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Learning Input Allomorphs: A procedure using the Output Driven Learner of Tesar (2013) *

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1 Introduction

This paper outlines the procedure for learning multiple *input* allomorphs of a single morpheme in the Output Driven Learner (ODL) of Tesar (2013).

1.1 Input Allomorphy (Mascaró 1996; 2007)

In generative phonology, the usual assumption is that a morpheme has a single underlying form which maps to one or more output allomorphs. Mascaró (1996); (2007) proposes that inputs have allomorphs just as outputs do; this style of analysis is desirable when there is a morpheme with phonologically-conditioned suppletive morphology (c.f. go~went obviously are not phonologically-conditioned, and are obviously not derived from a single underlying form). Once we admit the possibility of having multiple input allomorphs, there are significant consequences for the way that underlying forms of morphemes are learned.

Consider Language A: each root {r1, r2, rM} and each suffix {s1, s3} consists of a single underlying form which surfaces as one or more output allomorphs. For example, rM=/pá:/ has one morpheme alternate in rMs1: [pá:], which contains a [+long, +stress] vowel, and a second alternate in rMs3: [pa], which contains a [-long, -stress] vowel. Since both alternates stand in correspondence with a single input, at least one of them must be an unfaithful mapping. In rMs3, /pá:/[pa] shows vowel shortening, which incurs a violation of F:IDENT[length] (informally, do not change the [±long] value of a segment in mapping). This mapping also

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shows de-stressing of the root vowel, which incurs a violation of F:IDENT[stress] (informally, do not change the [±stress] value of a vowel in mapping).

Language B is like Language A, differing only in two respects:

i. Language LB preserves the length of unstressed vowels, whereas LA does not; and
ii. LB has a morpheme rM, which has two input allomorphs /pa/$_1$ and /pá:/$_2$. The words containing rM, rMs3 and rMs4, show a morphemic alternation [pa]~[pá:].

Depending on the constraints in the OT system or depending on the language, it may not be possible to predict the [pa]~ [pá:] alternation under the assumption that there is a single underlying form for rM. However, when we assume that rM has two *input* allomorphs, /pa$_1$/ and /pá:$_2$/, then neither mapping is unfaithful to the [length] values of the input nor its [stress] values. In the context of rMs1, /pá:/$_2$[pá:] avoids a violation of F:IDENT[length] (/pa/$_1$[pá:] does not; in fact this candidate is harmonically bounded in systems that do not contain a constraint requiring stressed vowels to be [+long]). In rMs3, /pá:/$_2$[pá:] avoids a violation of F:IDENT[length] (/pá:/$_2$[pa] does not).

A. Language A

r1=/pa/ [pá]	r4=/pá:/ [pá:]	rM=/pá:/ [pa]~ [pá:]	
.pa.ká.	.pá:.ka.	.pá:.ka.	s1=/ka/ [ka]~[ká]
.pa.ká:.	.pa.ká:.	.pa.ká:.	s3=/ká:/ [ká]

B. Language B

r1=/pa/ [pá]	r4=/pá:/ [pá:]	**rM=/pa, pá:/** [pa]~ [pá:]	
.pa.ká.	.pá:.ka.	.pá:.ka.	s3=/ka/ [ka]~[ká]
.pá.ka.	.pa:.ká.	.pa.ká:.	s4=/ká:/ [ka]~[ká]

1.2 Structure.

This paper is laid out as follows: In Section 2, the paka$_2$ system that is used by the ODL is defined. In Section 3, properties of the languages in the *paka$_2$* system that show an alternation in r5 are identified. In the remainder of the paper, I go through the procedure of the ODL in detail.

2 System

To investigate how a learner can arrive at multiple input allomorphs, a modified version of the *paka* system (Tesar 2013) called *paka*$_2$ was used. All rankings for the typology were calculated using OT Workplace Version 68 (Merchant, Prince and Tesar 2013).

GEN produces words that contain one root and one suffix from the table in (C). Each word must have one, just one, stress per word. In the input, each root and suffix vowel is specified for [±stress]. An underlyingly [+stress] vowel is unfaithfully mapped if its output correspondent is [-stress]; likewise an underlyingly [-stress] vowel is unfaithfully mapped if it corresponds to a vowel that is [+stress] in the output. In the input, each root and suffix vowel is also specified for [±long]. An underlyingly [+long] vowel is unfaithfully mapped if its output correspondent is [-long]; an underlyingly [-long] vowel is unfaithfully mapped if its output correspondent is [+stress].

