Book of Abstracts for the Workshop

Consonant Clusters and Structural Complexity

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Phil Hoole, Lasse Bombien, Marianne Pouplier: IPS Munich
Tine Mooshammer: Haskins Labs, New Haven
Barbara Kühnert: CNRS Paris

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Reducing Structural Complexity of Consonant Sequences: A Phonologist's Typology

Theo Vennemann
Institut für Deutsche Philologie, Ludwig-Maximilians-Universität, Munich

Consonant sequences of cardinalities different from one, in particular clusters (cardinality > 1), are inherently complex. That is evident from the fact that all languages have sequences of exactly one consonant, whereas not all languages have sequences of less than one consonant (empty sequences) or sequences of more than one consonant (clusters). There are even quite a number of languages that have exclusively sequences of exactly one consonant, thus in particular not allowing any consonant clusters at all. That consonant clusters are complex also shows in the facts (1) that genuine consonant sequences, i.e. sequences not containing nuclei in their syllabic arrangement, are in all languages very short and (2) that if a language has consonant clusters of cardinality n (i.e. n > 1 by definition of "cluster"), it also has consonant sequences of cardinality n-1.

The complexity of consonant sequences of cardinalities different from one is also evident from first language acquisition, where syllables of the structure CV (consonant plus vowel) emerge first, whereas syllable sequences with different syllable patterns are acquired later, in particular building up their cardinality of consonant sequences positionally one by one. It is further evident from language change, where no processes occur serving the goal of building up cluster complexity, but several processes are known reducing consonant sequence complexity. To be sure, there are processes leading to longer consonant sequences, namely among the copations (syncope); but their goal is not increasing consonant sequence length but reducing the number of syllables, which may lead to longer consonant sequences and thus greater consonant sequence complexity only as an incidental by-product.

Consonant sequences may also be complex by the internal distribution of consonantal strength, evaluated relative to their position in sequences of syllables and the distribution of rhythmical prominence (stress). There occur many kinds of language change reducing consonant sequence complexity by modifying consonantal strength or its distribution.

In my presentation I will illustrate, with examples from a number of languages, various additive, subtractive, metathetic, and adjustive mechanisms reducing the complexity of consonant sequences, and attempt to organize them in a partial typology of phonological change. This typology may serve phonologists in developing or refining their theories, and invite phoneticians to explain the clustering behavior of the world's languages with reference to the human physis, thus providing the purely descriptive phonological consonant syntaxes and theories of change with an explanatory synchronic and diachronic phonetic semantics.

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On the relationship of [sonorant] and [voice] in word initial clusters

Rina Kreitman - Emory University

In previous literature it has been reported that the feature [sonorant] and the feature [voice] are closely related. Voicing has long been linked to the feature [sonorant] as one of its phonetic correlates, since voicing is one of the attributes common to all sonorant consonant. Here, I focus on the relationship between the phonological features [sonorant] and [voice]. It has been suggested in the literature (Lombardi 1991), that the distribution of the feature [voice] in clusters can be predicted from the behavior of the feature [sonorant]. If sonority reversed clusters are prohibited, "voicing reversals", a situation where voicing decreases within a cluster pre-vocalically, should not be tolerated either. I begin by reporting on a cross-linguistic study of the typological distribution of these two features in word initial onset clusters, before discussing how they relate to one another. I, then, discuss some observations about markedness in onset clusters before concluding with some predictions and implications regarding onset cluster typology.

There are 4 logical possibilities for combining [–sonorant] (O) and [+sonorant] (S) in bi-consonantal word initial onset clusters, OO, SS, OS and SO, and 15 logical combinations of these clusters as in (1). The empty group, a language with no clusters, constitutes a 16th logical possibility but is not presented here. Based on a cross-linguistic survey of 62 languages from 22 language families I found that of the 15 logically possible language types, only 4 emerge as in table (2) with the relevant implicational relations in (3).

Next, I address the feature [voice] and the distribution of this feature in bi-consonantal onset clusters, focusing on obstruents. Out of the 4 logically possible combinations of [–voice]([–v]) and [+voice] ([+v]) in obstruent clusters, and 15 possible language types as in (4), only 6 emerge as occurring language types as in (5) with implicational relations in (6).

The different typological patterning of the two features implies that it is impossible to predict the typological patterning of clusters in terms of one of these features based on the other. A language can be of one type in terms of [sonorant] but of a different type in terms of [voice]. Russian and Modern Hebrew are examples of languages with different typological classifications. Russian is a type 4 language in terms of the feature [sonorant]; it allows all possible combinations of the feature [sonorant] in word initial clusters. However, it is a type 2 language in terms of the feature [voice] as it contains only [–v][–v] and [+v][+v] clusters word initially. Modern Hebrew, on the other hand, is the exact opposite; it is a type 2 language in terms of the feature [sonorant] as it allows only OS and OO clusters, but is a type 4 language in terms of the feature [voice] as it allows all possible voicing combinations in onset clusters. The varying typological classifications of the two languages suggest that although [sonorant] and [voice] may interact in some way and may be phonetically linked, their phonological interaction is complex and not straightforwardly transparent.

Moreover, markedness relations of clusters vary depending on the feature in question. That is, the least marked cluster, the cluster which is implied by all other clusters, in terms of the feature [voice] is a cluster in which both segments have identical negative specifications for the feature [voice]. Any cluster with mixed specification for the feature [voice], [+v][–v] or [–v][+v], is more marked than a cluster with the same voicing specification cluster internally, [–v][–v] and [+v][+v]. This is not the case for the feature [sonorant] where either OO or SS, in which the feature [sonorant] has the same value for both members of the cluster, are more marked than OS, a cluster with increasing sonority.

The typology presented in this paper can predict language type shifts due to historical changes. The prediction is that no matter the stage the language is in, it must become a language type predicted by the typology. This prediction is borne out by languages such as West Greenlandic and Popoluca, which shifted from languages that did not allow clusters to type 1 languages, which now allow OS clusters.

1. (a) {OS}
{OO}
{SS}
{SO}

(b) {OS,OO}
{OS,SS}
{OS,SO}
{OO,SS}
{OO,SO}
{SS,SO}

(c) {OS,OO,SS}
{OS,OO,SO}
{OS,SS,SO}
{OO,SS,SO}

(d) {OS,OO,SS,SO}

2.

Type	OS	OO	SS	SO	Language	Occurring clusters
Type 1	✓				Basque, Wa	{OS}
Type 2	✓	✓			Modern Hebrew, Kutenai	{OS, OO}
Type 3	✓	✓	✓		Greek, Irish	{OS, OO, SS}
Type 4	✓	✓	✓	✓	Russian, Georgian, Pashto	{OS, OO, SS, SO}

3. OS ⇒ OO ⇒ SS ⇒ SO

4. (a) {[–v][–v]}
{[+v][+v]}
{[–v][+v]}
{[+v][–v]}

(b) {[–v][–v], [+v][+v]}
{[–v][–v], [–v][+v]}
{[–v][–v], [+v][–v]}
{[+v][+v], [–v][+v]}
{[+v][+v], [+v][–v]}
{[–v][+v], [+v][–v]}

(c) {[–v][–v], [+v][+v], [–v][+v]}
{[–v][–v], [+v][+v], [+v][–v]}
{[–v][–v], [–v][+v], [+v][–v]}
{[+v][+v], [–v][+v], [+v][–v]}

(d) {[–v][–v], [+v][+v], [–v][+v], [+v][–v]}

5.

	[–v][–v]	[+v][+v]	[–v][+v]	[+v][–v]	sample language
Type 1	✓				Dutch, Kutenai
Type 2	✓	✓			Russian, Greek, Rumanian
Type 3	✓	✓	✓		Georgian
Type 4	✓	✓	✓	✓	Modern.Hebrew, Tsou, Khasi
Type 5	✓		✓		Biloxi, Camsa, Klamath
Type 6	✓		✓	✓	Bilaan, Amuesha

6.

[+v][–v]
⇓
[–v][+v]
⇓
[+v][+v] ⇒ [–v][–v]

Laryngeal restrictions in word-onset clusters: Evidence from a change in progress

Ioana Chitoran
Dartmouth College, USA

A major topic of interest surrounding consonant clusters is the cross-linguistic preference for laryngeal homogeneity in syllable onsets. Data from many languages point to such a preference (see Kehrein 2002 for a recent survey), and intuitively it makes sense. Laryngeal homogeneity is the result of voicing assimilation, one of the most common phonological processes affecting adjacent segments. Nevertheless, there are exceptions to laryngeal homogeneity in onsets. Not all onset clusters are homogenous in one language, and in some languages none of them are. This suggests that being part of the same onset does not necessarily encourage sharing a laryngeal property.

The goal of this paper is to propose a number of other factors that can interfere with the preference for laryngeal homogeneity, and which are based on considerations of gestural coordination. The data discussed will be limited to word onsets, because they are uncontroversial syllable onsets. The data come from Lezgi (Northeast Caucasian), and its particular interest lies in the fact that the formation of word onset clusters is currently a change in progress in Lezgi, resulting from the syncope of an unstressed high vowel in the first syllable of a word. Syncope is not complete, and the vowel is maintained as secondary articulation on the preceding obstruent. The three high vowels of Lezgi – [i, y, u] – are reported to be lost in pretonic position and following a voiceless obstruent (Kodzasov 1990, Haspelmath 1993):

(1)		*absolutive singular*	*absolutive plural*
a.	‘flower’	tʃ**y**k^{h}	tʃ^{ɥ}k^{hw}-ér
b.	‘cotton’	tʃ^{h}**i**t^{h}	tʃ^{hj}t-ér
c.	‘cannon’	t^{h}**u**p^{h}	t^{hw}p-ár

First I argue, based on acoustic data, that as a result of syncope the two consonants are being reorganized as a C1C2 onset cluster, from a C1VC2 sequence. There is evidence for this even though the vowel is not entirely lost, but it no longer counts as a syllable nucleus. The duration of the interval between the release burst of C1 and that of C2 (inter-burst interval – IBI) was found to vary as a function of the order of place of articulation of the two stops: a front-to-back cluster such as [tk] in [t^{hɥ}k^{w}en-ár] ‘store’ abs. pl. has a shorter IBI than a back-to-front cluster such as [kt] in [k^{hj}tab-ár] ‘book’ abs. pl. A short interval indicates a higher degree of overlap.

Second, I argue that the same syncope is the trigger for a number of consonant voicing alternations observed in the language (Haspelmath 1993, Yu 2004). One of them is illustrated in (1b) and (1c): when C1 and C2 are both aspirated surrounding a full vowel, C2 loses its aspiration in the syncope context. The stop system of Lezgi has a four-way voicing distinction: voiced, aspirated, unaspirated, and ejective. The second alternation is illustrated in (2):

(2)	*absolutive singular*	*absolutive plural*
‘frog’	qib	q^{hj}p-ér
‘throat’	tyd	t^{hɥ}t-ér

This is a dual alternation. First, an unaspirated C1 becomes aspirated in the syncope context. A voiced C2 becomes plain unaspirated in the same context. All three alternations are counter-intuitive. I argue that they can all be explained if the reorganization of C1 and C2 into a cluster also implies re-organizing their respective glottal gestures such that only one glottal gesture will be present in a cluster, and it will be associated with the release phase of C1. In the absence of articulatory data to test this hypothesis, supporting arguments are based on acoustic evidence for high vowel devoicing in the relevant examples, and on some dialectal variation attested for some of the voicing alternations.

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Language-specific aspects of the perception of illegal clusters

Pierre A. Hallé
Laboratoire de Phonétique et Phonologie, CNRS-Paris 3, and Haskins Laboratories

This talk focuses on the perception of some illegal consonant clusters, as constrained by language-specific phonological constraints in the listeners' native language, that is, loosely speaking, by phonotactic constraints. Such constraints not only specify the permissible sequences of consonants, regardless of syllabic structure, but also the consonants that are allowed to occupy a given syllable slot (e.g., onset or coda). (Here, we restrict ourselves to the discussion to utterance-initial consonant clusters.) An early mention of how nonnative consonant clusters are perceived appeared in Polivanov's (1931) "*La perception des sons d'une langue étrangère*." Polivanov reported, for example, that Japanese listeners hear an epenthetic vowel in the initial cluster of *drama* and produce either *dorama* or *dzurama* when they attempt to pronounce this word. It's important to note that, in Polivanov' account, such epenthesis occurs at the perceptual level. That is, Japanese speakers/listeners pronounce *drama* as *dzurama* because they *hear* an /u/ in /dr/, not just because their output grammar disallows /dr/. Of course both aspects may be viewed as tightly linked: speech perception is largely driven by the listeners' native phonology. But what is the processing locus at which the native phonology operates? Recent studies in psycholinguistics or at the crossroad of psycholinguistics and loanword phonology have supported the view that phonological repairs are the reflexion of early, automatic phonetic perception (Berent et al., 2007; Dupoux et al., 1999, 2001; Hallé et al., 1998; Peperkamp & Dupoux, 2003). Certain aspects of this early phonetic perception may reflect universal trends (Berent et al., 2007) but we focus here on those perceptually motivated phonological repairs that are clearly language-specific.

The probably most common type of repair is vowel epenthesis, as in Polivanov's example. Various other cases of within-cluster epenthesis are illustrated in Berent et al. (2007). Vowel prosthesis in sibilant + obstruent onset clusters is well documented in the loanword phonology (Fleischhacker, 2001) but not in the speech perception literature. We contributed to fill the gap in examining Spanish listeners' perception of /s/ + stop clusters in utterance-initial position. In Spanish, these *sC* clusters are illegal. Loans from English suggest that *sC* clusters are repaired with /e/ prosthesis (e.g., *steak* > *esteak*; *smoking* > *esmoquin*). But do Spanish listeners hear an initial /e/ in *sC* clusters? We used spoken words such as *especial* compared to words such as *astuto* and digitally removed the initial vowel, leaving pseudowords such as *special* vs. *stuto*. This material was presented to Spanish subjects for lexical decision (Hallé et al., 2008a). By and large, subjects were "fooled" by *special* but not by *stuto* pseudowords, suggesting they (perceptually) repaired *sC* with a prothetic /e/ (*special* > *especial*; *stuto* > **estuto*), whether this produced a word or not (Fig. 1). Hence, this case of prosthesis is largely prelexical. Now, how automatic is it? To answer this question, we ran a visual masked priming experiment with the same materials presented as printed primes (Hallé et al., 2008b). Although the primes were not consciously visible, we found facilitation priming for special–ESPECIAL but not for stuto–ASTUTO, at prime-target SOAs larger than about 100 ms. These data suggest, among other things, that this phonological repair occurs in print as well as in speech, that it is out of conscious control, and that it requires some additional processing time (Fig. 2).

Substitution repairs are much less documented in both loanword phonology and speech perception literature. Massaro and Cohen (1983) showed that the identification of an /r/-/l/ continuum was biased by "phonological context": more /r/ responses after /t, d/ than after /b, g/. But */tl/ is not perceived as /tr/: We have reported evidence for dental-to-velar perceptual shifts in word-initial /dl, tl/ clusters for both French and American but not Hebrew listeners, in line with the ban of /dl, tl/ in English and French but not Hebrew (Hallé & Best, 2007). These data confirmed earlier results obtained with /tl, dl/ nonwords produced by a native speaker of French (Hallé et al., 1998). Using an experimental design similar to that described above for Spanish, we also found that the dental-to-velar substitution repair at work during the overt presentation of /dl, tl/ pseudowords is largely prelexical: *tlavier* > *clavier* ('keyboard) vs. *tlacard* > **clacard*, not *placard* ('closet') (Fig. 3).

These data converge to suggest that phonological repairs occur at an early, automatic processing stage. Is this stage preceded by an even earlier stage at which phonetic perception is "faithful"? If such is the case, this stage would be even more deeply buried an more unavailable to consciousness than the phonological repair stage.

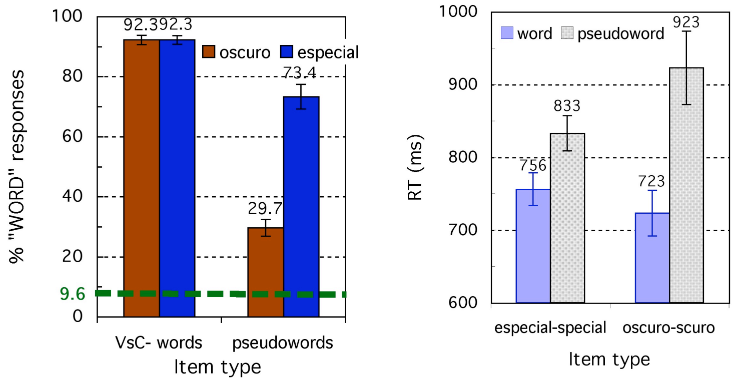

Figure 1. Auditory lexical decision on *oscuro*/*especial* compared to **scuro*/*special*: "word" response rates and response times

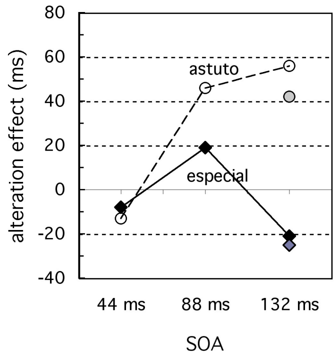

Figure 2. visual masked priming VsC/sC alteration effects w/SOA

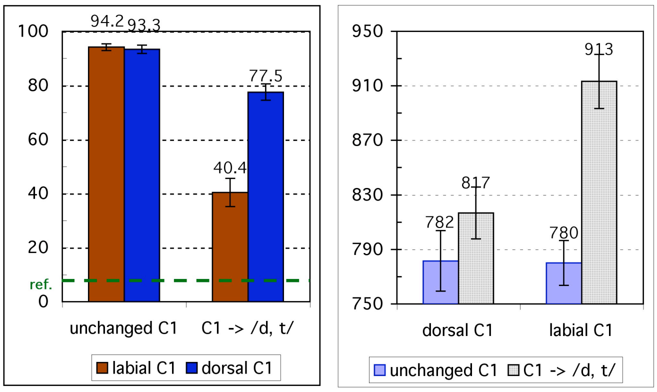

Figure 3. Auditory lexical decision on *placard*/*clavier* compared to **tlacard*/*tlavier*: "word" response rates and response times

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Consonant cluster retention and simplification in creole languages

Mareile Schramm (Universität Siegen)

It has often been observed that contact languages such as pidgins and creoles tend to have only unmarked CV syllables (e.g. Romaine 1988). While this claim has been shown to be untenable in its extreme form (e.g. Plag and Schramm 2003, Klein (to appear)), most researchers would agree that the restrictions on syllable structure are usually tighter in a pidgin or creole than in its lexifier language(s). Lexifier words which do not meet the requirements often undergo phonotactic restructuring such as consonant deletion or vowel epenthesis. Due to their rather more complex nature, consonant clusters are particularly prone to simplification.

In this paper I will take a closer look at the treatment of consonant clusters in six Caribbean creoles, with different (European) lexifier languages, including two creoles derived from each English, Dutch, and French.

While the degree of restructuring varies across the investigated creole languages, a comparison of patterns of cluster simplification reveals some interesting overall tendencies. Some types of clusters are readily preserved in most creoles (e.g. word-initial obstruent-glide or obstruent-liquid sequences), whereas others are typically simplified (especially sequences of two obstruents). Moreover, among the simplified sequences, some are preferably repaired by consonant deletion, others by vowel epenthesis. Sonority sequencing, but also manner and place features appear to play a role in determining a) whether or not a cluster is simplified in a given creole, and b) which kind of restructuring applies in case of simplification.

On the basis of the creole data, I will propose a ranking of the investigated cluster types according to their relative likelihood of undergoing simplification.

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Franz Katzir-Cozier, Massachusetts Institute of Technology, Department of Linguistics

Encoding perceived contrast between CC-clusters & simplified counterparts in coda CC-simplification

This paper examines grammatical constraints on word-final consonant cluster inventories ($VC_1C_2\#$). Crosslinguistically, languages such as Trinidad dialectal English (TE), African American English, Cameroon English, Quebec French, and Catalan show striking consistency in the set of clusters that are illicit word-finally as shown in (1) (cf. Côté 2004, Green 1992, Bobda 1994, Mascaro 1976). Languages that ban these clusters do not release final stops (cf. Archambault & Dumochel 1993). This makes it seem likely that simplification is related to the perceptibility of C_2 in the absence of release. The central claims of this paper are (1) that C_2 deletion is triggered when the distinctiveness of VC_1C_2 and VC_1, as a function of phonetic cues, falls below a particular threshold and (2) that speakers encode this perceptually based difference between simplified and preserved clusters in their grammars. Experimental results will show how the synchronic grammar of TE reflects the historical simplification process. A second experiment confirms that perceptibility does not just cause loss of C_2 over time but that the grammar attributes simplification to perceptual difficulty raised by unreleased C_2's.

Eleven TE speakers were forced to consider producing words that end in unattested clusters. If speakers' grammars reflect perceptibility, they should be more likely to preserve nonce clusters to the extent that C_2 is more perceptible. Subjects were exposed to nonce adjectives of the form X-y. Simplification occurs word-finally in TE but does not occur before the –y affix (eg. frosty /frɔsti/, */frɔsi/). Subjects were prompted to produce sentences that contained the bare X as a verb by reading the entire sentence that was presented visually (e.g*. They call him **gind**y because he likes to ___ a lot*) and filling in the blank by stripping the nonce adjective of its affix. The contents of X were varied as shown for stimuli in (2a) –(2c): (2a) X= [...VC_1C_2] sequences attested in TE; (2b) X = [...VC_1C_2] sequences unattested in TE and hypothesized to be discriminable from VC_1 even when C_2 is unreleased; (2c) X = [...VC_1C_2] sequences unattested in TE and difficult to discriminate from VC_1 when C_2 is unreleased, compared to sequences in (2b). Cues hypothesized to signal C_2's in the absence of release are given in (3) for real & unattested clusters (cf. Wright 2004). Subjects' responses were recorded and analyzed in Praat. The simplification pattern for attested clusters is consistent with data in (1). Simplification of unattested clusters is consistent with predictions in (3). For instance, the unattested cluster /mk/# was simplified significantly less frequently than unattested /mg/# ($p < .01$). I attribute this and similar effects to the fact that there are more cues to C_2 in significantly less frequently simplified clusters like /mk/# than for C_2 in more frequently simplified clusters like /mg/#.

The next experiment demonstrates that simplification is based on perceived contrast between $VC_1C_2\#$ & $VC_1\#$. In a binary forced choice identification task, $VC_1C_2\#$ & $VC_1\#$ stimuli recorded by a native Standard English (SE) speaker were presented to 9 SE subjects. Clusters included attested and unattested clusters of English. All releases of final stops were edited out, creating stimuli comparable to the unreleased $VC_1C_2\#$ strings that speakers of TE would have been exposed to prior to the changes that resulted in simplification of coda clusters. Sensitivity measures (d') of the perceptual contrast between $VC_1C_2 - VC_1\#$ are given in (4) & (5) for attested & unattested clusters respectively (cf. Macmillan & Creelman 2006). For each comparison, d' values are significantly larger for clusters that are significantly less frequently simplified ($p < .01$). There is a significant correlation between $VC_1C_2\#$ clusters simplified in languages with unreleased C_2's and $VC_1C_2\#$ clusters that cannot be distinguished from their $VC_1\#$ counterparts.

$VC_1C_2\#$ simplification occurs where there is insufficient perceptual contrast between $VC_1C_2\#$ and $VC_1\#$, due to insufficient cues to C_2. Results of the affix stripping experiment show that speakers encode this perceptually based contrast between $VC_1C_2\#$ & $VC_1\#$ for simplified & preserved clusters. This corroborates the P-map hypothesis, which states that there is a component of the grammar that encodes perceptibility differences between different contrasts and that these contrasts are reflected in constraint rankings (Steriade 2001).

