10 URLs (web page addresses); if a query produces more than 10 results, only 10 are returned at a time and each request for the next 10 counts as another query. Thus, a theoretical maximum of 10,000 URLs can be retrieved per day, but the typical number is approximately 5,000, since not all queries return the full 10

URLs. Because each Google search returns at most 1,000 results, it is important to send a variety of queries in order to give a variety of Tagalog web pages a chance to surface in the top 1,000.

The URLs retrieved each day are compared against those retrieved so far, and the new ones pulled out. Tam's program then retrieves the full text of each of the new URLs, though an existing program such as GNU wget can also be used. The corpus continues to be augmented, but at the time of the numbers reported here it contained 98,607 pages and approximately 20 million words of Tagalog.

The corpus can be converted into a list of word types, with token frequencies for each. A fragment is shown in (9).

(9) ....

magbabala	33
magbabalak	21
magbabalance	2
magbabalangibog	2
magbabalangkas	4
mag-babalangkas	1
magbabalanse	2
magbabalaod	10
magbabalat	2
magbabalatkayo	7
magbabalaud	5
magbabalay	2
magba-balebol	1

...

This file can then be searched for regular expressions corresponding to potentially infixed forms, such as `[ptk]in[lr][aeiouwy]` (*p*, *t*, or *k* followed by *in*, followed by *l* or *r* and then *a*, *e*, *i*, *o*, *u*, *w*, or *y*). The results must be hand-checked to eliminate strings that are not actually infixed forms, such as the proper name *mckinley*.

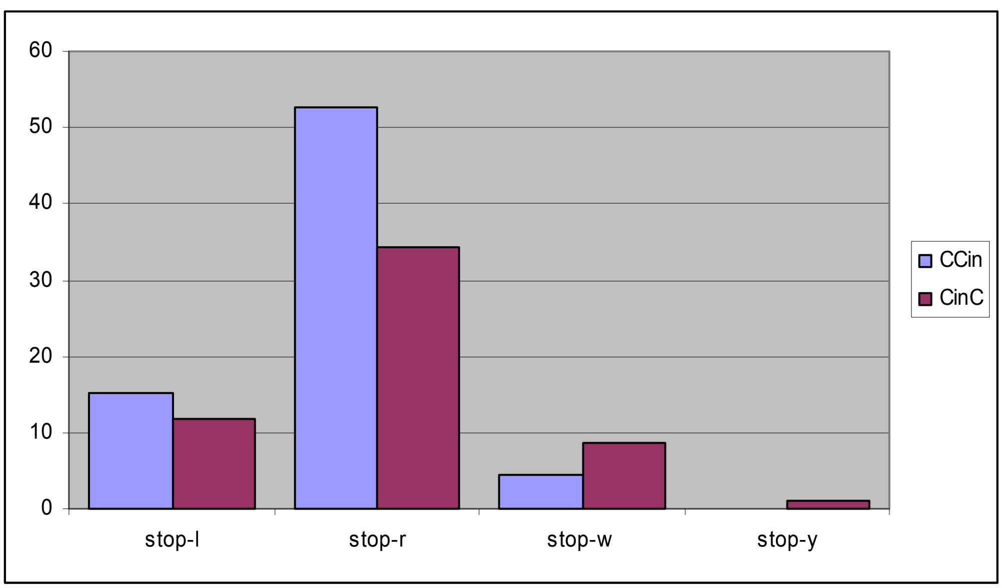
The initial clusters that have been borrowed into Tagalog as initial clusters are almost exclusively C-glide and stop-liquid.[4] (As discussed in section 3 below, *SC* clusters other than *s-glide* normally undergo prothesis, so that the stem is no longer cluster-initial.) But we can still

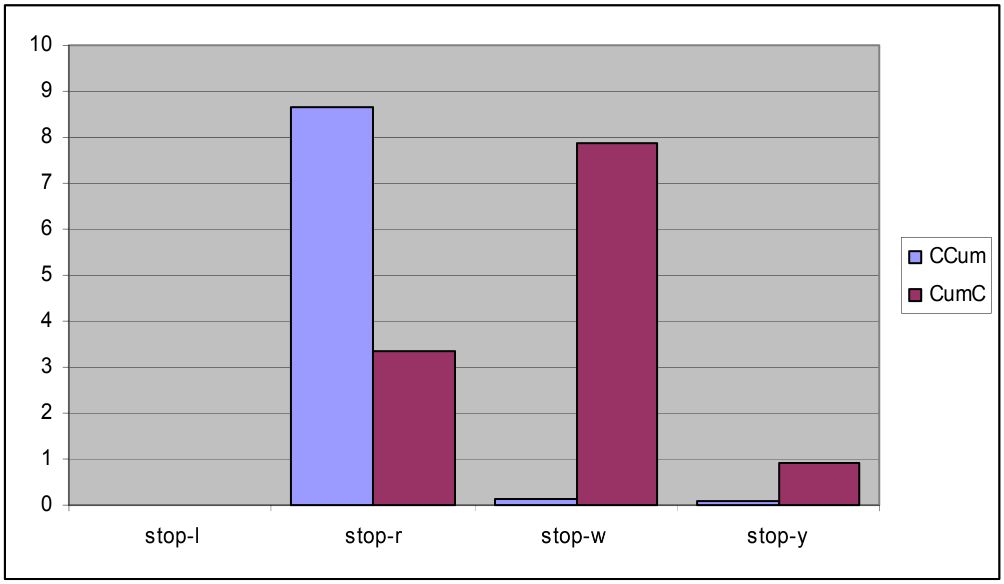
[4] There are some loans beginning in nasal-glide or liquid-glide (*mw*, *my*, *ny*, *ly*), but no infixed examples were found in the corpus. There are also loans beginning in *fl* or *fr* that take infixes, but none beginning in *fw* or *fy* (that take infixes) to compare them to.

test one prediction made by Fleischhacker's perceptual account. Although she does not compare different stop-C clusters, we can compare stop-liquid to stop-glide in the corpus data. Fleischhacker's perceptual explanation predicts that stop-glide should be more splittable than stop-liquid, just as sibilant-glide was found to be more splittable than sibilant-liquid.

The graph in (10) shows resulting frequencies for both split and unsplit variants, for both types of cluster (*ty*, *dy* are omitted because they can function as digraphs for [t͡ʃ], [d͡ʒ]; reduplicated forms are also omitted—see section 5.2). Frequencies are a combination of type and token frequency (most of the frequent stems appear with both variants, so type frequencies alone are not informative): in the top chart, for the infix *in*, each stem that appears with that infix contributes a total of 1 to the columns, divided according to proportional frequencies. For example, for the stem *practice,* there are 16 tokens total, 6 of *pr**in**actice/pr**in**aktis* and 10 of *p**in**ractice/p**in**raktis*, so the stem contributes 0.4 (6/16) to the *CCin* (cluster not split) column for stop-*r*, and 0.6 (10/16) to the *CinC* (cluster split) column for stop-*r*. The lower chart, for the infix *um*, works the same way.

(10)



