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Source: *Studies in Second Language Acquisition*, Vol. 20, No. 2, SPECIAL ISSUE: Interlanguage Phonetics and Phonology (June 1998), pp. 189-211
Published by: Cambridge University Press
Stable URL: https://www.jstor.org/stable/44485747
Accessed: 04-02-2019 19:22 UTC

SSLA, **20**, 189–211. Printed in the United States of America.

SECOND LANGUAGE PHONOLOGY, PHONETICS, AND TYPOLOGY

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In this paper, I address the nature of the mental representation of an interlanguage grammar. The focus will be on the necessity of positing some sort of hierarchical constituent structure to account for L2 phonology. I discuss relevant data from the domains of the acquisition of segments, syllables, moras, and metrical structure. The interaction of these domains is discussed.

In addition, I look at the acquisition of onset clusters and argue that the acquisition of liquids is correlated with the acquisition of consonantal sequences. Evidence from language change, language typology, and language acquisition suggests that there is a causal relationship between the two. The theoretical framework of feature geometry and derived sonority gives us the apparatus to explain what the second-language learners are doing.

In this paper, I am going to address a number of issues that have to do with the nature of the mental representation of an interlanguage grammar. My major focus will be on the necessity of positing some sort of hierarchical constituent structure to account for what L2 learners do in their phonology. In other words, I hope to show the utility of invoking a theory of abstract phonological representation that is not easily read off of the input. This approach to SLA has the potential of revealing the principles that underlie L2 behavior.

I will discuss relevant data from the domains of the acquisition of segments, syllables, moras, and metrical structure. Although it is useful to distinguish between the properties of representation at each of these levels, it is worth reminding ourselves that such a separation is somewhat artificial. We have long known that the properties of the syllable affect the properties of the metrical

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system, whether it be traditional notions such as a rhyme projection or Idsardi's (1992) richer notion of projection of elements from one tier to the other. Similarly, we know that the segmental tiers and the syllabic tiers are intimately related. Machinery such as the Sonority Hierarchy has long been useful in describing properties of syllable structure. Cross-linguistically, we note that the peak of a syllable has the highest sonority, whereas segments on the margins have lower sonority values. For the most part, sonority has been assumed to be a complex acoustic property. Such an approach has been influential in SLA research. For example, Broselow and Finer (1991) argued that second-language learners' treatment of L2 syllables (i.e., repair strategies) can be explained by a careful phonetic analysis that includes a multivalued phonetic minimal sonority distance parameter.

WHAT EXPLAINS THE PATTERNS?

Unlike many areas of linguistic theory, in the domain of syllable structure, the data are relatively uncontroversial. Sometimes clusters get simplified either by deleting a consonant or by adding a vowel. However, the question of whether phonetics, phonology, or typology provides a better explanation has been controversial. In this paper, I will present data from a variety of sources that combine to suggest that the best explanation of these co-occurence phenomena is phonological.

The Essential Data

I focus on the behavior of subjects from an L1 that does not allow onset clusters as they acquire the complex syllable structure of English. I will look at the connection between having a liquid contrast in the segmental inventory and having consonant clusters in the syllabic inventory. I will develop the argument first presented in Archibald and Vanderweide (1996) that there is, in fact, a causal connection between these seemingly unrelated phenomena. In short, L2 learners who have only a single liquid in their L1 (e.g., Korean) will have to acquire a second liquid (i.e., an /l/ vs. /r/ contrast) before they will be able to reliably produce a range of onset clusters that include liquids. The reasons for this will emerge out of a particular model of phonological feature representation (feature geometry) and a particular interpretation of how sonority is in fact a derived phonological notion and not a phonetic primitive (derived sonority).

Why It Is Not Phonetics

There are a number of reasons why I maintain that an abstract mental representation solution is preferable to more concrete phonetic or typological arguments. One is that many of the languages in question (e.g., Korean) have the [l] versus [r] distinction at the phonetic or allophonic level. Thus, the subjects do not have to learn how to make the sounds in question. They have to learn how to represent the sounds in question.

It could be more of a case of the interaction of different levels of representation. Just as added complexity on the syllabic level (e.g., quantity sensitivity) can lead to greater metrical complexity, so too does greater segmental complexity (/l/ vs. /r/) lead to greater syllabic complexity.

ACQUIRING NEW STRUCTURE

Since the discussion began on principles and parameters in SLA theory, there has been a rich debate on just how well L2 learners handled completely new structures. Much of this was framed within the debate of whether adults still had access to Universal Grammar. Not surprisingly, this was not a straightforward question to answer. Archibald, Guilfoyle, and Ritter (1996) argued that, at least in the domain of syntax, it is very difficult to find syntactic elements that are in the L1 but completely lacking in the L2. In other linguistic domains, though, it may be somewhat easier. Carroll (1989) investigated the acquisition of French gender by children in French immersion programs in Canada. She suggested that, although they may become quite accurate, immersion students are assigning gender in ways that are quite unlike those of native French speakers. They may often be attempting to compute gender assignment rather than storing it lexically.

All of this suggests that nonnative speakers of a language may have more success in determining new values for existing structures than in triggering the representations of completely new structures. In this light, it will be most interesting to look at the acquisition of new syllabic structures as the projection of the acquisition of new segmental contrasts. I argue that the acquisition of the segmental contrast is the logical precursor to the acquisition of the higher level structure. And just as the French immersion students could find ways to assign the correct gender sometimes, so too will we see nonnative speakers from an L1 with one liquid who can occasionally produce consonant clusters. However, I would predict that we would not see the stable production of consonant clusters in all environments and in all tasks until there is a consistent realization of the segment. I will return to this when we look at the data from the beginning Korean students.

Phonological Competence

In this section, I will review the existing literature to argue that we need abstract hierarchical representations to account for the behavior of L2 learners.