(1) F = Fricative, T = Voiceless Stop, N = Nasal, <…> = deleted C$_2$. Examples given in TE

C2 preserved TE Examples:	VN$_1$T$_2$#, VN$_1$F$_2$# [ænt˺], [ɪntʃ]	Vl$_1$T$_2$#, Vl$_1$b$_2$#, Vl$_1$g$_2$#, Vl$_1$N$_2$#, Vl$_1$F$_2$# [mɛlt˺], [bʌlb˺], [fɪlm], [ɛls]	T$_1$F$_2$# [æks]	Vs$_1$p$_2$# [lɪsp˺]
C2 deleted TE Examples:	VN$_1$ <d$_2$># [æn<d˺>]	Vl$_1$<d$_2$># [ol<d˺>]	VT$_1$<T$_2$># [æk<t˺>]	VF$_1$<T$_2$>#, Vs$_1$<t$_2$># [lɪf<t˺>], [lɪs<t˺>]

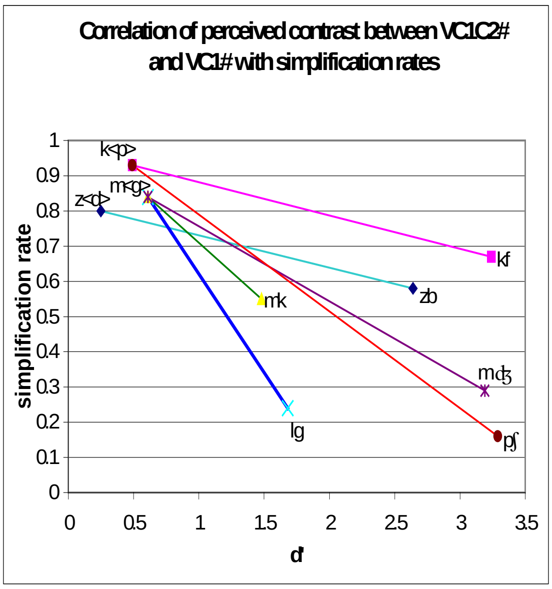
(2) (a) Attested clusters: ginty, vinty, genty, vunty, zanty; gindy, vindy, gendy, vundy, zandy; zilty, vilty, klelty, vulty, zalty; zilby, vilby, gelby, vulby, zalby; zilmy, shilmy, kelmy, wulmy, zalmy; zildy, vildy, geldy, vuldy, zaldy; gispy, bispy, kespy, wuspy, shaspy; gisty, bisty, kesty, wusty, shasty; kifty, difty, kefty, vafty, zafty; gickty, zickty, geckty, vuckty, chackty; gicksy, shicksy, gecksy, vucksy, chacksy; kifsy, vifsy, gefsy, vufsy, zafsy

(b) Unattested clusters with C$_2$ perceptible: gickfy, zickfy, geckfy, vuckfy, chackfy; kizby, dizby, kezby, vuzby, shazby; zimky, fimky, gemky, vumky, zamky; zilgy, vilgy, gelgy, ulgy, zalgy; zamjy, vumjy, zimjy, fimjy, gimjy; vupshy, bipshy, kepshy, shapshy, gipshy

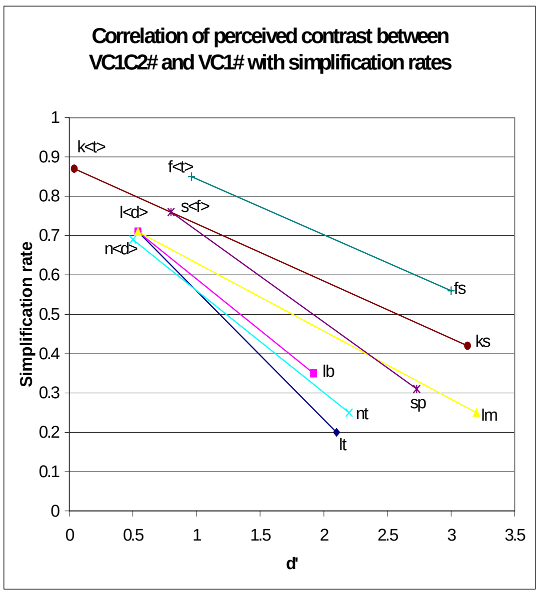
(c) Unattested clusters with C$_2$ imperceptible: gickpy, zickpy, geckpy, vuckpy, chackpy; kizdy, dizdy, kezdy, vuzdy, shazdy; zimgy, fumgy, gemgy, vumgy, zamgy

(3) Preserve		Cues contrasting preserved VC$_1$C$_2$# & VC$_1$#	Simplify	
Attested	Unattested		Attested	Unattested
Vlt, Vnt	Vmk	Vowel-Sonorant shortening because of final voiceless stop	Vld, Vnd, VTT	Vkp
Vlb	Vlg	Transition cues in the liquid for heterorganic final stop	Vld	Vmg
Vsp	Vzb	Transition cues in the /s/ or /z/ due to labial (Munson 2001)	Vst, Vsk, Vft (Naeser 1970)	Vzd (un-attested TE)
VnF, VlF, VTF	Vmd͡ʒ, Vkf, Vpʃ	Frication noise	Vnd, Vld, VTT	Vmg, Vkp

(4) Unattested Clusters



(5) Attested clusters



/sp st sk/ cluster reduction in phonological disorder: a longitudinal study

James M Scobbie

Phonological Disorder is the term given to a speech development disorder in which delayed or deviant phonetic output and impaired transmission of phonological contrasts occurs with no known aetiology. The cause of the disorder appears to be specifically linguistic, and might be primarily located in perception, production, or in the systemisation of the phonological system at a cognitive level. One indication that the cognitive level is intact comes from covert contrasts, in which close instrumental analysis reveals that the child is actually making distinctions which are not apparent to other members of their speech community.

It may be that that the change from clusterless to clusterful speech in pd children, which happens at a much later age than the norm, is due to gradual developments in production by the child that are hard for adults to perceive until they cross some perceptual threshold. Alternatively, it may be that the child relatively suddenly and quite dramatically changes their production to something close to the norm.

In this paper, data from the QMU Cluster acquisition study will be presented, and the following questions addressed:

- In what acoustic events is there evidence of gradual development as opposed to a categorical acquisition event?
- If a /st/ cluster is reduced to a stop, is it /t/ or /d/?
- How do the three /s/ clusters compare?
- How do the pd children compare to the controls?

The study followed eight children ranging in age from 4;1 to 7;0 with a persistent Phonological Disorder ("pd") longitudinally for about 18 months, to an age range between 5.10 to 8.8, where the children were recorded six times. In addition data from 12 controls in four groups aged 4;0, 4;6, 5;0 and 5;6 were analysed. (Note, some longitudinal data (sessions 3-6) from two pd children is currently lost due to hardware failure.) The pd children had a range of different reductions of their clusters /sp st sk/, including stop deleting, fricative deletion, and merger. The durational acoustic events discussed are based on six tokens from the following environments: /sp st sk/ and /t d/ before the rimes /ai ir or/: the fricative duration, stop duration, (and their ratio), VOT, and rime. In addition, the spectral quality of the frication and stop components is considered.

The results show a wide range of individual variation, in which any longitudinal pattern in development, even in duration-based ratios rather than raw duration, is relatively rare. There are, nevertheless, clear indications of gradual development in the spectral and durational behaviour of the children, as well as cases of covert contrast.

Acquiring and avoiding complexity in SLI vs typical development of French

Sandrine Ferré
Imagerie et Cerveau, Inserm U930 - CNRS FRE 2448 – University of François Rabelais - CHRU - Tours - France

This study questions the notion of phonological complexity by the comparison of the productions of speakers with and without language impairment faced to complex structures of French.

Cross-linguistic studies (Hayes et al, 2004) or acquisition data (Gierut, 2007, Thompson, 2007) are sources of arguments to define complexity, providing information on degree of markedness or age of acquisition. Complexity can occur simultaneously on two levels of structure: a complex syllable can contain complex segments (Cyran, 2003). Degree of complexity conditions de facto the type of syllable which can be licensed in a language. Then the syllabic positions are more or less constrained by the segmental value that they can accept (Angoujard, 1997)

Our aim is to better understand the notion of complexity by examining the treatment (errors and strategies) of structures known as complex in two developments and to confront theoretical models of organization of the sound form with these data.

The comparative study of atypical and typical is of special interest due to the fact that acquisition can be observed in slow motion but also because analyzing the precise cause of disordered language development allows for identification of areas of language complexity. Thus, so-called compensatory strategies, alternative strategies that are used by speakers whose linguistic performance is impaired, may be viewed as ways to avoid complexity. Children with grammatical SLI have tremendous difficulties to process phonological structures. Several explanations are proposed, but there is currently no consensus about what is affected in their phonology: underspecification of their representations, (Maillart et al, 2006), insufficient working memory (Gathercole & Baddeley, 1990), incapacity to build high level structures (van der Lely et al. 2004, Marshall, 2003).

To investigate the treatment of complexity, we built an experimental test « Syllabic Structure & Segments » (SSS) on the idea of complexity: this repetition task tests production of specific segments (sonorants [R, l], approximants [j, w, ɥ], and [s]) in different positions (initial, intervocalic and final) in structures with varying degrees of complexity (simple to triple consonantal clusters). This protocol thus raises the question of association between segments and syllabic positions, independently of any theoretical framework. Two groups of French subjects participated: children with SLI aged 7 to 15, and typically-developing children aged 3 to 4.

The results show that syllabic positions and all the tested phonemes are acquired. However, the association of the phoneme to the syllable is not solved in all the cases: some sounds are not allowed in specific positions. In particular, restrictions take place on coda and on branching structures, and this, through the ages, and the groups. This leads us to propose various constraints as for the possible values that a syllabic constituent can accept at each stage of the development. Moreover, according to the age and the type of development, various strategies are used to manage structural complexity: in the typical development, the omission is first largely used, then this strategy is gradually replaced by consonantal substitution; in SLI development, this procedure remains inoperative and young adults with SLI produce larges disturbances within the phonemic organization when the word presents complexity (consonants are disturbed (substitution, metathesis, …) but vowels are preserved). These data let suppose that the consonantal positions remain badly specified for these young adults: confrontation with complex structures generates a random treatment of the consonants which can be produced in every slot. From this point of view, the children with SLI would have difficulty to organize the consonantal line, when there are several adjacent consonants. These results allow us to think that structural complexity would lie at the same time in the number of adjacent elements that a constituent can accept and in the number of complex constituent present in a sequence.

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The acquisition of consonant clusters by Greek-speaking children

Eirini Sanoudaki
Bangor University
e.sanoudaki@bangor.ac.uk

Research on phonological acquisition has shown that structural issues are reflected in children's phonological acquisition, in that children tend to produce simpler structures before more complex ones. However, consonant clusters are notoriously peculiar in this respect: word initial clusters of non-rising (or falling) sonority (e.g. *st, sp*) are acquired before regular onset clusters (i.e. clusters of rising sonority, TR, e.g. *tr*, *pl*) by some children, and after by others (see Barlow 2001). This makes a successful comparison of the complexity/markedness of the two cluster types particularly difficult. Several proposals intending to tackle the problem have been put forward (e.g. Barlow 1997, Fikkert 1994, Lleó & Prinz 1997).

The only type of word initial clusters of non-rising sonority that has been examined extensively is s+obstruent clusters (sT), by virtue of being attested in well-studied languages such as English. However, other languages, such as Greek, allow a number of other word initial clusters of non-rising sonority (TT, obstruent-obstruent clusters, e.g. *ft, xt*).

In this study, I compare the acquisition of clusters of non-rising sonority (TT) to that of clusters of rising sonority (TR) in word initial and word medial position. Experimental production data were collected from fifty nine monolingual Greek children (aged 2;03-5;00, mean age 3;08) using a non-word repetition task. The results show a clear tendency for word initial TR clusters to be produced before word initial TT clusters. A comparison of the initial clusters with their word medial counterparts also shows differential behaviour. Specifically, word initial TT was acquired after word medial TT, while no such difference was found in TR acquisition.

These results are consistent with the marked status of word initial clusters of non-rising sonority that is generally accepted in phonological research. However, the findings regarding TT clusters are not in line with findings from other languages regarding sT clusters. This is particularly important, since it constitutes evidence for a differentiation between sT and the remaining clusters of non-rising sonority, despite evidence to the contrary from adult phonology (e.g. Seigneur-Froli 2006, Steriade 1982). We are thus faced with an apparent paradox: on the one hand, there is developmental evidence that the two cluster types are different in some way crucial to first language acquisition, and on the other hand, phonological processes in adult language create an identical structural profile of the two cluster types.

In light of such conflicting evidence, I explore a parametric model for the acquisition of consonant clusters which employs the subset principle, a condition widely assumed to be necessary for learnability. The model explains the developmental data whilst at the same time it covers the adult language phenomena. Specifically, the marked settings of a grammar that allows initial TT clusters form a superset of the marked settings required for initial sT clusters, which explains the developmental data, while the behaviour of the two cluster types in adult language is a consequence of the resulting representations having identical structure in grammars that allow them both.

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The occurrence of [j] after consonant clusters in American English

T. A. Hall
Indiana University

In American English the palatal glide [j] can occur in the context /…VC__V…/, e.g. *nephew, refuge, ambiguous, onion, Pennsylvania, million, value, Australia, erudite*. These examples illustrate that [j] can surface after a single consonant, which can be an obstruent, nasal or liquid.

In the present talk I investigate the occurrence of [j] after two (or more) consonants, i.e. in the context /...VCC__V…/. In particular, it will be shown that the palatal glide can only surface after certain combinations of two consonants but not others. For example, [j] can surface after a sequence of liquid plus obstruent in words like *argue, calculus* and *circular*. By contrast, there are no English words in which [j] surfaces after the reverse sequence (i.e. obstruent plus liquid). This point can be illustrated with words containing an obstruent plus liquid in which the following vowel must be pronounced [i]: *atrium, nucleus* and *bibliography*. Pronunciation of words like these with [j] is considered ungrammatical by native speakers.

In this talk I show that the restrictions on the occurrence of [j] after two consonants do not always follow from independent phonotactic constraints. (By contrast, the non-occurrence of the labial glide [w] after certain two-member consonant clusters follows from phonotactic statements that are independently necessary). I demonstrate that the generalizations governing the distribution of English [j] require crucial reference to sonority. In particular, it will be argued that the non-occurrence of [j] after certain two-member clusters requires reference to both (a) the Syllable Contact Law and (b) specific statements banning highly sonorous two-member syllable onsets (i.e. onsets consisting of nasal plus [j] or liquid plus [j]). It will be shown that the gaps in English phonotactics referred to above can be accounted for by appealing to both (a) and (b) together.

The proposal will be shown to derive additional support from the restrictions governing the rule of glide formation in Modern German, which converts /i/ to [j] before a vowel. Although glide formation can be shown to apply regularly after two consonants (/…VCCiV…/ → […VCCjV…]), certain combinations of consonants regularly block glide formation. Significantly, the contexts in which glide formation is blocked in Modern German are identical to the ones in which American English [j] is banned.

A gestural modeling of vowel clusters: Romanian diphthongs

Stefania Marin[1], Louis Goldstein[2]
[1]Institute for Phonetics, Ludwig Maximilian University, Germany
[2]Department of Linguistics, University of Southern California, USA; Haskins Laboratories

Romanian has alternating roots where a stressed diphthong/complex nucleus ['ea] alternates with unstressed [e] (['s**ea**ra] 'the evening', [s**e**'rata] 'the evening show'), and non-alternating roots, with [e] in stressed/unstressed contexts (['s**e**ra] 'the greenhouse', [s**e**ri'tʃika] 'the greenhouse-Dim.'). A significant acoustic difference has been reported between [e] in alternating and non-alternating roots, a difference not explainable as a stress effect ([5, 6]). This kind of evidence supported an Articulatory Phonology ([1, 2]) analysis of Romanian diphthongs as a cluster of two vowels synchronously coordinated with each other, resulting in a diphthong whenever vowel [a] is stressed and a blended vowel (different from an underlying non-alternating vowel) in the absence of stress. Starting from this hypothesis, the present paper presents a gestural model of the Romanian diphthong ['ea] and its alternation with unstressed vowel [e], with relevance to a model of stress in Articulatory Phonology.

The computational implementation of Articulatory Phonology used in this study is TADA (Task Dynamics Application), which models the planning of relative timing of gestures in an utterance by associating each gesture with a corresponding oscillator (or clock). The coupling relations among these oscillators are specified in a *coupling graph*, assumed to be part of the phonological representation of an utterance, which instantiates its syllable structure ([4]). To test the hypothesis that Romanian diphthongs and their alternations are the result of two vowels being synchronously coupled, stimuli were created with the oscillators for vowels [e] and [a] coupled in-phase (0 degree), resulting in their synchronous production, and as controls, with vowels [e] and [a] coupled anti-phase (180 degree), resulting in partly sequential (and overlapped) relative timing, and finally coupled in-phase, but triggered on successive cycles (360 degree), resulting in completely sequential timing. All the stimuli had an initial and final labial [b] flanking the relevant vowels. In order to determine how to best model stress differences, a preliminary study was carried out in which several possibilities were tested: activation duration of vowels, presence of a prosodic gesture that slows the time course of speech production during stressed syllables (cf. [3]) and also increases the spatial extent of gestures when stressed, and finally, relative *blending weight* of the two vowels. When two gestures that control the same goal variables overlap in time (as is the case for the vowels [e] and [a]), the control parameters of the two gestures are blended by a weighted averaging scheme ([7]). This preliminary study showed that the blending weight parameter successfully models Romanian stress effects: stimuli with greater blending weight for [a] share acoustic properties that make them be perceived predominantly as a diphthong (independent of the values of other parameters explored). This pilot study also shows that stimuli with vowels in 180/360-degree coordination are unambiguously perceived as hiatus stimuli, and stimuli with single vowels [e] and [a] are unambiguously perceived as such. For this reason, these control stimuli are not included in further experiments.

The main experiment was designed to manipulate blending weight systematically for synchronously coordinated vowels: while blending weight for [e] was kept constant, blending weight for [a] was increased in 10 steps, from a base stimulus where both vowels had the same weight to a stimulus with blending weight for [a] six times greater than that of [e]. These stimuli were used in a forced-choice identification task, in which 5 listeners had to decide whether the stimulus heard was a) a diphthong, b) vowel [e], or c) vowel [a]. The stimuli were presented ten times in random order. Subjects perceived stimuli with equal weight as vowel [e], stimuli in which [a] was weighted 3-4 times more strongly than [e] as diphthong [ea], and stimuli in which [a] was weighted 5-6 times more strongly than [e] as vowel [a] (Figure 1). This result supports the hypothesis that a cluster of two vowels synchronously coordinated is perceived as a vowel, unless other factor(s), such as stress, make it be perceived as a diphthong. In the present model, the factor responsible for triggering a diphthong percept is extra blending weight on one of the vowels. Thus, the result of this experiment also strongly suggests that a crucial parameter responsible for stress is blending weight, with extra blending weight conferred to the stressed vowel.

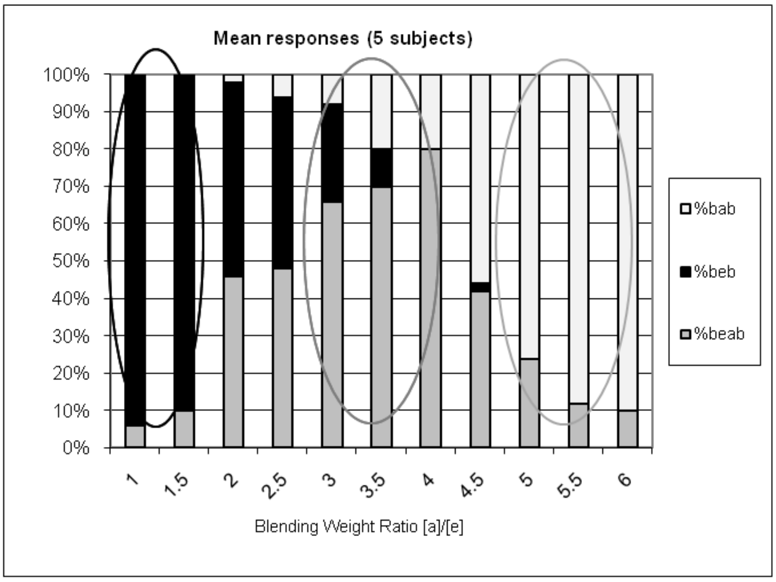

Figure 1. Perceptual experiment: mean percentage responses for 5 subjects.

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Schwas within Berber consonantal clusters: between reality and illusion

Rachid Ridouane & Cécile Fougeron
Laboratoire de Phonétique et Phonologie (CNRS – Sorbonne Nouvelle)

The syllable structure of Tashlhiyt is highly unusual, since this language allows any consonantal cluster, be it voiceless, to be a well-formed syllable (Dell and Elmedlaoui 1985, 1988, 2002, Prince and Smolensky 1993, Clements 1997). The most striking examples, taken as arguments in favor of this thesis, involve large series of words containing only consonantal clusters (e.g. [tb.dg] "it is wet", [tk.kst] "you took off"). Such words are claimed to surface with no schwa vowels that can act as syllable peaks. This claim, however, was based only on impressionistic phonetic observations and did not rely on any experimental phonetic data (Dell & Elmedlaoui 2002). On the basis of his belief that all words have syllables and all syllables have vowels in all languages, Coleman (2001) proposes what he calls "the Coproduction Analysis of Syllabic Consonants" and interprets Tashlhiyt syllabic consonants as sequences of *schwa vowels plus consonants*. More specifically, he argues that epenthetic schwa vowels are introduced by the phonological component to repair syllable structure.

As was shown in Ridouane & Fougeron (2006), there is a high variability in the acoustic manifestation of schwa-like vowels within clusters containing voiced consonants (see also Coleman 2001). To account for cases where no schwas are present acoustically, Coleman claims that there is a schwa vowel associated with syllable nuclei, but 'hidden' behind the consonant gestures. If this claim is correct, then we should see the effect of the schwa gesture on the position of the tongue body during the articulation of the consonant gestures. To test this, we recorded data on supra-laryngeal articulations using Electropalatography (EPG). Two subjects were recorded while producing various types of consonantal clusters. One set of data is composed of what one might call *homorganic words*:

(1)	[n.tl] "hide, imp."	[tn.tl] "she hided"
	[tn.tlt] "you hided"	[tn.tl.tn] "she hided them, masc."
	[tn.tl.tnt] "she hided them, fem."	[tn.tlt.tnt] "you hided them, fem."

Preliminary results from one subject show that these items are deprived of schwa vowels. During the production of these homorganic sequences, the speaker never moves the tongue away from the alveolars, a gesture necessary to produce a schwa vowel. Even if the consonants in these clusters are coordinated such that they do not overlap, the motion of the tongue from /t/ to /n/ or from /t/ to /l/ will not result in an intrusive vowel, since it is never pulled away from the alveolar ridge (cf. a similar discussion in Gafos 2002 for Moroccan Arabic). Another set of data is composed of C1C2.C3V items, where C2 differs only in voicing:

(2)	*C2-voiceless*	*C2-voiced*
	[tk.nu] "she bended"	[tg.nu] "she sew"
	[tk.ru] "she rent"	[tg.ru] "she gathered"

These data are currently analyzed. Preliminary results from one subject show that unlike items where C2 is voiceless, items containing a voiced C2 display a visible vocalic element in the acoustic signal. We plan to record additional data using both EPG and Ultrasound. The aim is to compare the tongue shape in [C1C2voiceless] to the tongue shape of [C1C2voiced]. If schwa is inserted in the voiced cluster, as is claimed by Coleman, the tongue shape changes in this cluster should be different from those produced for [C1C2voiceless] clusters. On the other hand, if as we believe, this schwa is a mere intrusive element, the tongue shape changes in [C1] to [C2 voiced], should be more similar to those produced during [C1C2voiceless] (cf. Davidson & Stone (2004) for a similar discussion on Polish clusters produced by English speakers).

Linguistic experience and the processing of clusters in speech

Andrea Weber

Abstract

Languages differ with respect to the sequential arrangement of phonetic segments in morphemes, syllables, and words. Not all possible combinations of segments occur in a given language (e.g., English has a prevocalic /pl/ cluster but no /pf/ cluster), and some combinations occur more often than others (e.g., many English words begin with /pl/ and relatively few with /sn/). It has been pointed out many years ago that the rules and probabilities applying to the sequencing of phonemes in a language provide a rich source of information, and indeed its use by human listeners has been amply attested in perceptual experiments.

In particular, phonotactic rules and probabilities can be used as juncture cues to word boundaries. For example, an English listener will posit a boundary between /p/ and /f/ since the cluster /pf/ cannot occur syllable-internally in English. This will help to parse the sequence ”hope for” correctly because no other boundary assignment would give rise to two legal English syllables. Phonotactic regularities are thus one information source which can help listeners to segment the continuous speech stream into individual words (which is a prerequisite for language comprehension). The ability to exploit phonotactic rules and probabilities comes, of course, from linguistic experience; it is by experiencing a particular language that we learn its phonotactic regularities. But also more subtle acoustic-phonetic information can potentially signal the presence of a syllable or word boundary; for example, in all languages phonetic segments in word-initial position tend to be longer than those in word-medial or word-final position. Again, there is substantial evidence that listeners can use this type of information for the identification of boundaries. In this talk I will discuss evidence of how both sources of information, phonotactic regularities and acoustic-phonetic cues, influence the process of speech segmentation for human listeners. Specifically, I will argue for the importance of experience with a particular language in modulating the segmentation process.

Articulatory and acoustic evidence for syllable structure effects on reaction times

C. Mooshammer[a], L. Goldstein[a,b], M. Tiede[a,c], H. Nam[a] and M. Gao[a]
[a]Haskins Laboratories, New Haven, CT, USA
[b]University of Southern California, Los Angeles, CA, USA
[c]MIT Research Lab of Electronics, MA, USA
tine@haskins.yale.edu

The time the speaker needs for planning and initiating utterance has been found to be affected by a number of factors such as neighborhood density, word and syllable frequency, the number of units to be produced and syllable complexity. Effects of the latter are explored further in this study. Shorter latencies for complex onsets (CCV) as compared to simple onsets (CV) have been explained by effects of segment-specific biomechanical constraints at the level of motor execution (Rastle & Davis 2002), and by neighborhood density at the planning level (Kawamoto & Kello 1999). Within the framework of Articulatory Phonology, shorter planning latencies for CV syllables (compared to VC) have been attributed to quicker stabilization for tighter gestural coupling hypothesized for in-phase coupling of the onset consonant and release with the vowel (Nam 2007). Since tighter coupling might also account for shorter latencies for items beginning with a consonant cluster, we tested both onset complexity (C vs. CC) and coda complexity (open vs. closed syllables) within a single experiment, in which we acquired acoustic and articulatory reaction time data.

Procedure

In order to avoid word and syllable frequency effects, we applied the delayed naming paradigm (see e.g. Rastle et al. 2005). In this method, a target word is displayed to the subject for a period varied randomly between one and two seconds prior to the onset of an audiovisual triggering cue, which is the signal to the subject to produce the word as quickly as possible. American English monosyllabic words varying in syllable structure were tested in two conditions. In the first subjects produced the word with no additional context (simple delayed naming). In order to facilitate detection of acoustic stop onsets, subjects in the second condition sustained an approximate schwa until their reaction to the stimulus (postvocalic naming). 20 native speakers of American English served as subjects in the acoustic-only experiments and 3 in the EMMA experiments.