The morpheme *r5* has two input allomorphs: /pa, pá:/. The first input allomorph r5$_1$ /pa/ is [-long, -stress]; the second input allomorph r5$_2$ has the complete opposite feature specifications: [+long, +stress]. In candidates that contain *r5*, the violation profile depends on the input allomorph that is selected. For example the word *r5s1* [páka] may involve unfaithful mapping of the [-stress] value of the input allomorph r5$_1$, which is underlyingly [-stress], (/**pa**ka/[**pá**ka]) or it may involve unfaithful mapping of the [+long] value of the input allomorph r5$_2$, which is underlyingly [+long], (/**pá:**ka/[**pá**ka]).

C. *paka*$_2$ morphemes

	roots		*suffixes*	
	r1	/pa/	*s1*	/ka/
	r2	/pá/	*s2*	/ká/
	r3	/pa:/	*s3*	/ka:/
	r4	/pá:/	*s4*	/ká:/
	r5	/pa, pá:/		

The CON of the paka system is given in (D). This system has Markedness (M) constraints for the positioning of stress (ML, MR); these constraints interact with the Faithfulness (F) IDENT[stress], which assigns a violation for each unfaithful mapping of [stress]. These constraints also interact with M.WSP which assigns a violation to each [+long] vowel that is unstressed.

D. **CON**

F.IDENT[stress]

a. Assign a violation for each [-stress] input vowel that has a [+stress] output correspondent.
Assign a violation for each [+stress] input vowel that has a [-stress] output correspondent.

M.ML

b. Assign a violation for each word that has initial stress.

M.MR

c. Assign a violation for each word that has final stress.

F.IDENT[long]

d. Assign a violation for each [-long] input vowel that has a [+long] output correspondent.
Assign a violation for each [+long] input vowel that has a [-long] output correspondent.

M.NoLong

e. Assign a violation for each [+long] vowel.

M.WSP

f. Assign a violation for each [+long] vowel that is [-stress].

3 Languages that show alternations due to there being input allomorphs

The *paka*$_2$ typology has 39 languages; this number is greater than the *paka* typology, which has only 24 languages. Going from the *paka* system to the *paka*$_2$ system involves refinements of the rankings; these refinements are due to the inclusion of words with *r5* /pa, pá:/ which neutralizes faithfulness to length.

Consider the phonotactic inventories of Languages L15 and L14. All words that contain the roots {r1, r2, r3, r4} are exactly the same in both of these languages. The mappings of words containing r5 are different in each language. For example, in language L15, r5s1 /pá:ka/[pá:ka] has selected the $r5_2$ input allomorph, which contains a [+long, +stress] vowel, which is mapped faithfully. Contrastingly, in L14, r5s1 /paka/[páka] has selected the $r5_1$ input allomorph, which contains a [-long, -stress] vowel, which is mapped to a [+stress] vowel.

The ODL obtains phonotactic ranking information from the phonotactic inventory of L15 that vowels are contrastive for length; e.g. by comparing [páka] and [páka:], which differ in the length value of the second vowel, the learner obtains the necessary ranking information for [+long] vowels to surface in unstressed positions. Once morphological analysis has been carried out, the learner will then arrive at a contradiction in the [long] specification of the input *r5*. In the words *r5s1* [pá:ka] and *r5s2* [pá:ka] the root vowel is [+long]; in the other words that contain *r5, r5s3* [paká] and *r5s2* [paká:] the root vowel is [-long]. In this system, no ranking produces a vowel length contrast in both stress and unstressed positions while r5 shows an alternation in [length]. This is possible, however, when there are two input allomorphs of r5: one must be [-long] and the other [+long].

(1) L15

Phonotactic Inventory: {.pá.ka., .pá.ka:., .pá:.ka., .pá:.ka:., .pa.ká., .pa.ká:., pa:ká, pa:ká:}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/ [pá:]~[pa:]	r4=/pá:/[pá:]	r5={/pa/,/pá:/}[pá:]~[pa]	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pá:.ka./pá:/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa:.ká.	.pá:.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka:.	.pá.ka:.	.pá:.ka:.	.pá:.ka:.	.pá:.ka:./pá:/	s2=/ka:/[ka:]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pa.ká:./pa/	s4=/ká:/[ká:]~ [ka:]

Unlike in Language L15, r5 does not show an alternation in the length of the root vowel in L14; this despite the fact that the language is contrastive for vowel length. After phonotactic learning and

morphological analysis, the learner does not detect any contradictions in the value of r5: it is always [-long] in the output.