Stress. In a number of papers, I have addressed the question of L2 learners acquiring stress. My broad conclusions suggest (a) that adult interlanguages do not violate metrical universals and (b) that adults are capable of resetting their parameters to the L2 setting. The subjects were quite good at putting

Table 1. Metrical parameters

	Spanish	Polish	Hungarian	English
P1 (word tree)	right	right	left	right
P2 (foot type)	binary	binary	binary	binary
P3 (strong on)	right	right	left	right
P4 (built from)	left	left	left	left
P5 (Quantity-sensitive)	yes	no	yes	no
P6 (sensitive to)	rhyme	NA	nucleus	rhyme
P8 (extrametrical)	yes	no	no	yes
P8A (extrametrical on)	right	NA	NA	right

English stress on the right syllable.[1] Thus, their interlanguages are a combination of UG principles, correct L2 parameter settings (from resetting), and incorrect L1 parameter settings (from transfer).

In Archibald (1992) I examined the acquisition of English stress by Polish speakers. In Archibald (1993b) I examined Spanish speakers, and in Archibald (1993a) I examined Hungarian speakers. The basic research design used in these studies was to have the subjects perform both production and perception tasks related to stress assignment. First, they had to read a list of words and then sentences out loud. Stress placement was transcribed on the key words. Then the subjects listened to the same words they produced as they were read out loud on a taped recording by a native English speaker. The subjects had to mark which syllable they perceived stress to be on. In both the production and the perception tasks, transfer of the L1 parameter setting into the L2 grammar was evident.

Table 1 illustrates how languages may differ in their parameter settings.[2] When the parameter settings are different in the first and the second language, there is the potential for transfer. Often, the L1 parameter settings transfer into the L2.

Spanish Speakers Learning English. As can be seen in Table 1, Spanish and English stress are virtually identical. One of the instances in which we can see L1 influence though is in the transfer of diacritic extrametricality markings. This can help us to explain certain L2 errors. Consider Spanish *caníbal* ("cannibal"). The underlying representation must be [kaníba(l)], in which the final consonant is extrametrical. Otherwise, we would get the unmarked stress pattern [kanibál]. When speakers were asked to produce this word in English, [kaníbal] was elicited in informal research sessions. The lexical marking of extrametricality seems to have been transferred into English. This is a cognate, and it could be claimed that this is just a simple case of transfer. However, I do not think it is a trivial task for us to be as explicit as we can regarding what exactly is transferring. This gives us some information about what elements of the lexical representation do transfer. If there is extrametricality marked in the learner's lexicon, then this will transfer.

Polish Speakers Learning English. Polish stress is for the most part fixed and is assigned to the penultimate syllable. Polish differs from English in how it treats extrametricality and quantity sensitivity. Both of these differences affect the interlanguage grammars of Polish subjects learning English. As a result of lacking extrametricality, the Polish subjects tended to have a lot of penultimate stress in English words that have antepenultimate stress because of extrametricality. For example, the word *cabinet* has stress on the antepenult in English because the final syllable is extrametrical. The Polish subjects, lacking the extrametrical marking, placed the stress on the penult. One exceptional subclass that emerged was words ending in *-a* for the Polish subjects. Polish has a suffix *a*, which is marked as extrametrical. In English words that ended in *-a*, Polish subjects often assigned antepenultimate, rather than penultimate, stress. For example, they would produce *cínema* not *cinéma*.

In addition, the Polish subjects showed no evidence of referring to the internal structure of the syllable when assigning stress. They were building quantity-insensitive feet. For example, the closed penult of a word like *agénda* was no more likely to attract stress than the tense vowel in the penult of a word like *aróma*.

Hungarian Speakers Learning English. Hungarian is also a language of primarily fixed stress. Main stress occurs on the initial syllable of a word. This is the result of the word tree being strong on the left in Hungarian (in English, it is strong on the right). Hungarian, like English, is quantity sensitive, but unlike English, it is sensitive to the structure of the nucleus. Thus, in Hungarian a branching nucleus will attract stress, as opposed to English branching rhymes attracting stress.

These two differences, in fact, accounted for the majority of the Hungarian subjects' errors. They tended to transfer their L1 parameter settings and assign initial stress to English words. In addition, syllables with long vowels (as opposed to syllables closed by consonants) tended to attract stress for the Hungarian subjects, as they would in the L1. Initial stress could be seen in productions such as *ágenda* (rather than *agénda*). The domain of quantity-sensitivity difference was evident in the fact that the branching nucleus in the penult of a word like *aróma* was more likely to attract (correct) stress than the branching rhyme of a word like *agénda*, which was often produced as *ágenda*.

Tone and Stress. Without going into the details, I would like to note that the preceding studies describe what subjects whose L1s had stress did when trying to acquire English stress. In Archibald (1997), I described the case in which the subjects' L1s are tone (e.g., Chinese) or pitch-accent languages (e.g., Japanese). I argued that these learners are not computing stress placement in English, but rather are storing it lexically. This seems to be analogous to Carroll's (1989) study of the acquisition of gender by French immersion students. I now turn to a discussion of abstract hierarchical representation on another level.

Moraic Structure

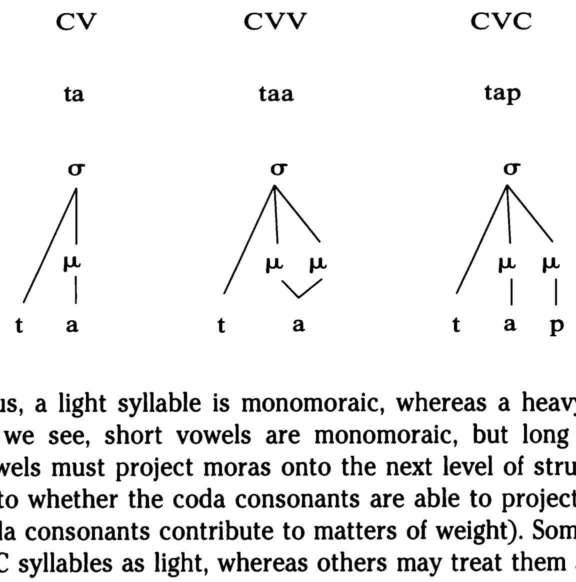
Broselow and Park (1995) investigated the properties of interlanguage syllable structure within moraic theory. They seek to explain the fact that Korean learners of English sometimes add an extra vowel in the pronunciation of English words and sometimes do not.