Results and Discussion

Means and standard deviations of the acoustic latencies of 10 speakers from the acoustic-only experiment are shown in the figure below. In both conditions, we found clear and significant effects of onset complexity. Items with complex onsets are initiated faster than simple onsets, and simple onsets faster than onset-less syllables. In the first condition (without schwa) a subtle coda effect was found with longer latencies for CVC and CCVC than for CV and CCV. Furthermore, words starting with the fricative /s/ are generally produced with shorter latencies. Preliminary results from articulatory measurements corroborate these findings, but only for the postvocalic condition (see Kawamoto et al. in press for possible reasons).
In summary our results suggest that articulatory gestures are initiated quicker the more complex the syllabic onset is. This at a first glance contradictory result can be explained by differences in planning due to the settling time of oscillators and/or by c-center effects.

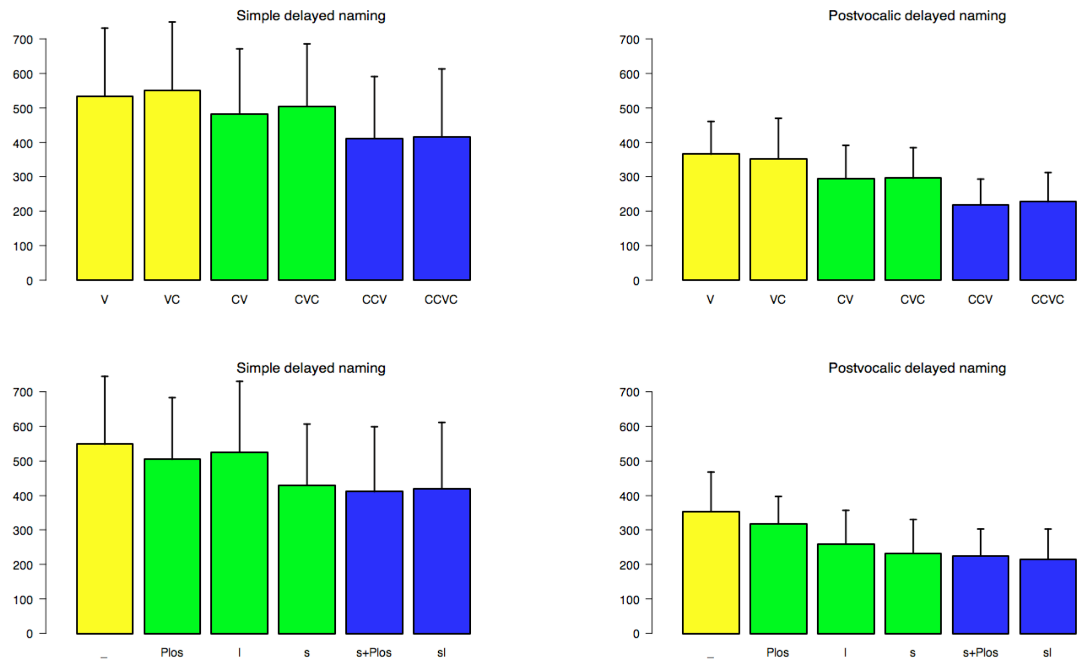

Figure 1: Acoustic reaction times depending on syllable structure (upper panels) and onset type (lower panels) for two different tasks: simple delayed naming (left panels) and postvocalic delayed naming (right panels).

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Probabilistic phonotactic grammar and lexical acquisition: The role of syllable complexity

Natalie Boll-Avetisyan, Utrecht University

We know that humans are sensitive to phonotactic distributions in their language (e.g. Scholes 1966; Bailey & Hahn 2001), and it has been suggested that such probabilistic phonotactic knowledge is put to use in lexical acquisition (Storkel & Rogers, 2000; Gathercole, Frankish, Pickering & Peaker, 1999). It is controversial, whether this probabilistic knowledge is informed by abstractions from lexical entries (e.g. Pierrehumbert 2003), or also by sub-lexical representations (e.g. Vitevitch & Luce 1999).

This study aims at providing psycholinguistic evidence that probabilistic phonotactic effects on lexical acquisition are produced by a phonotactic grammar represented at a sub-lexical level. A study by Roodenrys and Hinton (2002, henceforth R&H), however, suggests that only lexical factors play a role. R&H examined the impact of lexical and sub-lexical cues on short-term memory (STM) recall in native speakers of English. The result was that recall performance of CVC nonwords was influenced by the lexical neighborhood density of the nonwords, but not by the frequency of the CV and VC bi-phones composing them. Assuming that the mechanisms active in STM recall are the same as those active in lexical acquisition (cf. Gathercole 2006), the findings of R&H allow for the conclusion that lexical acquisition is aided exclusively by lexical factors.

I hypothesized that the failure to demonstrate an influence of bi-phone frequency in R&H was due to the simple syllable CVC structure of their stimuli. Consonant clusters in syllable margins are subject to much stronger co-occurrence restrictions than CV, VC, or CVC strings. Therefore, effects caused by a sub-lexical phonotactic grammar should increase with syllable complexity. I predicted that recall performance of complex syllable stimuli (CVCC, CCVC, and CCVCC) would be influenced by bi-phone frequency.

This prediction was tested on native speakers of Dutch by means of a serial recall recognition task. Stimuli were simple and complex syllable nonwords composed of high versus low frequent bi-phones. Lexical neighborhood density was controlled. Overall, participants were faster in recalling high bi-phone frequency than low bi-phone frequency nonwords. As predicted, the difference in recall performance between high and low bi-phone frequency nonwords increased with syllable structure complexity. Pairwise comparisons revealed that the interaction between bi-phone frequency and syllable structure was due to the difference in recall of complex and simple CVC stimuli, because recall of CVC items, just as it was the case in R&H, was not affected by frequency (figure 1).

However, there was a possible confounding factor which may have explained the results: Stimulus duration was longer in items that provoked longer recall latencies. To check whether the result was affected by stimulus duration instead of an interaction of bi-phone frequency and syllable complexity, I ran a second experiment controlling for stimulus duration. Here, the participants performed significantly better in recalling high bi-phone frequency nonwords of all - even of the CVC - syllable structure types. However, the interaction between syllable complexity and bi-phone frequency is less clear. Preliminary analysis reveals a difference only in performance between CVC and CCVCC (figure 2).

These results support the hypothesis that probabilistic phonotactic knowledge is independent from lexical knowledge, since lexical frequency was controlled for. Yet it is not clear why in experiment 2 an effect of bi-phone frequency was found, while it did not show up in R&H. It might well have arisen, had R&H used complex stimuli, since the frequency effect was larger among the complex items. It would therefore seem desirable that future experiments involve stimuli of increased structural complexity to test assumptions concerning the role of probabilistic phonotactics in lexical acquisition.

By demonstrating that probabilistic phonotactics influence STM recall independently of lexical factors, and that recall performance is increasingly affected by bi-phone frequency among structurally complex nonwords, this study indicates that lexical acquisition might be bootstrapped by a probabilistic phonotactic grammar represented outside the lexicon.

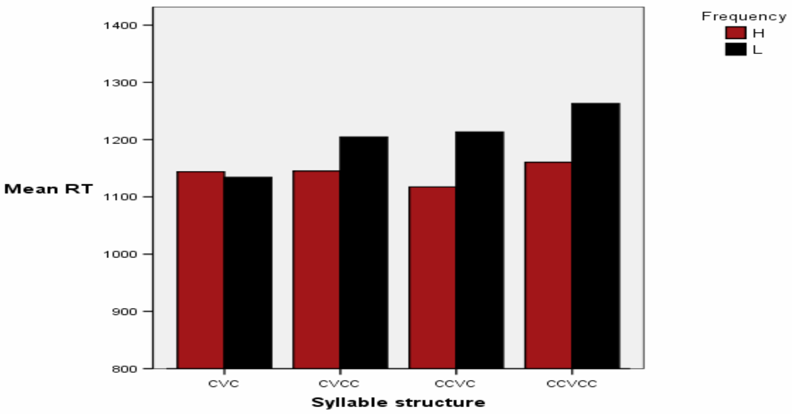

Figure 1: Reaction time means for experiment 1

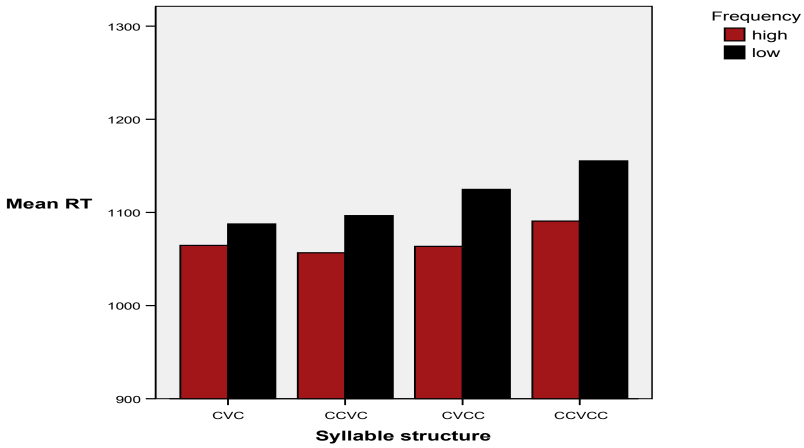

Figure 2: Reaction time means for experiment 2

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Factors affecting errors in consonant cluster production and perception

Adam Buchwald
New York University

This talk will address errors in the production and perception of consonant clusters. The data discussed were obtained to help determine factors that affect the likelihood of error in each modality, as well as to examine the outcomes of errors. We will highlight similarities and differences in the perception and production of consonant clusters along these dimensions.

In production, the data discussed explore the error productions of VBR, an aphasic speaker of English whose deficit leads to vowel insertion errors in consonant clusters (e.g., *bleed* → [bəlid]). This discussion will present acoustic and articulatory evidence that the repairs reflect VBR adopting the gestural timing used for consonant-schwa-consonant onsets in English, indicating a schwa epenthesis repair pattern. We will also discuss the factors that make these errors more or less likely, focusing on issues of consonant cluster frequency and complexity.

After establishing key properties of these aphasic production errors, we then turn to speech perception and word recognition errors. The data discussed come from a large corpus of spoken word recognition errors (more than 15000 errors) whose collection is in progress. In discussing these errors, we will focus on contrasts between perception errors and production errors. In particular, we consider the range of consonant cluster "repairs" in perception to determine if perceivers epenthesize vowels in consonant cluster perception errors (either anaptyxis or prothesis). In addition, we consider whether factors such as consonant cluster frequency and complexity affect the rate of correct perception of consonant clusters.

As we will see, repair strategies seen in consonant cluster production are seldom used in perception, although the likelihood of error in either modality is somewhat constrained by frequency. Many of the inconsistencies between errors in these modalities can be explained by the physical systems involved in the production and perception of clusters. The talk will conclude with a discussion of whether it is feasible to establish a definition of consonant cluster well-formedness that encompasses both the perception and production of consonant clusters.

Syllable structure and syllable frequency in apraxia of speech: an investigation of spontaneous speech

Anja Staiger & Wolfram Ziegler
EKN – Clinical Neuropsychology Research Group • City Hospital München Bogenhausen
Supported by DFG – German Research Foundation (ZI 469 / 10-2)

Background

Syllable structure has been observed to influence the occurrence of errors in apraxia of speech (e.g., Romani & Galluzzi, 2005), i.e., the patients seem to benefit from speech units with simple syllable structures (syllables without consonant clusters). In addition, syllable frequency was revealed as a factor influencing error rates in these patients (e.g., Aichert & Ziegler, 2004). Since complex syllables tend to be less frequent than simple syllables, the two factors are presumably confounded. Overall, the observation of syllable structure effects is incompatible with the idea of *holistically* stored syllable motor programs - an assumption which can be inferred from the speech production model of Levelt et al. (1999; but see Ziegler, in press).

Both factors, *syllable structure* and *syllable frequency*, have almost exclusively been examined by single-word paradigms. The aim of our approach was, however, to determine if influences of syllable structure and syllable frequency can also be detected in the *spontaneous speech* of patients with apraxia of speech. (1) We asked whether distributions of the sublexical parameters (*syllable structure* and *syllable frequency*) in the patients' speech samples differ from those of unimpaired controls. (2) We examined whether the factors *syllable structure* and *syllable frequency* affect articulatory accuracy in the patients. Additionally, interactions between the two sublexical parameters were analysed.

Methods

Five patients with a primary diagnosis of a mild-to-moderate apraxia of speech participated in the study. We analysed speech samples containing a minimum of 1000 syllables per participant taken from an interview about every-day-life topics and a retelling of short video sequences. The patients' speech samples were phonetically transcribed and analysed for errors. For the distributional analyses of syllable structure and frequency we used a software-tool which operates on a database for sublexical frequencies in German (Aichert et al., 2005) derived from CELEX (Baayen et al., 1995). For comparisons with normative data, a control group comprising 15 neurologically healthy persons was examined.

Main contributions

The results show that the distributions of syllable structure types and syllable frequencies were similar in the spontaneous speech samples of apraxic speakers and of unimpaired controls. An influence of syllable structure on the patients' error rates was only found within the low-frequency syllables (see figure).

Conclusion

The distribution data revealed that the patients with apraxia of speech circumvented neither complex nor low-frequency syllables in spontaneous speech. Hence, no pattern of avoidance was found. The higher error rates on complex syllables in low-frequency units indicate that an increase in structural complexity affects only those articulatory patterns which are less motorically overlearned. The result provides further evidence for the hypothesis that syllable programs are not represented as holistic units. Rather, they should be considered as representations with a hierarchically organised internal structure.

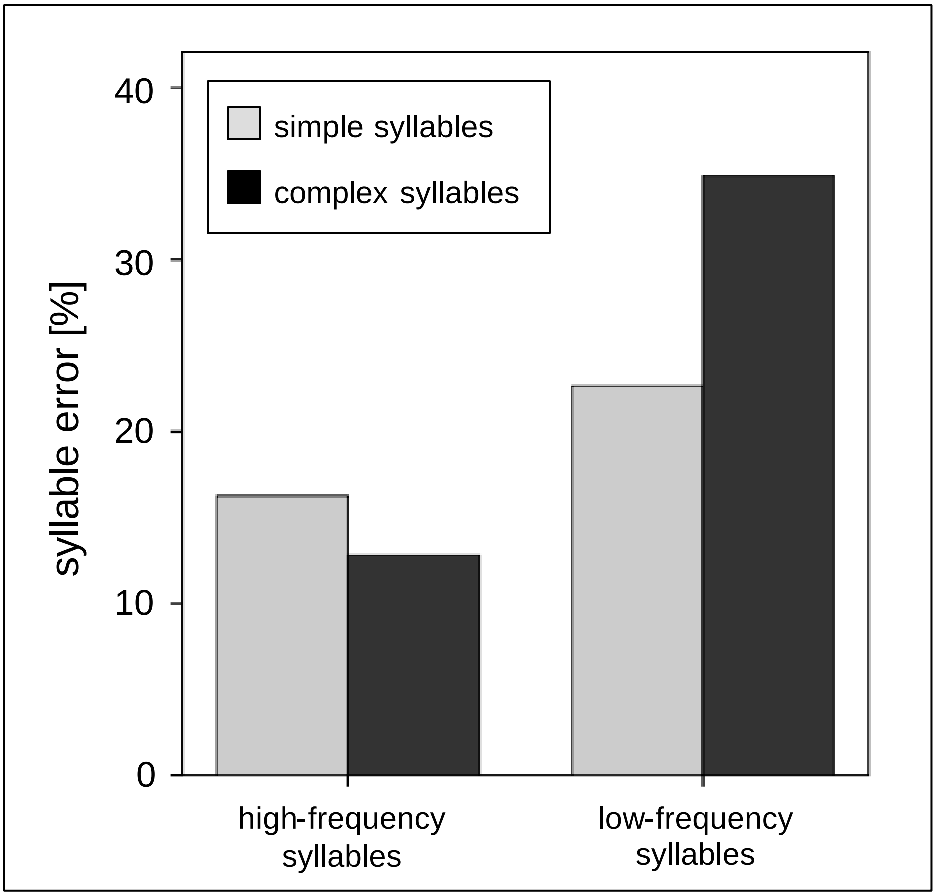

Figure: Influence of syllable complexity (simple vs. complex) for a group of patients with apraxia of speech (mean error rates by frequency and complexity)

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Consonant Cluster Simplification by Children with Cochlear Implants

Steven B. Chin
Department of Otolaryngology–Head and Neck Surgery
Indiana University School of Medicine
Indianapolis, Indiana, USA

Initial consonant cluster simplification patterns are examined in children with 5 or more years of experience with a cochlear implant. A cochlear implant is an auditory aid for people with severe or profound sensorineural hearing loss. It is an electronic device, part of which is surgically implanted into the cochlear and the remain part worn externally. The cochlear implant converts mechanical sound energy into a coded electrical stimulus that directly stimulates remaining auditory neural elements in the cochlea, bypassing damaged or missing hair cells.

Data from 10 children at two intervals were analyzed. The children received cochlear implants between the ages of 1.4 and 6.1 years (M=3.6 years). At the earlier interval, the children ranged in age from 6.4 to 11.1 years (M=9.2) years and had used their implants between 5.0 and 7.1 years (M=5.7 years). At the later interval, the children ranged in age from 9.8 to 16.1 years (M = 13.5 years) and had used their cochlear implants for between 8.4 and 11.5 years (M=10.0 years). For the analysis of initial consonant clusters, at both intervals, children were asked to say the English words and derived pseudo-words *plane*, *brush*, *brushy*, *tree*, *drum*, *drummy*, *clock*, *clocky*, *crying*, *glove*, *glovey*, *green*, *flag*, *frog*, *froggy*, *stove*, *stovey*, and *sleep* while being audiorecorded. Children's speech was transcribed phonetically for analysis.

At the earlier interval, 63% of the consonant clusters were produced correctly, in terms of both segmental faithfulness (correct number of segments) and feature faithfulness (correct feature composition of segments); at the later interval, this increased slightly to 65%. Consonant clusters with two segments, at least one of which was featurally unfaithful, comprised 22% of the productions at the earlier interval and 20% of the productions at the later interval. Reduced realizations, consisting of a single segment that was featurally either faithful or unfaithful, accounted for 9% of productions at the earlier interval and 12% at the later interval. Epenthesis occurred in 5% of the tokens at the earlier interval and 3% at the later interval. Finally, there was a single example of onset deletion, which occurred at the later interval.

Incorrect realizations with two segments reflected markedness constraints that held generally for singleton segments. In this regard, the effects of two high-ranked markedness constraints were particularly evident: *LIQUID (no liquids) and *VELAR (no velars). The first accounted for forms such as [d̪wʌmi] 'drummy' and the second for such forms as [traɪɪn] 'crying'. A high ranking of both constraints was reflected in such forms as [twaɪɪn] 'crying'.

Incorrect realizations with a single segment generally showed the pattern predicted by the sonority dispersion principle, with the less sonorant of the segments realized, for example, [bʌʃi] 'brushy'. Conflicts with sonority (Pater & Barlow, 2003) also occurred; for example, [lɑk'] 'clock' and [lip̪] 'sleep', reflect markedness constraints such as *VELAR and *FRICATIVE ranked higher than the margin constraints operating in the sonority-based reductions. As with children with normal hearing (Chin & Dinnsen 1992), epenthetic and null realizations occurred rarely.

Cluster simplification by children with cochlear implants thus entails patterns similar to those exhibited by children with normal hearing, reflecting basic phonological principles that hold similarly for both groups.

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Influence of intra- and intersyllabic complexity in patients with apraxia of speech

Authors: Ingrid Aichert, Nadine Pulow, Anja Wunderlich & Wolfram Ziegler
EKN Clinical Neuropsychology Research Group, Neuropsychological Department, City Hospital Munich, Germany

Abstract

Apraxia of speech (AOS) is described as a neurogenic speech motor disorder resulting from a disturbance of the programming of articulatory gestures. The syllable plays an important role in the description of the symptoms as well as in the discussion about the pathomechanism of AOS. Segmental errors seem to be sensitive to syllable frequency and intrasyllabic structure: low frequency syllables evoke more errors than high frequency syllables and consonant clusters within a syllable are more error prone than single consonants (e.g. Aichert & Ziegler, 2004, Staiger & Ziegler, in press). With regard to the speech production model of Levelt et al. (1999) it is assumed that in AOS the syllable-sized motor programs, which are stored in a "mental syllabary", are partially destroyed (e.g. Aichert & Ziegler, 2004). However, until now little attention has been paid to the influence of *intersyllabic* structure on error production in AOS. This negligence is also reflected in current models of phonetic encoding, where processes above the syllable level are not considered (e.g. Guenther et al., 1998; Levelt et al., 1999).

Therefore, the aim of the present study was to clarify the influence of *inter*syllabic complexity on the error mechanism in and compare it with the influence of *intra*syllabic complexity.

In a repetition task we presented 72 monomorphemic words which comprised 9 different structures (8 words per structure). The two-syllabic words were controlled for the intersyllabic complexity: The list contained single consonants (e.g., CV.CV – [haːkən]), consonant clusters (e.g., CVC1.C2V – [vɛs.pə]) and ambisyllabic structures (e.g., CVC1.C1V – [ʃʏsəl]). The material also included monosyllabic words with simple (VC – [aːl], CV – [feː], CVC – [hoːf]) and complex syllables (CCVC – [blɛç], CVCC – [lɪçt], CCVCC - [knɛçt]). All words were controlled for word frequency, and in the bisyllabic words the first, stressed syllable was additionally controlled for syllable frequency.

We will present error data from 8 patients with apraxia of speech. The results will be discussed with regard to the pathomechanism of apraxia of speech and the question about the internal structure of phonetic representations.

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Assimilation within complex words in German

Pia Bergmann (Freiburg University, pia.bergmann@germanistik.uni-freiburg.de)

This paper investigates assimilation in coronal-dorsal consonant clusters in German binary compounds and particle verbs by means of electropalatography (EPG). Whereas assimilation is obligatory in word-internal /ng/ or /nk/-clusters in German, it is optional across the boundary of the phonological word, e.g. /ʊŋgarn/ 'Hungary' vs. /ʊn#gɛrn/, or /ʊŋ#gɛrn/ 'reluctantly'. External factors like speaking style oder speech rate may constrain the occurrence of velarization of the nasal in these cases (cf. Wiese 1996). Since high frequency has been shown to enhance reduction and assimilation (cf. Bush 2001, Bybee 2001, Stephenson 2003), the present study focuses on the influence of word frequency on the occurrence of assimilation across the phonological word boundary.

Acoustic and articulatory data were collected at the Institute for Linguistics – Phonetics in Cologne using electropalatography (Reading EPG3). We recorded six speakers from the north-western part of Germany. The stimuli contained the coronal-dorsal clusters /n#g/, /n#k/, /t#g/ and /t#k/ in high frequency and low frequency compounds and particle verbs, e.g. high frequency particle verb *ein#geben* 'to enter' vs. low frequency particle verb *ein#gerben* 'to tan'. All stimuli were presented in accented and unaccented position in the sentence. Additionally, we collected control items with the same consonant clusters across a syntactic boundary (e.g. *Stein geben* 'to give a stone'), and control items with C1 or C2 followed and preceded by a vowel (i.e. VC1#V and V#C2V), all of them being embedded into carrier sentences.

We measured gestural overlap and plateau durations (cf. Byrd et al. 1995, Byrd 1996, Bombien et al. 2007), as well as the ratio of velar constriction with respect to the acoustic nasal. These variables may be viewed as an indicator for degree of assimilation (cf. Kochetov et al. 2007 for gestural overlap). Analysis of the nasal-stop clusters revealed clear tendencies for high frequency words to be produced with higher ratios of velar constriction within the acoustic nasal and with shorter plateau durations than low frequency words and control items. Concerning gestural overlap, however, there is a high amount of intra- and inter-speaker variation. Specifically, speakers show different strategies in combining plateau duration and gestural overlap in order to produce high frequency vs. low frequency words in accented vs. unaccented position. The poster will present the results for the investigated stop-stop clusters and compare them to the nasal-stop clusters. A special focus will be on speaker specific strategies combining more than one variable.

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Prosodic effects on articulatory coordination in initial consonant clusters in German

Lasse Bombien[a], Christine Mooshammer[b], Philip Hoole[a] & Barbara Kühnert[c]

[a]LMU Munich, [b]Haskins Labs New Haven, [c]Université Paris 3 and CNRS Paris

Abstract

This study examines how articulatory coordination in heterorganic initial consonant clusters is modulated by prosodic condition. Extending the paradigm of articulatory strengthening at domain edges to clusters, we provide EPG data of 7 speakers as well as EMA data of two speakers including domain-initial clusters (/kl/, /kn/ and /sk/) in different prosodic positions, varying the strength of the preceding boundary and the position of lexical stress. (e.g. 'Claudia vs. Klau'sur, i.e. stressed vs. unstressed target cluster).

The results show that C1 was consistently lengthened at higher boundaries, but only if the cluster was preceded by a clear pause. C2 was only weakly and inconsistently affected. There were no effects on the spatial domain at all. No consistent effects of lexical stress were found for either C1 or C2. Regarding overlap of C1 and C2 there was a tendency, albeit quite weak, in the direction of more overlap at the lower boundary levels and in unstressed condition. However, differences in timing between segmentally different clusters were consistent and much larger than boundary and stress effects. Especially for /kl/ vs. /kn/ we find that the lateral's timing to /k/ is much closer than the nasal's.