(2) L14

Phonotactic Inventory: {.pá.ka., .pá.ka:. .pá:.ka., .pá:.ka:, .pa.ká., .pa.ká:., pa:ká, paká:}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá:] [pá:]~[pa:]	r4=/pá:/[pá:]	r5={/pa/,/pá:/} [pá]~[pa]	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pá.ka./pa/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa:.ká.	.pá:.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka:.	.pá.ka:.	.pá:.ka:.	.pá:.ka:.	.pá.ka:./pa/	s2=/ka:/[ka:]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pa.ká:./pa/	s4=/ká:/[ká:]~ [ka:]

The language L12 differs from L15 and L14 in that it is not contrastive for vowel length at all. Consequently, words that contain *r5* do not show an alternation in the vowel length of the root *r5*. In Language L12, r5 always surfaces as [-long]. In terms of their outputs, words that contain *r5* are exactly like words containing *r1*.

The ODL does not obtain the ranking information for a contrast in the length of vowels in phonotactic learning. After morphological analysis, the learner will not detect a contradiction in the [long] value of the root *r5* since it always surfaces as [-long], as in L14.

(3) Language 12

Phonotactic Inventory: {.pá.ka. .pa.ká.}

r1=/pa/[pá]~[pa]	r3=/pá/[pá]	r2=/pa:/[pá]	r4=/pá:/[pá]	r5={/pa/,/pá:/}	
.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka./pá:/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa.ká.	.pá.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka./pá:/	s2=/ka:/[ka]
.pa.ká.	.pá.ka.	.pa.ká.	.pá.ka.	.pa.ká./pa/	s4=/ká:/[ká]~ [ka]

3.1 General phonological properties of L14, L15, L31, and L30

The learning procedure is for L15 and L31, which show and alternation in the length of root vowel for r5. Along with L14 and L30 which have exactly the same alternations for {r1, r2, r3, and r4} as L15 and L31 respectively, these languages share several phonological properties that distinguish them from other languages; these properties are summarized in the table in (4). Note that the phonotactic inventories of the languages discussed below: L14, L15, L31, and L30 as well as L12 and L4 are all given in (5)-(10):

a. Length is contrastive in stressed and unstressed positions.
    i. Each language's phonotactic inventory includes the minimal pair [páka] and [pá:ka], which show a contrast in the length value of the stressed vowel.
    ii. Likewise each inventory has the pair [páka] and [páka:], which show a contrast in the length of the unstressed vowel (hence length is contrastive everywhere).
    iii. In languages that are not contrastive for vowel length, the learner will not detect any contradictions once words containing *r5* are included, since r5 invariably surfaces as short. For example, L12 includes both [páka] and [paká], so it is contrastive for stress. It does not however include a pair that is contrastive for length; e.g. it does not have the pair [páka] and [pá:ka]. In words that contain *r5*, every root vowel invariably surfaces as [-long]; likewise every suffix vowel is invariably [-long].
b. Stress is contrastive. Each language's phonotactic inventory includes both [páka] and [paká].
    i. Languages L15 and L14 have default initial stress. The only forms with final stress are a subset of words that contain a suffix that is underlyingly [+stress] following a root that is underlyingly [-stress], including r5 words with the input allomorph $r5_1$ /pa/. For example, in L15 and L14 the words *r1s3* [páka] and *r3s3* [páka] have initial stress; contrastingly, in *r5s3* [paká], stress is final.
    ii. Languages L30 and L31 have default rightmost stress. Words with the root morpheme *r5* are not the only forms that have initial stress; a subset of words with the root morphemes *r3* and *r4*, which are stressed underlyingly, also have initial stress.

iii. In languages that are not contrastive for stress, there will be no alternations in the value of [stress] value of r5. In words that contain *r5*, the root vowel invariably surfaces as [-stress] in languages with default final stress or [+stress] in languages with default initial stress. For example, in L4, stress is invariably initial, r5 invariably surfaces as [+stress].

c. Stress does not attract to a long vowel. Each language's phonotactic inventory includes the pair of words [páka:] and [paká:]. The first word [páka:] has stress on the initial vowel, which is [-long] rather than the second vowel, which is [+long]. The second word [paká:] shows that stress may fall on the [+long] suffix vowel; stress on the suffix vowel must be due to the fact that it is underlyingly [+stress].