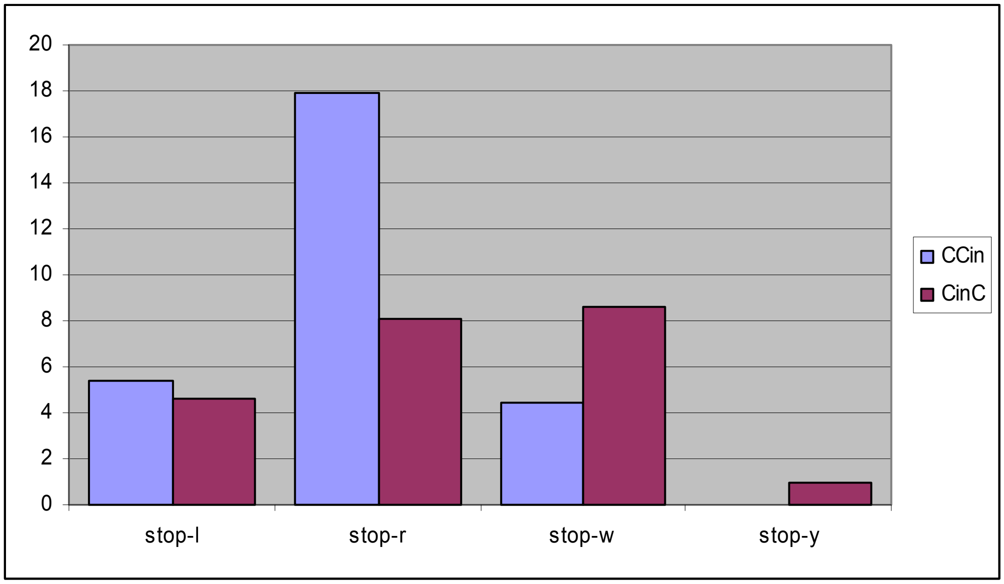


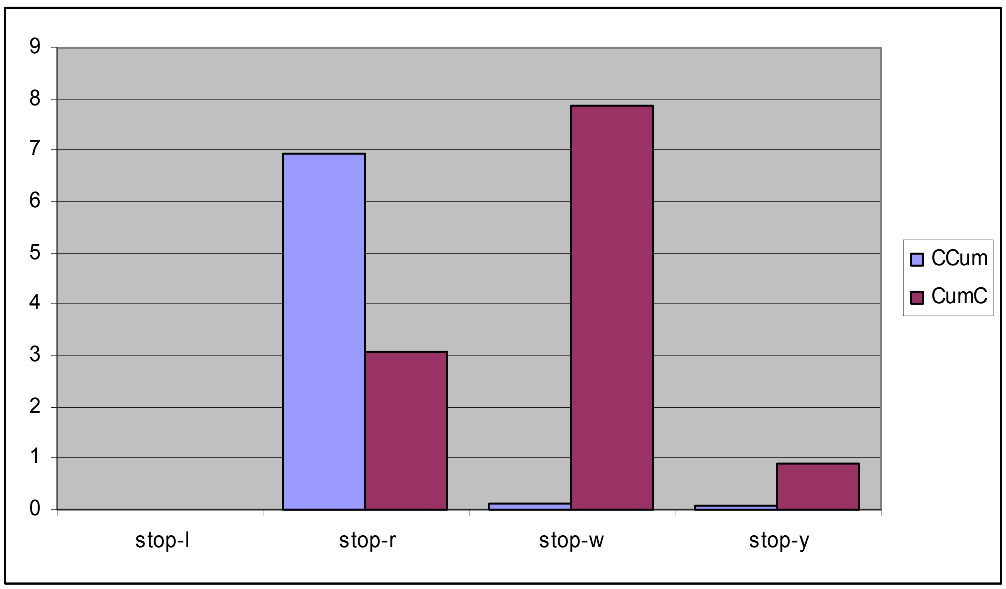
The main trend to note is that for stop-liquid clusters, non-splitting more common, but for stop-glide clusters, splitting is more common. This is true for both infixes, though the numbers are less robust for *um*. The trend seems to be sharper for stop-glide clusters with *um* (though overall numbers are smaller). This may because of an observation of Orgun & Sprouse (1999) that there is a strong dispreference for the infix *um* to follow *w* or *m*. In the case of C*w* clusters, this would mean that there would be an additional pressure for *um* to split the cluster (and since most of the stop-glide data are from stop-*w* clusters, this probably explains the difference).

There is a possible etymological confound.[5] English is poor in words beginning with stop-glide sequences, and the stop-glide categories in the corpus data are made up entirely of Spanish loans, whereas the stop-liquid categories are a mix of English and Spanish loans. If there is a difference in splitting behavior between the two etymological classes, this could skew the results. The charts in (11) show the results for Spanish-origin[6] loans only, and although the numbers are smaller, the trend remains the same.

[5] Thanks to participants in the UC Berkeley linguistics colloquium for pointing this out.
[6] It is not always easy to determine whether a word is a Spanish loan. *Translado* 'translated' for example, appears Spanish, but is not a real Spanish word; more likely, it is the English word *translate* altered to look more Spanish (and thus more Tagalog, since Spanish loans have been in the language much longer and are better incorporated) by using the English-to-Spanish *-ated/-ado* correspondence. Other alterations are not so easy to detect. For example, is *transporma* from Spanish *transformar* or from English *transform*, with the *-a* added to give a more Spanish appearance? Clearly English-origin items such as *translado* are excluded from the Spanish-origin counts, but ambiguous cases such as *transporma* are included.

(11)





Thus, as predicted, stop-glide clusters are treated as more splittable than stop-liquid clusters. These results are not entirely decisive, however, on the question of whether speakers have implicit phonetic knowledge and a bias in how to apply it. These loans, especially the Spanish ones, have been in the language for some time, so it is possible that rather than individual, on-the-spot decisions about how to infix words, we are now witnessing the conventions that have resulted from historical transmission, and the original motivation for treating stop-glide and stop-liquid clusters may not have involved any bias on speakers' part. For example, some older loans from Spanish have an epenthetic vowel, as in *palantsa* 'iron', from Spanish *plancha*. If, as appears to be the case (and as would be predicted by Fleischhacker), this epenthesis is more common in stop-glide clusters than in stop-liquid clusters, the greater splittability of the stop-glide clusters could be a historical relic of their previous status as non-clusters (see section 5.2 for further discussion along these lines).

A better testing ground would be clusters that are unattested or nearly unattested, since there should be no existing convention on how to treat them, and speakers will be forced to make their own decisions. Such a testing ground does exist: sibilant-consonant (SC) clusters. Except for *s*-glide, *SC* clusters are rare word-initially in Tagalog. Spanish does not allow word-initial *SC* clusters except for *s*-glide, so no such clusters come in from Spanish loans. English does of course have a range of *SC* clusters, but, except for *s*-glide, they normally undergo prothesis when borrowed into Tagalog. For example, 'score' is normally pronounced *ʔiskor*, and the infix is placed before the prothetic vowel (*ʔ-um-iskor*), so that the issue of whether to split the cluster does not arise. Speakers do not entirely reject non-prothesized forms, but they very rarely occur with infixation. In the corpus, there were only 24 tokens, 17 of them the nickname of a sports team (*eskumor*, based on 'score', which unusually has prothesis but an infix after the cluster).[7]

What will speakers do, then, if forced to perform infixation on words beginning with *SC* clusters? Will they follow the cross-linguistic pattern identified by Fleischhacker?

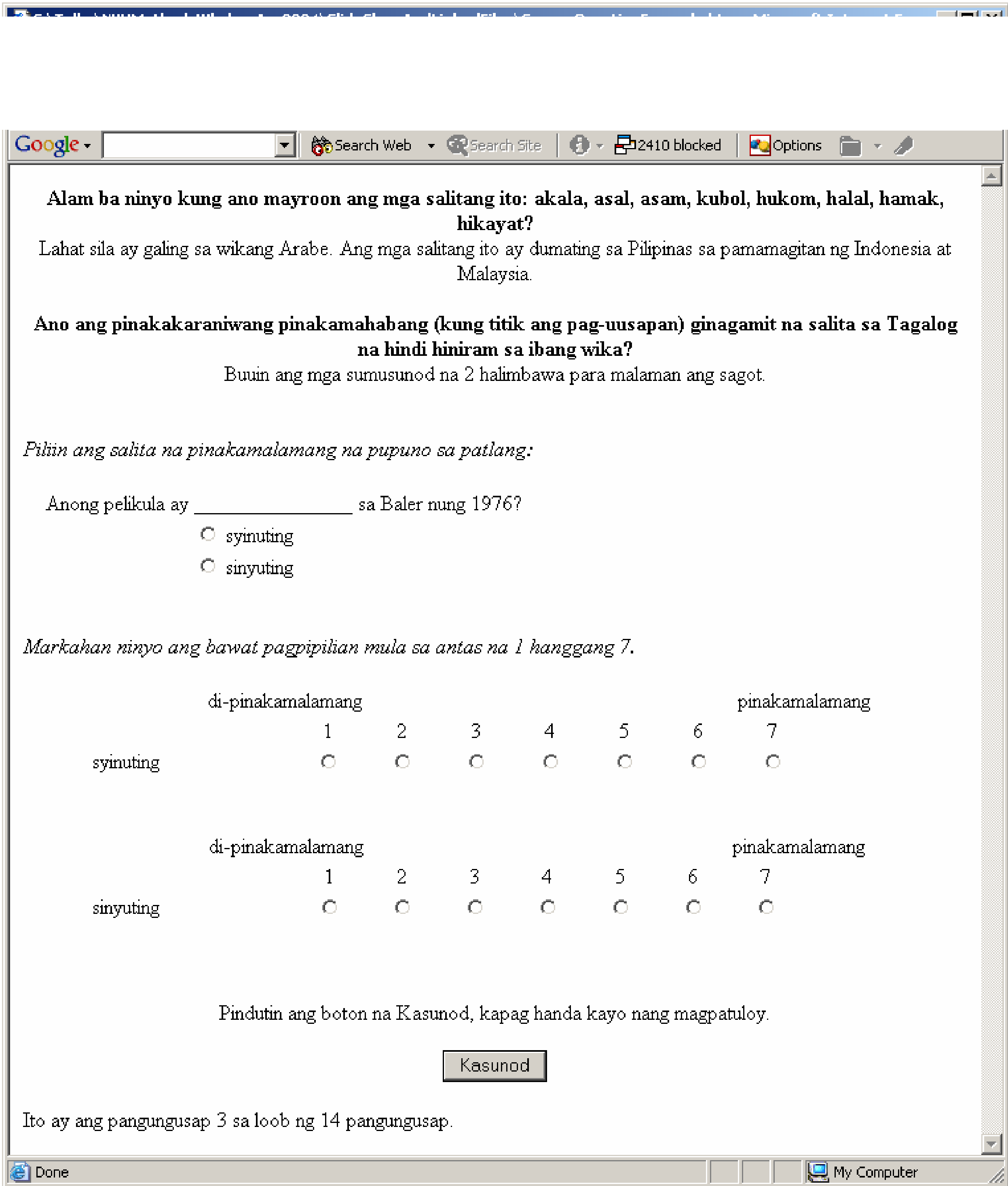
3. Survey

A survey was conducted to probe speakers' behavior on sibilant-consonant clusters, as well as to confirm the corpus findings on stop-consonant clusters. The survey was conducted over the web. This allowed participants to be located anywhere in the world while completing the survey. In particular, it was hoped that many of the participants would be living in the Philippines, and 35 (out of 62 participants who provided usable data). reported that they were. Participants were recruited through announcements in Tagalog-language web forums that contained a link to a welcome page. That page collected demographic information in such a way as to screen out non-

[7] The other tokens are *scr**in**utinize* (from *scrutinize*), *isk**in**etch* (from *sketch*—this word may have the prefix *i-* or be formed similarly to *eskumor*), *sl**in**ice* (from *slice*), *s**in**low* (from *slow*), *spr**in**ayan* (from *spray*, with the suffix *–an*), *sp**in**ray-paint* (from *spray-paint*), *st**in**alk* and *st**in**o-stalk* (from *stalk*), *str**um**ay* (from *stray*), and *str**um**ing* (from *string*).

Tagalog speakers (the directions and questions are in Tagalog, and each response must be typed into a plain textbox; understanding of Tagalog is necessary to provide appropriate answers). The participant would then see 14 screens like the one shown in (12). Every second item begins with a fun fact in teaser-and-answer form. This was the only reward for participation. The materials were real sentences adapted from the corpus. The participant must choose the best option to fill in the blank, and then rate each option. The stimuli were real words when possible, except that any prothetic vowel in the original sentence was removed. For *sm* and *sn*, no good examples could be found, so sentences with Tagalog synonyms of *smuggle* and *snow* were used, and the loans substituted (without prothesis) for the original words. Item and response orders were randomized separately for each participant. Professional translations were provided by 101 Translations. See the appendix for details on the survey materials and criteria for data inclusion.