Dynamic Phonotactics
A case study of Georgian consonant clusters

Prof. Dr. Marika Butskhrikidze
University FAMA, Kosovo
butsmar@yahoo.com

Consonant sequences of Georgian, for example, /prckvn/, /mc'vrtn/, /brt'q'/ in words such as /prckvna/ 'to peel', /mc'vrtneli/ 'trainer', /brt'q'eli/ 'flat', have long been an object of an interest for professional linguists as well as interested laymen.

For the simple reason that these rows of consonants seem so unpronounceable, anybody might wonder whether this presents a legacy of the orthography or a phenomenal endowment of Georgian speakers. Concerning the former, native speakers pronounce words like the above, with all the consonants, with no difficulty. As for the latter, equally complex patterns of consonant clustering in, for instance, Polish, Berber and Bella Coola assign a broader scope to the phenomenon and consequently allocate it among the interesting objects of study of a general language theory and language modelling.

Previous analyses of Georgian consonant clusters within the Generative framework include: (i) Headless Syllable Analysis (Nepveu 1994); (ii) Semi-Syllable Analysis (Cho & King 1996) and (iii) Syllabified Consonant Analysis (Bush 1997). This paper is still another attempt to analyse Georgian consonant sequences. However, unlike the previous approaches, it is based on different theoretical and methodological premises.

Many researchers within the Generative framework have been considering phonotactics as the static part of language. This approach to phonotactics has led to the production of some defective descriptions and formalizations. The paper offers a re-examination of the study of phonotactics by considering it to be dynamic. The dynamic nature of phonotactics follows from considering language as an open system as opposed to closed system, assumed within the Generative framework. This novel approach implies a re-examination of the methodology, which substantially differs from ones employed previously and, subsequently, the introduction of new formal tools. The hypothesis about dynamic nature of phonotactics is demonstrated by way of an analysis of Georgian consonant sequences, called the Gradual Consonant Analysis. Types of evidence on which the analysis is based are as follows:

(1) *Types of evidence in GCA*
a) Paradigmatic and syntagmatic
b) Historical
c) Phonetic
d) Comparative

The analysis of the Georgian consonant clusters demonstrates that consonant sequences in Georgia are derived, they are the result of vowel deletion and complex segment formation. Thus, not only processes apply to structures, but structures are determined by processes. Such type of interaction between structure and process indicates that phonotactics is dynamic. Language is an open system, it changes continuously, so does phonotactics and the application of the GCA to Georgian consonant sequences is an illustration of the dynamic nature of language and of its components.

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Schwa reduction and syllable structure in European Portuguese

Conceição Cunha – Universität Tübingen

The goal of this presentation is the analysis of complex consonant clusters resulting from schwa reduction in the syllable structure of European Portuguese (EP). It extends the metrical approach of syllable structure for Brazilian Portuguese by Bisol (1999).

Schwa: Although three types of schwa can be distinguished in EP (Veloso 2007), they all can be reduced in EP. This reduction is quite often attested in *allegro* but also possible in *lento* speech. The conspicuous phenomenon of schwa-reduction in EP brings about a series of consonant clusters which are not predicted by the existing theories. The phonological approach of the syllable structure of Portuguese captures the two varieties together and excludes the phonetic consonant clusters from the phonological inventory of the language (Mateus & d'Andrade 2000, Freitas 1997).

Prosodic Evidence: The prosodic disparity between EP and BP, especially in secondary stress, rhythm and intonation confirms the phonological differentiation of the two Portuguese varieties. In BP, the rhythm results from the alternation of stressed and unstressed syllables in the prosodic word (ω) as well as in the phonological phrase (ϕ). A certain *isochronie* seems to be caused by the epenthetic simplification of complex consonant clusters and the syntax-sensitive retraction of stresses (Truckenbrodt & Sandalo 2003). In EP, secondary stress both in ω and in ϕ is optional and cannot be moved: so we can have two stresses in adjoining syllables (*<u>in</u>.cons.ti.tu.cio.<u>nal</u>.**men**.te*) or several unstressed syllables between stressed syllables (<u>o</u>.to.ri.no.la.rin.go.lo.**gis**.ta). The rhythmic and intonational approaches identify the obligatory initial secondary stress in the intonation phrase (I); all other secondary stresses are optional.

Proposal: Due to the pronounced schwa reduction, some complex consonant clusters should be included in the syllable structure of EP. The crucial ones are as follows. **i.** onsets formed as: plosive+plosive, fricative+plosive, plosive+fricative, plosive+nasal and nasal+nasal (1). **ii.** optional consonant clusters in all sequences with plosive or fricative plus tap or lateral with an orthographic –e. (2); **iii.** onsets and codas with two or three consonants resulting from cancellation of the historical epenthetic vowel (Bisol 1999) (3). **iv.** clusters up to five consonants in the *allegro* speech, in which /r/ seem to become sometimes the syllable nucleus (4). **v.** onsets with duplicate consonants in all contexts, where the same consonant was separated by a schwa. (5). Frota (2000) considers the same phenomenon in ϕ and in I.

Concluding remarks: This proposal may be conflicting with the current phonological approaches of EP, which generally do not accept the existence of such consonant clusters, but it seems to be absolutely necessitated by the rhythmic and prosodic classification of EP. Last but not least, it gives some reasons why EP and BP appear to be so different in the relevant respects in speech.

Examples:

(1)	Plosiv + Plosiv:	obter	‘to obtain’
	Plosiv + Frikativ:	óbvio	‘obvious’
	Plosiv +Nasal:	admirar	‘to admire’
	Frikativ + Plosiv:	afta	‘thrush’
	Nasal +Nasal:	amnésia	‘amnesia’
(2)	[fli.ci.dad]	felicidade	‘happiness’
	[difɾẽt]	diferente	‘different’
	[ɔbdjẽt]	obediente	‘obedient’
(3)	[ʃku.du]	escudo	‘buckler’
	[ʃkɾa.vu]	escravo	‘slave’
	[klub]	clube	‘club’
	[si.dadʃ]	cidades	‘city pl’
	[alɛgrʃ]	alegres	‘happy pl’
(4)	[dʃpɾ.zar]	desprezar	‘despise’
	[dʃpɾʃ.ti.ʒju]	desprestígio	‘lost of face’
	[dʒgɾ.ɲa.du]	desgrenhado	‘unkempt’
(5)	[bbi.dɐ]	bebida	‘drink’
	[ppi.nu]	pepino	‘cucumber’

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Hidden Phonotactic Knowledge of L2 Listeners

Xiaoli Dong
Utrecht Institute of Linguistics OTS
Utrecht University

Numerous studies have shown that speakers are sensitive to phonotactic structures which are absent in their native language (Berent & Shimron 1997; Davidson 2000; Moreton 2002; Coetzee 2004; Berent et al. 2006; Albright 2006, 2007). For instance, first language (henceforth, L1) speakers have sonority-related preferences for consonant-consonant (henceforth, CC) onset clusters in nonce words despite the lack of lexical evidence (Davidson 2000; Berent et al. 2006). With respect to the second language (henceforth, L2) acquisition of consonant clusters, it is shown that not all new clusters are equally difficult for L2 learners (Broselow & Finer 1991; Eckman & Iverson 1993; Carlisle 1997, 1998; Hancin-Bhatt & Bhatt 1997). However, apart from Berent et al. (2006), most of the studies on phonotactics are based on production rather than perception. It is not clear whether the preferences for certain phonotactic structures are due to articulatory limitations or to phonological grammars. Therefore, perception tasks were conducted in this study.

Following the minimal violation model of Pater (2004), according to which the role of the phonological grammar in perception is to regulate the markedness of representations based on the acoustic signal, marked structures will be regulated to a larger extent than less marked ones. Given the fact that Mandarin Chinese does not allow any complex onsets while Dutch does so, the current study examines the sensitivity of Mandarin Chinese listeners of Dutch and Dutch native listeners to the markedness of illegal Dutch CC onset clusters (*tl*-, *dl*-; *pm*-, *km*-; *fm*-, *xm*-). Experiment 1 tested whether Mandarin Chinese of Dutch and Dutch native listeners had accurate perceptions of Dutch /l/ and /r/. Experiment 2, a syllable number judgment task, examined the effect of vowel epenthesis. Experiments 3 and 4 were comparative wordlikeness judgment tasks, in which the listeners were asked to select a form which was more Dutch-like within a pair of nonce words.

The results of the perception tasks suggest that Mandarin Chinese of Dutch and Dutch native listeners have different hidden phonotactic knowledge about the illegal Dutch CC onset clusters. Sonority-wise, markedness constraints play a very important role in both groups of listeners' perception grammar. Interestingly, the OCP [COR, -cont] constraint is only active in Dutch native listeners' perception grammar, not Mandarin Chinese. Strikingly, although all the Mandarin Chinese listeners in the tasks were advanced learners of Dutch, they still use their L1 phonotactic grammar to perceive L2 phonotactics. I will adopt Coetzee's (2004) proposal for comparative tableaux, which is that input ~ output mappings show the learners' preferences for certain phonotactic structures in comparative wordlikeness judgment tasks. In the present study, I will propose that the hidden phonotactic knowledge of Mandarin Chinese of Dutch and Dutch native listeners can be accounted for by the comparisons of surface ~ lexicon mappings in the comparative perception tableau. In Mandarin Chinese listeners' perception grammar, the sonority-wise markedness constraints are still ranked higher than the faithfulness constraints in perception. In contrast, in Dutch native listeners' perception grammar, the faithfulness constraints in perception always outrank the markedness constraints (including sonority-wise constraints and the OCP constraint), which might be due to their rich linguistic experience with the consonant clusters.

Results of Experiment 4: the second comparative wordlikeness judgment task

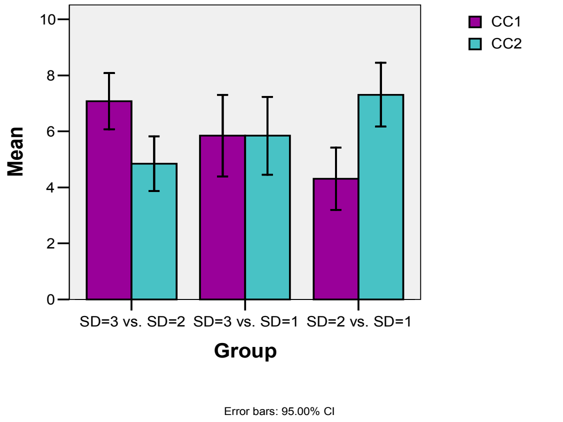

Figure 1 Ratings to the illegal Dutch CC onset clusters with different SDs by Mandarin Chinese listeners

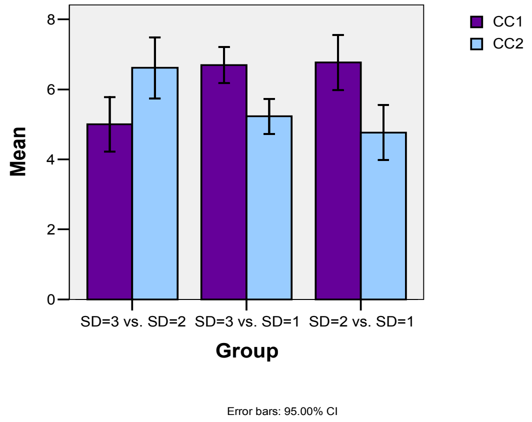

Figure 2 Ratings to the illegal Dutch CC onset clusters with different SDs by Dutch listeners

Note: (1) SD stands for the sonority distance of CC onset clusters.
(2) The illegal Dutch onset clusters of SD=3 are *tl-*, *dl-*; SD=2 are *pm-*, *km-*; SD=1are *fm-*, *xm-*.

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Online effects of phonotactic constraints across two languages

Roberto S Gutiérrez, Lewis P Shapiro, Jessica A Barlow, Leah Fabiano-Smith, Cynthia Kilpatrick, Mary Orton, & Julie Merrill
San Diego State University/University of California San Diego

First language (L1) interference is often apparent in bilinguals' second language (L2) production, which is frequently associated with L1 phonotactics. For instance, native Spanish speakers often simplify final consonant clusters of English, as in as *card* pronounced as [kar], because they are in violation of Spanish phonotactics. Spanish phonotactics permit very few phonemes to occur in word final position; English is much less restrictive and permits numerous word final phoneme singletons and clusters. Cluster simplifications also lead to omissions of morphological markers, such as third person singular (e.g., *he adds* produced as *he add*), and regular past tense (e.g., *they called* as *they call*). Though much is known about the effects of L1 phonotactics on L2 production, little is known about the effects of such constraints on receptive tasks, particularly those that purport to measure *implicit* knowledge, on-line. Thus, the objective of our study is to gain insight into the processing of final clusters that are illegal in an individual's L1 but permitted in the L2, with the goal of uncovering some fundamentals of bilingual receptive language. We wish to determine whether bilinguals process the relationship between subject and verb when the agreement is phonotactically constrained in the L2, as with the following examples:

1. Grammatical: <u>The policeman</u> frisk<u>s</u> the <u>*lousy*</u> felon outside the crime scene.
2. Ungrammatical: *<u>The policeman</u> frisk the <u>*lousy*</u> felon outside the crime scene

We used a Pitch-Change Task to measure listeners' *implicit* knowledge and processing of phonotactics and their relation to morphosyntax. This task has been used successfully in our lab to examine localized lexical and syntactic constraints during on-line sentence comprehension. Briefly, sentences like (1) and (2) above (see also Table 1) were presented to participants over headphones. In each sentence, the pitch over a target word (the adjective immediately following the verb, as with *lousy*, above) was manipulated by lowering it to 120, 125, or 130% from its unaltered form. Subjects were required to listen to the sentences for meaning and also to press a response button as soon as they heard "a different pitch from the rest of the sentence"; reaction times (RTs) to this pitch change were recorded as a measure of local processing load.

Participants included 25 sequential Spanish-English bilinguals and 25 simultaneous Spanish-English bilinguals. The sequential bilinguals were exposed to Spanish (L1) from birth, and were first exposed to English at approximately age 5. The simultaneous bilinguals were exposed to both Spanish and English from birth. A control group was also included, which consisted of 25 age-matched Native English speakers who spoke and heard only English until entering high school.

<u>Results and Discussion</u>: For the native English control group, when subject-verb agreement was ungrammatical, mean RTs were significantly slower compared to grammatical counterparts. This pattern suggests that the grammaticality of the sentence was implicitly recognized even though the participants were simply required to judge a localized pitch change. More pertinent to the goals of the study is that the group of sequential bilinguals performed similarly to the controls; that is, RTs to the pitch change over the adjective was slower in the ungrammatical relative to the grammatical strings, and this pattern was observed for both English and Spanish phonotactics. This pattern suggests that sequential bilinguals – if they acquire L2 at a relatively young age – can achieve native levels of morpho-syntactic language processing in spite of the potential effects of L1 phonotactics. If so, we would also expect simultaneous bilinguals to perform native-like because they were exposed to English even earlier than sequential bilinguals. Surprisingly, we observed that the simultaneous bilinguals showed no grammaticality effect, nor did they show any effect due to phonotactic complexity. These patterns suggest that individuals who have learned two languages early and at roughly the same time may have a wider scope of acceptability. We tentatively surmise that this broadened ability to accept constructions that are clearly ungrammatical (in either language) may reflect the implicit knowledge that acquiring multiple languages will yield structural variation. To buttress this case we would need to extend our work to other aspects of structural distinctions among target languages, including syntactic forms that are not based on phonological distinctions. Finally, we also discuss our results in terms of the possible cognitive benefits of bilingualism.

Table 1: Conditions and Example Sentences

	Phonotactically Unacceptable Right edge in Spanish		Phonotactically Acceptable Right edge in Spanish
UG	*She mark the daily timesheet on the counter.	UG	*He eye the daily newspaper behind the table.
3rd person present	She marks the daily timesheet on the counter.	3rd person present	He eyes the daily newspaper behind the table.
3rd person past	She marked the daily timesheet on the counter.	3rd person past	He eyed the daily newspaper behind the table.
UG	*Peter clamp the sturdy piece of wood onto the workbench.	UG	*Kelly pile the sturdy branches near the barn.
3rd person present	Peter clamps the sturdy piece of wood onto the workbench.	3rd person present	Kelly piles the sturdy branches near the barn.
3rd person past	Peter clamped the sturdy piece of wood onto the workbench.	3rd person past	Kelly piled the sturdy branches near the barn.

Figure 1:

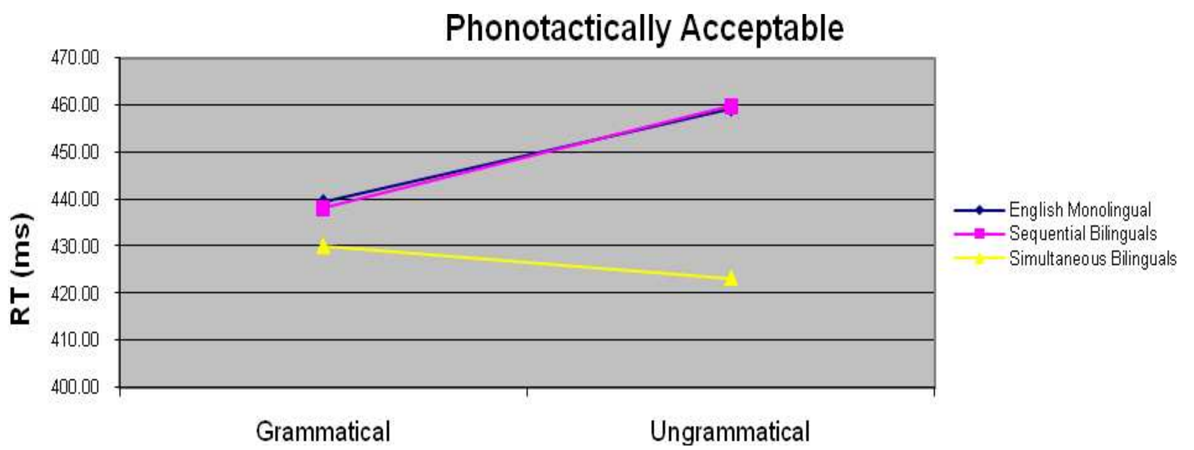
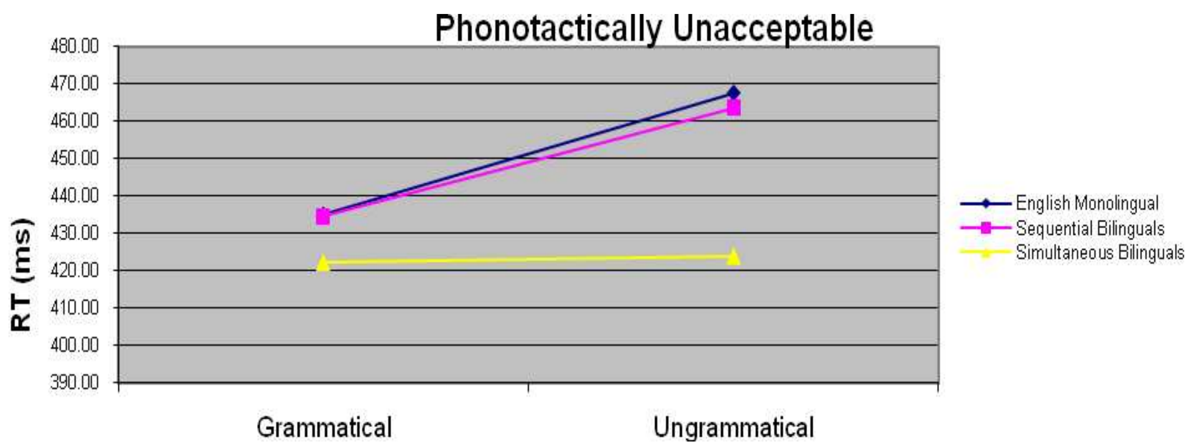


Figure 2:



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Gestural coordination of initial consonant clusters in Italian: Evidence for syllabification of 'impure-s'

Anne Hermes, Martine Grice & Doris Mücke
I*f*L Phonetik, University of Cologne, Germany

Coordination patterns between consonants and vowels depend on their role in syllable structure (Browman & Goldstein 1988, Honorof & Browman 1995, Goldstein et al. 2007). In codas, consonantal gestures are anti-phase with the vowel, whereas in onsets, they are in-phase with it. However, in complex onsets, consonants are anti-phase with each other (Nam & Saltzman 2003, Goldstein et al. 2008). Two measures have been proposed as indicators of syllable affiliation. If a sequence of consonants forms a complex onset:

(i) the timing of the *C-center* (the 'temporal center of gravity', Saltzman et al. 2006) is *stable* with respect to the vowel, where the distance is measured between the mean of consonantal targets in an onset and the vowel target (see figure 1; Browman & Goldstein 2000).

(ii) the distance between the *rightmost consonant* within the cluster and the vowel *decreases*, measured as the time between the targets of the 'rightmost consonant' and the vowel (Goldstein et al. 2007, Shaw & Gafos 2008).

Recent articulatory studies have shown that in languages which have been analysed as disallowing complex onsets, and where thus only the rightmost consonant in word initial clusters belongs to the target syllable (such as Tashlhiyt Berber: *mun*, *s-mun*, *t-s-mun*) there is a stable timing between the vowel and the rightmost consonant (Goldstein et al. 2007). Similar results were obtained for Moroccan Arabic by Shaw & Gafos (2008), thus confirming that it is possible to gain information about syllable affiliation from the relative timing of articulatory gestures.

Many languages, including English and Italian, have /sC/ clusters word initially. In onsets, /sC/ incurs a sonority violation if C is a plosive. However, the timing of the oral constriction gestures associated with /sp/ and /spl/ word initial clusters in English (see figure 1) indicate that, despite sonority violations, /s/ forms part of a complex onset.

In this study, we investigated the temporal coordination of word initial consonant clusters in Italian. In Italian, words beginning with a consonant cluster with an initial sibilant are treated differently in the morphology from words beginning with either a single sibilant or a cluster with no sibilant (definite article alternation, e.g. *il sale*, *il premio* but *lo studente*; Davis 1990). Moreover, there are indications from psycholinguistic studies that /s/ in word-initial clusters - referred to as 'impure-s' - is neither clearly part of the onset nor part of the coda of the preceding syllable (Bertinetto 2004).

We recorded a native Italian speaker with an electromagnetic articulograph (EMMA), investigating target words containing simple onsets and clusters of the types /C/ - /CC/ - /sC/ – /sCC/ embedded in carrier sentences like *Per favore dimmi ___ di nuovo* ('Please say ___ again') (13 target words x 10 repetitions). Variables relating to measurements in (i) and (ii) were investigated, comparing mean relative timing of consonantal gestures with the respective vowel.

Preliminary results reveal a C-center effect when comparing word initial /r-pr/ in *rima* 'rhyme' and *prima* 'first', see fig. 2a: The C-center remains stable (mean Δ 11ms, t-test: $p>0.05$ ns), while the distance from the rightmost consonant to the following vowel decreases (mean Δ 39ms, t-test: $p<0.001$). However, clusters containing an 'impure-s' such as *spina*, showed no C-center effect (see fig. 2b, comparing *pina* 'female proper name' and *spina* 'thorn'). Adding /s/ to the beginning of the word does affect the timing of the C-center relative to the vowel. The same is true for /s/-clusters followed by two consonants, such as in *sprima* (see fig. 2c; *sprima* is a logatome but is timed in the same way as *sprema* 'squeeze').

These results thus indicate that although word initial clusters in Italian generally form complex onsets, those clusters containing a sibilant ('impure-s') do not. Furthermore, the observed differences between Italian and English /s/-clusters suggest that the syllabification of initial /s/-clusters is language specific.

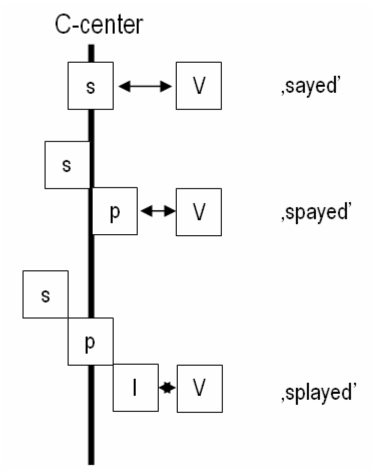

Figure 1: Stable temporal relation of C-center to the vowel in English and a decrease (arrow) from the 'rightmost consonant' to the vowel (Browman & Goldstein 2000)

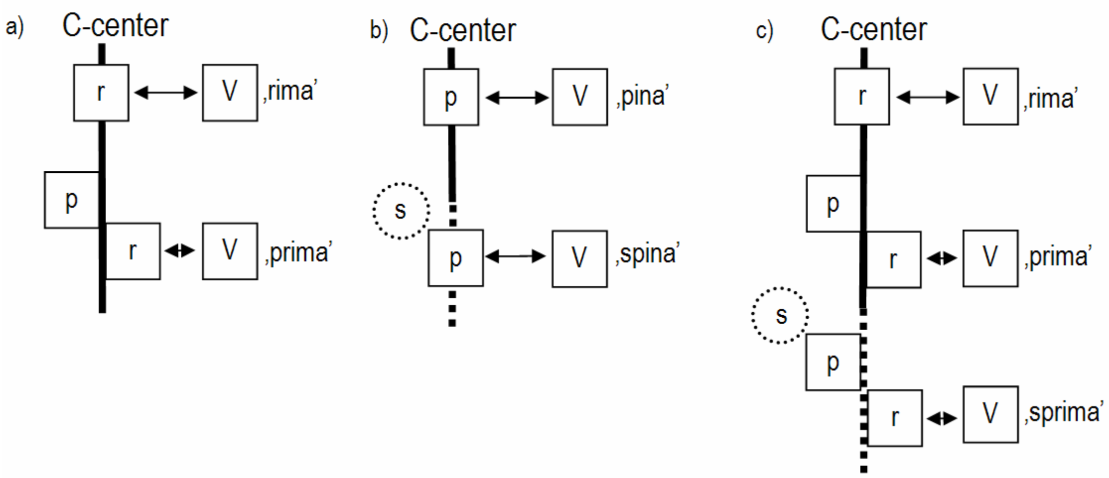

Figure 2: (a) C-center Effect for initial clusters in Italian */r-pr/*; (b) No C-center effect for */p-sp/* distance from V to rightmost C stable; (c) C-center effect only if /s/ is not counted for */r-pr-spr/*

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Tonogenesis in Lhasa Tibetan – A gestural account

Fang Hu
Phonetics Lab, Institute of Linguistics, Chinese Academy of Social Sciences
hufang@cass.org.cn

Both Consonant cluster and tone contribute to structural complexity in syllable production, but they differ in that the production of consonant cluster is temporally sequential while the production of tone is a simultaneously laryngeal superimposition upon the voiced segments. An intriguing typological observation in Sino-Tibetan languages (or perhaps in all languages in the world) is that non-tonal languages are generally associated with a sequentially complex syllable structure, typically characterized by a complicated set of prevocalic (and postvocalic) consonant clusters, whereas tonal languages are associated with a much simpler syllable structure, typically no consonant clusters or extremely limited in both prevocalic and postvocalic positions. Focusing on Lhasa Tibetan, this paper aims to provide a detailed explanation on how the sequential structural complexity, consonant clusters, develops into a laryngeal complexity, tones.