(4) Phonotactic inventories and behavior of r5 in the Languages L15, L14, L30 and L31.

	Stress is contrastive	**Length is contrastive in stressed position**	**Length is contrastive in untressed position**	**r5 length alternation**
Inventory→	[páka],[paká]	[paká],[paká:]	[páka],[páka:]	e.g. r5s1 [pá:ka], r5s3 [paká]
L15	yes	yes	yes	yes
L14	yes	yes	yes	no
L30	yes	yes	yes	no
L31	yes	yes	yes	yes
L12	yes	no	no	no
L4	no	yes	no	no

(5) L15

Phonotactic Inventory: {.pá.ka., .pá.ka:., .pá:.ka., .pá:.ka:., .pa.ká., .pa.ká:.}

r1=/pa/[pá]~[pa]	r3=/pá/[pá]	r2=/pa:/[pá:]	r4=/pá:/[pá:]	r5={/pa/,/pá:/}[pá:]~[pa]	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pá:.ka./pá:/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa:.k.	.pá:.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka:.	.pá.ka:.	.pá:.ka:.	.pá:.ka:.	.pá:.ka:./pá:/	s2=/ka:/[ka:]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pa.ká:./pa/	s4=/ká:/[ká:]~[ka:]

(6) L14

Phonotactic Inventory: {.pá.ka., .pá.ka:. .pá:.ka., .pá:.ka:, .pa.ká., .pa.ká:.}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá:]	r4=/pá:/[pá:]	r5={/pa/,/pá:/}[pá]~[pa]	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pá.ka./pa/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa:.ká.	.pá:.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka:.	.pá.ka:.	.pá:.ka:.	.pá:.ka:.	.pá.ka:./pa/	s2=/ka:/[ka:]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pa.ká:./pa/	s4=/ká:/[ká:]~[ka:]

(7) L31

Phonotactic Inventory:{.pa.ká., .pa:.ká ,.pa.ká:., .pa:.ká:, .pá.ka., .pá.ka:., .pá:.ka:, .pá:.ka.}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá]~[pá:]	r4=/pá:/[pá]~[pá:]	r5={/pa/,/pá:/}	
.pa.ká.	.pá.ka.	.pa:.ká.	.pá:.ka.	.pá:.ka./pá:/	s1=/ka/[ka]~[ká]
.pa.ká.	.pa.ká.	.pa:.ká.	.pa:.ká.	.pa.ká./pa/	s3=/ká/[ká]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pá:.ka:./pá:/	s2=/ka:/[ká:]~[ka:]
.pa.ká:.	.pa.ká:.	.pa:.ká:.	.pa:.ká:.	.pa.ká:./pa/	s4=/ká:/[ká:]

(8) L30

Phonotactic Inventory:{.pa.ká., .pa:.ká ,.pa.ká:., .pa:.ká:, .pá.ka., .pá.ka:., .pá:.ka:., .pá:.ka.}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá]~ [pá:]	r4=/pá:/[pá]~ [pá:]	r5={/pa/,/pá:/}	
.pa.ká.	.pá.ka.	.pa:.ká.	.pá:.ka.	.pa.ká./pa/	s1=/ka/[ka]~[ká]
.pa.ká.	.pa.ká.	.pa:.ká.	.pa:.ká.	.pa.ká./pa/	s3=/ká/[ká]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pa.ká:./pa/	s2=/ka:/[ká:]~ [ka:]
.pa.ká:.	.pa.ká:.	.pa:.ká:.	.pa:.ká:.	.pa.ká:./pa/	s4=/ká:/[ká:]

(9) Language 12

Phonotactic Inventory: {.pá.ka. .pa.ká.}

r1=/pa/[pá]~[pa]	r3=/pá/[pá]	r2=/pa:/[pá]~[pa]	r4=/pá:/[pá]	r5={/pa/,/pá:/}[pa]~[pá]	
.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka./pá:/	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa.ká.	.pá.ka.	.pa.ká./pa/	s3=/ká/[ka]~[ká]
.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka.	.pá.ka./pá:/	s2=/ka:/[ka]
.pa.ká.	.pá.ka.	.pa.ká.	.pá.ka.	.pa.ká./pa/	s4=/ká:/[ká]~ [ka]