A mora is a unit of phonological weight that captures the differential behavior of certain syllable types cross-linguistically. With respect to phonological phenomena like stress, it is often the case that not all syllables are treated equally. For example, it may be the case that a CVC syllable attracts stress in a way that a CV syllable does not. For this reason, a distinction is made between light and heavy syllables. A light syllable is associated with one unit of quantity whereas a heavy syllable is associated with two units of quantity as shown in (1).

(1) Light syllable = one unit of quantity
Heavy syllable = two units of quantity

Languages do vary in terms of what syllable types they classify as light or heavy, but let us consider the types shown in (2).

(2)



Thus, a light syllable is monomoraic, whereas a heavy syllable is bimoraic. As we see, short vowels are monomoraic, but long vowels are bimoraic. Vowels must project moras onto the next level of structure. Languages vary as to whether the coda consonants are able to project a mora (i.e., whether coda consonants contribute to matters of weight). Some languages may treat CVC syllables as light, whereas others may treat them as heavy. This is what Hayes (1995) refers to as the Weight-by-Position Rule. Consonants in certain positions may project a unit of weight. Onsets are understood to link directly to the syllable node (without any moraic slot) for reasons that I will not go into here.[3]

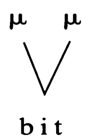
Broselow and Park (1995) began by presenting the data shown in (3) from native speakers of Korean who were learning English.

(3)	a.	bit^{h}ɨ	"beat"	b.	bit	"bit"
		c^{h}ip^{h}ɨ	"cheap"		t^{h}ip	"tip"
		p^{h}ik^{h}ɨ	"peak"		p^{h}ik	"pick"
		rut^{h}ɨ	"route"		gut	"good"
		k^{h}ot^{h}ɨ	"coat"		buk	"book"

Note that the Korean speakers insert an epenthetic [ɨ] at the end of the words in column (a), but not at the end of the words in column (b). Each of the words in the two columns ends in the same consonants, so it cannot be triggered by the final consonant in the English word. Broselow and Park (1995) suggested that it is the quality of the vowel in the English root that determines whether epenthesis takes place. The epenthetic vowel is added to words that have long (bimoraic) vowels and not to words that have short (monomoraic) vowels. What would cause this difference in behavior?

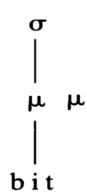
Broselow and Park (1995) assumed coda obstruents are nonmoraic in Korean. Syllabic nuclei must be monomoraic in Korean (in contrast with English, in which they may be either mono- or bimoraic). In their view, the L2 learner begins by perceiving the L2 English input of a word like *beat* and setting up a representation that includes a bimoraic vowel shown in (4).

(4)



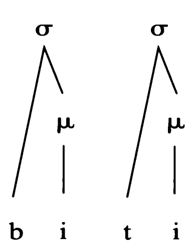
Because this is an illicit structure in Korean, the second mora is delinked from the vowel, as shown in (5).

(5)



This triggers epenthesis, which fills the empty mora, and then onset formation occurs, as shown in (6).

(6)



They argue, then, that what the Korean learners are doing is attempting to preserve the mora count of the original English word (which has two moras attached to the vowel). Because this is an illicit structure in Korean, they set up a new syllable that allows the bimoraic structure to be preserved.

With respect to the grammatical properties in question, they assume the structures shown in (7).

(7)

<table>
<tr><th></th><th>Korean</th><th>English</th><th>IL Grammar</th></tr>
<tr><td>Coda C Weight Parameter</td><td>μ
|
Son</td><td>μ
|
any C</td><td>μ
|
Son</td></tr>
<tr><td>Nucleus Weight Parameter</td><td>μ</td><td>μ, μμ</td><td>perception: μ, μμ
production: μ</td></tr>
</table>

Note, however, that much of their analysis rides on the assumption that the learners are setting up a mental representation for the target word that violates the rules of Korean representations. In other words, the subjects are assumed to set up a representation that includes a vowel associated with two moras, even though Korean does not allow this. This is assumed to be the input, or perception, representation of the learners. The input representation accounts for the fact that learners who produce forms like [bitɨ] for *beat* would still be able to access the correct lexical item when exposed to the input string [bit]. So, why do they understand [bit] but produce [bitɨ]? Broselow and Park (1995) adopt what they call the Split Parameter Setting Hypothesis, which assumes that there are two different representations: one governing perception and the other governing production.

Broselow and Park (1995) assume that the nonnative speakers move through the stages shown in (8).

(8) Stage 1: L1 setting governs perception and production
Stage 2: L2 setting governs perception
L1 setting governs production
Stage 3: L2 setting governs production and perception

This captures the widely observed phenomenon that perception is in advance of production.

Although I do not think that this phenomenon necessitates a dual representation, I will not address that issue here. Just as in theories of L1 acquisition, researchers have abandoned the intuitively appealing dual-lexicon model (Menn and Matthei, 1992) and have instead tried to situate acquisition within a plausible psycholinguistic framework of comprehension and production research. This needs to be done in SLA research as well.

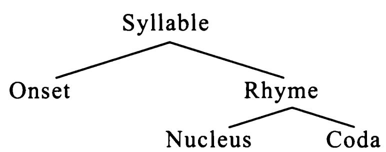
I turn now to a discussion of the importance of syllable structure in L2 phonology and the presentation of the argument that the syllable structure is projected off a segmental contrast.

Syllable Structure

There have been two major approaches to looking at L2 syllable structure: the structural and the typological. The structural approach is illustrated by the work of Broselow (1988) and Osbourne (1996), whereas the typological approach is illustrated by the work of Eckman (1991). I will briefly review each in turn and then present some data that argue for the superiority of a structural approach.

A Structural Approach. One of the most common models of syllable structure is shown in (9).

(9) The internal structure of the syllable



The languages of the world vary according to such criteria as whether syllabic nodes can branch or not. Some languages (e.g., Japanese) do not allow branching onsets or codas. Ignoring some complexities, let us assume that all syllables must be CV or CVC. More complex syllables (e.g., CCVCC) are not allowed.

A common phenomenon in L2 learning involves modifying an L2 word so that it fits the L1 syllable structure (Broselow, 1988). Consider the words in (10) spoken by someone whose L1 is Arabic.