As is well documented in the literature, modern Tibetan languages exhibit a variegated scenario of tonal developments: they constitute a tonality continuum from completely atonal to highly tonal such that there is no clear dichotomy between a tonal and an atonal language (Huang, 1994; Sun, 1997). Lhasa Tibetan occurs as a highly developed tone language at a cost that it lost nearly all historical consonant clusters as well as the voicing distinction among the prevocalic consonants. The acoustic data show that Lhasa has six phonetic tonal melodies: long high level, long low rising, short high falling, short low rising, checked high falling, and checked low rising. Roughly, tonal register contrast results from historical prevocalic voicing distinction that is further developed from the simplification of the prevocalic consonant clusters; tonal duration contrast correlates with different syllable types.

Based on a comparative analysis of Tibetan languages in the tonality continuum, it is argued that a stepwise simplification of the prevocalic consonant clusters triggers the tone, whereas the other factors are not crucial in Tibetan tonogenesis. For instance, the simplification of the postvocalic consonant clusters may help define tonal contour and differences in rhyme duration may affect pitch alignment, and thus both contribute to the further development of tone.

In addition to the acoustic study, a pilot EMA study is conducted. An examination of the gestural coordination among tone, vowel, initial and final consonant from two Lhasa speakers reveals that the tone gesture behaves like a consonant, rather than a vowel gesture, which is supportive to the proposed hypothesis in the present study that the tone, the laryngeal complexity, emerges from the simplification of consonant clusters, the sequential structural complexity.

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Articulatory patterns underlying regressive place assimilation across word-boundaries in German

Marion Jaeger and Phil Hoole

Institute of Phonetics and Speech Processing, Munich, Germany

E-mail: jaeger@phonetik.uni-muenchen.de, hoole@phonetik.uni-muenchen.de

Several cross-linguistic surveys (Mohanan, 1993; Jun, 1996) reveal typological patterns that govern regressive place assimilation. Of particular interest to our current research concerning *articulatory patterns* underlying regressive place assimilation is that alveolar nasals show a greater tendency to assimilate than alveolar plosives.

Up until now, no articulatory study has investigated the possibility that the acoustic properties of nasals may allow the tongue tip (TT) to move more freely and as a result permit speakers to ease articulation by means of greater TT reductions in alveolar nasals as compared to alveolar plosives, and by doing so making perceived assimilation in nasal#plosive sequences across word-boundaries (indicated by #) more likely.

Moreover, previous articulatory studies that have investigated regressive place assimilation looked at place of articulation either in plosive#plosive (Byrd, 1996) or nasal#plosive (Ellis and Hardcastle, 2002) sequences but not both. Additionally, we know of no EMA study that investigated the influence of word frequency upon regressive place assimilation, despite the fact that first, TT reduction is often assumed to be a prerequisite for regressive place assimilation (Jun, 2004) and second, several studies (Jurafsky et al., 2001; Bell et al., 2003) indicate that articulation is more reduced in words and phrases with higher word-frequency and greater lexical probability.

The current project was thus designed to test and compare the effect of several phonetic and lexical factors upon the intra- and interarticulatory timing and movement magnitude of various articulators in $V_1C_1\#C_2V_2$ sequences in German speakers with a main focus on manner of articulation and word frequency.

Until now, data of three speakers who participated in a reading task, are analyzed. In the non-palatal vowel context [a], for all speakers, the vertical TT position at a point in time 25% into the acoustic closure phase of the CC cluster is lower in nasal than oral C_1 items (S1, S2, S3) and lower in high than low frequency words (S1, S3). In addition, the vertical TT position is lower in high frequency words with a nasal vs. a plosive C_1 (S21, S2, S3).

Consonantal overlap in non-palatal vowel context show greater TT#TB onset overlap in words with a nasal vs. a plosive C_1 (S2), greater TT#TB onset overlap in high frequency words with a nasal C_1 (S1), and greater TT#LL onset overlap in high frequency words with a nasal C_1 items (S1, S2, S3).

TT reduction and CC onset overlap do not correlate in items with measurable TT excursions and incomplete assimilation. However, word pairs with a high frequency word or a significant co-occurrence frequency exhibit patterns that are akin to a nasal velar or nasal labial stop in control items and are perceived as such by listeners (Figure 1).

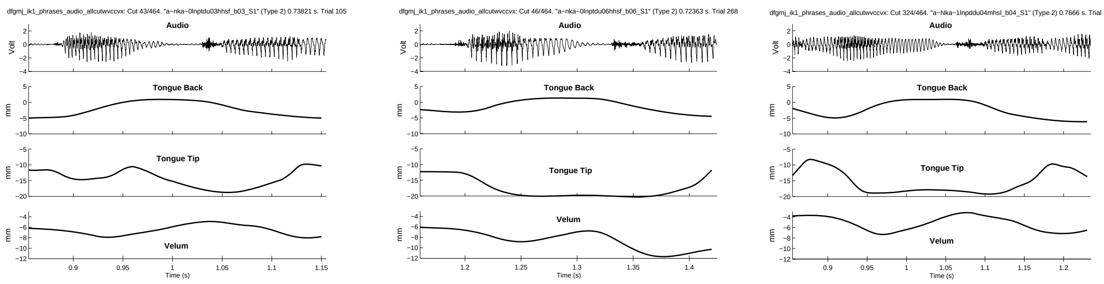

Figure 1: From top to bottom: Acoustic signal, tongue back, tongue tip and velum trajectories. On the left side: "dann kann" [n#k] sequence with measurable but reduced tongue tip excursion, in the middle, "dann kann" [n#k] sequence with no visible tongue tip excursion, on the right side, "lang kann" [ŋ#k] control item. In both target items maximal velum lowering is reached before tongue back constriction onset and ends at tongue back constriction offset resulting in a nasal velar consonant, also observable in the acoustic signal.

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Role of prosody in L2 segmental perception of French clusters by Japanese learners

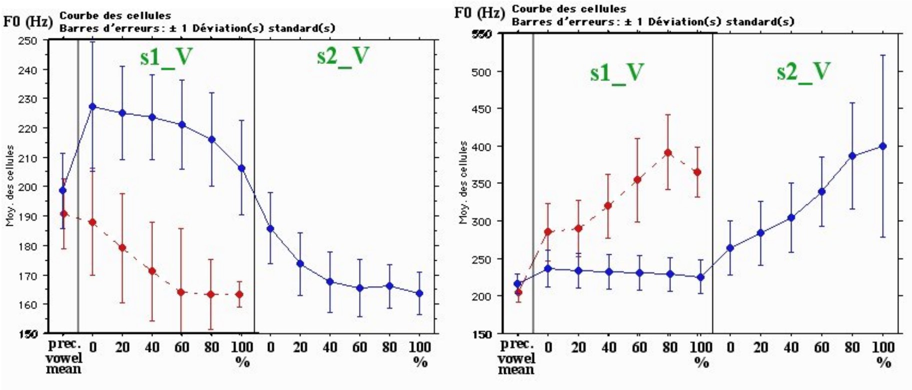
Takeki KAMIYAMA, Université Pairs III, Université de Marne-la-Vallée
Shigeko SHINOHARA, Phonetics Laboratory, Sophia University

This paper focuses on the role of prosody in segmental perception of CCV clusters vs. CVCV sequences in French by Japanese speakers learning French.

Previous studies report a heavy reliance on prosodic patterns for word segmentation in early stages of lexical acquisition (Christoph et al. 1995 for French; Jusczyk et al. 1999 for English). In the production of young children, consonant clusters are mostly resolved through consonant deletion (Bernhardt and Stemberger 1998): the result is that prosodic patterns remain more or less intact as compared to the adult target. In contrast, recent loanword studies show that consonant clusters are overwhelmingly resolved through vowel epenthesis rather than through consonant deletion (Paradis and Béland 2002; Uffmann 2004). This pattern seems to be also reflected in adult L2 production (Shinohara 1992). A consequence of vowel epenthesis is a distortion of prosody in the target language, the number of nuclei being increased. As production patterns may reflect adult speakers' insensitivity toward prosodic information in L2, this study tests if prosodic information is still exploited in access to segmental information in L2 speakers of French.

We studied Japanese speakers' perception of minimal pair words in French differing only by the presence or absence of a vowel, such as *boulette* /bulɛt/ 'small ball' and *blette* /blɛt/ 'beet', embedded in different intonation contours: the first syllable in CVCV words may or may not be pronounced with a higher F0 than the second one. We exploited the possible intonation difference in French affirmative and interrogative sentences. That is, the affirmative sentences optionally have a high F0 on the initial syllable of a sentence final lexical word (of less than three syllables) when preceded by a function word, whereas yes-no question sentences have a flat contour in this position (Vaissière 2002). As to the perception of clusters, Japanese speakers are known to perceive an illusory epenthetic vowel (e.g. /ebzo/ perceived as /eb*u*zo/ (Dupoux et al. 1999)). Therefore, we can suppose that they have difficulties differentiating these minimal pairs. However, this task might be facilitated by the prosodic prominence in affirmatives. We recorded 2 female native speakers of French pronouncing 28 minimal pair words embedded in two different contexts (68 sentences in total). One of the speakers produced the first syllable of CVCV words in affirmatives with a higher F0 than the second one (see Figure 1). In subsequent experiments, these recordings and manipulated stimuli with imitated F0 curves were used for auditory perception tests with native speakers of Japanese learning French. The learners tended to respond more correctly to the target sequence with a higher pitch. These results suggest that tonal prominence facilitates the perception of segmental sequences in L2.

Figure 1: Mean F0 of the affirmatives (left) and the interrogatives (right) with mono- (dashed lines) and disyllabic words (plain lines) pronounced by Speaker 1 (16 sentences each). The first value ("prec. vowel mean") indicates the mean F0 of the vowel preceding the target word. The time axis is normalized, i.e. 0% and 100% points correspond to the beginning and the end of the vowel. Error bar: 1 standard deviation (SD).



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English Compensatory Shortening and Phonetic Representations

Jonah Katz
Dept. of Linguistics & Philosophy, MIT

The question of whether phonetic representations consist primarily of articulatory or acoustic information has been the basis of a lively debate in the phonetics literature. In the domain of speech production, for instance, some theorists posit the articulatory gesture as the primary unit of phonetic representation (e.g. Browman & Goldstein 1986). Others argue that patterns of speech production are primarily organized to achieve acoustic goals (e.g. Kingston & Diehl 1994). In this paper, I present evidence for the view that phonetic representations include acoustic targets. The evidence comes from a nonce-word production experiment on the phenomenon known as *Compensatory Shortening* (CS) in English (Munhall et al. 1992). The experiment shows that CS in English occurs in some subset of both onsets and codas, but fails to occur in certain contexts where an exclusively articulatory theory would predict it, especially in complex onsets and codas.

In CS, the presence of a consonant somewhere in a syllable causes shortening of the syllabic nucleus. For instance, the current study shows that the vowel in /dab/ is significantly shorter than the vowel in /da/. This is a case of one consonant vs. zero; I refer to cases of CS for cluster vs. singleton onsets/codas as *incremental* CS. Frameworks such as Articulatory Phonology (Browman & Goldstein 1986 *et seq*.), which declare the gesture to be the fundamental combinatorial unit of language, account for CS through constraints on gestural coordination (Nam 2004, Goldstein et al. 2006). The targets for a vowel gesture remain constant from one token to the next; this is the representation of what a vowel *is* in this theory. This predicts that onset consonantal gestures should produce a large CS effect and that adding more consonantal gestures to an onset should 'eat away' ever more of the vowel. For coda consonantal gestures, on the other hand, they predict little CS for singleton consonantal gestures, and no incremental CS.

The current study finds that singleton consonants induce CS effects in both onset and coda position in English. No evidence is found for incremental CS effects in onset or coda position, with the exception of obstruent-liquid clusters. None of the asymmetries between onset and coda consonants predicted by the articulatory theory are borne out by the data.

I argue that the best way to reconcile these findings with what we know about the coordination of vowel and consonant gestures is to utilize acoustic targets for duration. Two approaches to analyzing the data using weighted constraints are sketched: in the *dual-target* approach, durational patterns emerge from a conflict between articulatory duration and acoustic duration targets; in the *dual-domain* approach, the pattern instead emerges from a conflict between acoustic duration targets at the segmental and syllabic levels. Although the data presented here are not sufficient to disambiguate between these two approaches, they argue strongly against a model in which durational patterns emerge from articulatory considerations alone.

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/t/-deletion in Russian consonant clusters: electrophysiological evidence for a language-specific pre-lexical compensation mechanism

Viktor Kharlamov, Department of Linguistics, University of Ottawa
Kenneth Campbell, School of Psychology, University of Ottawa
Nina Kazanina, Department of Experimental Psychology, University of Bristol

Cross-linguistically, languages that allow word-internal sequences of consonants often reduce the size of such clusters by deleting one of the segments. For example, in Russian, the sequence /stn/ tends to surface as [sn] in /mestnij/ 'local', /ntstv/ is usually pronounced as [nstv] in /agentstvo/ 'agency', etc. The present study addresses the question of how such reduced forms are recognized by the listeners. Since cluster simplification can be both productive and optional, perception grammars of native speakers need to contain a compensation mechanism that allows mapping of two or more competing surface forms onto a single underlying representation. In the case of Russian, listeners need to recognize both [stn] and [sn] as possible output forms of the sequence /stn/. The current paper demonstrates the existence of an early pre-lexical compensation mechanism for the /t/-deletion in word-internal consonant clusters by Russian speakers. The mechanism is not found in English speakers, which suggests its language-specificity and relation to the native language phonology.

Previous research on processing of assimilated and lenited forms has demonstrated that assimilations and lenitions may not be processed in the same way. Mitterer and Blomert (2003) and Mitterer et al. (2006) argue that phonological assimilations are compensated for with the help of a pre-lexical mechanism which is largely language-independent. Mitterer and Ernestus (2006), on the other hand, claim that lenition and deletion processes are dealt with post-lexically and the speaker's native language plays an important role in recovering the underlying forms. However, the conclusions in Mitterer and Ernestus (2006) are based entirely on the results of identification experiments and it remains unclear whether at least some compensation for lenition may occur at a pre-lexical level.

Native speakers of Russian and English participated in the present study. Similar to Russian, English has the cluster /stn/ (e.g., *fastness*), but the deletion process does not apply and English listeners should not have developed a special mechanism for recognizing the reduced forms. The non-word sequences [asna], [astna] and the control stimulus [askna] were used. Subjects from both language groups performed an identification task and their ERPs were recorded in a passive listening oddball paradigm. A number of Russian subjects also participated in a discrimination task. The results of the three tasks demonstrate important differences in processing between the two language groups and, for the Russian subjects, between the critical and the control conditions. Russian speakers' reaction times and error rates are higher in the [astna] than the [askna] condition. No such effect is present for English subjects. In the electrophysiological experiment, enhanced mismatch negativity (Näätänen et al. 2007) peaking at around 150 ms post the onset of the [t] is observed in the critical [astna] condition for English but not Russian listeners. In the control [askna] condition, enhanced mismatch negativity is present in both language groups. These results indicate that the /t/-deletion in the Russian word-internal /stn/ cluster is compensated for pre-lexically and that the compensation mechanism develops under the influence of the phonological regularities in the listener's native language.

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Broken Consonant Clusters: Effects on Word Recognition

Tom Lentz*, Utrecht Institute of Linguistics OTS

Phonotactic well-formedness affects lexical access (Vitevitch & Luce 1998). This study investigates this for Dutch s-consonant clusters (henceforth /sC/). We hypothesise that different degrees of phonotactic combination strength exist, with different effects on lexical access. Clusters are good or neutral; illegal clusters cannot be tested as there are no lexical items containing them. Therefore we included broken versions of the clusters, that violate a positive phonotactic combination without becoming illegal.

We ran a cross-modal priming experiment with a lexical decision task on (59) Dutch /sC/-words. Visual targets were presented on a screen, preceded by auditory primes of three types: unrelated words, faithful primes, or words that were 'broken-cluster' versions of the target (henceforth BC). Clusters were 'broken' by a syllable boundary caused by /ɛ/-prothesis. E.g., the target /steːn/, steen (stone), was primed by [ɛsteːn], [steːn], and an unrelated word (baseline).

/sC/ clusters were grouped on Observed over Expected ratio (O/E); "good" ones (/st/, /sx/, /sp/) have an O/E around 2, "neutral" ones around 1 (/sl/, /sm/, /sn/, /sk/). This values are language-specific; they were computed on the Spoken Dutch Corpus.

Vitevitch & Luce (1999) show how the (strong) effect of lexical neighbourhood density hides phonotactic effects. They are contrary to each other: for better clusters, the neighbourhood is larger, slowing down recognition, while the well-formedness of the clusters themselves facilitate recognition. They found the phonotactic effect for real words to be most pronounced in a lexical decision task, but still subordinate to the neighbourhood effect. In our experiment, words with good onsets were recognised faster overall (main effect of cluster type). This suggests the phonotactic difference is quite pronounced.

Faithful primes indeed *prime*, i.e. decrease reaction times; BC primes do too, but to a lesser extent (main effects). Interestingly, the BC primes have less priming 'power' for good clusters than for neutral clusters (interaction effect). A possible explanation is that a good cluster is a sub-lexical chunk. Breaking the cluster means it has to be (re)combined. Neutral clusters had to be combined anyway; only good clusters loose their advantage when broken.

Extensions of this experiment have been executed. More severe mutilation of the cluster, [u]-epenthesis (/steːn/ – [s**u**teːn]), leads to loss of priming. Dutch native listeners are compared to people new to the language-specific phonological status on /sC/-clusters, namely Japanese and Spanish learners of Dutch. They are hypothesised to have perceptual epenthesis towards L1 phonotactics (hearing [steːn] as /suteːn/ resp. /ɛsteːn/, (Dupoux *et al.* 1999, Jacquemot *et al.* 2003)), therefore breaking up clusters anyway. Preliminary results indicate there is no effect of (Dutch) phonotactics on recognition time (compared to the native listeners) and that BC clusters are processed more like faithful clusters (confirming perceptual pro-/epenthesis).

The L2 data are to show if the phonotactic knowledge is language-specific. Apart from that, this study shows how a statistical measure for consonant clusters matches behavioural data. Additionally, this might shed some light on the status of combinations, comparing 'accidental' (neutral) clusters with explicitly good ones.

*Tom.Lentz@let.uu.nl; Janskerkhof 13A, NL-3512 BL Utrecht, Netherlands

Results and analysis

The results are analysed with a (conservative) mixed effects model with crossed random effects; an ANOVA for items and participants gives slightly higher significance as it does not correct for crossed random effects (Quené & Van den Bergh in press).

Table 1. Main effects and interactions

Effect	Significance
Broken Cluster prime	< 0.001 ***
Faithful prime	< 0.001 ***
Phonotactic probability	< 0.001 ***
Broken Cluster prime * cluster type	< 0.05 *
Faithful prime * cluster type	> 0.15 (n.s.)

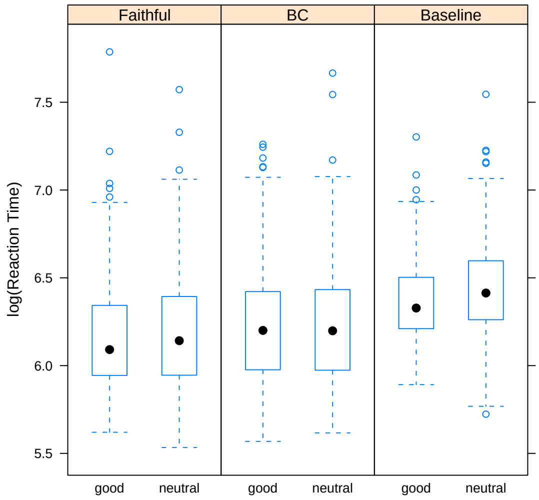

Figure 1. LOG(reaction time) per condition. Note that neutral is slower than good, except in the BC case.

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The acoustic analysis of spirantization of Persian affricates before plosives

Zahra mahmoodzade & Mahmoud Bijankhan
University of Tehran, Iran

It is thought that Persian affricates spirantize before plosives, especially in words with a high frequency of use in everyday speech. In order to test this hypothesis experimentally, we put voiced and voiceless affricates /ʤ, ʧ/ before labials /p, b/, dentals /ṭ, ḍ/ and velars /k, g/ in the stress position of sense and nonsense one-syllable words in connected speech. The production of nonsense words were done in a carrier sentence like " read this word: C_1ˈa-C" (C_1 is /v/ or /h/). Each sentence repeated three times by five male speakers at the University of Tehran Phonetic Lab. 180 tokens altogether were produced.

For studying spirantization acoustically, four acoustic parameters including silence duration, frication duration, rise time and amplitude rise slope were investigated. A previous study done by Mahmoodzade and Bijankhan (2007) showed that all mentioned parameters can make a significant difference between affricates and fricatives in Persian. The mean value of each parameter of the affricates in the clusters was compared statistically (ANOVA) with the mean value of the same parameter of /ʤ, ʧ/ and /ʒ, ʃ/ when they are in the intervocalic position of front low vowel.

Results show that the acoustic implementation of affricates parameters was done in the syllable context except when the sense word is a frequent word. In this case the voiced affricate closure is not produced by the speakers and the release phase is longer. Therefore the phonetic implementation of affricate is like a voiced fricative. We conclude the spirantization, in the syllable domain, is a matter of frequency of use and not an output of a phonological rule licensed by the position. We will experiment this outcome in the other phonological domains too.

In the Sense words, the clusters are made of just voiced affricate before plosives /b/ and /ḍ/. The spirantization happened when the affricate is before dental /ḍ/. An explanation is that the stop phase of both affricate and plosive is produced by the same articulator; therefore the spirantization here is for ease of articulation.

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Changing Frequencies:

Devising a new Phonotactic Probability and Neighbourhood Density Calculator

Matthew Moreland, University of Reading, UK

Presented is a new calculator for the comparison of monosyllable stimuli in terms of phonotactic probability (PP) and neighbourhood density (ND). The calculator has been devised for the *Wokingham Language Intuition Study* (*Wo*LIS), which considers Educated Southern British English speakers' intuitions regarding the post-initial placement of the palatal approximant /j/ and, for direct comparison with previous claims (e.g. Chomsky & Halle, 1965), judgements of initial /b/ and /p/.

Previous PP and ND studies have largely adopted one of three pronunciation lexicons and one of two corpora in making their calculations: the 1964 *Merriam-Webster Pocket Dictionary* with 20,000 lemmata (e.g. Vitevitch & Luce, 2004), *CELEX* with 52,446 lemmata (Burnage, 1990; Baayen, Piepenbrock & Gulikers, 1995), and the *Carnegie Mellon Pronouncing Dictionary* (1993-2004 editions) with almost 60,000 lemmata. For frequency counts, the Brown corpus of one million words is often adopted because of the accessibility of the Kučera & Francis (1967) word counts (employed in the *Hoosier Mental Lexicon*, HML, by Nusbaum, Pisoni & Davis,1984), as is the 18 million-word set of the *COBUILD* corpus used by the *CELEX* database (employed by Bailey & Hahn, 2001, and others).

Most of these resources are based on General American and as such do not accurately reflect British English pronunciation or frequency. The exception is *CELEX,* with pronunciations from the revised 14th edition of the *English Pronouncing Dictionary* (Jones, Gimson & Ramsaran, 1977/88), but a resource based on a much larger corpus and with updated British English pronunciations is created by combining a set of 68,728 pronunciations representing approximately 60,000 lemmata and suffixes from the 17th edition of the now *Cambridge* EPD (Roach, Hartman & Setter, 2006) with occurrence-per-million frequency counts from the 100 million-word British National Corpus (Leech, Rayson & Wilson, 2001). For ease of use and modification, the resulting calculator is rooted in Microsoft Excel, taking advantage of its maximum capacity extension to over 1 million rows of data in the 2007 edition. A current limitation of the calculator is that it is only lemma-based (as in the HML), but a wordform-based version is planned for the future.