(12)



Alam ba ninyo kung ano mayroon ang mga salitang ito: akala, asal, asam, kubol, hukom, halal, hamak, hikayat?

Lahat sila ay galing sa wikang Arabe. Ang mga salitang ito ay dumating sa Pilipinas sa pamamagitan ng Indonesia at Malaysia.

Ano ang pinakakaraniwang pinakamahahabang (kung titik ang pag-uusapan) ginagamit na salita sa Tagalog na hindi hiniram sa ibang wika?

Buuin ang mga sumusunod na 2 halimbawa para malaman ang sagot.

Piliin ang salita na pinakamalamang na pupuno sa patlang:

Anong pelikula ay ________________ sa Baler nung 1976?

- ○ syinuting
- ○ sinyuting

Markahan ninyo ang bawat pagpipilian mula sa antas na 1 hanggang 7.

	di-pinakamalamang						pinakamalamang
	1	2	3	4	5	6	7
syinuting	○	○	○	○	○	○	○

	di-pinakamalamang						pinakamalamang
	1	2	3	4	5	6	7
sinyuting	○	○	○	○	○	○	○

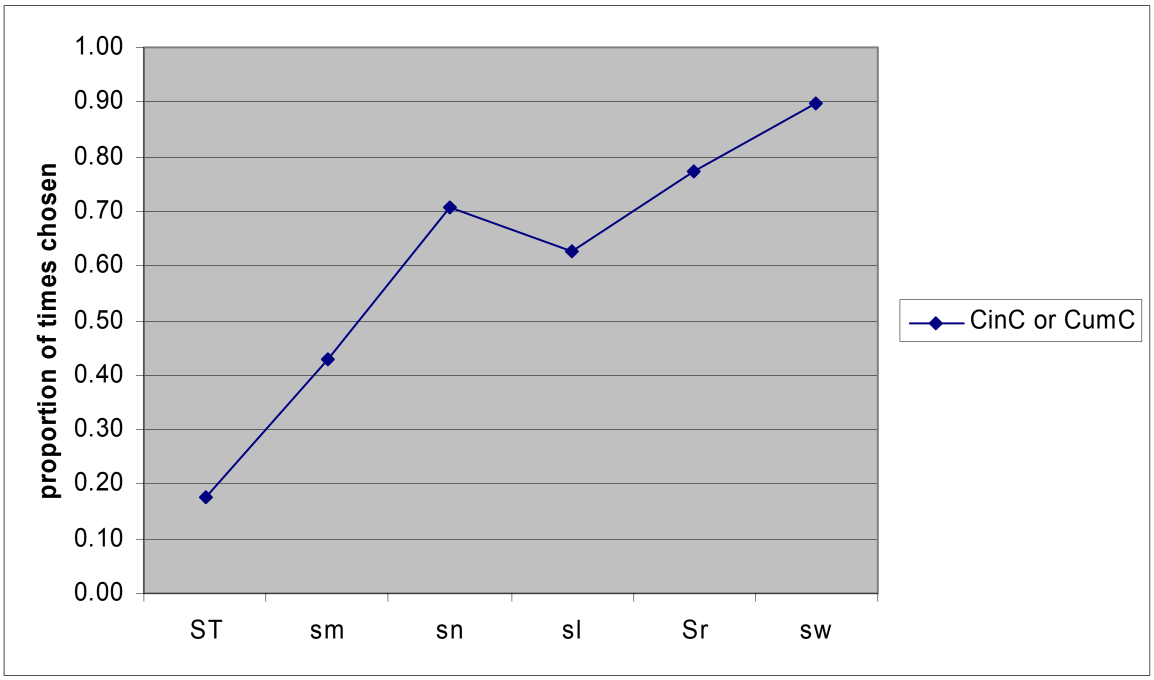
Pindutin ang boton na Kasunod, kapag handa kayo nang magpatuloy.

[Kasunod]

Ito ay ang pangungusap 3 sa loob ng 14 pangungusap.

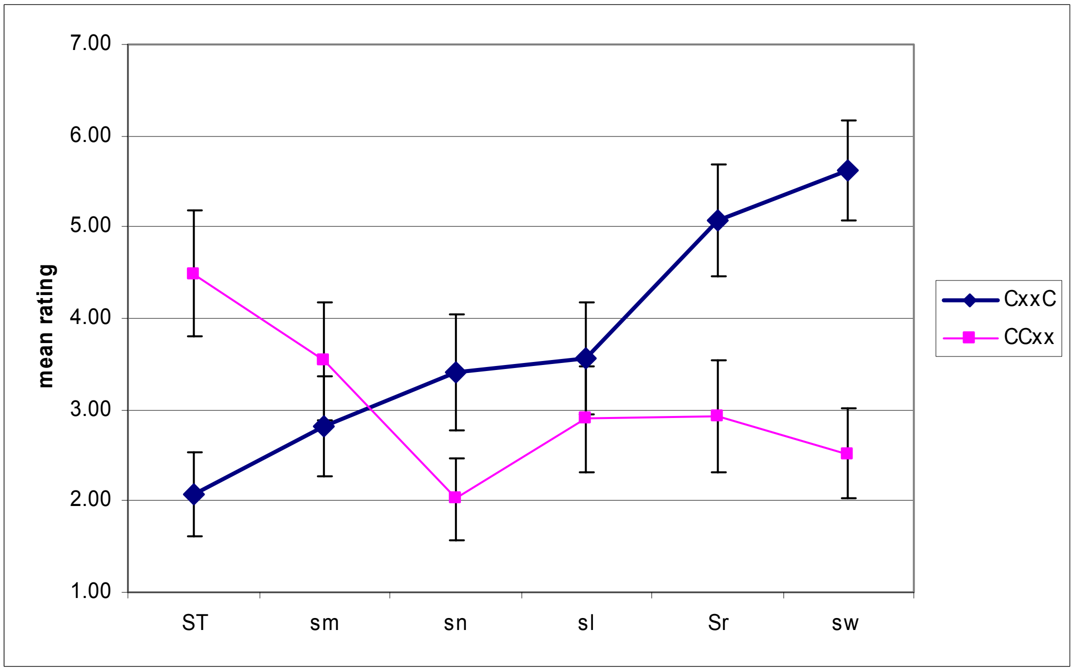
Results are of two kinds, choices and ratings. The chart in (13) shows, for each cluster type, the proportion of the time that participants chose the split-cluster option (since this was a binary forced-choice task, the proportion of the time that participants chose the non-split option is simply the mirror image). We can see that splitting was seldom chosen for *s*-stop clusters (on the left), but was usually chosen for *sw* clusters (on the right).

(13)



The chart in (14) shows, for each cluster type, the average rating assigned by participants. Error bars indicate 95% confidence interval. Note that the vertical axis shows the full range of possible ratings, from 1 (worst) to 7 (best). Looking first at the heavier line—CxxC, ratings for split-cluster options—we see that the rating is lowest for *s*-stop clusters, and highest for *sw*. The lighter line (CCxx) shows ratings for non-split options. Although the rating is highest for *s*-stop clusters, it is still not very high. This is to be expected, since normally a word beginning with an *s*-stop cluster would undergo prothesis; that is, neither infixation option is expected to be very acceptable.

(14)



Because the theory predicts in which direction each difference should be, we can perform paired (by participant) *t*-tests on each pair of cluster types. The table in (15) shows, for each pair of clusters, whether they behave significantly differently according to each of three measures: *t*-test comparison of rating differences between split and unsplit, *t*-test comparison of log ratio of split to unsplit rating, and Fisher's Exact Test on the number of times the split and unsplit options were chosen. The *p*-values shown for all tests are one-tailed: they test whether there is a difference in the predicted direction. No differences in the non-predicted direction (that is, ratings and choices for *sn* vs. *sl*) were significant.

(15)

		sT	sm	sn	sl	sr	sw
	sm						
rating differences		*n.s.*					
rating log ratios		*n.s.*					
choices		*p*<.01					
	sn						
rating differences		*p*<.0001	*p*<.001				
rating log ratios		*p*<.0001	*p*<.005				
choices		*p*<.0001	*p*<.005				
	sl						
rating differences		*p*<.005	*p*<.005	n.s.			
rating log ratios		*p*<.005	*p*<.01	n.s.			
choices		*p*<.0001	*p*<.05	n.s.			
	sr						
rating differences		*p*<.005	*p*<.005	n.s.	*n.s.*		
rating log ratios		*p*<.005	*p*<.005	n.s.	*n.s.*		
choices		*p*<.0001	*p*<.001	n.s.	n.s.		
	sw						
rating differences		*p*<.0001	*p*<.0001	*p*<.005	*p*<.005	n.s.	
rating log ratios		*p*<.0001	*p*<.0001	*p*<.05	*p*<.005	n.s.	
choices		*p*<.0001	*p*<.0001	*p*<.05	*p*<.005	n.s.	

I conclude from these results that Tagalog speakers do indeed make distinctions among non-*sw SC* clusters, despite having almost no previous experience of how to infix words that begin with them. This suggests that speakers do have implicit knowledge about the splittability of these clusters.