(10)

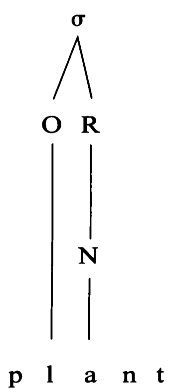
English Target	Nonnative Speaker's Version
plant	pilanti
Fred	Fired
translate	tiransilet

Arabic does not allow branching onsets or codas, so an English word like *plant* cannot be mapped onto a single Arabic syllable. A characteristic of Arabic is that illicit consonant clusters are modified by an epenthetic [i].

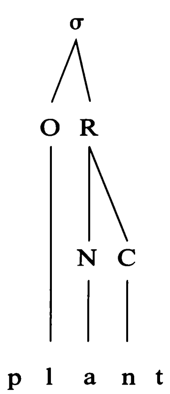
With this in mind, let us look at the steps that an Arabic speaker would go through in syllabifying *plant.*[4]

Step 1. Initial syllabification: Assign vowels to nucleus (N) and nucleus to rhyme (R).

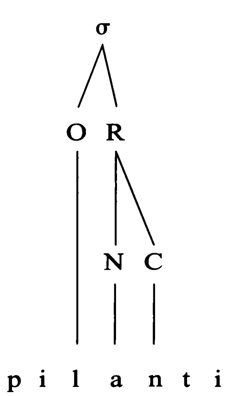
Step 2. Assign allowable onset (C) consonants (in Arabic, one).



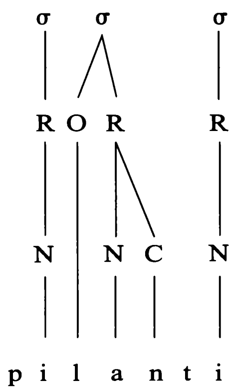
Step 3. Assign allowable coda (C) consonants (in Arabic, one).



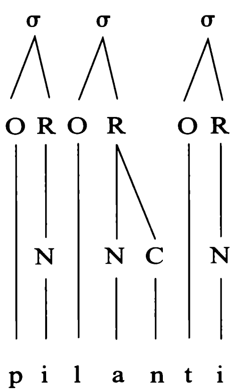
Step 4. Add epenthetic [i] to the right of unsyllabified consonant.[5]



Step 5. Assign vowels to nucleus and nucleus to rhyme.



Step 6. Assign allowable onset consonants (in Arabic, one).



As this example helps to show, we can explain why Arabic speakers pronounce English words the way they do by investigating the principles of syllabification in the L1. Especially at the beginning levels of proficiency, the structure of the interlanguage is influenced by the structure of the L1.

The structural properties of syllabification are, in fact, more complex than this because languages can vary not just by whether nodes can branch but by which sequences of sounds are allowed within a given constituent. I will, however, provide some discussion of a structural approach to sonority that I think illuminates the issues.

A Typological Approach. Eckman and Iverson (1993, 1994) suggested that typological principles are all that are needed in order to understand why some consonant clusters are more difficult than others for L2 learners to acquire. Eckman (1991) proposed the Structural Conformity Hypothesis, which maintained that the grammars of L2 learners were subject to the same principles as the grammars of monolinguals. The types of principles that he referred to were drawn from a distributional analysis of the world's languages. With respect to syllable structure in second language learners, Eckman and Iverson referred to the principles shown in (11).

(11) (a) A voiced stop followed by a liquid or glide is more difficult than a voiceless stop followed by a liquid or glide.
(b) A voiced fricative followed by a liquid or glide is more difficult than a voiceless fricative followed by a liquid or glide.
(c) A voiceless fricative followed by a liquid or glide is more difficult than a voiceless stop followed by a liquid or glide.

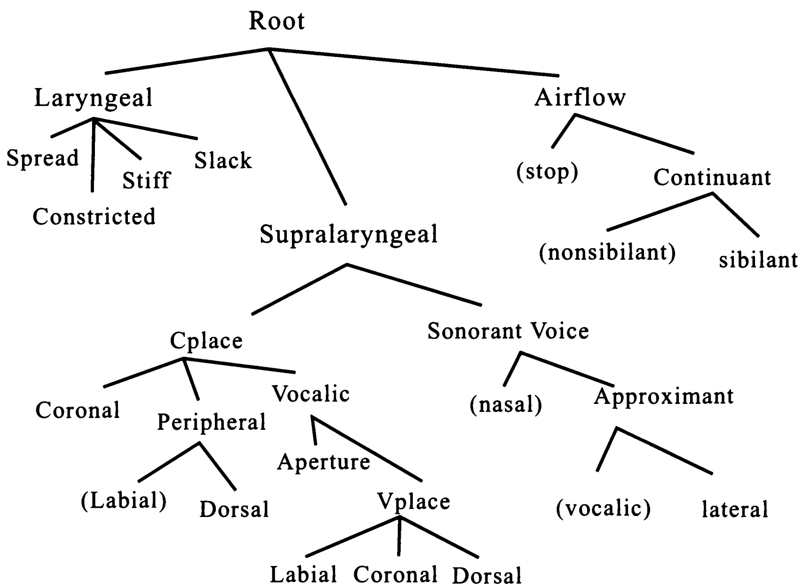
As argued in Archibald and Vanderweide (1996), I would suggest that the data that result from this type of approach are fascinating but, in fact, need to be explained rather than function as the explanation.

Derived Sonority/Derived Typology.[6] What I will argue in this section is that what we see as typological facts are, in fact, derivable from the same relationship between liquids in the segmental inventory and tautosyllabic clusters.

The behavior of the Korean subjects can be accounted for within a model of hierarchical segment structure that treats sonority as a phonological construct derived from the complexity of the segmental representation.