The calculator at present draws on two existing methods of PP calculation and one of ND calculation. The first PP method involves *Positional Segment & Biphone Frequencies* as per Jusczyk, Luce & Charles-Luce (1994) and Vitevitch & Luce (2004), considered alongside constant-adjusted values to ensure that low frequency items are not discounted by logarithmic scaling. The second PP method is that of the *Onset-Rime Probabilistic Grammar* (Coleman & Pierrehumbert, 1997), adjusted for monosyllables in line with Shademan (2007) on the basis of Albright & Hayes' data (2003), such that all initial onsets and all stressed rimes are included in the calculations. However, items with zero-probability onsets or rimes are treated separately from the rest of the data, rather than with Good-Turing estimation.

The ND calculation is that of the *Single Phoneme Edit Distance* based on Luce (1986) and Sommers (nd), whereby a neighbour is any word created by the substitution, addition or deletion of a phoneme. The log (base 10) constant-adjusted frequency values of these items are summed to obtain a frequency-weighted neighbourhood density measure.

Statistics from a subset of the *Wo*LIS project's 165 stimuli are compared with figures from the online probability calculator of Vitevitch & Luce (nd, detailed in Vitevitch & Luce, 2004). More information about the calculator can be found at http://www.phonotactics.co.uk (alternatively http://www.personal.reading.ac.uk/~llr06mlm/calculator.htm).

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Coordination of tones and vowel gestures in German nuclear pitch accents

Doris Mücke, Martine Grice & Anne Hermes
I*f*L Phonetik, Universität zu Köln

In a production study we investigated the relative timing of tones and vowel gestures in rising nuclear pitch accents in German, concentrating on the effect of syllable structure (open and closed syllables).

In an acoustic study on Greek it was found that tones are closely aligned with acoustically defined boundaries in the segmental string: In prenuclear accents, the start of an accentual rise (L) co-occurs with the beginning of the initial consonant in the stressed syllable, while the end of the rise (H) co-occurs with the beginning of the vowel in the following unstressed syllable (Arvaniti et al. 1998). What is important here is that the acoustic alignment pattern is stable across different syllable structures. However, in a number of studies on other languages, such as Dutch (Ladd et al. 2000; Schepman et al. 2006), Spanish (Prieto & Torreira 2007) and Italian (D'Imperio et al. 2007a), syllable structure had effect on the alignment of the tones. More specifically, H peaks were later in closed syllables. For example, in Dutch **CVC**V words (stressed syllable closed) peaks were on average of 40ms later than in **CV:**.CV (stressed syllable open) words (for H relative to the beginning of the intervocalic consonant). For Spanish **CV**.CV words (stressed syllable open) the peak came at the beginning of the intervocalic consonant, in **CVN**.CV words (stressed syllable closed) it was around the middle of the sonorant coda. What these studies have in common is that on the phonetic surface (in the acoustic record), the H peaks occur on or in the vicinity of the intervocalic consonant, unlike Greek, where it was on a vowel.

In this study we recorded four speakers (two each from Vienna and Düsseldorf) with an electromagnetic articulograph (EMMA) to investigate (a) acoustic alignment patterns for H tones relative to segmental boundaries and (b) articulatory alignment patterns for H relative to dynamically defined articulatory gestures (see also D'Imperio at al. 2007b, Prieto et al. 2007, Gao 2008, Mücke et al. 2008). In both varieties of German, we found that the alignment of the H tone in nuclear LH pitch accents was strongly affected by syllable structure: Although H always co-occurs with acoustic and articulatory landmarks corresponding to the intervocalic consonant, H was on average 25ms later for acoustic anchors and 21ms later for articulatory anchors in closed syllables (**CVC**V) than in open syllables (**CV:**CV). We argue that the effect of syllable structure is related to the fact that the intervocalic consonant has a different function in the two types of target word: in **CV:**CV it is simply an onset, and in **CVC**V it is additionally a coda.

Figure 1 shows a model for coordinating H peaks with a consonant gesture in a gestural score in words like Mahmi [ma:mi] versus Mammi [mami]: the consonantal gesture (lip closure gesture) is coupled in-phase to the vowel gesture (tongue body gesture). Both gestures start simultaneously (Browman & Goldstein 2000, Nam & Saltzman 2003), forming the onset and the nucleus of the stressed syllable. In **CV:**CV, the intervocalic consonant is the onset of the second syllable, and is therefore initiated later. It is thus unsurprising that the syllable structure effect is present when looking at co-occurrence with the nearby landmark corresponding to the intervocalic consonant.

These considerations led us to investigate alignment latencies for H peaks relative to a landmark that is some distance away (remote landmark). We calculated latencies for H peaks relative to the vowel articulation in the stressed syllable (the articulatory target of V1). Here the syllable structure effect disappeared for H relative to the vowel gesture in the stressed syllable, in that latencies from H to the vowel target did not differ across the two syllable structures. Figure 2 provides a preliminary model for the coordination of H peaks with the vowel gesture. Tones and vowel gestures show complex patterns of movement, akin to consonant and vowel gestures (see Gao 2008 who found C-center effects for tones and consonant gestures in Mandarin Chinese). We argue here that the H target is triggered by the vowel target of the accented syllable. We thus argue that tonal alignment patterns are best accounted for in the articulatory approach in terms of coordination rather than co-occurrence. This account also provides a link between articulatory coordination and phonological association, since the vowel of the stressed syllable, which is coordinated with the tone, also has a phonological association with that tone.

Appendix:

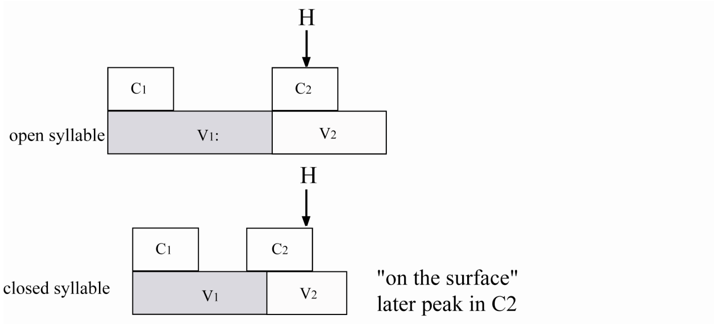

Figure 1: Gestural score for words whose stressed syllable is open (**CV:**.CV) or closed (**CVC**V), and the temporal occurrence of H peaks (black arrows). On the phonetic surface, H peaks occur later in closed syllables with respect to the intervocalic consonant.

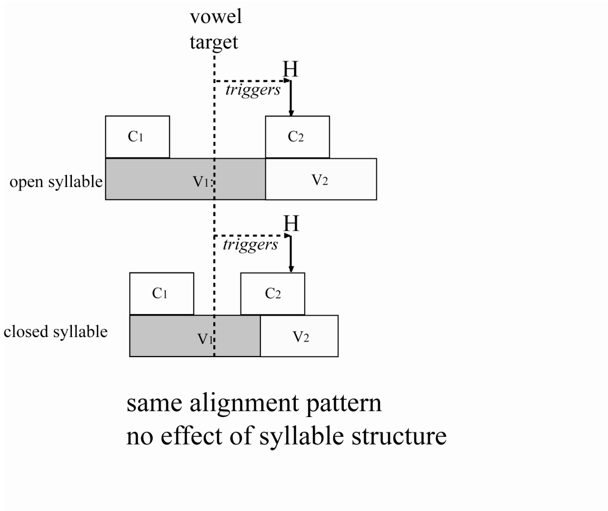

Figure 2: Coordination of the H target (black arrows) with the vowel target (vertical dotted line). Note how the target for the vowel of the stressed syllable (remote landmark) is a constant distance from H.

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The Articulatory Organization of Onset and Coda Clusters in German

Marianne Pouplier
Institut für Phonetik und Sprachverarbeitung
Ludwig-Maximilians-Universität München

Consonants differ systematically in their kinematic properties as a function of syllable position (Krakow, 1999). Further, in complex onsets different timing patterns have been observed compared to complex codas: While onset clusters have been described as being coordinated globally as an ensemble of gestures with the following vowel (the so-called c-center effect, Browman & Goldstein, 2000), coda consonants have been hypothesized to be coordinated locally, or left-edge, with the preceding vowel. At the articulatory level, an underlying c-center organization is indicated by a shift in the timing of the rightmost onset consonant towards the vowel as more consonants are added (e.g., ***l**au vs. b**l**au*). Local gestural coordination affects no such shift in timing. These timing patterns have been hypothesized to arise from the in-phase and out-of-phase coupling modes governing gestural coordination in onset and coda position (Nam & Saltzman, 2003).

Empirical c-center investigations have mainly been based on English, yet a previous study of German clusters based on EMG data failed to find a c-center effect (Pompino-Marschall, Kühnert, & Tillmann, 1990). Byrd's (1995) study of English coda consonants suggested that complex codas may also exhibit c-center, not left-edge coordination. The current study uses EMA data to systematically compare the articulatory organization of German consonant sequences in onset and coda position. We investigate in particular whether onsets show c-center coordination to the following vowel, and whether coda consonants are timed locally to the preceding vowel or consonant gesture.

Results show that the onset clusters /bl-, schm-, schp-, sk-/ exhibit c-center organization for all four subjects. For three out of four subjects, however, the clusters /kl-, pl-, gm-/ and /km-/ do not show c-center coordination when the timing of the right most consonant of the cluster is compared to a singleton consonant. When the timing of a complex CCV onset is compared to an identical across-word cluster (VC#CV), however, a c-center effect emerges also for /kl-, gm-/ and /pl-/ onsets, indicating that articulatory constraints on consonant co-production may influence articulatory timing more than syllable-position. The failure of /km-/ to exhibit c-center coordination may be attributed to the extremely rare occurrence of that cluster in a single word of low frequency which none of the subjects was familiar with.

As to coda clusters, stop-stop clusters (/-bt, -kt/) show the predicted local coordination pattern. For /l/-initial clusters (/-lm, -lp/) and stop-sibilant clusters (/-ps, -ks/), subjects vary whether they show c-center coordination or a timing pattern not predicted by the gestural syllable model at all, namely an increasing time interval between the vowel anchorpoint and the leftmost coda consonant. The results can be related to Byrd (1995) who observed an increasing (acoustic) vowel duration with an increasing number of coda consonants.

Overall, the results suggest that the temporal organization of consonant clusters differs not only as a function of prosodic position, but also depends on the particular gestures involved, that is, gestural timing in different syllable positions interacts with articulatory constraints on consonant co-production and possibly the sonority hierarchy.

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An ultrasound and audio-visual study of Cw sequences in Shona

Elizabeth Rogers and Eric Vatikiotis-Bateson
Department of Linguistics
University of British Columbia

This study reports on an ultrasound and audio-visual investigation of putative Cw clusters in the Bantu language, Shona. Preliminary results suggest that these involve a complex of two secondary articulations, namely, labiovelarisation.

The secondary articulations labialisation and velarisation have received various treatments in the Shona literature (e.g. Doke 1931, Fortune 1985, Maddieson 1990, Pongweni 1990). While it has been proposed that Shona phonetically (and even phonemically) contrasts secondary articulations, there has been little agreement as to what this articulation is. An early phonetic account of Shona (Doke 1931) argued that there is a contrast between plain and velarised consonants and that velarisation is the result of interactions with the semi-vowel [w]. In contrast to this, Pongweni (1990) argues in favour of labialisation rather than velarisation. Additionally, the origin of these articulations has been debated; that is, whether they are due to an underlyingly complex segment or the gestural coordination of a consonant cluster.

The present research is part of a larger research program investigating the phonetic realisation of secondary articulations in Shona. The data set under investigation includes putative Cw clusters, with contrasts such as ***m**edza* 'swallow' vs. ***mw**edzi* 'moon'. Audio-visual and ultrasound recordings were made of a male speaker of the Karanga dialect of Shona. A preliminary analysis showed that these sounds have the following distribution of secondary articulations: i) coronal consonants + /w/ surface with both labialisation and velarisation, ii) velar consonants + /w/ surface with clear labialisation, and, iii) labial consonants + /w/ surface with clear velarisation (cf. Figures 1 and 2). The quantative analysis includes measures of lip rounding and protrusion (from video recordings), and raising of the back of the tongue (from ultrasound recordings). These results will be presented in conjunction with corresponding acoustic data, providing a description of the articulatory and acoustic characteristics of these sounds.

Figure 1: Example of [m] from ***m**angwanani* ‘good morning’.

Figure 2: Example of $[m^w]$ from ***mw**ana* ‘baby, child’.

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Obligatory release and stiffness modulation in Moroccan Arabic

Authors: Kevin Roon[1,2], Adamantios I. Gafos[1,2], Phil Hoole[3], Chakir Zeroual[4,5]
[1]New York University, Dept. Linguistics; [2]Haskins Labs; [3]IPS, Munich University; [4]University Sidi Mohamed Ben-Abdellah-Morocco; [5]Laboratoire de Phonétique et Phonologie, Univ. Paris III. Email: kdroon@nyu.edu

The present study provides evidence that the linguistic production system adjusts articulation timing online to achieve a categorical linguistic goal. Specifically, it presents data from Moroccan Arabic supporting the hypothesis that the dynamical parameter of stiffness (Munhall et al., 1985) is modulated during production to assure release in heterorganic stop-stop clusters in this language.

Dell and Elmedlaoui (2002: p. 231) describe a required "audible release" between two heterorganic stops in a cluster in Moroccan Arabic. In articulatory terms, this can be stated as an "open transition" (Catford, 1988): in heterorganic stop-stop clusters, there must be some period of time between the articulatory closures of the first and second stops. If in a given utterance the onset of C2 toward closure (C2 Onset) starts too early with respect to the release of C1 constriction (C1 Release) for whatever reason, there might be no intervening time between the closures of the two consonants. This is prohibited in this language. The present study tested the hypothesis that, in a C1C2 sequence, the stiffness of the C2 closing phase is modulated online during production to ensure open transition. Decreased stiffness results in longer movement durations in achieving the same displacement, all other things being equal (Byrd and Saltzman, 1998). Therefore, by decreasing stiffness, the C2 closing phase will take longer and the obligatory gap between the consonant closures will be maintained.

The present study used 3D electromagnetic articulography data collected from three native speakers of Moroccan Arabic. Stimuli were heterorganic stop-stop clusters in three word positions: word-initial, -medial, and -final. Clusters of both place orders (Hardcastle and Roach, 1979) were included (anterior-posterior, "tk", and posterior-anterior, "kt"). Stiffness of the C2 closing phase was calculated as the peak velocity (cm/s) of the receiver on the primary oral articulator of the consonant (Lower Lip for /b/, Tongue Tip for /d, t/, and Tongue Back for /g, k/) during the closing phase of the movement divided by the physical displacement (cm) of the receiver during the closing phase (Munhall et al., 1985). Relative C2 Onset was calculated (ms) as the timepoint of C1 Release minus the timepoint of C2 Onset. Larger values indicate earlier Relative C2 Onsets (Figure 1). Pearson correlation coefficients were calculated between Relative C2 Onset and stiffness of C2, within speaker across all word positions. The results strongly supported the hypothesis that stiffness was lower when Relative C2 Onset was larger (i.e., earlier). There was a significant negative correlation for each speaker's data (coefficients: Speaker OB = -0.794, Speaker YZ = -0.789, Speaker CZ = -0.568; for all 3 speakers $p < 0.001$). These correlations were not affected by word position. Scatterplots of each speaker's data are shown in Figure 2. Similar analyses using peak velocity during the C2 closing phase instead of stiffness showed no significant correlations, in further support of the hypothesis that it is stiffness specifically that is modulated.

This result gives insight into one mechanism by which separation of the two closures is effected, and at the same time supports the possibility of obligatory release as a linguistic goal. The question then arises as to whether that goal is articulatory or acoustic. Analysis of these speakers' acoustic and articulatory data is included to address this question.

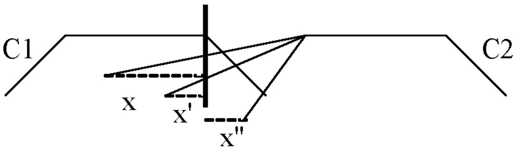
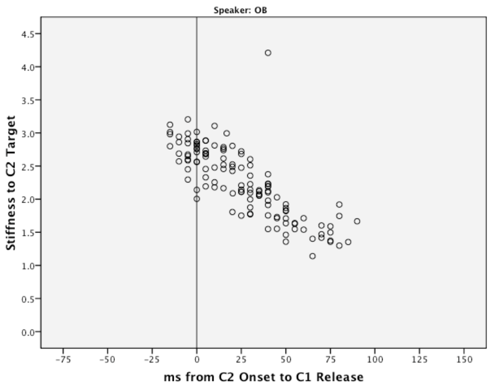
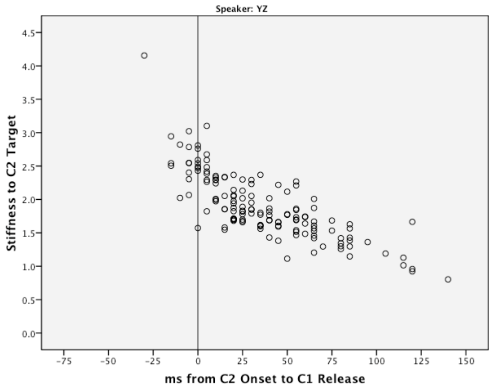


Figure 1. C2 Onset relative to C1 Release (vertical line). Larger positive values (x compared to x') indicate an earlier C2 Onset relative to C1 Release. Negative values indicate C2 Onset after C1 Release (x'').



a



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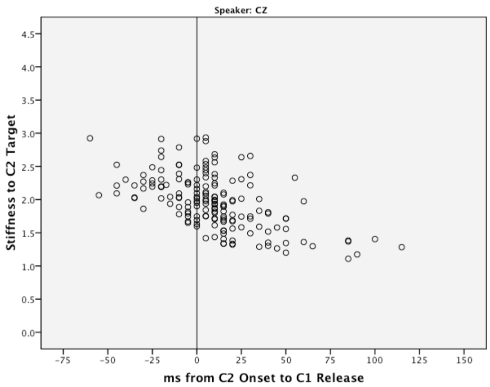

c

Figure 2. Scatterplots showing the significant negative correlation between Relative C2 Onset with stiffness of C2 closing phase for Speakers OB (a), YZ (b), and CZ (c).

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Syllable complexity and the sonority hierarchy in Italo-romance dialects

Stephan Schmid (Universität Zürich)

Empirical research in dictionaries has shown that Italo-romance dialects can be situated along a continuum of increasing phonotactic complexity, ranging from dialects with fewer syllable types like Sicilian and Venetian to dialects with a greater number of more complex syllable types like *Feltrino*, *Romagnolo*, and Friulian [3]. In the vein of a phonological reinterpretation of the isochrony hypothesis [1], the two poles of this continuum are claimed to correspond to the ideal types of 'syllable-based' and 'stress-based' languages; moreover, the degree of syllable complexity in Italo-romance dialects is reflected by durational properties of the speech signal [3], according to the metrics proposed by the 'Rhythm Class Hypothesis' [2].

In Italo-romance, 'syllable-based' dialects exhibit a strong preference for open syllables, with codas mainly consisting of word-internal sonorants; moreover, syllable onsets essentially follow the sonority hierarchy. Quite differently, 'stress-based' varieties allow word-final consonant clusters, but there are further differences within this dialect type. The phonotactics of Friulian, for instance, adheres quite well to the the sonority sequencing principle (with the exception of word-final –s, a plural morpheme which might be interpreted as an appendix). On the other hand, Romagnolo and Piedmontese show rather marked consonantal clusters also in syllable onsets (for instance, sequences of two plosives). The present contribution discusses these findings from a typological point of view, addressing the relationship between the structural complexity of consonantal clusters and general properties of speech rhythm.

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Stress and rate effects on consonant clusters across word boundaries

M. Tiede[a,b], C. Mooshammer[a], M. Gao[a], and L. Goldstein[c,a]

[a]Haskins Laboratories, [b]MIT Research Lab of Electronics, [c]University of Southern California

Overview

This work presents results of an ongoing kinematic study of gestural phasing between successive consonantal gestures, in contexts varied by speaking rate, stress, and interpolated word boundary. Context-dependent timings of articulatory gestures associated with the production of consonant clusters are of interest for their implications for speech organization and planning, yet studies of these phenomena remain sparse. Browman & Goldstein [1] used X-ray microbeam data to establish that inter-gestural timing variability was less within word onsets (e.g. *pea splots*) than across word boundaries (*peace plots*). Using EPG, Bryd [2] found less overlap and reduced timing variability in onset clusters than in codas or heterosyllabic sequences. Tiede et al. [3] showed using EMMA that phasing between /k/ and /t/ under rate differences in *pact op* vs. *pack top* contexts was significantly less variable in codas than across word boundaries. These results suggest a ranking for licensed inter-gestural variability, in which onsets < codas < word boundary junctures. In this work, a more comprehensive set of possible English clusters is examined in an effort to confirm the generality of this hierarchy, and to investigate other aspects of gestural coordination within clusters.

Procedures

Subjects to date include two female and one male native speakers of American English, with normal hearing and no apparent speech deficits. Midsagittal magnetometry was used to observe sensors attached to their tongue, jaw, and lips. Speech materials contrasted such sequences as *mosque ought* (/sk#/), *moss caught* (s#k), and *Ma Scott* (/#sk/), embedded in a consistent carrier. Stress differences (weak/strong, strong/weak) were elicited in the form of responses to questions; e.g., “Did you say hops bought again?” (Spoken:) “I said hops CAUGHT again.” For one subject normal (casual) and fast speaking rates were also elicited. Temporal offsets of velocity extrema associated with points of maximum constriction were measured for each consonantal gesture. To normalize across conditions these offsets were then expressed as percentages of the carrier duration. For example, in the sequence *Ma Scott* the offsets of the /s/ and /k/ gestures of interest were converted to their respective percentages of the initial /m/ to final /t/ duration for each token.

Preliminary Results

An example of normalized timings is shown in Figure 1 below, contrasting *hop Scott* with *hops caught*. The primary effect of the stress difference is to shift all three consonant gestures by about 10% of the carrier duration, reflecting the primary stress cue of augmented vowel length. Regardless of stress, /k/ initial words (*caught*) are phased earlier in the context than /k/ in /sk/ sequences (*Scott*). A regression of /s/ to /k/ phasing with carrier duration (Figure 2) shows significant correlations for strong/weak patterns that are opposite in slope, which may help distinguish word boundary placement for the less audible second word. Categorizing these and similar effects for the contrasts shown in Table I remains work in progress to be presented.

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ps#	hops ought	lp#sk	help ski
p#s	hop sought	lps#k	helps key
ps#k	hops caught	sk#	mosque ought
p#sk	hop Scott	s#k	moss caught
p#skr	leap scree	sk#	Ma Scott
ps#kr	leaps Cree		

Table I: Contrasts examined to date

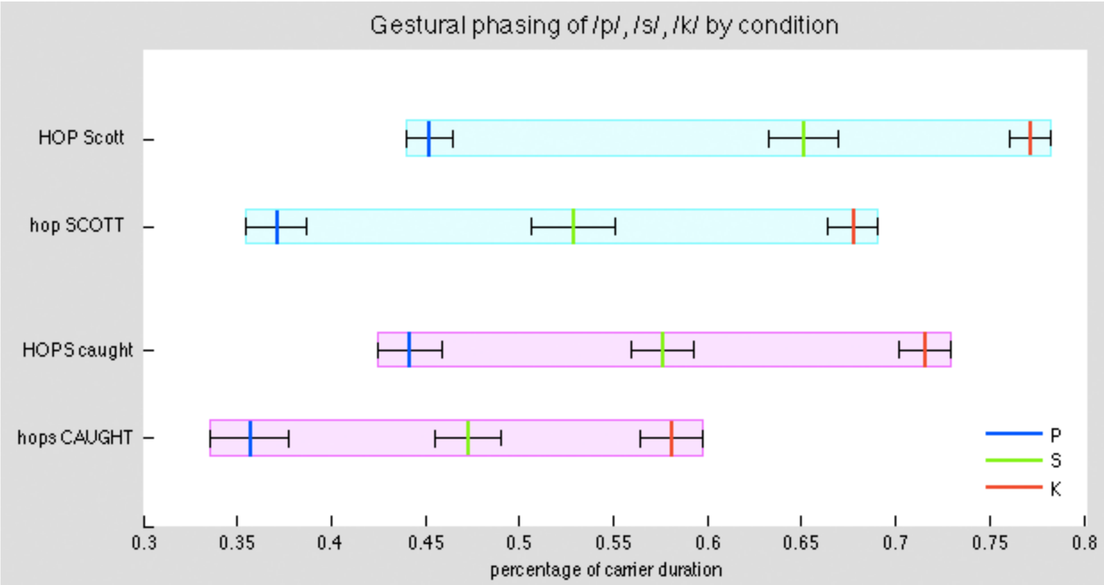

Figure 1: Grouped subject phasing results for /psk/ clusters, normal speaking rate (N=21, showing 95% confidence intervals).