(10) Language 4

Phonotactic Inventory: {.pá.ka., .pá:.ka.}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá:]	r4=/pá:/[pá:]	r5={/pa/,/pá:/}	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pá:.ka./pá:/	s1=/ka/[ka]
.pá.ka.	.pá.ka.	pá:.ka.	.pá:.ka.	.pá:.ka./pá:/	s3=/ká/[ka]
.pá.ka.	.pá.ka.	pá:.ka.	.pá:.ka.	.pá.ka./pá:/	s2=/ka:/[ka]
.pá.ka.	.pá.ka.	pá:.ka.	.pá:.ka.	.pá.ka./pá:/	s4=/ká:/[ka]

4 The procedure in ODL

The table in (12) gives an outline for the procedure for the learning of the grammar and a lexicon with input allomorphs for the languages L15 and L31. In this section, each stage of the ODL is briefly overviewed, before the remainder of the paper, which provides a detailed description of each stage.

Phonotactic Learning is the stage in ODL where the learning of the phonotactic grammar takes place. In Languages L15 and L31, the phonotactic inventory consists of {.pá.ka., .pá.ka:., .pá:.ka., .pá:.ka:., .pa.ká., .pa.ká:., pa:ká:}. Each phonotactic inventory displays the following contrasts: [páka] and [paká], which are contrastive for stress; and [páka:] and [páka], which are contrastive for the length of vowel in the the unstressed syllable. In Phonotactic Learning, the learner obtains support for the ranking information that allows these contrasts to occur.

After the morphological analysis of words has been carried out, the next stage of ODL is setting the [length] features of each morpheme via *Inconsistency Detection*. This stage involves overlaying the input features set for surface forms onto the morphemes. For example, given that the surface form [páka] has a [-long] vowel in the initial syllable, the word r1s1 [páka] matches this surface form and the root *r1* will be tested with a [-long] value.

The length feature of a particular morpheme is tested by constructing an input with a single disparity; e.g. given the word r2s1 [pá:ka], the inputs /páka/ and /pá:ka:/ each have a single length disparity: /pàka/ has a single disparity in the length of the vowel in r1; /pá:ka:/ has a single disparity in the length of the vowel in s1. To test the [length] value of the root r2, the learner constructs a candidate where the input contains a single disparity in the root r2: *r2s1* /páka/→[pá:ka]. If r2s1 /pá:ka/→[páka] is inconsistent, then all inputs that contain a [-long] vowel for r2 are inconsistent and r2 is set to [+long]. Likewise, the learner also constructs a candidate where the input contains a single disparity in the [length] of the suffix: *r2s1* /pá:ka:/→[pá:ka]. If r2s1 /pá:ka:/→[pá:ka] is inconsistent, then all inputs that contain a [+long] vowel for s1 are inconsistent and s2 is set to [-long].

It is in the construction of the lexicon that the learner detects a contradiction in the length of the root r5. Given the word r5s1 [pá:ka],the learner then tests r5 as [+long] based on this form. However, the learner detects an error when it processes the word r5s2 [paká] with the underlying length feature of r5 as [+long]. It responds by performing Multi-Recursive Constraint Demotion (MRCD) (Tesar 1997) to resolve

the error, ranking IDENT[length] below WSP and NOLONG. However, the application of MRCD produces another error in the ranking, since all vowels are then predicted to neutralize in length. No ranking allows r5 to surface as [+long] in some environments while [-long] in other environments, assuming that r5 has a single underlying form.

A true contradiction has arisen in the learning of the length feature of r5. In r5s1 the learner learns that r5 must be [+long] while in r5s3, the learner learns contradictorily that r5 must be [-long]. The learner resolves this error by constructing two input allomorphs for r5: one input $r5_1$ contains a [-long] vowel and the other $r5_2$ a [+long] vowel.

Once the learner posits two input allomorphs for r5, it can obtain further phonotactic ranking information in the stage of learning referred to here as *Input Allomorph Phonotactic Learning*. Within the r5 paradigm, r5s1 [pá:ka] and r5s2 [paká] show a contrast stress value of r5, with r5 surfacing as stressed [pá:] before s1 and unstressed [pa] before s2.