I adopt the model of segment structure shown in (12) taken from Archibald and Vanderweide (1996).[7]

(12)



Feature geometries were introduced as a modification of the earlier view (Chomsky & Halle, 1968) that phonological features were unorganized bundles. It was demonstrated that phonological features were organized into a hierarchical structure that revealed certain dependency relations. For example, we could not represent the feature [dorsal] without including the feature [peripheral]. In this way, the number of possible representations was constrained. Feature geometries also represent markedness conventions by means of parentheses. If, for example, we consider the place features, we note that [coronal] is the unmarked place feature. A bare Cplace node will be phonetically realized as [coronal]. Labial and dorsal sounds have more phonological structure. This could be illustrated with a familiar example from child phonology. Many English-speaking children who produce the word *doggie* pronounce it as [gagi]. Interestingly, it is rarely pronounced [dadi]. If we were merely assuming that children at this stage lacked the ability to produce two consonants with different places of articulation in a single word, we would have no explanation of the asymmetry. However, feature geometry provides a nice explanation. As an unmarked coronal, the [d] has no phonological material to spread. However, the [g] actually has some phonological material (the feature [dorsal]) that can spread back and change the place of articulation of the [d].

The organizing nodes are assumed to have some sort of articulatory basis. The laryngeal node deals with states of the larynx. The airflow node deals with distinctions that have to do with constriction or obstruction of the vocal tract. The supralaryngeal node deals with variation above the larynx (e.g., place of articulation).[8]

The Sonorant Voice (SV) node represents sonority.[9] In general, the more SV structure a segment has, the more sonorous it is (Rice, 1992). Traditionally, sonority was assumed to be a complex phonetic property of a segment that could be determined only instrumentally. Rice (1992) demonstrated the utility of viewing sonority as a phonological construct off of which the phonetic effects could be read. This allows us to derive the sonority hierarchy shown in (13).

(13)				
	Ø	SV	SV	SV
			Approximant	Approximant
				Lateral
	Obstruents	Nasals	/r/	/l/

Least sonorous .... Most sonorous

Obstruents have no SV structure and are, therefore, the least sonorous, whereas /l/ is the most sonorous, having the most SV structure.

It is important to remember that the structure of a segment is based upon the contrasts it is involved in phonologically. Rice (1995) showed how the representation of a lateral is dependent on the contrasts found in the segmental inventory. The structures in (14) show how a Korean liquid could have quite a different representation from an English liquid.

(14) /n/ versus /r/ versus /l/ contrast (English)

```
    Root
     |
     SV
     |
Approximant
     |
  Lateral
```

/n/ versus liquid contrast (Korean)

```
    Root
     |
     SV
     |
Approximant
```

The acquisition of English /l/, then, means the acquisition of the contrast between /l/ and /r/, which means the acquisition of the *representation* of /l/, not just the phonetic ability to produce a lateral. I would argue that the acquisition of this representation is an essential step in acquiring English onset clusters. Vanderweide (1994) showed that children acquiring English as their L1 did not start producing tautosyllabic onset clusters until they had acquired the appropriate representation for [l].

Phonological Government. Following Rice (1992), I assume that phonotactic constraints result from universal principles of phonological government and syllabification determined by deriving sonority via the segmental structure discussed in the previous section. Following Vanderweide (1994), I adopt the definition of phonological government given in (15) and the syllabification algorithm given in (16).

(15) Government: A segment governs an adjacent segment if it has more feature structure than the adjacent segment within a governing domain. Sonorant voice, supralaryngeal, and root are governing domains.

(16) Syllabification Algorithm

Process:	A segment (A) governs a segment (B)?
Possibilities:	Y (yes)/N (no)
Resulting Parse:	Y → A and B are heterosyllabified
	N → A and B are tautosyllabified

To account for the observed variation in allowable onset sequences cross-linguistically, I propose the minimal sonority distance parameter given in (17).

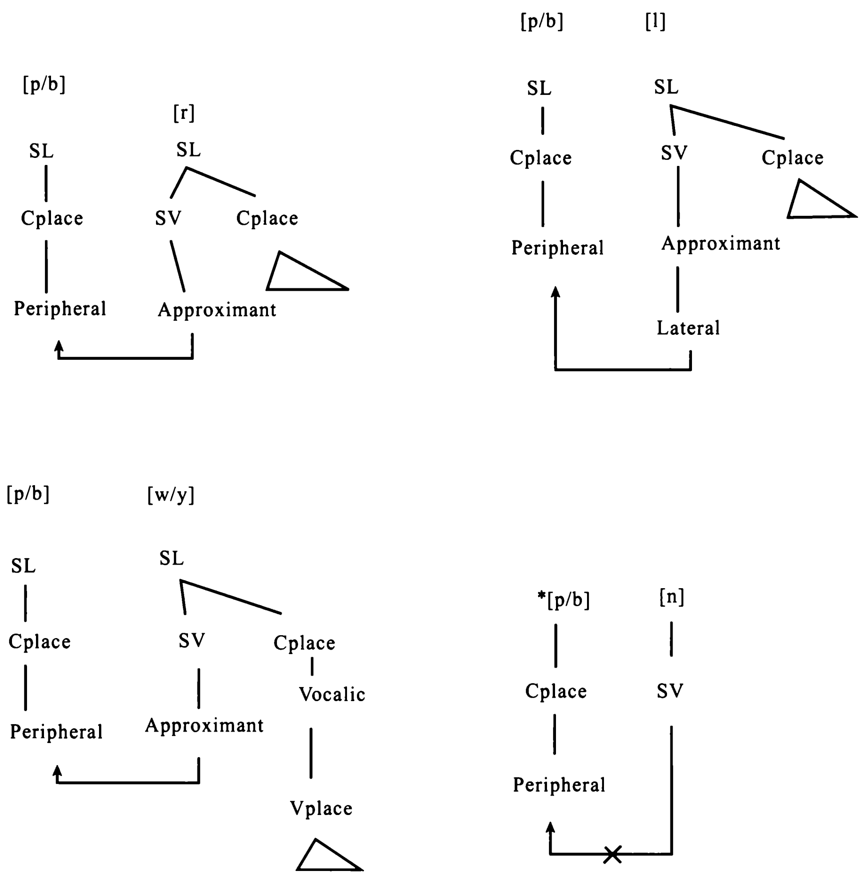
(17) Minimal Sonority Parameter

Parameter:	SV government requires that the governor (B) must have at least X more nodes than the governee (A)
Settings:	X = 1, 2, or 3
Default:	X = 3

English and Korean have different settings of this minimal sonority distance parameter. English has a setting of $X = 2$ (allowing stop + liquid onsets), but Korean has a setting of $X = 3$ (prohibiting onset clusters).