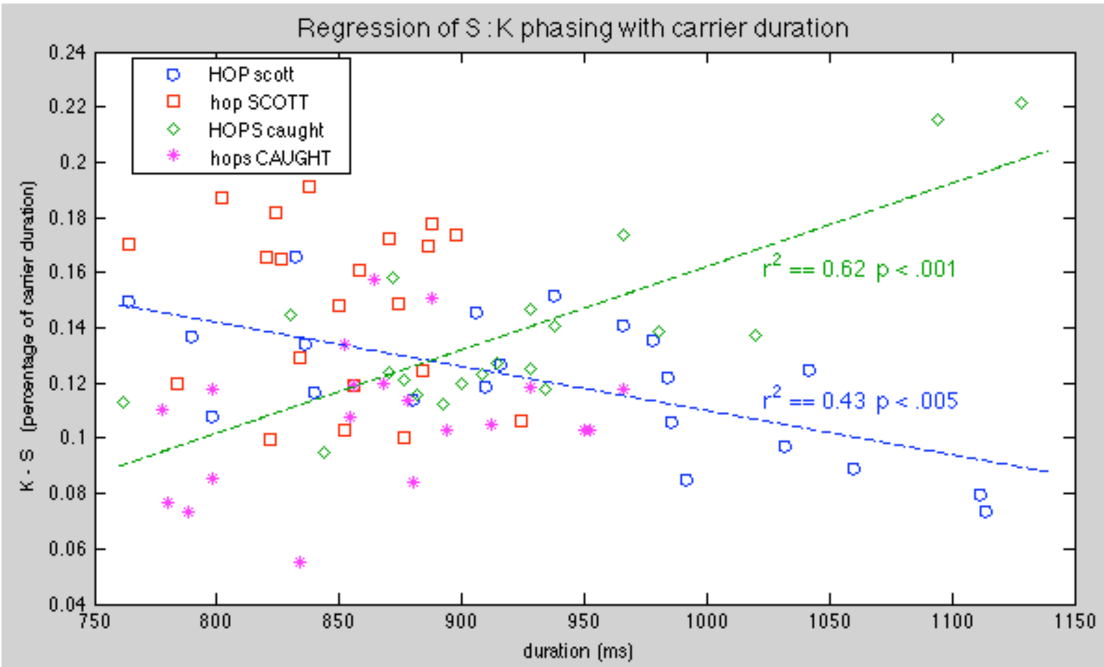

Figure 2: Interaction of /s/ to /k/ phasing with carrier duration

Effects of high-vowel loss in Northern Greek dialects

Nina Topintzi[1], Mary Baltazani[2]

1. Aristotle University of Thessaloniki and University of Patras, topintzi@enl.auth.gr
2. University of Ioannina, mbaltaz@cc.uoi.gr

Northern Greek (NG) dialects (roughly covering the areas of central Greece, Thessaly, Macedonia, Epirus, Thrace, Euboea, and some islands in the Ionian and NE Aegean) have a characteristic process of high-vowel deletion in unstressed syllables leading to the creation of various consonant clusters, as shown in (1).

(1)	NG	Standard Greek	
	plíθka	plíθ<u>i</u>ka	'I washed'
	plí	p<u>u</u>lí	'bird'
	fsó	f<u>i</u>só	'blow'
	vnó	v<u>u</u>nó	'mountain'

While this phenomenon is well-documented (Chatzidakis 1905, Papadopoulos 1927, Newton 1972, Browning 1991, Kondosopoulos 2000, Trudgill 2003), it is described as vowel deletion, without much attention paid to its phonetic and phonological properties.

In this paper we examine two aspects of this process using data from the area of Kozani (Western Macedonia). First, the extent to which this process is categorical, that is, whether some residue remains at the position of the now-lost vowel. Preliminary results suggest that, at least in some cases, such deletion is not always total. The exact phonetic nature of this residue and the extent of this process are investigated in more detail.

The second aspect we investigate has to do with possible effects of the deletion to the segments left behind, especially the nature of clusters it creates. Such deletion in many cases creates clusters that are permitted in the standard language, such as /pl/, while in other cases it creates clusters that are banned in the standard language, such as /tγ/. This result generates two interconnected questions; first, are the permitted clusters identical to the corresponding original clusters, e.g. is the [pl] in *plí* < *pulí* 'bird' the same as the [pl] in *plío* < *plío* 'ship' and second, if indeed vocalic residues are systematic, are they only present between "illicit" clusters, e.g. [tɣ] in *tɣaɲ* < *tiɣáni* 'frying pan', [ðʎ] in *ðʎ* < *ðuʎá* 'work, job', or does it emerge more generally?

The significance of answering those questions is two-fold: not only will it allow us to understand the phenomenon more fully and describe it more accurately, but it is also a vital step before addressing the phonological status of the residue—if it occurs systematically in Northern Greek data (cf. proposals such as excrescent/intrusive vowels, Hall 2006; minor syllables in Svantesson 1983, Sloan 1988, Gafos 1998).

Place and Manner Interactions in Greek Cluster Phonotactics

Marina Tzakosta
University of Crete

The fundamental assumption underlying cluster formation is that the bigger the distance between the members of a cluster on the sonority scale (SS) is, the better structured the cluster is (cf. Clements 1988a, b). This implies that 'perfect' clusters with the biggest possible distance between their members are less prone to repair strategies and have more chances to remain intact. Put differently, deletion, fusion and epenthesis apply more frequently to CC sequences marked by the smallest distance on the SS compared to CL clusters. In this paper we make a typological account of consonant clusters in Greek L1 acquisition and L2 learning placing emphasis on CL and CC sequences.[1] Given that these cluster types appear at different points in phonological development, our aim is to demonstrate that differences in their developmental order in L1 and L2 are due to their difference at the level of their perceptual load. Different perceptual loads are theoretically translated into distinct phonological representations. Complex representations mirror structures with 'heavy' perceptual load.

It is interesting that, although sonority distance determines cluster perfection, non-perfect clusters emerge massively in standard Greek, its dialectal variants as well as language development. Non-perfect clusters are consonantal sequences consisting of members highly adjacent on the SS with respect to place *or* manner or *both* place *and* manner of articulation (examples in (1)). We argue that CC sequences make up non-perfect but *acceptable* clusters. In order to identify the exact phonological structure of different cluster types we suggest that the SS should be evaluated separately with respect to place and/ or manner of articulation. In other words, the SS should be divided into two distinct scales, one for manner and one for place of articulation (figures 1 & 2, respectively); clusters need to respect the sonority of either manner or place scale in order to be characterized as acceptable. Scales are vacuously satisfied when cluster members are grounded at the same point on the scale. Scales are satisfied from left to right; hence CL clusters are perfect because they respect the sonority of both place and manner. On the other hand, clusters consisting of [fricative + stop] (1a), [fricative + fricative] (1b) and [stop + stop] sequences (1c) constitute acceptable clusters in Greek while [stop + fricative] clusters (1d) violate the manner scale; therefore they are non-acceptable unless the second member is /s/ (1e). However, clusters whose members differ, even minimally, with respect to place or manner are preferred to those sharing the same place or manner. To be more specific, SS and FF clusters tend to be substituted for FS ones, as shown in the examples (2a-d).

In our view, adjacency of the members of acceptable clusters on either scale entails that CC cluster are characterized by more complex phonological representations, closely similar to those of affricates (see also Nikolaidis et al. 2007, Tzakosta & Karra 2007, Tzakosta and Vis 2007a, b). In relation to that, we assume that cluster complexity aggravates cluster recognition and perception in L1 acquisition and L2 learning and, eventually, impoverishes faithful production. Thus, even though CC and CL clusters are both targeted in L1 and L2, CC sequences appear later than CL in phonological development. More specifically, CC sequences undergo different kinds of repair strategies such as deletion, epenthesis, fusion, stopping, assimilation while CL clusters are correctly produced. CL clusters are produced even in cases where they are not contained in the target form (2e-g). The above observations entail that CC sequences require special teaching methods used for preschool children-native speakers of Greek as well as second language learners from different linguistic backgrounds.

[1] C represents stops and/ or fricatives and L stands for laterals or rhotics. S stands for stops and F for fricatives.

Examples

1. a. **FS:** /**xt**i.zo/ ‘construct-1sg.pres.’ b. **FF:** /a.**vγ**o/ ‘egg’
c. **SS:** /**pti**.**si**/ ‘flight’ d. ***SF:** */a.**tx**os/ e. **Cs**: /ek.pli.**ks**i/ ‘surprise

2. a. /e.**vð**o.ˈma.ða/ → [e.**vd**o.ˈma.da] ‘week’ (Dutch 1)
b. /ˈ**γð**i.no/ → [ˈ**gd**i.no] (Romanian 2)
c. /a.**vγ**ó/ → [a.**vg**ó] (Romanian 2)
d. /**fθ**ó.ri.o/ → [**ft**o.rá] (Romanian 3)
e. /u.ra.nós/ → [i.**γr**a.nós] ‘sky’ (Dutch 2)
f. /cí.ni.si/ → [**kl**í.si] ‘circulation’ (Dutch 3)
g. /é.ᵐ**b**o.**r**os/ → [é.**ᵐbr**os] ‘merchant’ (Dutch 3)

Figure 1

S	F(/SIB)	AFFR	N	L	G	V
1	2	3	4	5	6	7

Figure 2

VEL	LAB	COR
1	2	3

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Consonant clusters in Samoyedic languages
a typological investigation

Várnai, Zsuzsa
Hungarian Academy of Sciensces,
Research Institute for Linguistics, Budapest
varnai@nytud.hu

The purpose of this paper to present a phonotactic description of the word stock of Samoyedic languages, esp. of Nenets (Tundra), Enets, Nganasan and Selkup (Taz dialect), which are endangered Uralic languages spoken in North-Siberia in Russia. They have not yet been thoroughly investigated in the phonological literature.

It is important to consider the ways that the segments are allowed to combine with each other in making longer structures, such as syllables. Some languages allow very free combiations of segments, while in others the combinations are strongly restricted. In this paper the complexity of sequencing of segments within syllables will be discussed in choosen languages.

In this paper I discuss the constraints that apply within the constituents of the syllable, than I define the syllable template, and the representation of the syllable, after that I specify the possible complexity of the onset and the coda in these languages.

Some remarks of my investigation are: Samoyedic languages permit consonant clusters, but they are very restrictive in terms of complex edge components, for example many of them do not permit initial consonant clusters, or more than two consecutive consonants in other positions, esp. at the boundary of the syllable. There is no complex edge components in any Samoyedic language in any position, except for final complex codas in Nenets, so two consonants are not allowed in the onset position of a syllable at all. There are medial and final branching codas and final CCC clusters only in Nenets. Consonants cannot appear as syllable nuclei in chosen languages. According to these observations several Samoyedic language are counted as having moderately complex syllable structure, and some of them are classified as having complex syllable structure.

At last but not least I re-examine the clusters of choosen languages from the viewpont of the sonority hierarchy, and show the typological relation of the well- and ill-formed clusters, and shortly I want to show what happenes in these languages with the Russian loanwords.

Degree of temporal overlap within Moroccan Arabic stop-stop clusters and its relation to place order and voicing

Chakir Zeroual[1,2], Adamantios I. Gafos[3,4], Philip Hoole[5]
Faculté Polydisciplinaire de Taza-Morocco; 2Laboratoire de Phonétique et Phonologie (UMR 7018 CNRS /Sorbonne -Nouvelle, Paris); 3New York University; 4Haskins Laboratories; 5Institut für Phonetik und SprachlicheKommunikation, Ludwig-Maximilians-Universität München).

1. Introduction

Previous studies (Chitoran et al. 2002 , Gafos et al., to appear) showed that the temporal overlap in the C1C2 clusters depends on three main parameters: (i) Word position: more overlap in the medial compared to the initial position (VC1C2 > #C1C2V); (ii) Place of articulation order: more overlap in anterior_ posterior than in Post_Ant clusters (pt vs tp) (see Gafos et al., to appear for a different version of this parameter); (iii) the manner of articulation: more overlap in sonorant_stop than in stop_stop clusters.

No exhaustive study identified the possible effect of phonation type (voiced vs. voiceless) on the degree of temporal overlap in the stop-stop clusters ([+V+V], [+V-V], [-V+V], [-V-V]). Two main reasons can explain this lack: (i) Voicing assimilations and neutralization (Lombardi, 1995, 1999; Jessen, 1998; Kehrein, 2002) observed in stop-stop clusters reduces the combinations to [+V+V] or [-V-V]. (ii) Although some basic coordinations principles have been proposed (Browman & Goldstein, 1986), the temporal coordinations between the laryngeal and supralaryngeal gestures have not yet been fully worked out for all possible consonant sequences. Several phonologists claim that MA has the four combinations: [+V +V], [+V-V], [-V+V], [-V-V]. In this study, we analyze the acoustic realizations of these four stop_stop clusters, and evaluate the relation between the degree of temporal overlap and place order, as well as between the degree of overlap and phonation type.

2. Method and materials

Four MA speakers participated in a 3-dimensional EMA experiment. Results of SM and SA speakers are discussed here. Vertical and horizontal movements of the tongue (tip, mid, dorsum), lips, and the jaw were tracked at 200 Hz sampling rate. Items including stop-stop clusters attested in MA in the aCCa context (Table 1) have been pronounced 8 times in: *galha __ hnaya,* 'he told him __ here.' Gestural Onset, Target, Release and Offset were identified automatically from tangential velocity of the opening and closing phases using a 20% threshold criterion. The degree of overlap was calculated with a formula given in Fig. 2.

3. Results

Acoustic data: A stop is defined as voiced only if it is produced with vocal fold vibrations during more than 50% of its closure phase. [+V+V] are produced by SM and SA with continuous voicing in the two place orders, and a vocoid between C1C2 only in the Post_Ant order. In [+V-V] and [-V+V] no progressive voicing or devoicing assimilations are observed. In [-V+V] we have a regressive voicing assimilation in the Ant_Post order especially for SA, but not in the Post_Ant order. The observations made here for MA are consistent with the "close connection between negative voice onset time in plosives […] and the occurrence of regressive assimilation" proposed by Rooy et al. (2001).

EMA data: In order to elaborate more detailed comparisons, we analyzed the effect of voicing separately for the two place orders (Fig. 1). For both SM and SA the degree of overlap is significantly more important in the Ant_Post order that in Post_Ant order. The mean difference between the place orders is larger for SM than for SA. These analyses show also that the effect of voicing is significant for SM in the Ant_Post order and Post_Ant order. For SA, the effect of voicing is significant in the Post_Ant only.

These observations show that the effect of place order on the degree of temporal overlap in the stop-stop cluster is more regular than voicing.

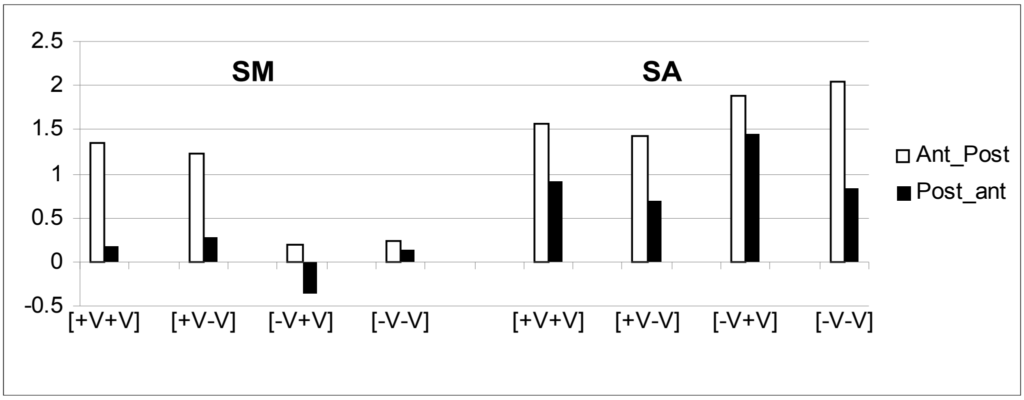

Figure 1: Mean temporal overlap in the stop_stop clusters, produced by SA and SM in aCCa context, classified by phonation type and place order.

Table1

Medial stop_stop clusters used in our EMA experiment according to their place order and voicing.

[b d g t k]: MA stop consonants	Ant_post	Post_ant
[+V+V]	[bd] [bg] [dg]	[db] [gb] [gd]
[+V-V]	[bt] [bk] [dk]	[gt]
[-V+V]	[tg]	[tb] [kb] [kd]
[-V-V]	[tk]	[kt]

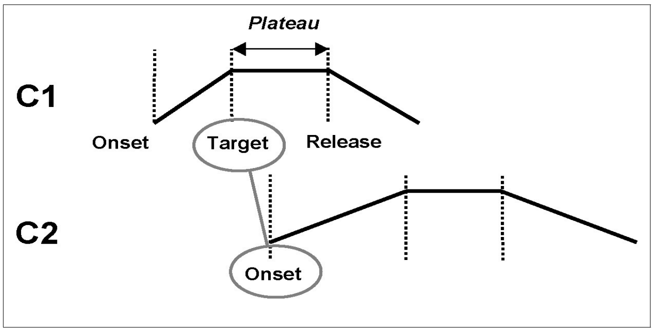

Figure 2: Temporal gestural overlap within a C1C2 cluster.
Overlap = 1 - (Onset C2 - Target C1)/(Plateau C1). Overlap > 1, C2 Onset occurs before C1 Target; between 0 and 1, C2 Onset occurs during C1 plateau; Overlap = 0, C2 Onset occurs at same time as C1 Release; Overlap < 0, C2 Onset occurs after C1 Release.

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Why are voiced affricates avoided cross-linguistically?
Evidence from an aerodynamic study.

Marzena Zygis & Susanne Fuchs
Zentrum für Allgemeine Sprachwissenschaft, Berlin

The goal of this paper is twofold. First, it will be shown that several typologically unrelated languages share the tendency to avoid voiced sibilant affricates. Second, this tendency will be explained by appealing to the phonetic properties of these affricates, in particular to their articulatory-aerodynamic complexity .

As far as the first goal is concerned, it will be presented that in several Slavic, Germanic, Bantu and other languages, a phonemic gap is attested, i.e., voiced coronal affricates do not occur while their voiceless counterparts do (see Zygis 2006). Interestingly, in several of these inventories, coronal stops and fricatives create a contrast with respect to voicing.

With respect to the second goal it is argued that (i) the complex articulation and (ii) conflicting aerodynamic relations are responsible for the lack of voiced affricates in phonemic inventories. The latter point is supported by results of an aerodynamic experiment involving parallel recordings of airflow, intraoral pressure, and acoustics. Four German and four Polish speakers participated in this study producing a series of voiced and voiceless stops, fricatives and affricates. German and Polish differ with respect to the occurrence of voiced affricates in the native vocabulary and also with respect to their voicing contrast (in Polish voiced affricates occur, Polish has a real voicing contrast instead of an aspiration contrast).

The main difference we found is that in voiceless affricates the intraoral pressure rises quickly (steep slope) whereas in voiced affricates it is relatively slow during the stop portion of the affricate, but can often reach a similar pressure peak during the fricative as in the voiceless counterpart (see Figure 1) We suppose that the different pressure variations mirror laryngeal-oral coordination. In voiceless affricates glottal opening starts with a short delay after closure onset (Hoole et al. 2003) and the pressure can rise very quickly. In opposition, for the voiced affricate the glottis seems to be closed during large parts of the stop portion which allows to maintain the transglottal pressure difference and therefore voicing. However, in the fricative part of the affricate we often found devoicing and a high intraoral pressure peak necessary for the realization of frication which rather speaks for a laryngeal abduction.

On the basis of experimental evidence it is argued that conflicting air pressure requirements for maintaining voicing are difficult to meet. In particular, the air pressure released from the stop component of the affricate is too high to maintain voicing during the fricative. These findings are interpreted with respect to laryngeal-oral coordination.

a. b. c.

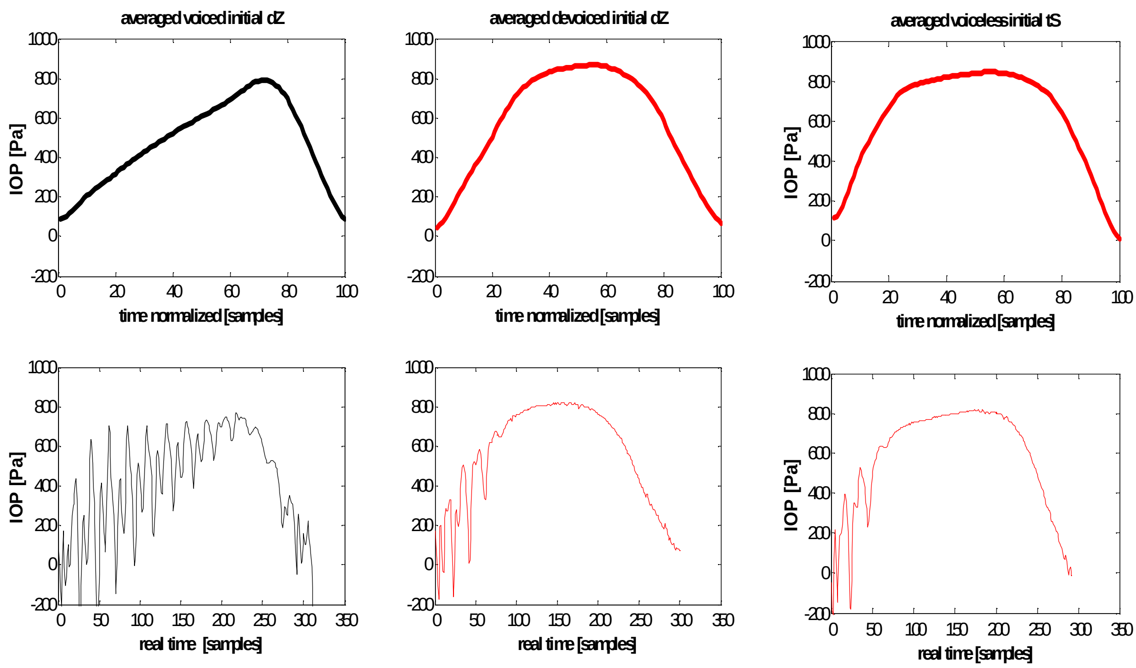

Figure 1: First track: averaged and filtered intraoral pressure profiles in (a) voiced initial [d͡z], (b) devoiced initial [d͡z] and (c) voiceless initial [t͡s]. Second track: examples for single unfiltered tokens.

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Learning Phonotactic Constraints from Continuous Speech: A Computational Study

Frans Adriaans, Utrecht University

Infants acquire knowledge of phonotactics well before the end of the first year of life (e.g., Jusczyk et al., 1993) and use this knowledge in the segmentation of continuous speech (Mattys and Jusczyk, 2001). This suggests that models of phonotactic learning should consider continuous speech as a source of data through which phonotactics can be acquired. Existing models of phonotactic learning, however, assume that phonotactic constraints are induced from the lexicon (Pierrehumbert, 2003; Hayes and Wilson, 2008).

The present paper addresses two issues in phonotactic acquisition, taking a computational angle. First, we investigate whether it is possible to induce phonotactic constraints from transcriptions of continuous speech. Second, we empirically determine the role of abstract phonotactic constraints in speech segmentation. More specifically, we predict that learned restrictions on the co-occurrences of natural classes provide a more reliable cue for detecting potential word boundaries than restrictions on segment co-occurrences.

We propose a computational model for the induction of phonotactic constraints from continuous speech, which combines statistical learning with generalization. As input to our model, we use the broad phonetic transcriptions of the Spoken Dutch Corpus (Goddijn and Binnenpoorte, 2003), where all word boundaries within utterances have been removed. Using statistical learning, the learner categorizes biphones into two types of phonotactic constraints, which will serve as a basis for generalization:

$*xy$:	'Sequence xy should not occur word-internally.'
CONTIG-IO(xy):	'Sequence xy should occur word-internally.'

The learner creates more abstract constraints from the statistically learned biphone constraints using a generalization algorithm. This algorithm takes advantage of the similarity between the biphone constraints, which is quantified as the number of overlapping features. If two constraints have different values for one single feature, a new constraint is created where this feature has been removed. The consequence is that the resulting constraints cover sequences of natural classes, instead of sequences of segments.

As a result of generalization, the learner has to deal with overlapping, and possibly conflicting constraints in speech segmentation. For example, the general constraint CONTIG-IO([*plosive*][*liquid*]) states that no boundary should be inserted into a cluster consisting of a plosive followed by a liquid. This conflicts with the biphone constraint *tl, which says that the consonant cluster 'tl' should not occur word-internally. We borrow the principle of strict domination from Optimality Theory (Prince and Smolensky, 1993) in order to resolve conflicts between the learned phonotactic constraints. Such constraint ranking captures segment-specific exceptions to natural class generalizations.

We conducted a series of computer simulations, which aim at comparing 'pure' statistical models, such as transitional probability (TP, Saffran et al., 1996), to our constraint induction model. The models are tested on their ability to detect word boundaries in the Spoken Dutch Corpus. The results in Table 1 show that the constraint induction model outperforms transitional probability (as measured by d-prime). In addition, our model is conservative: It places fewer boundaries than the TP model, but the boundaries that are predicted, are highly reliable. We conclude that generalization over statistically learned biphone constraints provides the learner with a more reliable cue for detecting word boundaries in continuous speech than statistical learning alone (i.e. without generalization).

Model	**Hit rate**	**False alarm rate**	**d-prime**
Random baseline	0.5012	0.4991	0.0051
Transitional probability (TP)	**0.6108**	0.2241	1.0399
Constraint induction	0.3681	**0.0747**	**1.1060**

Table 1: Simulation results for the Spoken Dutch corpus

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Limited Consonant Clusters in OV languages

Hisao Tokizaki and Yasutomo Kuwana
Sapporo University
toki@sapporo-u.ac.jp   y_kuwana@edu.sapporo-u.ac.jp

It has been pointed out that languages with object-verb order (OV) tend to have simple syllable structure (Lehmann 1973, Gil 1986, Plank 1998). This is the case in some OV languages such as Ijo, Yareba and Warao, whose syllable form is CV. However, examination of data in Haspelmath et al. (2005) shows that a number of OV languages have (moderately) complex syllable structure. In Tokizaki and Kuwana (2007), we have argued that OV languages do have simple syllable structure if we (re)consider (i) the classification of syllable complexity, (ii) simplification of syllable structure and (iii) geographical gradation of the variety of word-final consonants and tones.