4. OT analysis

Steriade (2000, 2001) proposes that language users have a P-map, or perceptual map, that they can use to look up the perceptual distance between two fragments of phonological material, such as word-final voiced bilabial stops vs. word-final bilabial nasals. Steriade argues that these P-map distances translate into constraint rankings: a faithfulness constraint is ranked by default according to the size of the perceptual difference that its violation creates. That is, if constraint FAITH1 is violated when underlying *x* becomes surface *y*, and FAITH2 is violated when underlying *z* becomes *w*, and $\Delta(x, y) > \Delta(z,w)$, then FAITH1 >> FAITH2 (for underlying-surface or input-output correspondence—the same principle applies within other correspondence-constraint families, such as output-output or base-reduplicant.) I would soften this claim (as may have been Steriade's intent) to say that FAITH1 outranks FAITH2 by default: if a learner has no language-specific evidence to overturn that ranking, then the ranking stands, though it may be detectable only through probes such as literary invention, loan adaptation, and experimental tasks. This allows for the possibility that a series of historical events could lead to a situation in which the data compel learners to overturn the default ranking.

The similarity hierarchy proposed by Fleischhacker 2000a (3) is repeated as (16), with *S* substituted for C_1 in order to follow Fleischhacker more closely. Adopting Steriade's proposal, Fleischhacker translates the similarity scale into the constraint ranking in (17).

(16) Δ(ST, SV) > Δ(Sm,SV) > Δ(Sn,SV) > Δ(Sl,SV) > Δ(Sr,SV) > Δ(SW,SV)

(17) DEP-V/S_T >> DEP-V/S_m >> DEP-V/S_n >> DEP-V/S_l >> DEP-V/S_R >> DEP-V/S_W

DEP constraints (McCarthy & Prince 1995) penalize insertion of segments. These are context-sensitive DEP-V constraints, which penalize insertion of a vowel in a particular context, such as between a sibilant and a stop (S__T) as in /sparta/ → [s**e**parta]. By ranking LEFT-ANCHOR (McCarthy & Prince 1995: the leftmost segment of the underlying form must correspond to the leftmost segment of the surface form) at some point in this scale, Fleischhacker obtains a given language's cut-off point for cluster splitting. Additional markedness and faithfulness constraints determine which unsplit clusters are adapted faithfully and which receive a preceding epenthetic vowel. Prince & Smolensky's 1993/2004 *COMPLEX, the markedness constraint penalizing consonant clusters, drives the epenthesis (For languages where no clusters receive a preceding epenthetic vowel, the cut-off constraint is not LEFT-ANCHOR but rather a markedness constraint against consonant clusters). The tableaux in (18) illustrate the analysis for a language which prothesizes sibilant-stop clusters, and epenthesizes within sibilant-*l* clusters.

(18)

source word [spV…]	*COMPLEX	DEP-V/S__T	LEFT-ANCHOR	DEP-V/S__l
a spV…	*!			
b sipV …		*!		
c ☞ ispV …			*	

source word [slV…]	*COMPLEX	DEP-V/S__T	LEFT-ANCHOR	DEP-V/S__l
d slV …	*!			
e ☞ silV …				*
f islV …			*!	

In order to extend this account to similar patterns in reduplication, imperfect puns, and alliteration, Fleischhacker (2000b) introduces an additional family of default-ranked contextual MAX constraints, which penalize deletion of segments (McCarthy & Prince 1995), shown in (19). In reduplication, the relevant constraint for splitting is not DEP but MAX, since a segment of the base is deleted in the reduplicant (ge-g**r**ot). In imperfect puns and alliteration, the relevant constraint is either DEP or MAX, depending on which member of the pair is taken as primary (Bonaparte/B**l**own-apart).

(19)

MAX-T/S_V >> MAX-m/S_V >> MAX-n/S_V >> MAX-l/S_V >> MAX-R/S_V >> MAX-W/S_V

To further extend the account to infixation, neither DEP nor MAX will suffice, since there is no epenthesis or deletion taking place. The faithfulness constraint that is violated by infixation within a cluster seems to be CONTIGUITY (McCarthy & Prince 1995), which requires adjacent segments' correspondents to remain adjacent. In the case of the context-sensitive CONTIGUITY family in (20), particular consonant clusters in the uninfixed form are required to remain adjacent in the infixed form.

(20) CONTIG-ST >> CONTIG-Sm >> CONTIG-Sn >> CONTIG-Sl >> CONTIG-SR >> CONTIG-SW

This is not quite right, however, because the ranking in (20) follows from the similarity hierarchy in (16) only if the reason for the contiguity violation is insertion of material beginning with a vowel, as in infixation (or vowel epenthesis). We need to further specify the context in which the CONTIGUITY constraint applies, as in CONTIG-ST/V..., meaning "adjacent ST in one form must not have their correspondents in another form separated by a string beginning with a vowel."

Since what appears to be at stake in all these cases is the similarity of a C_1-C_2 transition to a C_1-V transition, I propose to simplify the discussion by introducing a notation that directly encodes this, *MAP:

(21) *MAP-S_1S_2(X,Y): *X* in string S_1 must not correspond to *Y* in string S_2

(This is similar to Boersma's 1998 *REPLACE constraints, but there are enough differences that I believe it is clearer to use a different name.) I assume, as above, that the default ranking of these constraints is determined by Steriade's P-map: the more perceptually different *X* and *Y* are, the higher the default ranking of *MAP-(X,Y). That is, if $\Delta(X, Y) > \Delta(Z, W)$, then *MAP-$S_1S_2$(X,Y) >> *MAP-$S_1S_2$(Z,W) by default.

Because the *MAP family relies on perceptual comparisons, it can presumably compare only actual surface forms. Therefore, S_1 and S_2 in (21) can be two surface forms in an inflectional or derivational paradigm; a base and a reduplicant; a foreign source word and its borrowed form; or two rhyming, alliterating, or punning words; but not an underlying form and a surface form.

In order to be able to refer easily to environments, one further addition to the notation is needed. *X* and *Y* in (21) could be segments, but they can also be segments notated for context, as in ${}^{A}P^{B}$, *P* preceded by *A* and followed by *B*. *A* or *B* could also be left unspecified, as in ${}^{A}P$, P^{B}, or simply *P*. *A*, *B*, and *P* can be very specific (*n*), very general (C), or in between ([+nas]). We can now write out a family of *MAP constraints that, with the right specification of S_1 and S_2, covers all of Fleischhacker's cases (epenthesis, reduplication, puns, alliteration) plus infixation: [8]

(22)

*MAP(S^T,S^V)>>*MAP(S^M,S^V)>>*MAP(S^N,S^V)>>*MAP(S^L,S^V)>>*MAP(S^R,S^V)>> *MAP(S^Y,S^V)

[8] As Fleischhacker (2000a) discusses, Iraqi Arabic requires a (non-context-sensitive) CONTIGUITY-CC constraint, which could be replaced in this case by the coarse-grained *MAP(C^C, C^V).

The tableaux in (23), which can be compared to those in (18), illustrate the application of this family, with S_1=source word and S_2=borrowed word, to epenthesis in a language where sibilant-stop clusters are not split but sibilant-*l* clusters are split. LEFT-ANCHOR has also been replaced by *MAP($^{\#}$C,^{V}C), which forbids a word-initial consonant from corresponding to a postvocalic consonant. In order to allow for the language-particular differences in Fleischhacker's typology, this constraint must be freely rankable against the hierarchy in (22). This suggests that the P-map treats some comparisons as orthogonal—it is beyond the scope of this paper to investigate this question, but a plausible conjecture is that in order to have a default ranking, two constraints must refer to distances on the same perceptual dimension, although just what the dimensions of the perceptual space are is not yet known.

(23)

source word [spV…]	*COMPLEX	*MAP-SourceBorrowed (S^T, S^V)	*MAP-SourceBorrowed ($^{\#}$C,^{V}C)	*MAP-SourceBorrowed (S^l, S^V)
a spV…	*!			
b sipV …[9]		*!		
c ☞ ispV …			*	

source word [trV…]	*COMPLEX	*MAP-SourceBorrowed (S^T, S^V)	*MAP-SourceBorrowed ($^{\#}$C,^{V}C)	*MAP-SourceBorrowed (S^l, S^V)
d trV …	*!			
e ☞ tirV …				*
f itrV …			*!	

The tableaux in (24) illustrate that the analysis is analogous for infixation. S_1 and S_2 are uninfixed and infixed forms instead of source and borrowed forms. Instead of *COMPLEX, the constraint driving splitting is ANCHOR-STEM, which requires a word to begin with stem material and thus forces the infix inwards. LEFTMOST (Prince & Smolensky 1993/2004), which keeps the

[9] Only the relevant *MAP violations are shown. This candidate also violates *MAP(^{S}T, ^{S}V).

infix as close to the left as possible, plays the role analogous to that of *MAP-SourceBorrowed ($^{\#}$C,^{V}C), by favoring the splitting rather than the non-splitting solution to ANCHOR-STEM. (The reason for using ANCHOR-STEM to force infixation rather than Prince and Smolensky's NOCODA is that infixation within a cluster is not predicted under their analysis, since the result *g-um.-rad.wet* has just as many codas as prefix **um.-grad.wet*.[10])

The tableaux in (24) show an idealized situation in which sibilant-stop clusters never split and sibilant-*l* clusters always split. We can see that the *MAP constraints predict parallel behavior for epenthesis and infixation.

(24)

	in + uninfixed form [spɪn]	ANCHOR-STEM	*MAP-UninfixedInfixed (S^T, S^V)	LEFTMOST	*MAP-UninfixedInfixed (S^l, S^V)
a	**in**spɪn	*!			
b	s**in**pɪn		*!	s	s
c	☞ sp**in**ɪn			sp	sp

	um + uninfixed form [gradwet]	ANCHOR-STEM	*MAP-UninfixedInfixed (S^T, S^V)	LEFTMOST	*MAP-UninfixedInfixed (S^l, S^V)
d	**um**gradwet	*!			
e	☞ g**um**radwet			g	*
f	gr**um**adwet			gr!	