By virtue of r5 there being two input allomorphs for r5 that differ in length, it is possible to compare two candidates that differ in stress (but appear to also have a length disparity): $r5_2$s1 /{pa,pá:}ka/→[pá:ka]~[paká] has a single disparity in the stress of the second vowel; $r5_1$s2 /{pa,pá:}ká/→[paká]~[pá:ka]. The fusion of these two ERCs is IDENT[stress] » ML & MR & NOLONG.

In candidates that do not have multiple input allomorphs, these mappings necessarily involve additional disparities. For example, r3s3 [pa.ká] has exactly the same surface form as $r5_2$s1; r1s3 has exactly the same surface form as $r5_1$s1. The learner did not posit input allomorphs for any morphemes except for r5, so each of these words consists of a root and suffix, each of which has a single underlying form. If r3s3 and r1s3 are used in Phonotactic Learning, the entailed ranking is IDENT[stress] or IDENT[length] » ML & MR & NOLONG (jointly entailed by the fusion of Phonotactic I and Phonotactic II).

(11) 1 disparity for Input allomorph Phonotactic Learning

r5**s2**	/{pa, pá:}ka/	[pa.ká]	2 [stress] disparity	r3s3	/paká/	[pa.ká]	1 [length] disparity; 2 [stress] disparities
r5**s1**	/{pa, pá:}ka/	[pá:.ka]	1 [stress] disparities	r1s3	/pá:ka/	[pá:.ka]	1 [length] disparity; 2 [stress] disparities

The final stage of learning uses *Contrast Pairs* to determine the value of [stress] features for all the roots and suffixes. The words r5s3 [paká] and r5s1 [pá:ka] form a contrast pair that the learner can use to determine that s1 is [-stress] and s3 is [+stress]. The method involves testing both input allomorphs for r5 with the same stress value; i.e. they are both [+stress] or they are both [-stress]. This is required to omit the possibility of an alternation of stress in r5s3 [paká] and r5s1 [pá:ka] being due to the different [stress] values of each r5 allomorph.

To set the stress feature of each r5 input allomorph, the learner then constructs an input for r5s1 [pá:ka] where all values of [stress] for $r5_1$ and $r5_2$ are tested, given the fact that s1 has been set to [-stress]. r5 surfaces as [+long] and [+stress] in the word $r5_2$s1 [pá:ka]. The learner determines that the input allomorph $r5_1$ /ʔ, +/ cannot be [+stress] because this is inconsistent when $r5_2$ is both [+stress] and [-stress]. This information allows the learner to set the stress feature of each r5 input allomorph both at once, with $r5_1$ being set to [-stress] and $r5_2$ set to [+stress].

Finally, with all stress features set, the learner may determine the dominant stress positioning constraint. In L15, ML» MR & WSP allows underlyingly short and stressed vowels to surface with stress; this despite some words containing a long unstressed vowel; for example r3s4 /páká:/[páka:] incurs a violation of WSP.

(12) The procedure for learning multiple input allomorphs in ODL

		Learned	Example from *paka*$_2$ system
§5	**Phonotactic Learning**	Phonotactic I	In L15, [páka] and [paká] are contrastive.
		Phonotactic II	In L15, [pá:ka] and [páka] are contrastive.
		Phonotactic III	In L15, [páka:] and [páka] are contrastive.
§6	**Inconsistency Detection to set [long] features**	[long] features	[long] features set for suffixes {s1, s2, s3, s4} [long] features set for roots {r1, r2, r3, r4} **r5** must be set to both [-long] and [+long] at once. Posit input allomorphs of r5: **r5**$_1$ tested with [-long]; **r5**$_2$ tested with [+long] results in no errors.
§7	**Lexicon Construction**		Setting of [length] features
§8	**Input Allomorph Phonotactic Learning**	Input Allomorph Phonotactic I	Support for the ranking for *Input Allomorph Phonotactic I* obtained from r5 words that contrast in stress.
§9	**Contrast Pairs to set [stress] features**	[stress] features set L15: {ML»MR, WSP} L31: {MR»ML, WSP}	r5s3 and r5s1 are a contrast pair used to show that s1 is [-stress] and s3 is [+stress]. The method initially involves testing both input allomorphs with the same stress value; i.e. they are both [+stress] or they are both [-stress]. With s3 is set to [+stress], r3s3 [páka] shows an unfaithful mapping of r3. The learner learns that r3 cannot be [-stress]. r5s1 [pá:ka] shows that r5$_2$ /ʔ, +/ cannot be [-stress] and r5$_1$ /ʔ, -/

			cannot be [+stress]. With all stress features set, the learner determines the dominant stress positioning constraint.