In this paper, we would like to argue that consonant clusters are limited at word boundaries and between words in OV languages. First, we will show that a number of OV languages have vowel epenthesis and consonant deletion to avoid consonant clusters, as shown below:

(1) Hindi Epenthesis
  a. pre:m → pəre:m (CCVC → CVCVC)
  b. krisn → krisən (CCVCC → CCVCVC)
(2) Basque Epenthesis/Deletion ← Borrowed from Latin
  a. liburu ← libru(m) (CVCVCV ← CVCCV)
  b. luma ← pluma(m) (CVCV ← CCVCV)
(3) Nambikuara
  wlinhantsu → wəlinhantsu (CCV.. → CVCV..)

Second, we will show that OV languages tend to have no consonant cluster at coda position. Moreover, a number of OV languages have limited variety of coda consonants (cf. VanDam 2004). For example, Japanese may have only /n/ at coda, and Xhosa only /m/.

Figure 1 shows OV languages with limited coda, no consonant clusters (at coda position) and phonological changes to avoid consonant clusters. Then, these languages conform to the generalization that OV languages have simple syllable structure.

We will also argue that consonant clusters in OV language are limited because OV languages have left-branching structure such as [[[[…] X] Y] Z]. It will be argued that left-branching structure has short juncture between words, which are closely connected to each other making agglutination, […]-X-Y-Z (Tokizaki and Kuwana 2008, cf. Kayne 1994, Holmberg 2000, Julien 2002). Thus, in OV languages, consonant clusters should be avoided at word boundaries and between words. On the other hand, VO languages have right-branching structure such as [X [Y [Z […]]]], which has long juncture between words. For these languages, consonant clusters at word boundaries do not pose a problem because each word is separated from its adjacent words by long juncture. Thus, VO languages are allowed to have complex syllable and isolating morphology.

In sum, this study shows an interesting correlation between phonology, morphology and syntax. Limited consonant clusters allow languages to be agglutinative and to have OV (head-final, more generally) word order. Of course we need to investigate consonant clusters and coda variety in more languages than presented here. We hope that we can get feedback from the participants of this workshop.

Figure 1

Language	Coda (C)	Consonant Cluster (CC)	Phonological Change	Example
Basque			Epenthesis/ Deletion	
Georgian				ts'k -> tsɩk
Avar	n, m, w, j	No CC at coda		
Rutul	d, l, s, x	No CC at coda		
Lezgian	m, b, k, l, z, r	No CC at coda		
Kurdish (Central)	w, n, m, r, k, t, v, š, ž	No CC at coda		
Persian			Epenthesis	drožki -> doroške
Mogol	n, m, r, d	No CC at coda		
Hindi			Epenthesis	pre:m -> pərem
Tulu			ɨ-Insertion	
Kannada		No coda		magal -> magalu
Yagaria		No coda/CC		
Haida			reduced vowel-Insertion	
Lakhota		No CC at coda		
Nambikuara			[ɨ]/[ə]-Insertion	wlinhantsu -> wəlin…
Japanese	n	No CC		
Korean	n, ŋ, m, l, p, t, k		ɨ-Insertion	bad-bat -> batɨ-bat
Tamil	n, ɲ, ŋ, m, l, ɭ, ɾ, r, j			
Kanuri	n, m, l, ɹ			
Xhosa	m			

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Temporal stability as an index of syllable structure: data and model

Jason Shaw[1], Adamantios I. Gafos[1], Philip Hoole[2], Chakir Zeroual[3,4]

[1]New York University; [2]Institut fuer Phonetik und Sprachverarbeitung, Ludwig-Maximilians-Universitaet Muenchen; [3]University Sidi Mohamed Ben-Abdellah-Morocco; [4]Laboratoire de Phonétique et Phonologie.

In previous analyses of phonological constituency using kinematics, an index of temporal stability has been used as a diagnostic of structural organization (Browman and Goldstein 1988, Honorof and Browman 1995, Byrd 1995). In this paper, we use this index to diagnose syllabic constituency in Moroccan Arabic (MA) and develop a computational model to study the range of validity of this methodology. We find evidence for simplex Onsets in MA and expose the range of conditions under which the stability index reliably reflects phonological organization.

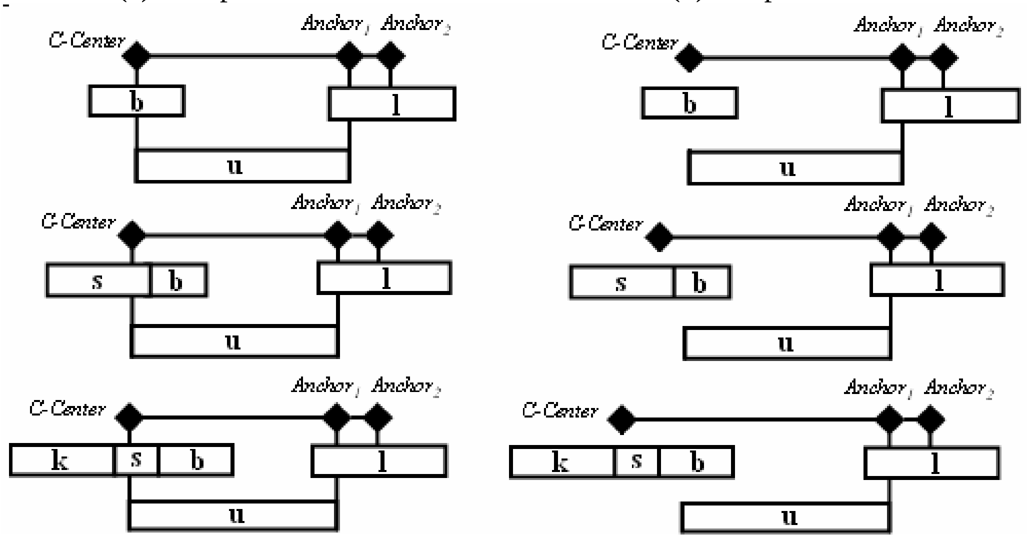
To evaluate the syllabic affiliation of initial consonant clusters in MA we collected articulatory data using EMA. Stimuli consisted of pairs (e.g. *tab* 'to repent' vs. *ktab* 'book') and triads (e.g. *bulha* 'her urine', *sbulha* 'her ear (of grain)', *ksbulha* 'to own for her') differing only in the number of initial consonants. If the initial clusters are parsed into a complex syllable Onset, then intervals measured from the center of the cluster should be more stable than intervals measured from the left or right edges of the cluster. This pattern of stability reflects C-Center timing (Browman and Goldstein 1988, Honorof and Browman 1995, Byrd 1995), as schematized in (1a). If MA has simplex Onsets, then intervals measured from the right edge of the consonant cluster should be more stable than intervals measured from the C-Center. This pattern reflects the temporal organization schematized in (1b). For each stimuli set, the relative standard deviation (RSD) of intervals measured from the left edge, right edge and C-Center to two separate anchor points was calculated. Representative results from one stimuli pair are provided in the table in (2). Of the intervals measured to Anchor 1, the *C-Center-to-anchor* interval has the lowest RSD. This resembles the English results and supports the complex Onset timing hypothesis in (1a). Of the intervals measured to Anchor 2, however, the *right edge-to-anchor* interval shows the lowest RSD. This result supports the simplex Onset hypothesis in (1b).

To make sense of the apparently conflicting evidence in our data, we develop a computational model. We hypothesize that the apparent stability advantage of the C-Center is due to variability inherent in anchor 1. To demonstrate this, the model implements the simplex Onset hypothesis in a probabilistic grammar of gestural coordination. It generates temporal landmarks for one-, two- and three-consonant clusters. For each cluster type, the vowel was timed locally to the pre-vocalic consonant, as in (1b). For each simulated token a series of 20 anchors was generated. Each anchor was drawn from a distribution with the same mean but gradually increasing variance. We then submitted the simulated data to the same stability analysis conducted on the EMA data. Results of the stability analysis on the simulated data, given in (3), show that, as anchor variability increases, the RSD of the *C-Center-to-anchor* interval increases at a slower rate than the RSD of the *right-edge-to-anchor* interval. At the level of anchor variability associated with anchor 8 in (3), the C-Center shows improved stability over the Right Edge despite Simplex Onset timing.

In sum, the model implements the simplex Onset hypothesis in (1b) and successfully matches the stability patterns in the EMA data for both high and low variability anchors. The key finding is that C-Center stability can emerge even in a language with simplex Onset temporal organization.

(1) Hypothesized timing patterns for complex and simplex syllable Onsets.

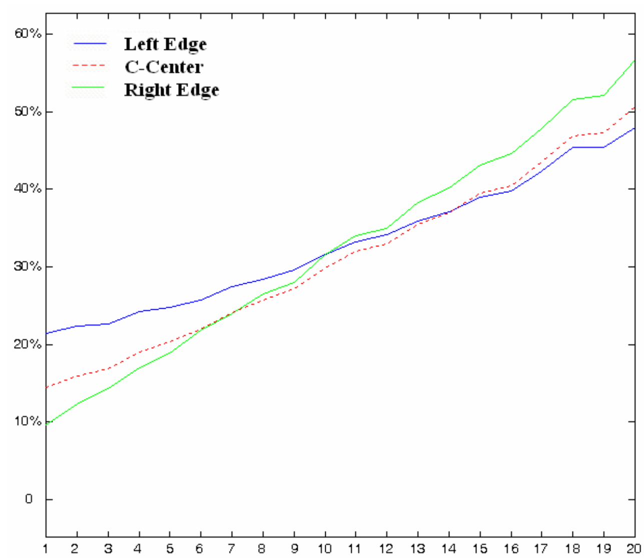
(a) Complex Onsets (b) Simplex Onsets



(2) Relative standard deviation (RSD) of intervals measured from the left edge, C-Center, and right edge of consonant clusters to 2 anchor points (RSD minima highlighted).

Anchor 1 (Vowel offset)						Anchor 2 (post-vocalic consonant)					
Left Edge		C-Center		Right Edge		Left Edge		C-Center		Right Edge	
SD	RSD	SD	RSD	SD	RSD	SD	RSD	SD	RSD	SD	RSD
103	28%	68	**23%**	63	25%	84	21%	33	10%	15	**5%**

(3) Stability results for triads generated by a model implementing the simplex Onset hypothesis. The y-axis shows RSD for three intervals (left edge, right edge and C-Center to anchor); the *x*-axis shows the anchor number in order of lowest to highest variability.



Syllabic quantity in Ancient Greek: effects of cluster compressibility

Donca Steriade, MIT

In Homer's poems, CC clusters typically cannot follow a light syllable. In later Greek, some clusters – e.g. the stop+liquid class – begin to follow light positions. This transition is generally interpreted – [1] – as going from heterosyllabic division of all clusters in Homer's Greek to a later acceptance of some complex onsets: a transition from e.g. [ak.ra] to [a.kra], keeping strings like [ak.sa] divided throughout. This study proposes a new account of the difference between [kr]- and [ks]-type clusters and explains in the process several undocumented differences in their metrical distribution. The key proposal is that syllabic division is not the only factor in determining weight categories: the duration of the entire V-to-V interval matters as well. Clusters where C_2 does not mask the release of C_1, can be produced with more extensive overlap [2], [3], [4]. [kr]-type clusters belong in this class. In some languages, they yield shorter V-to-V durations than [ks]-type clusters [5]. I will conjecture that the transition from Homer's prosody to later Greek involves not a change in syllabic division but rather a change in inter-consonantal overlap. Clusters like [kr], which are in principle compressible, are produced with substantial overlap, and thus a shorter V-to-V interval, after Homer. Clusters like [ks] are quantitatively invariant because they are incompressible.

In Greek metrical texts, syllables differ in prominence (as strong vs. weak) and quantity (heavy ¯ vs. light ˘). Strong syllables are heavy. Weak ones are light or heavy depending on the foot-type: e.g. a dactyl ($¯^s$ $˘^w$ $˘^w$) has two weak-light positions while a spondee ($¯^s$ $¯^w$) has one weak-heavy position. When a CC initial follows a short nucleus, in positions which the meter designates as weak-light, we assume parses like $[C_0V]^w$.#$[CCVC_0]$. When CC follows a short V in heavy position, leftward resyllabification is said to create a closed syllable [6]: [V#C].$[CVC_0]$.

This long-standing view of syllabic weight has yet to confront a striking distributional restriction ([7]; here): heterosyllabic initials $[V\#C_1].[C_2VC_0]$ are allowed after short V's only in strong position. Weak-heavy positions may be occupied by closed syllables, but not if closed by leftward resyllabification: $[VX]^s.[CVC]^w$ spondees exist, but not $[VX]^s.[CV\#C]^w$. The preliminary generalization is that resyllabification cannot add C's to any weak light syllable.

I argue that this phenomenon is a consequence of word-to-syllable alignment. This condition is overridden only by an effect of strong attraction comparable to that of English [8]. Attraction to a metrically strong V explains why $[CV\#C]^s.[CVC_0]$ parses are attested; left-alignment explains why $[CV\#C]^w.[CVC_0]$ is impossible. Alignment also makes sense of other details of Greek quantity, including the total impossibility of light parses for heteromorphemic clusters, e.g. $*[C_0V]^w[k\#rVX]$.

Against this background, a real paradox unfolds. One expects that CC initials should be permitted to follow a short nucleus in weak-light position: we should then encounter parses like $[CV]^w\#[CCVX]$. But these are only attested for the [kr]-type initials, and only in post-Homeric poetry; they are generally impossible for Homer. Instead, the relevant strings are avoided. It emerges that, when V_1 is short and in weak position, no metrical parse of $V_1\#CCV_2$ is possible for the [ks]-type clusters; and for *any* cluster in Homer.

The solution is that metrically light positions must contain both a light syllable and a short V-to-V interval: a short nucleus plus at most one C. For this reason, strings like $[C_0V_1]^w\#[CCV_2X]$ are quantitatively unclassifiable: they contain a light syllable but a long V_1-to-V_2 interval. For Homer all CC clusters yield long intervals; in later Greek, the compressible [kr]-type clusters begin to yield short V-to-V intervals. A general model of quantity assignment will be proposed into which these proposals are integrated.

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The Perceptual Consequences of Voicing Mismatch in Obstruent Consonant Clusters

So-One K. Hwang, Philip J. Monahan and William J. Idsardi (U. of Maryland)

Introduction: Psycholinguistic research has demonstrated the role of language-specific phonetic inventories in speech perception (Näätänen et al. 1997). Relatively few studies, however, have discussed the role that the knowledge of phonological processes play in mapping between the acoustic input onto the underlying linguistic representations. Fowler & Brown (2000) and Flagg et al. (2005) demonstrate that English listeners encounter difficulty when they are presented with a nasalized vowel followed by an oral consonant, a sequence that violates the rule of regressive nasal assimilation. The primary aim of the current study is to extend these results to voicing assimilation contexts, and moreover, to relate the findings to a phonological constraint against mixed-voicing clusters that seems to hold universally (Mester & Itô 1989). Across two segment identification experiments, we find that responses to incongruent clusters (e.g., [ds], [tz]) are slower and less accurate than responses to congruent clusters (e.g., [dz], [ts]), replicating previous findings. Moreover, within incongruent clusters, items such as [ds] are significantly more difficult to process than items such as [tz]. Additionally, items such as [dz] are facilitated relative to items such as [ts]. These results suggest that only marked features (here [+voice]) induce expectations for upcoming segments in phonological perception, as predicted by underspecification theories.

Procedure: In Experiment 1 (n=10), we tested the English alveolar stop-fricative clusters: [uts], [udz], [utz], and [uds]. Stimuli were created by splicing or cross-splicing a fricative to create congruent ([uts], [udz]) or incongruent ([utz], [uds]) sequences. The participants were instructed to respond whether they heard [z] or [s]. Given previous results (Fowler & Brown 2000; Flagg et al. 2005), we predict that incongruent clusters should result in slower reaction times (RTs) and lower accuracy rates than congruent clusters. In Experiment 2 (n=12), we sought to replicate the results from Experiment 1 and to extend them to bilabial ([ups],[ubz]) and velar ([uks],[ugz]) stops with a similar set of predictions.

Results: The results from Experiments 1 and 2 (Figures 1-4) replicated previous findings in that the congruent clusters were responded to more quickly and more accurately (all $p < 0.0001$). Additionally, in both experiments, the *vd-s* ([ds], [bs], [gs]) stimuli were less accurately and more slowly (all $p < 0.0001$) identified than the other three categories. The results for *vd*-z are somewhat less clear. There was no significant difference in accuracy presumably due to a ceiling effect. The reaction times for *vd-z* ([dz], [bz], [gz]), however, were significantly faster (all $p < 0.05$), although the effects were somewhat smaller. In summary, we find that for RTs: *vd-s* < *vl-z*, *vl-s* < *vd-z*. Thus, voiced stops induce the expected congruency difference while voiceless stops do not.

Discussion: The pattern of results show that the differentiation between congruent and incongruent clusters only holds for cluster that begin with [+voice] stops. These results are consistent with a theory of underspecification, according to which only positive features have import in phonological processes. The theory puts a marked value on voiced items and no value on voiceless items (Lombardi 1991, 1995). Underspecified stops are interpreted to have minimal phonological influence and thus make no overt, positive prediction of either voicing or voicelessness on the following fricative. The differences found within the incongruent clusters (i.e., *vd-s* and *vl-z*) as well as within the congruent clusters (i.e., *vd-z* and *vl-s*) suggest that a general constraint against voicing mismatch in syllable-internal obstruent clusters is not adequate to explain the results and instead we need specific constraints for each cluster type.

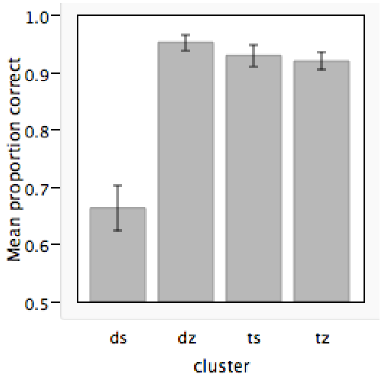

Figure 1: Mean proportion correct responses for each cluster in Experiment 1. Error bars indicate one standard error of the mean.

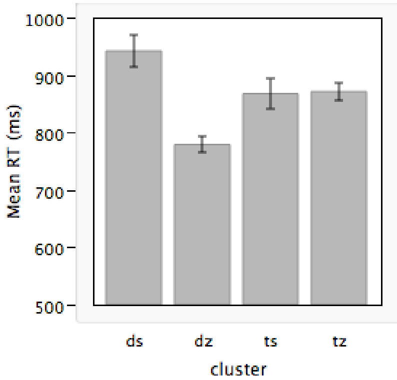

Figure 2: Mean reaction times for correct responses for each cluster in Experiment 1. Error bars indicate one standard error of the mean.

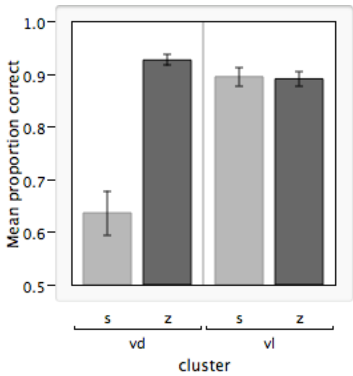

Figure 3: Mean proportion correct responses for each cluster in Experiment 2. Error bars indicate one standard error of the mean.

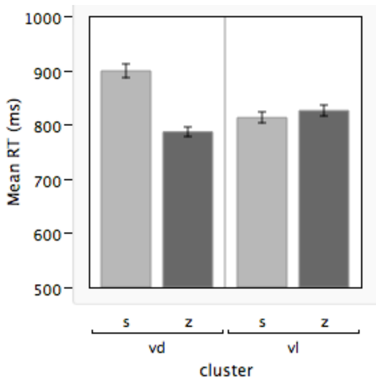

Figure 4: Mean reaction times for correct responses for each cluster type in Experiment 2. Error bars indicate one standard error of the mean.

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Overlap-Driven Consequences of Nasal Place Assimilation in Zulu

Claire Halpert (MIT)

In most contemporary theories of place assimilation (Padgett 1994, Jun 2004), the laryngeal composition of assimilating clusters (e.g. mb from /nb/) is irrelevant to the process of assimilation: the formal representation of assimilated [mb] is such that no interaction is expected with laryngeal neutralization. However, interconsonantal overlap is a known factor both in place assimilation (Jun 2004; Kochetov, Pouplier & Son 2007) and in the triggering of laryngeal neutralization (Chitoran, Goldstein & Byrd 2002). Therefore, if place-assimilated clusters like [mb] are represented as overlapped nasal+stop, the process of place assimilation is predicted to increase the likelihood of laryngeal neutralization on the nasal or on the stop. The present study verifies this prediction by contrasting the behavior of assimilated and unassimilated nasal-stop sequences in Zulu (Southern Bantu). The findings support the inclusion of at least two distinct degrees of overlap between consonants in phonological representations.

Zulu exhibits a direct interaction between place and laryngeal features: in NC clusters that undergo place assimilation, implosion and aspiration on C following the nasal are systematically lost (1). In this paper, I examine these and other effects of Zulu place assimilation in NC clusters. I propose that place assimilation takes place through spreading of the place gesture, which in concert with a *LENGTH constraint against lengthening of the place gesture forces a high degree of overlap in assimilated NC structures. I will argue that all of the changes seen in assimilated NC occur to satisfy markedness violations that result from the overlapped structure.

Some Zulu nasals must become homorganic to a following C (2). Others surface with invariant features in all contexts (3). All Zulu N_iC_i clusters where the nasal has undergone place assimilation display secondary effects on C_i. I focus on three effects, shown in (2): de-aspiration of aspirated consonants, affrication of fricatives, and loss of implosion. The presence of these effects in assimilated N_iC_i contrasts with their absence in non-place-assimilated mC clusters, as in (3), suggesting that their occurrence is directly linked to the process of place assimilation. The right theory of place assimilation, then, must predict these various secondary effects.

I propose that in Zulu nasal place assimilation, a high-ranked *LENGTH contstraint forces the place gesture of C to spread onto N without becoming longer. Additionally, intergestural ALIGNMENT constraints (Gafos 2002) require overlap between the place gesture and other gestures of C to be maintained. Since no extra length is added to the place gesture, maintaining overlap between it and other of C's gestures while at the same time overlapping it with N will result in overlap not just between place and N, but between other gestures associated with C and N, as well. This overlap becomes problematic for recovering nasality (cf. Cohn 1993, Silverman 1997, Browman & Goldstein 2000), particularly when it is overlapped by aspiration and glottalization. The interaction between place assimilation and affrication (e.g. nv $\longrightarrow$mbv) is attributed to the distinct avoidance of nasal continuants (cf. Padgett 1994).

The formal analysis includes *LENGTH, high-ranked recoverability-motivated markedness constraints, the family of ALIGN constraints, as well as gestural faithfulness constraints. Following the results of Chitoran et al (2002), I use a markedness constraint LAR that prohibits more than one laryngeal gesture in overlapped clusters. When *LENGTH, ALIGN, and markedness are ranked high, the result is that the problematic features are deleted from the entire cluster, as with aspiration and implosion (4).

Preliminary evidence for *LENGTH, which predicts that assimilated NC should have the same duration as plain C, was found in recordings made of a Zulu speaker producing C and NC in minimal pairs. While more data is needed in order to refine our understanding of how *LENGTH operates in Zulu, current results show a significant difference between the length of assimilated and non-assimilated clusters, while little to no difference between the durations of assimilated NC and plain C (6).

(1) a. iN + ɓali ⟶imbali ‘flower’
b. iN + tʰando ⟶int’ando ‘free will’

(2) a. iziN + **ʃ** angane ⟶izin**tʃ** angane ‘wanderers’
b. iziN + **kʰ**alo ⟶iziŋ**k**alo ‘ridges’
c. iziN + **ɓ**ambo ⟶izim**b**ambo ‘ribs’

(3) a. um + ɬaba ⟶u**mɬ**aba ‘world’
b. um + tʰetʰo ⟶u**mtʰ**etʰo ‘law’
c. um + ɓala ⟶u**mɓ**ala ‘color’

(4) *LENGTH. ALIGN, LAR, *ɓ̃>> MAX(nas) >> MAX(implosion)

(5)

/N + ɓ/	*LENGTH	ALIGN	LAR	*ɓ̃	MAX(+nas)	MAX(imp)
☞ /mb/ (same length as ɓ)						*
/mɓ/ (longer)	*!					
/mɓ/ (same)			*!			
/ɓ̃ɓ/				*!		
/ɓɓ/					*!	

(6)

	/um+m/ [m]	**/iN+m/ [m]**	**/m/ [m]**	/um+n/ [mn]	/n/ [n]
Duration	335ms	**169ms**	**166ms**	272ms	101ms

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Author Index

U Subway station *Universität* exit *Schellingstraße*

IPS Institute of Phonetics, Schellingstraße 3

IBZ *Internationales Begegnungszentrum*, Amalienstraße 38

1 Hotel Hauser, Schellingstraße 11

2 Hotel stefanie garni, Türkenstraße 35

3 Hotel Savoy, Amalienstraße 25

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Consonant Clusters and Structural Complexity

Programme

Thursday, 31 July 2008

14:00 Registration, Coffee, Demos at the IPS
16:00 Session: Session 1
19:00 Opening Reception

Friday, 01 August 2008

9:00 Session: Session 2
10:30 Coffee Break
11:00 Session: Session 3
12:30 Lunch
14:00 Session: Session 4
15:30 Coffee Break
16:00 Session: Session 5

Saturday, 02 August 2008

9:00 Session: Session 6
10:30 Coffee Break
11:00 Session: Poster Session
12:30 Lunch
14:00 Session: Session 7
15:15 Coffee Break
15:45 Session: Session 8