These concepts, along with derived sonority and segmental representations, account for the differences in English and Korean syllabification. The trees in (18) show the allowable onset clusters in English.[10]

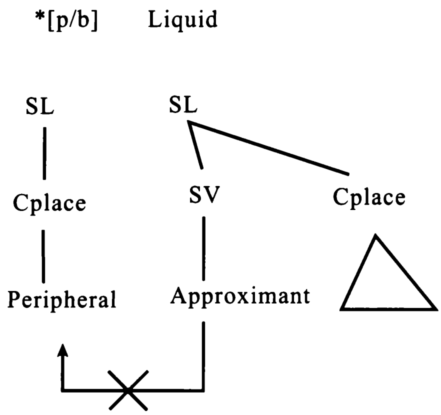
(18) English Structures[11]



The first three clusters are well formed tautosyllabically because, in each, the governor has at least two more SV nodes than the governee. The last cluster is not allowed in English because the governor has only one more SV node than the governee.

The trees in (19) show why Korean (with a minimal sonority distance of 3) does not permit any consonant clusters.

(19) Korean Structures



Let us turn now to a look at the acquisition of English syllable structure by Korean speakers.

Acquisition of English Syllable Structure

The Korean speakers reported by Broselow and Finer (1991) and Eckman and Iverson (1993) produced English onset clusters with few errors, which suggests that they have reset the MSD parameter to the English setting. The error rates were, in fact, negligible (less than .05%).

Because neither Broselow and Finer (1991) nor Eckman and Iverson (1993) included scoring data on the production of the two liquids [l] and [r], I gathered preliminary data from eight Korean speakers. Five of the subjects were beginners and three were at an intermediate level of proficiency (as assessed by their placement in ESL classes). Spectrographic analysis of the production of tokens containing [l] and [r] revealed two interesting facts. All of the subjects had an acoustic difference between their [l] and [r] sounds in some (but by no means all) words, and they all had some consonant clusters in onset position. The spectrograms in Figure 1 illustrate this point.

The spectrogams in Figures 1 and 2 compare the production of *car* (left of Figure 1) and *call* (right of Figure 2). They sounded virtually identical. However, when the production of *feel* (right of Figure 1) is compared with that of *fear* (left of Figure 2), there is an obvious difference both visually and auditorially.

The second point worth noting is that there was variation in production. Sometimes the distinction was clearer than at other times. The spectrogram in Figure 3 illustrates the production of the word *caring* twice in a row. The first version came out much more like an [l], and the second one was much more like an [r].

The spectrograms in Figures 4 and 5 compare the production of *roll* by a native speaker and a Korean subject.

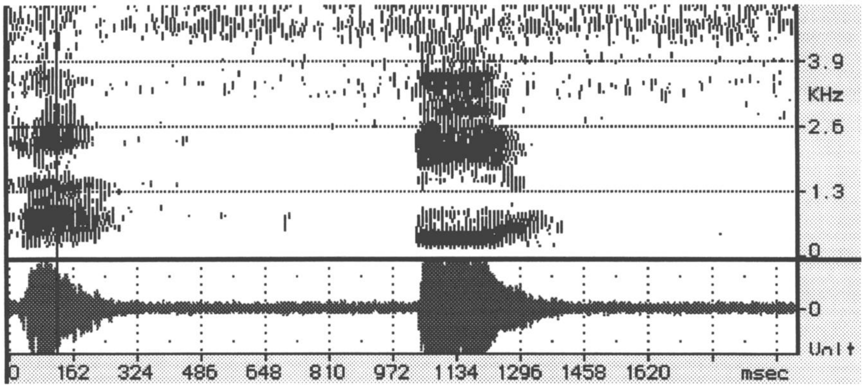


Figure 1. *Car* versus *feel* as spoken by a native speaker of Korean.

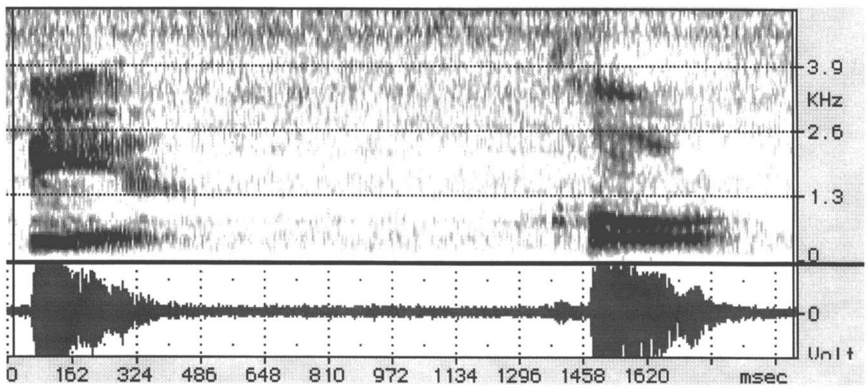


Figure 2. *Fear* versus *call* as spoken by a native speaker of Korean.

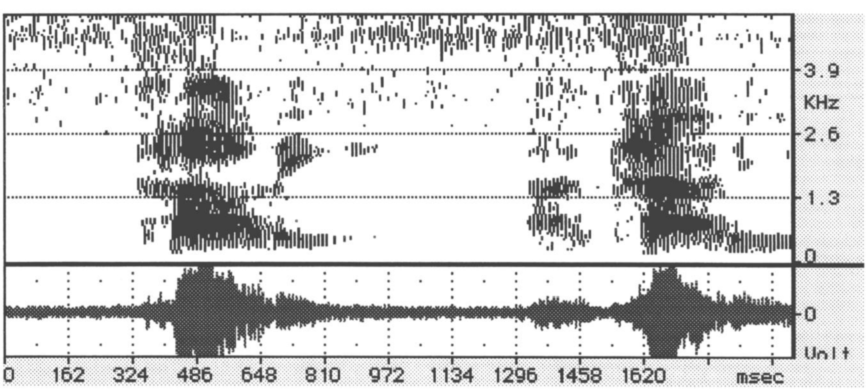


Figure 3. *Caring* spoken twice by a native speaker of Korean.