[10] Ross 1996 attempts to repair the NOCODA analysis by adding variably ranked *COMPLEX, which would prefer *g-um.-rad.wet*. If, however,*COMPLEX stands for a family of constraints requiring a consonant to be adjacent to segments that allow expression of its acoustic cues (Steriade 1999), then this makes incorrect predictions about which clusters should split more often. See the discussion of cluster markedness in section 5.1 below. Moreover, language-internal evidence requires that *COMPLEX >> NOCODA, since word-internal clusters are syllabified heterosyllabically (*ak.lat* 'book). See section 5.1.

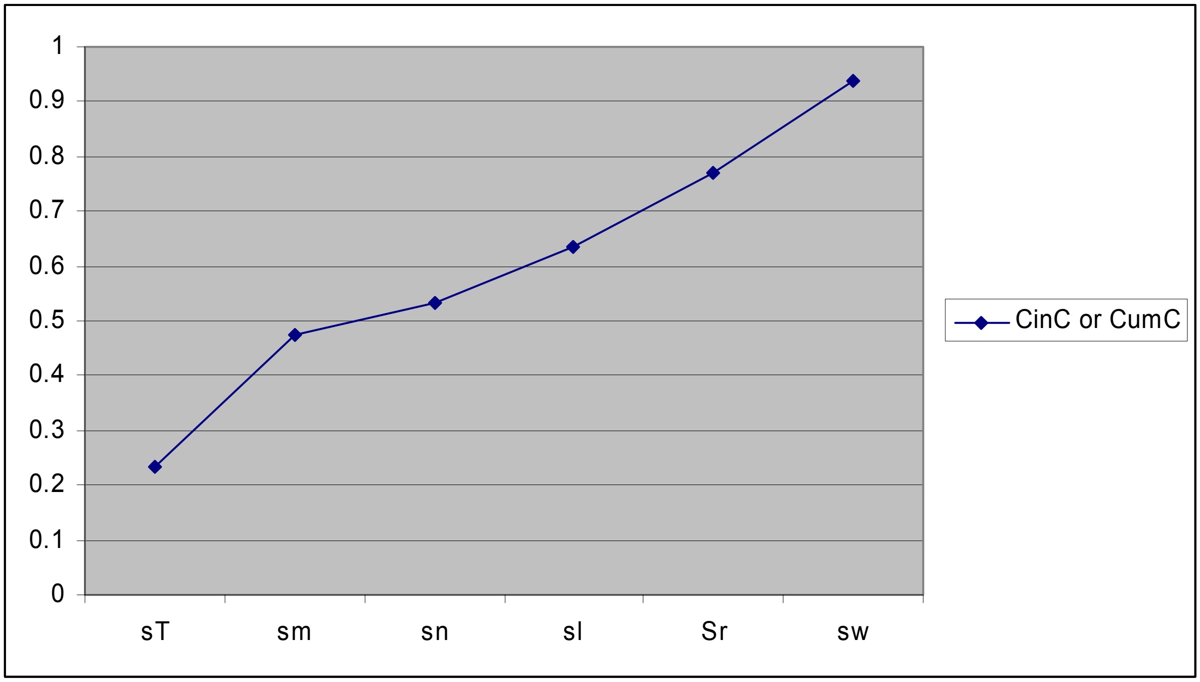
It might be objected that LEFT-ANCHOR is violated in vowel-initial words such as *abot*, "infixed" as *um-abot* 'attain'. But, words spelled (and often transcribed) with an initial vowel actually begin with a glottal stop (unless preceded by a consonant-final word within the same phrase, in which case the glottal stop is optional). If this glottal stop is underlying, then the infixed form *ʔ-um-abot* does satisfy LEFT-ANCHOR. If the glottal stop is epenthetic, then the constraints requiring its insertion force LEFT-ANCHOR to be violated no matter what (the word cannot begin with *a*), so LEFTMOST pushes the infix as far to the left as possible.

Of course, we have seen in the corpus data that there is variation for every cluster, and the same is true in the survey data. Variable constraint ranking, along the lines of Boersma 1997 and 1998, Hayes & MacEachern 1998, and Boersma & Hayes 2001 can model these results. The ranking values shown in (25), learned using Hayes & al. 2003, derive idealized outputs shown in (26), which are similar to those in the experimental results (cf. (13)), except that the non-significant bump for *sn* is smoothed.

(25) Boersmian ranking values

112.000	ANCHOR-STEM
99.387	*MAP-UninfixedInfixed(S^T, S^V)
97.543	*MAP-UninfixedInfixed(S^m, S^V)
97.355	LEFTMOST
97.075	*MAP-UninfixedInfixed(S^n, S^V)
96.398	*MAP-UninfixedInfixed(S^l, S^V)
95.206	*MAP-UninfixedInfixed(S^r, S^V)
93.036	*MAP-UninfixedInfixed(S^w, S^V)

(26)



4.1 Further discussion of *MAP constraints

The *MAP notation is not equivalent to McCarthy and Prince's (1995) original correspondence constraints. IDENT(F), which prohibits changing feature values, translates into *MAP(+F,–F) and *MAP(–F,+F), as well as context-specific versions of this, depending on the case. On the assumption that *MAP constraints refer only to actual pairs of segments in the correspondence relation, and not to higher-level properties of the correspondence relation, DEP and MAX cannot be easily translated. DEP-violating insertion of a vowel between two consonants violates *MAP(C^C,C^V) and *MAP(C^C,C^V), but insertion in other contexts violates other *MAP constraints. The situation is similar for MAX: deletion violates different constraints depending on the context.

Anchoring constraints also do not translate. ANCHOR requires the edgemost segment one form to correspond to the edgemost segment of the other form. If ANCHOR is violated through deletion, say of an initial vowel, then *MAP(^{V}C, $^\#$C) may be violated. If ANCHOR is violated through insertion of material at the edge, or through metathesis, then a constraint like *MAP($^\#$C,^{V}C) may be violated. If the leftmost consonant in one form has multiple correspondents in the other form, exactly one of which is edgemost (e.g., [t_1a] vs. [t_1it_1a]), then ANCHOR is satisfied but *MAP($^{\#}$C,^{V}C) is violated. The *MAP notation does not express the idea that at least one correspondent of a segment should have a certain property. UNIFORMITY (no coalescence) and INTEGRITY (no splitting), which also refer to higher-level properties of the correspondence relation (how many distinct correspondents does some segment have), also do not translate. Coalescence and splitting do violate *MAP constraints, but different ones depending on context. For example, /an$_1$b$_2$a/ → [am$_{1,2}$a] violates *MAP-IO(^{stop}V,^{nasal}V) and *MAP-IO(N^{stop},N^{V}), among others. LINEARITY (no metathesis) does not translate because *MAP does not assess long-distance relationships. Metathesis does violate *MAP constraints, but which ones depends on context: /atpi/ → /apti/ violates *MAP(V^{t},V^{p}), *MAP(C^{C},C^{V}), etc.[11] Finally, the translation of I-CONTIG (no skipping) and O-CONTIG (no intrusion) also depends on context. For example, /atpa/ → /atipa/ violates *MAP(C^{C},C^{V}) and *MAP(^{C}C,^{V}C), as well as more-specific versions of those constraints.

Thus, adopting the *MAP constraints for output-output correspondence makes slightly different predictions than using the McCarthy/Prince faithfulness constraints, though the differences may disappear under modifications to the McCarthy/Prince theory. For example, the *MAP approach predicts that there could be a language in which word-internal foreign [y] is broken into [iu], but word-final foreign [y] is adopted intact, because *MAP(V$^{\#}$,V^{V}) is ranked high and *MAP(V^{C},V^{V}) is not. RIGHT-ANCHOR DOES not make this prediction, since as long as one correspondent of word-final [y] is final (the [u]), the constraint is satisfied. But, context-specific faithfulness constraints have been proposed (see Beckman 1999, for example), and if we allow a constraint such as INTEGRITY/__# (no splitting of a word-final segment), the language described would be predicted.

When it comes to contextualized faithfulness constraints, such as DEP-V/X__Y, the two notations diverge more sharply. Violation of a contextualized faithfulness constraint generally entails violation of more than one *MAP constraint, and multiple contextualized faithfulness constraints may entail violation of a shared *MAP constraint. This is illustrated in (27), where an assortment of faithfulness constraints can be seen to share the property that if one of the faithfulness constraints is violated, so is *MAP(T^{R}, T^{V}). This makes an empirical prediction, though one that is difficult to test: for a given pair of forms (source and loan, base and

[11] In effect, *MAP requires immediate precedence relations, rather than precedence relations in general, to be preserved. See Heinz (2005) for an argument that LINEARITY should be redefined along just those lines.

reduplicant, etc.), if one of the changes in (27) is forbidden by *MAP(T^R, T^V), the rest must also be forbidden. And if *MAP(T^R, T^V) is ranked too low to forbid one of the changes, it is ranked too low to forbid the rest (though some other constraint might). The faithfulness constraints do not make that prediction.

(27)

	Faith violations	*Shared *MAP violation*	*Other *MAP violations*
$[ge]_R$-$[grot]_B$	MAX(C)/T__R, ANTICONTIG-TV	*MAP(T^R, T^V)	*MAP(^RV, ^TV)
gradwet ~ garadwet	DEP(V)/T__R, CONTIG-TR	*MAP(T^R, T^V)	*MAP(^RV, ^TV), *MAP($^T\text{Ø}^R$, $^TV^R$)
gradwet, g-um-radwet	CONTIG-TR	*MAP(T^R, T^V)	*MAP(^TR, ^NR)
Bonaparte – blownapart (puns and alliteration)	DEP(C)/T__R, CONTIG-TV	*MAP(T^R, T^V)	*MAP(^TV, ^RV), *MAP($^T\text{Ø}^V$, $^TR^V$)

I consider it an attractive property of the *MAP approach that the commonality Fleischhacker (2000b) identifies in all the cases in (27), that a stop followed by a liquid corresponds to a stop followed by a vowel, is expressed in violation of a shared constraint, *MAP(T^R, T^V).