5 Phonotactic Learning

In *Phonotactic Learning* of Language L15, the learner obtains the support for a contrast in vowel length in stressed and unstressed position, as well as the support for stress to be lexically contrastive.

Phonotactic I (13). IDENT[stress] » ML & MR.

- The learner obtains the support for the ranking IDENT[stress] or ML » MR.
- The first winner-loser pair is /páka/→ [páka]~[paká]. The winner has fewer violations of IDENT[stress] or ML. The loser has fewer violations of MR.
- The second winner-loser pair is /paká/→ [paká]~[páka]. The winner has fewer violations of IDENT[stress] or MR. The loser has fewer violations of ML.

Phonotactic II (13).IDENT[length] » NOLONG

- The learner obtains the support for the ranking information IDENT[length] » NOLONG.
- The first winner-loser pair is /pá:ka/→[pá:ka]~[páka]. The winner has one fewer violations of IDENT[length]; the loser has fewer violations of NOLONG.
- The second ERC is simply included to show that there is no new ranking information (the learner would not construct this pair). In the winner-loser pair is /páka/→[páka]~[pá:ka], the winner has fewer violations of IDENT[length] and NOLONG.

Phonotactic III (13). IDENT[length] » NOLONG & WSP

- The learner obtains the support for the ranking information IDENT[length] » NOLONG & WSP.
- The first winner-loser pair is /páka:/→[páka:]~[páka]. The winner has one fewer violations of IDENT[length]; the loser has fewer violations of NOLONG and WSP.
- Again this second ERC is simply included to show that there is no new ranking information (the learner would not construct this pair). The second winner-loser pair is /páka/→[páka]~[páka:]. The

winner has fewer violations of IDENT[length] and NOLONG. (Candidates the show lengthening in the presence of stress are harmonically bounded in this system.)

- The fusion of these two ERCs is IDENT[length] » NOLONG & WSP. Since Phonotactic II is entailed by Phonotactic III, only Phonotactic III is given in subsequent tableaux.

No other constraint can dominate the faithfulness constraint IDENT[stress] except for the other Faithfulness constraint IDENT[length] (and vice versa). BCD applies to the ERCs in (13) to yield one of the following rankings, with only one F in the top stratum:

a. {IDENT[stress]} » {ML, MR}»{IDENT[length]} » {WSP, NOLONG} as in (14).

b. {IDENT[length]} » {WSP, NOLONG} » {IDENT[stress]} » {ML, MR} as in (15).

(13) Phonotactic Learning of L15 and L31

a. **Phonotactic I**	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
i.	páka	páka					*	
ii.	páka	paká		**		*		
iii.	páka~	paká		W		W	L	
	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
iv.	paká	paká				*		
v.	paká	páka		**			*	
vi.	paká~	paká		W		L	W	
vii.	**Fusion**			**W**		**L**	**L**	
b. **Phonotactic II**	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
i.	pá:ka	pá:ka					*	*
ii.	pá:ka	páka			*		*	
iii.	pá:ka~	páka			W			L

	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
iv.	páka	páka					*	
v.	páka	pá:ka			*		*	*
vi.	páka ~	pá:ka			W			W
vii.	**Fusion**				**W**			**L**
c. **Phonotactic III**	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
i.	páka:	páka:	*				*	*
ii.	páka:	páka			*		*	
iii.	páka:~	páka	L		W			L
	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
iv.	páka:	páka:					*	
v.	páka:	páka	*		*		*	*
vi.	páka ~	páka:	W		W			W
vii.	**Fusion**		**L**		**W**			**L**

(14) L15 and L31: BCD after Phonotactic Learning: {IDENT[length]} » {ML, MR} » {IDENT[stress]} » {WSP, NOLONG}

		Input	Output	Ident[stress]	ML	MR	IDENT[length]	WSP	NOLONG
a.	Phonotactic I	páka	páka	W	L	L			
b.	Phonotactic III	páka	páka:				W	L	L

(15) L15 and L31: BCD after Phonotactic Learning: {IDENT[stress]} » {WSP, NOLONG}»{IDENT[length]} » {ML, MR}

		Input	Output	IDENT[length]	WSP	NOLONG	Ident[stress]	ML	MR
a.	Phonotactic I	páka	páka				W	L	L
b.	Phonotactic III	páka	páka:	W	L	L			

6 Inconsistency Detection for [length] features

Inconsistency Detection is the stage of learning where the learner temporarily assigns a feature value to an input and tests whether a winning candidate containing an input with this feature is consistent with the learner's current grammar.