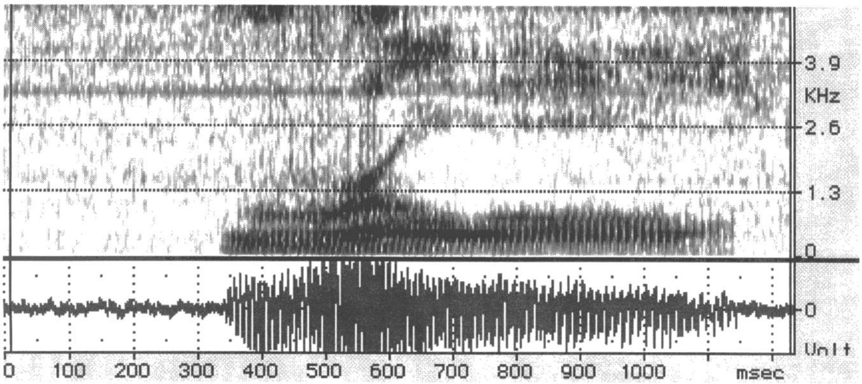


Figure 4. *Roll* as spoken by a native speaker of English.

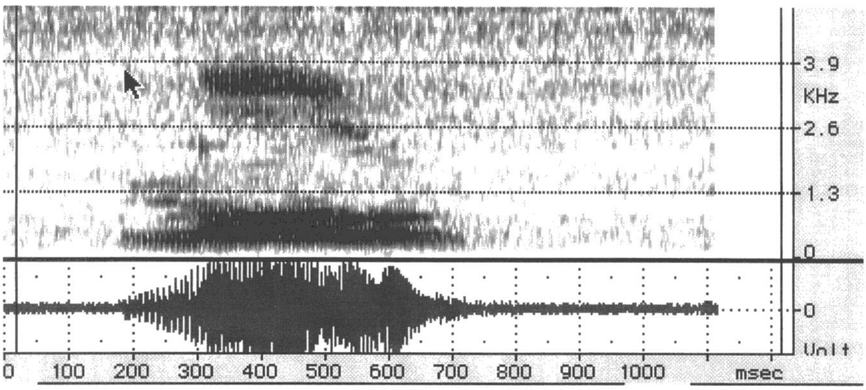


Figure 5. *Roll* as spoken by a native speaker of Korean.

Generally speaking, [l] has a higher third formant than [r] (Borden, Harris, & Raphael, 1994). This means that the transition from an [r] to a vowel will usually result in a rise of F3, which can clearly be seen in the production by the native speaker of English in Figure 4. The transition from an [l] to a vowel, however, will usually have quite a level F3, which can be seen in the Korean speaker's production in Figure 5. This suggests that processing constraints explain these subjects' productions.

The subjects, then, display a variable ability to produce some onset clusters and some [l]s and [r]s correctly. What was lacking from the pool of subjects was someone who was at a low enough level of proficiency to lack any /l/ versus /r/ contrast. I would maintain that these results are consistent with my hypothesis. What would falsify my claim would be to find a subject who does not have the /l/ versus /r/ contrast but who does have onset clusters. In essence, I am proposing an implicational hierarchy in which the presence of onset clusters implies the presence of an /l/ versus /r/ contrast but the presence of an /l/ versus /r/ contrast does not imply the presence of consonant clusters.

Thus, I am arguing that the acquisition of the liquid contrast is directly related to the acquisition of branching onsets. But is there any independent evidence? I would argue that the evidence from a variety of sources strongly suggests that there is a connection between the two phenomena.

INDEPENDENT EVIDENCE

Typology

First, let us consider some typological evidence that suggests that languages respect this condition. If there is only one liquid, there are no onset clusters. If these really were two independent phenomena, this pattern would not be expected. Allowing complex onsets is clearly a way of expanding the number of possible syllables in a language. And if a language were simply motivated to expand the number of possible syllables, then there is no reason why, for example, a [pl] cluster should be blocked in a language that has /l/ but not /r/.

I report on languages from a number of language families to control for genetic relationships. I began by looking through Maddieson's (1984) *Patterns of Sounds* to see what languages were listed as having only a single liquid. He lists: Azerbaijani, Korean, Japanese, Dan, Dagbani, Senadi, Akan, Lelemi, Beembe, Teke, Vietnamese, Tagalog, Hawaiian, Mandarin, and Zoque.[12] I then sought out information on the syllabic inventories of some of these languages and expanded into some other language families. I have found no robust counter-examples to the claim that a language with a single liquid will not allow obstruent + liquid clusters.

Amazonian Languages. Sanuma (Borgman, 1990) has only one liquid ([l]), and the licensed syllable types are V and CV. There are isolated occurrences of [pl] and [kl] clusters but only in onomatopoeic forms, which would suggest that they are not productive.

Yagua (Payne & Payne, 1990) also has only one liquid ([r]) and allows syllables of the types CV and CVV.

African Languages. Kikuyu (Armstrong, 1967) has only one liquid ([r]) and allows no clusters except homorganic N + C clusters word initially.

Ganda (Cole, 1967) has only one liquid ([l]) and allows only C + glide clusters and homorganic N + C clusters word initially.

Akan (Dolphyne, 1988) has one liquid and allows only C + glide and homorganic N + C clusters. There are some [pr] and [fr] clusters allowed, but there is strong evidence that they are derived from CVCV forms.

Nkore-Kiga (Taylor, 1985) has one liquid and only allows C + glide clusters.

Austronesian Languages. Most familiar to Western linguists may be languages such as Japanese, Chinese, Korean, and Vietnamese, which have only one liquid in their phonemic inventories and allow no obstruent + liquid clusters. Proto-Austronesian has been argued to have had four liquids (Baldi, 1991) and to have allowed CVCVC and CVCCVC words. However, the syllabification of the second word type is not clear.

North American Languages. Cayuga (Dyck, personal communication, citing Chafe, 1977) presents some interesting data that at first appear to be counterexamples. Cayuga has only one liquid ([r]), yet [tr] and [kr] clusters are allowed. Upon closer inspection, however, it emerges that the clusters must be heterosyllabified in order to explain the properties of stress placement.