4.2 *MAP and loanword adaptation

This section contains a final note on *MAP constraints. It was suggested above that correspondence between surface forms is regulated by *MAP constraints, whereas input-output relations might be governed by classic correspondence constraints. While I will not argue for this point, there is evidence that the correspondence constraints governing loan adaptation (a surface-to-surface phenomenon) are distinct from those governing input-output relations, whether or not they have the same form. This has no doubt been assumed implicitly by many studies of loanword phonology, and is sometimes made explicit (e.g., Kang 2003, pp. 224-225).

In Korean, for example, word-final consonants that in foreign words are treated differently from underlyingly word-final consonants. The data in (28) illustrate neutralization of underlyingly word-final coronal consonants in both conservative and colloquial Korean (Han 2002). (The suffixed pattern is different for verbs, but coda neutralization works the same way.)

(28)

		word-final				conservative with locative suffix	colloquial with locative suffix	
낟	/nat/	[nat˺]	‘cereal grain’	낟에	/nat-e/	[na.de]	[na.se]	‘to the cereal grain’
밭	/pat^{h}/	[pat˺]	‘field’	밭에	/pat^{h}-e/	[pa.t^{h}e]	[pa.t^{h}e], [pa.se]	‘to the field’
낫	/nas/	[nat˺]	‘sickle’	낫에	/nas-e/	[na.se]	[na.se]	‘to the sickle’
낮	/natʃ/	[nat˺]	‘daytime’	낮에	/natʃ-e/	[na.dʒe]	[na.dʒe], [na.se]	‘to the daytime’
낯	/natʃ^{h}/	[nat˺]	‘face’	낯에	/natʃ^{h}-e/	[na.tʃ^{h}e]	[na.tʃ^{h}e], [na.se]	‘to the face’

Regardless of whether we look at the normative or the colloquial data, it appears that coda [s] is forbidden, and underlying word-final /s/ is realized as [t]. We could analyze this as CODA-CONDITION, DEP-V >> IDENT(continuant), as illustrated in (29), where CODA-CONDITION is shorthand for the restriction that in Korean, coda obstruents may only be lenis, unaspirated, unreleased stops.

(29)

	/nas/	CODA-CONDITION	DEP-V	IDENT(cont)
a	[nas]	*!		
b	[na.sɨ]		*!	
c	☞ [nat˺]			*

In the adaptation of loans that end in [s], we might expect the same thing to happen: taking a foreign pronunciation such as English [t^{h}ɛnis] ‘tennis’ as input and subjecting it to the same constraint hierarchy, we would expect the output *[tʰenit].[12] In fact, the pronunciation is [tʰenisɨ], with vowel epenthesis rather than change of /s/ to [t] (Hong 2001). This seems to require a different ranking between IDENT(continuant) and DEP-V, as shown in (30).

(30)

English: tʰɛnɪs	CODA-CONDITION	IDENT(cont)	DEP-V
d [tʰe.nis]	*!		
e ☞ [tʰe.ni.sɨ]			*
f [tʰe.nit]		*!	

If we view loan adaptation as input-output mapping, there is a ranking paradox between (29) and (30). But we could also view loan adaptation as an attempt to produce something that is phonotactically legal in Korean, while sounding as much as possible like the original. (See Peperkamp (in press) for discussion along these lines.) In that case, we would claim that epenthesized [tʰenisɨ] is treated as more similar to English [tʰɛnɪs] than hypothetical [tʰenit] is. This could be accounted for by ranking *MAP-SourceBorrowed(s,t) >> *MAP-SourceBorrowed(s#,sɨ), on the plausible assumption that Δ(s,t) > Δ(s#,sɨ). This ranking is independent of the ranking DEP-IO-V >> IDENT-IO(continuant):

(31)

/nas/	CODA-CONDITION	DEP-IO-V	*MAP-SourceBorrowed(s,t)	IDENT-IO(cont)	*MAP-SourceBorrowed(s#,sɨ)
a [nas]	*!				
b [na.sɨ]		*!			
c ☞ [nat˺]				*	

[12] [tʰenit] (태닛 or 테닛) is legal, but as the last name of former CIA director George Tenet, not as 'tennis'.

English: [tʰɛnɪs]	CODA-CONDITION	DEP-IO-V	*MAP-SourceBorrowed(s,t)	IDENT-IO(cont)	*MAP-SourceBorrowed(s#,sɨ)
d [tʰe.nis]	*!				
e ☞ [tʰe.ni.sɨ]					*
f [tʰe.nit]			*!		

Many more examples could be cited of cases where the normal input-output mappings of a language appear to be contradicted in its loanword phonology, but where a loan can plausibly be regarded as the perceptually closest approximation of the foreign original that is nonetheless phonotactically legal (e.g., Hyman 1970 on Nupe, Kenstowicz 2003 on Fijian; of course, other factors, such as orthography, knowledge of the source language's phonology, and conventionalized mappings can also play a role—see Haugen 1969; Paradis 1996; Hualde 1993, 1999). It remains unclear whether such phenomena should be attributed to active attempts by the loan-importing speaker to create a good perceptual match between the source words and the borrowed word, or to passive misperception of the source word. Experimental work by Dupoux & al. (1999) has shown that such passive misperception does occur, but it is unknown whether it occurs in all relevant cases.

5. Discussion of alternatives

It has been argued above that the survey results on SC clusters can be accounted for by assuming that speakers have implicit knowledge of how the similarity between C_1C_2 and C_1V, varies depending on C_2, and that they apply this knowledge so as to maximize the similarity of infixed and uninfixed words. This section considers alternatives of two types: first, that speakers do apply implicit phonetic knowledge, but it is not the knowledge of similarity posited above; and second, that the results can be explained without recourse to implicit knowledge at all.

5.1 Other candidates for implicit knowledge

An alternative to the perceptual account given above might be an articulatory account. Hall (2003) proposes that svarabhakti vowels (vowels sandwiched between two consonants that do not behave as though they contribute to the syllable count, and that have either the same quality as a nearby vowel or, less often, a default quality) result from loosely coordinated consonant articulations. If two adjacent consonants are pronounced with a gap in between, an excrescent (svarabhakti) vowel can result. If an adjacent vowel's gesture overlaps that gap, the excrescent vowel has the same quality as that adjacent vowel; otherwise, the excrescent vowel has a default quality. (An example from Hall is Dutch [fɪləm], a variant of [fɪlm] 'film'.)

Hall examines the distribution of svarabhakti vowels crosslinguistically and finds many regularities. First, these vowels occur only between a sonorant and another consonant (in either order). Hall attributes this to the relative unmarkedness of vowel-sonorant overlap (as compared to vowel-obstruent overlap) and to special C-C phasing constraints for sonorants that cause them to be more loosely coordinated with other consonants, though the root cause of either of these is unknown.

Loose coordination of a CC cluster could plausibly lead to greater splittability, even in a language that does not have excrescent vowels. Suppose that obstruent-obstruent clusters such as *ST* are subject to a constraint requiring the release of *S* to coincide with the target of *T*.[13] If that constraint is defined to refer to underlyingly adjacent *S* and *T*, then it would be violated if an infix splits the cluster. Obstruent-sonorant clusters (i.e., all the other Tagalog clusters examined here) would not be subject to this constraint, and so we predict lesser splittability of *ST* as compared to all the other clusters.[14]

Looking within the sonorants, Hall finds that in most languages not all sonorants trigger a svarabhakti vowel, and she proposes the following implicational hierarchy:

(32) *least likely to trigger svarabhakti* *most likely to trigger svarabhakti*

obstruents < glides, nasals (within which *m* < *n*) < *r* < *l* < *ɾ*, *ʁ* < gutturals

[13] "Release" and "target" are terms referring to landmarks within a gesture (Browman & Goldstein 1986). In temporal order, the gestural landmarks are onset, target, center, release, and offset. If the release of C_1 coincides with the target of C_2, there is no gap between the two consonants.

[14] This is not exactly faithful to Hall's account of svarabhakti vowels. She proposes a general constraint, applying to all consonants, requiring alignment of C_1's release to C_2's target, and a specific constraint for obstruent-sonorant clusters requiring obstruent C_1's center to be aligned with sonorant C_2's onset, a configuration that results in an excrescent vowel. These two constraints would both be violated by infixation into an obstruent-sonorant cluster.

This is similar to Fleischhacker's hierarchy for epenthesis in SC clusters, which raises the possibility that the hierarchies really both follow from the same cause, whether articulatory, along Hall's lines, or perceptual, along Fleischhacker's:

(33) *least splittable* *most splittable*
S-stop < *S*-*m* < *S*-*n* < *S*-*l* < *S*-rhotic < *S*-glide

There is one strong mismatch between Hall's hierarchy for svarabhakti and Fleischhacker's for epenthesis: the place of glides within the hierarchy. In this respect, the Tagalog survey data are consistent with Fleischhacker's hierarchy and not with a splittability interpretation of Hall's, suggesting that loosely coordinated articulation is not the source of splittability. Still, Hall's evidence for putting glides to the left of liquids in this hierarchy comes only from Hausa; most of the languages she surveys lack glides in the relevant environment. The other differences are less significant. First, there are no loanwords beginning with a C-guttural cluster in Fleischhacker's survey (and a source language providing such words would be hard to find), so gutturals do not appear in her hierarchy. And second, Fleischhacker groups all rhotics together. The languages in her survey that distinguish laterals from rhotics were Farsi, where *S*-rhotic clusters are split but *S*-*l* are not; and Wolof, where *S*-rhotic clusters are split but *S*-*l* vary. In Farsi, the rhotic is a tap, [ɾ] (sɛɾi laŋka 'Sri Lanka', Shabnam Shademan, p.c.), which would not be a mismatch with Hall's hierarchy. In Wolof, the rhotic is the phoneme usually described as a trill, though at least for the speaker consulted it achieves only one vibration in this environment, making it hard to distinguish from a tap (Mariame Sy, p.c.). In the Wolof case, it is hard to say whether we should regard the rhotic as the tap [ɾ] (which would match Hall's hierarchy) or the trill [r] (which would not). The rhotic in the Tagalog cases can be either a tap, which both hierarchies (and the survey data) put to the right of laterals, or an English-like [ɹ], which does not occur in the languages examined by either Hall or Fleischhacker. In summary, the Tagalog evidence is marginally more consistent with Fleischhacker's typology than with Hall's, making the perceptual account seem somewhat more likely.