Mesoamerican Languages. Suárez (1983) described the cases of a few Mesoamerican languages. It is argued that Proto-Uto-Aztecan had no liquids. Huichol developed one liquid and allowed syllable types of CV, CVC, and CVVC (i.e., no clusters). Nahuatl developed two liquids and allows CCV syllables. Suárez further notes that many languages in Mesoamerica that previously lacked the phonemes [b, d, g, f, x, ñ, l, r, and ɾ] now have them, and many languages also have new consonant clusters with a stop or fricative plus lateral or flap. I would argue that it is the acquisition of the liquid contrast that predicts the emergence of consonant clusters, not just the increase in inventory size.

Creoles

Data from creoles also seem to support the connection. Romaine (1988) noted that creoles have no initial or final consonant clusters, and Bender (1987) suggested the following prototypical consonant inventory for creoles: p, t, k, b, d, g, f, s, m, n, l/r, w, y. There were a couple of interesting counterexamples, though. There was a creole known as Pitcairnese spoken on the island that was peopled by the mutineers from the *Bounty* and by indigenous peoples. The creole had clusters, but it was most likely due to the nature of the Polynesian language. All of the English people died within 10 years of settlement, and it is unlikely that they had a lasting effect on the creole (Romaine, 1988). The other interesting potential counterexample is the creole known as Russenorsk (used in northern Norway), which also has clusters. However, the creole (exceptionally) has two liquids as well. We also see this profile in Haitian creole (Ritter, 1991), which has two liquids and allows onset clusters. It seems, then, that when creoles behave exceptionally in allowing clusters, they also have a liquid contrast in the segmental inventory.

Additionally, we note in the case of Nigerian Pidgin English (Barbag-Stoll, 1983) that the speakers modify the syllable structure of Yoruba (which is CV) to allow some CVC words when they are borrowed from English, but they never produce any consonant clusters.

First Language Acquisition

Vanderweide (1994) provided a reanalysis of Smith's (1973) acquisition of phonology study and noted that the subject Amahl first had no consonant clusters and then acquired heterosyllabic sequences of an obstruent plus a sonorant (e.g., *panda*). Then he acquired heterosyllabic clusters of two obstruents (e.g., *doctor*). Finally, after acquiring the liquid contrast, he acquired tautosyllabic onset clusters (e.g., *black*).

CONCLUSION

Drawing on data from a variety of sources, I have argued in this paper that insights into L2 speech will be gained if we adopt the notion of abstract hierarchical representations at a variety of linguistic levels. These levels are, of course, related. Interesting connections between the tiers continue to be discovered.

At first, it may seem to be coincidence that the acquisition of liquids is correlated with the acquisition of onset clusters. The researcher might be tempted to conclude that, because consonant clusters are not allowed in the L1, this restriction is simply transferred to the L2. Why invoke such complex, abstract theoretical machinery to explain simple transfer? I would argue that the diverse array of evidence from sources such as language change, language typology, and language acquisition suggests that there is a causal relationship. The theoretical framework of feature geometry and derived sonority provides the apparatus to explain what the L2 learners are doing (and representing). In this respect, transfer is not always simple: complex structures and principles are transferring. It is not merely a statement of "no clusters" that transfers. Rather, it is a complex interaction of the properties of the segmental inventory determining the feature geometry of a segment that, in turn, influences the allowable sequences of segments.

Many years ago, Trubetzkoy (1939) stated that one of the most basic principles of phonology was the principle of contrast. As we unearth further ways in which the phonology of a language can be projected off its segmental inventory, his words continue to ring true.

Although more empirical data must be collected and analyzed to see whether this proposed connection of liquids and clusters is observed in subjects from a variety of first languages, this avenue of inquiry demonstrates the utility of incorporating insights from theoretical phonology into a model of SLA.

NOTES

1. Subjects achieved about 70% correct for the production task and about 85% correct for the perception task. The tasks are described below.

2. I will briefly outline what these parameters are designed to account for. P1 determines where primary stress goes on a word. P2 determines whether there are alternating stresses in the word (resulting in secondary stresses when interacting with the word tree). P3 determines whether the foot is strong on the left edge (trochaic) or the right edge (iambic). P4 determines how the metrical tree is constructed. P5 captures the fact that some languages (quantity-sensitive languages) treat heavy syllables differently than light syllables when it comes to attracting stress. P6 determines whether the language is sensitive to heaviness in the nucleus or rhyme. P8 and P8A capture the fact that languages seem to have the option of treating items on the edges exceptionally. For example, segments or syllables that are pronounced may not influence the metrical structure.

3. For the most part, arguments have to do with compensatory lengthening. If a segment is deleted from a moraic position, then it is often the case that the segmental material from the neighboring

segmental slot will spread to the empty position. This does not seem to occur when a segment is deleted from the onset position.

4. I am not necessarily claiming that these are psycholinguistically real steps, but when we follow them through, we will see how the pronunciation of the Arabic speakers is explained. It is traditional in phonology to build syllable structures by assigning segments first to the nucleus, then to the onset, and finally to the coda.

5. Arabic uses an epenthetic [i] to break up illicit consonant sequences that arise in morphological derivations.

6. Much of the work in this section draws on Archibald and Vanderweide (1996).

7. For other models and related discussion, see Clements and Hume (1995). For a discussion of the L1 acquisition of this type of structure, see Rice and Avery (1995).

8. Place features are broken down into those that describe consonants (Cplace) and those that describe vowels (Vplace).

9. Spontaneous voice is treated separately from the laryngeal node due to the fact that, cross-linguistically, we often note the sonorants behaving differently from the obstruents with respect to voicing. As a result, they are assigned different structures. For example, a language may devoice final obstruents but not final sonorants.

10. The triangle notation indicates that the structure under that node is not relevant to the discussion.

11. SL stands for Supralaryngeal. The arrows indicate potential government relationships.

12. This selection clearly excludes certain language families. A reviewer had commented on my lack of dealing with European languages. The fact that the European languages all have a liquid contrast removes them from my data set.

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