Another alternative to the perceptual account is that speakers' implicit knowledge really does not concern cluster splittability at all, but concerns the markedness of the infixed word. One possibility is that speakers deploy infixes so as to eliminate marked clusters. We would therefore expect that marked clusters would split the most often, and unmarked clusters would split the least often. This seems, however, to be the opposite of what happens. The splittability hierarchy is repeated in (34) with grouping into broad sonority classes. I will argue here that the clusters that split the least often are actually the most marked, and vice versa.

(34)

least often split			*most often split*
sibilant-stop (ST)	sibilant-nasal (SN)	sibilant-liquid (SR)	sibilant-glide (SW)
		stop-liquid (TR)	stop-glide (TW)
most marked			*least marked*

There are a few criteria we could use to determine which clusters are more marked. Crosslinguistically, it has been claimed that the greater the sonority distance between C_1 and C_2, the less marked is the cluster C_1C_2 (e.g., Greenberg 1978, Selkirk 1984). This would predict that *TW* should be less marked than *TR*, and that the *SC* clusters towards the right in (34) should be less marked than those towards the left. Steriade's (1995) theory of consonant cuing claims that consonant clusters are marked because of C_1's reduced perceptibility: C_1 lacks a following vowel or sonorant whose formants it can alter, and lacks a release burst. This predicts that greater sonority of C_2 should reduce markedness: again, *TW* should be less marked than *TR*, and that the SC clusters towards the right should be less marked than those towards the left. (Though Steriade 2004 proposes that in Latin, *CW* clusters are more marked than other clusters.) Under both theories of markedness, it is actually the more marked clusters that split the least often.

Tagalog-internal evidence, though limited, points in the same direction. We can look first at adaptation of English loans, where *TR*, *TW*, and *SW* are tolerated, but not other word-initial *SC* clusters. (They are, as discussed above in section 3, repaired by prothesis.) This would suggest that *TR*, *TW*, and *SW* are less marked than the rest. Within native words, there is often variation between C_1VC_2 and C_1C_2 when C_2 is a glide (and V matches it in color, i.e. backness and rounding[15]), but not when C_2 is a liquid, no matter what the intervening vowel:

[15] The main reason to believe that the vowel is deleted, not inserted, is that Tagalog lexical roots obey a disyllabic minimum (and most roots do not exceed that minimum), which is sometimes even enforced in loans (*narses* 'nurse', from English plural *nurses*; *boses* 'voice' from Spanish plural *vozes*; *lamsyed* 'lamp' from English *lampshade*; and

(35) piják ~ pják 'squawk'

buwán ~ bwán 'moon'

puɾók *pɾók 'district'

This suggests that *TW* is less marked than *TR*, though it is also possible that similarity preservation is at work here. (I.e., since *TVW* is highly similar to *TW*—especially if *V* matches the glide in color—deletion of *V* is permissible, but since *TVR* is less similar to *TR*, deletion is not permissible there). A final piece of Tagalog-internal evidence comes from syllabification. Word-internal clusters are normally syllabified $C_1.C_2$, avoiding a complex onset. Evidence for this syllabification comes from speakers' intuitions (Schachter & Otanes 1972) and from stress facts. Stress (sometimes characterized as length—see Schachter & Otanes, French 1988, and Zhang 2001 for discussion) in native Tagalog words can fall on either the penult or the ultima, except not on a closed penult. When a verbal suffix is attached, stress shifts one syllable to the right (36).

(36)

Open penult: penultimate or final stress				*Closed penult: final stress only*			
bí.roʔ	'joke'	bi.rú.ʔ-in	'to joke'	ʔik.líʔ	'shortness'	ʔik.li.ʔ-án	'to shorten'
ta.nóŋ	'question'	ta.nu.ŋ-ín	'to question'				

Loans can have stress on a closed penult, but these words behave differently under stress shift: stress shifts to the final syllable (with secondary stress sometimes remaining on the closed syllable), as shown in (37a). There are some rare exceptions to this pattern, which behave as though the penult were not closed—stress shifts one to the right (37b). In those cases, the cluster is a C-glide cluster. Apparently, word-internal C-glide clusters can optionally be syllabified as complex onsets, suggesting that C-glide is less marked as an onset than other types of cluster. Again, this makes the wrong prediction for the splitting facts.

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bolpen 'pen' from English *ball(-point) pen*). It would be an odd coincidence if all the underlyingly monosyllabic native roots began with consonant-glide clusters (and almost no disyllabic or longer roots began with such clusters).

(37) a. ɾén.da ‘rein’ ɾen.da.h-án ‘to rein’ (Spanish *rienda*)

b. di.lí.**ɾj**o ‘delirium’ di.lì.-di.li.**ɾj**ú.-han ‘feigned delirium’ (Spanish *delirio*)

(As mentioned in fn. 10, this argues against using *COMPLEX to explain the existence of infixation variants in which the infix splits the onset cluster: if *COMPLEX is viewed as a complex of constraints against complex onsets of varying degrees of markedness, then the wrong prediction is made about which clusters should split most easily.)

A second markedness-based possibility is that speakers are avoiding the <u>creation</u> of marked clusters. Whenever a CC cluster is split by a VC infix, a new cluster is created, as the *mr* cluster of *g-**um**-**r**adwet*. If this force is responsible for differences in cluster splittability, then we expect that C_1C_2 should be more splittable the less marked a *nasal-*C_2 cluster is. Again, this is the opposite of what happens:

(38)

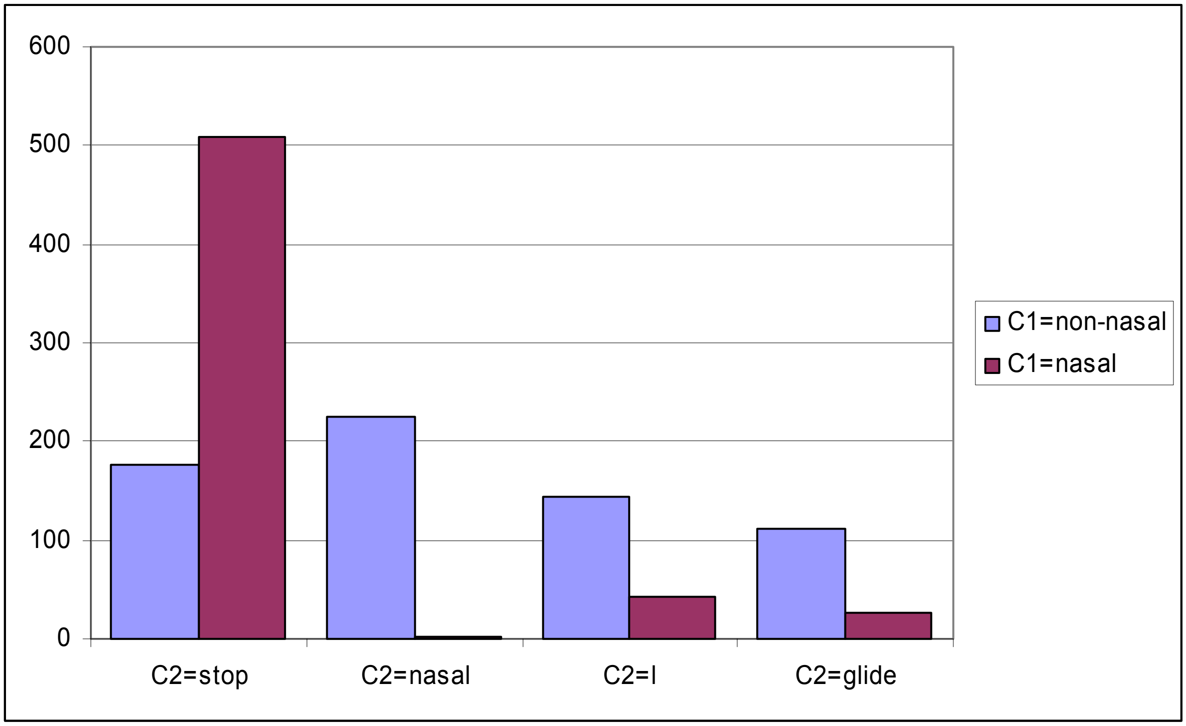
least often created			*most often created*
nasal-stop	nasal-nasal	nasal-liquid	nasal-glide
least marked			*most marked*

In order to establish nasal-C cluster markedness, we can look at both cross-linguistic and Tagalog-internal evidence. Vennemann’s (1988) cross-linguistically based Syllable Contact Law posits that coda-onset transitions should be of falling sonority. That would make *nasal-stop* the least marked cluster. If we interpret the syllable contact law more broadly, so that flat sonority is also worse than rising sonority, and that the greater the sonority rise, the worse, then the clusters in (38) become more marked towards the right.

Tagalog-internally, we can compare frequencies of root-internal *nasal-C* clusters, shown in (39).[16] Nasal-stop clusters have the highest raw frequency (dark bars), as well as the highest frequency relative to the control case, oral-stop clusters (light bars). By those criteria, nasal-stop clusters should be the least marked, despite being created least often by infixation. (All three Tagalog nasals are combined since their post-nasal frequency is so low; there is no column for C2=r, because [ɾ] in native words occurs only intervocalically.)

[16] Counts are from disyllabic native roots found in English 1987.

(39)



5.2 Explanations without implicit knowledge?

Is it possible to account for the survey results without attributing implicit knowledge to speakers? An account based on misperception of an infix's location seems implausible—speakers would have to actually mishear ***kw**-in-ento* as ***k**-in-**w**ento*, and moreover do so more often than they mishear ***dr**-in-owing* as ***d**-in-**r**owing* (or vice versa: mishear ***k**-in-**w**ento* as ***kw**-in-ento* less often than ***d**-in-**r**owing* as ***dr**-in-owing*). But even if such mishearing were possible, it would not account for the survey data, since the *SC* clusters are ones that speakers have almost never heard within an infix before—there has been nothing to mishear, and the survey participant must make a decision on the spot.[17]

The discussion above of excrescent vowels suggests a more plausible misperception-based account, though I will present some evidence that argues against it. Suppose that clusters are splittable to the extent that they are actually pronounced or perceived with an extra vowel.

[17] Shelley Velleman (p.c.) raises the possibility that, if the *TR*-*TW* difference has a historical origin, speakers could pick up on sonority as an important factor in determining splittability and extend that factor's applicability to the *SC* cases. This would require implicit knowledge of sonority differences, but the bias about how to apply those differences would come from language-specific evidence.

That is, if *slip* 'slip' is really disyllabic *s**i**lip*, it should of course be infixed *s-um-ilip*.[18] Speakers might still spell the words as *slip* and *sumlip*, but they are treating the stem as though it begins with CV, not with a cluster.[19] To explain cluster differences, we could plausibly assume that greater sonority of C_2 encourages the production or perception of an extra vowel. (See discussion of Hall's svarabhakti hierarchy above). Assuming that these "extra" vowels have the same status as other vowels, this theory predicts that words with split clusters are treated as though they had an unspelled extra syllable. That prediction is contradicted by some data on infixation with reduplication (indicates incomplete realis aspect).

In native words, when infixation and one-syllable reduplication combine, the result is a prefixed copy of the stem's CV, with an infix after the copied C, as in *b-um-a-bago* 'is changing'. When this construction is applied to a cluster-initial loan, several variants are possible. Examples are shown in (40), with corpus frequencies.

(40)

I. Onset copied, not split by infix		II. Onset copied, split by infix		III. Onset simplified, C_2 skipped		IV. Onset simplified, C_2 vocalized (if C_2 is glide)		
		g-um-wa-gwapo	1	g-um-a-gwapo	12			'be handsome'
		s-um-we-sweldo	3	s-um-e-sweldo	7	s-um-u-sweldo	33	'pay salary'
				s-um-i-sweldo				
kw-in-e-kwenta	1			k-in-e-kwenta	2	k-in-u-kwenta	20	'count'
		b-um-ya-byahe	3	b-um-a-byahe	22	b-um-i-byahe	4	'travel'
pr-in-o-problema,	28	p-in-ro-problema	3	p-in-o-problema	249	N.A.		'have
pr-in-u-problema		p-in-ru-problema		p-in-u-problema				problem'
pr-in-o-promote,	11	p-in-ro-promote	1	p-in-o-promote		N.A.		'promote'
pr-in-u-promote		p-in-ru-promote		p-in-u-promote				

[18] Cena (1979) assumes that splitting of a loan cluster by the infix (and partial reduplication) results from an extra vowel, though in the examples he considers the vowel is robust, and spelled.

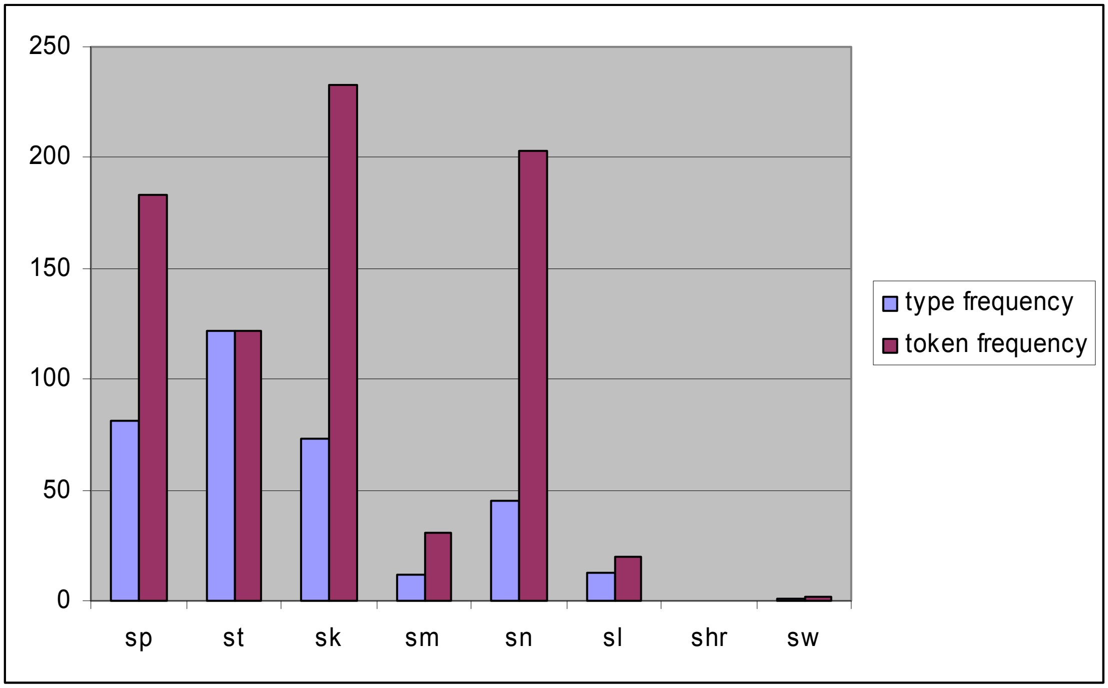
[19] Many loans that, in the source language, begin consonant-glide can optionally be spelled with an extra vowel in Tagalog: *byahe*, *biyahe* 'travel', from Spanish *viaje*. In the corpus data, only tokens spelled without this extra vowel were used. It is possible that sometimes the extra vowel is pronounced though not spelled. The reverse does seem to occur, as attested by reduplicated forms in the corpus such as *babiyahe*. The vowel *a* in the reduplicant makes sense only if the stem is treated as *byahe*, not *biyahe*.

p-in-re-prepare	1	p-in-e-prepare p-in-i-prepare p-in-e-prepara	10	N.A.	‘prepare’
p-in-ri-prito	2	p-in-i-prito	32	N.A.	‘fry’

Variant II, with the onset copied and split, demonstrates that a cluster can be split without being treated as though it has an extra, unspelled syllable (though this variant is, admittedly, not very frequent). If there were such an extra syllable, the variant II spellings would indicate the pronunciations *g-um-**u**wa-g**u**wapo*, *t-in-**a**ra-t**a**rabaho*, etc., with the first two syllables of the stem copied, which is illegal.

Another possible explanation for the survey data is based on initial cluster frequencies. (Thanks to Colin Wilson and Christian Uffman raising this possibility.) Consider the possibility that speakers interpret prothesis as evidence of a cluster’s non-splittability. Then, the word-initial *SC* clusters of English loans that receive a prothetic vowel most often might be treated as the least splittable. Under this account, speakers would have implicit knowledge of splittability, but that knowledge would not be phonetic and would be based on direct evidence of splittability. Corpus data can be used to evaluate the viability of this possibility. In order to keep the amount of data to be inspected manageable and minimize the number of spurious items, counts are restricted to prothesized English loans beginning with *SC* clusters that have Tagalog morphology (reduplication, infixation, prefixation, and/or suffixation). The counts in (41) do show that *ST* clusters appear most often, which could explain their low level of splittability. But the greater splittability of *sn* compared to *sT* is not explained, since *sn* is about as frequent as *sp*, *st*, and *sk*. The prediction for a *sm-sn* difference is in the wrong direction: since *sn* is much more frequent than *sm*, it should be less splittable, not more splittable as it was in the survey. The frequency idea has nothing to say about differences between *TR* and *TW*, since neither is prothesized.

(41)



6. Summary

The corpus and survey data presented here have shown that Tagalog speakers' treatment of word-initial clusters parallels the cross-linguistic treatment of these clusters found by Fleischhacker (2000a, 2000b): the more sonorous the second member of the cluster, the more likely that the cluster will be split in such a way that the first consonant becomes prevocalic. The survey data show Tagalog speakers making these distinctions even among word-initial clusters that are almost unattested with infixation, making a purely diachronic account unlikely. I have argued that Tagalog speakers have some implicit knowledge of these clusters, plausibly how similar the C_1-C_2 transition is to a C_1-V transition. Additionally, speakers must have a bias about how to apply that knowledge: the beginning of the infixed form should be similar to the beginning of the uninfixed form.

Appendix: survey details

Materials

Each participant sees fourteen items, in random order. Six items are for *SC* clusters, and the rest can be considered fillers from the perspective of this study.

- 1 of {in+scan, um+skor, in+specify, in+stop}
- in+smuggle
- um+snow
- um+slip
- um+shrink
- 1 of {in+swerte, um+sweldo}
- in+byahe
- um+byahe
- in+bwisit
- um+bwelo
- 1 of {in+flash, in+frame}
- 3 of {in+syuting, in+pwesto, in+block, in+break, um+drive, in+drive, in+drowing, um+grabe, um+gwapo, in+create, in+kwento, in+plano, in+promote, in+pwersa, um+pwersa, in+trabaho, um+trabaho}

The two response options are in random order on each trial.

Criteria for data inclusion

A data triple (binary choice plus rating of each option) was excluded if the option chosen received a lower rating than the option not chosen. If a participant made more than 2 such errors, or if the participant completed fewer than 5 items, all data from that participant was excluded.

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