For example, the [length] feature of second vowel in the word [páka] may be tested with [+long] in the input, /páka:/. In Languages L15 and L31, the mapping /páka:/[páka] is not consistent with the ranking information obtained in Phonotactic Learning, namely the ranking information called Phonotactic III: IDENT[length] » WSP, NOLONG. The second vowel of [pák**a**] cannot be [+long] and thus it must be set to [-long]. In the *paka2* system, the stage of Inconsistency Detection proceeds until all the [length] features are set for each surface form.

6.1 Languages L15 and L31

In L15 and L31, vowel length is contrastive in unstressed syllables (entailing that vowel length is contrastive in stressed syllables). The table in (16) gives the features that have been set in L15 and L31.

Note that these inputs are for surface forms that have not yet undergone morphological analysis. This step is new in the ODL learner (note however it is not necessary for systems with input allomorphs).

(16) *L15 and L31*

Phonotactic Inventory: {.pá.ka., .pá.ka:. .pá:.ka., .pá:.ka:, .pa.ká., .pa.ká:.}

	Syllable 1		**Syllable 2**	
Surface	**Stress(S)**	**Length (L)**	**S**	**L**
[páka]		-		**-**
[pá:ka]		+		-
[pá.ka:]		-		**+**
[pá:.ka:]		+		+
[.pa:.ká]		+		-
[paká]				-
[paká:]				+

The tableau in (17) gives the two rankings from Phonotactic Learning, Phonotactic I and Phonotactic III and a pair of words that show a length contrast in the second vowel.

- In (17)a, the ranking NOLONG or WSP » IDENT[length] is required for long vowels to shorten in unstressed syllables. The first winner-loser pair is /páka:/→[páka]~[páka:]; this pair is used to test the length value of the second vowel in [páka]. The winner does better on NOLONG and WSP; the loser does better on IDENT[length]. The ranking that is required for vowel shortening in unstressed syllables is inconsistent with Phonotactic III in (13), which is in fact the contra-ERC: IDENT[length] » NOLONG & WSP. From this inconsistency, the learner determines that the length value of the second vowel in [páka] cannot be [+long]. From (17)a, we observe that *all* vowels are faithful to their [length] value in the input.
- In (17)a, the second winner-loser pair is /páka/→[páka:]~[páka]; this pair is used to test the length value of the second vowel in [páka:]. The winner is harmonically bounded by the loser; there is no ranking that allows [-long] vowels to surface as [+long]. From this inconsistency, the learner determines that the length value of the second vowel in [páka:] cannot be [-long].

(17) Setting the length features of unstressed syllables via Inconsistency Detection:

a. The second syllable of [páka] cannot be underlyingly [+long], it must be set to [-long].

b. The second syllable of [páka:] cannot be underlyingly [-long], it must be set to [+long].

c. The first syllable of [páka] cannot be underlyingly [+long], it must be set to [-long].

d. The first syllable of [pá:ka] cannot be underlyingly [-long], it must be set to [+long].

e. The second syllable of [paká] cannot be underlyingly [+long], it must be set to [-long].

f. The second syllable of [paká:] cannot be underlyingly [-long], it must be set to [+long].

g. The second syllable of [pá:ka] cannot be underlyingly [+long], it must be set to [-long].

h. The second syllable of [pá:ka:] cannot be underlyingly [-long], it must be set to [+long].

	Input	Winner	Loser	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
		Phonotactic I			W		L	L	
		Phonotactic III		L		W			L
a.	/pá.ka:/	[pá.ka]	[pá.ka:]	W		L			W
b.	/pá.ka/	[pá.ka:]	[pá.ka]	L		L			L

7 Constructing a Lexicon with phonotactically contrastive features

After the learner has set the features for surface forms, it then decomposes all words into their constituent morphemes, and begins constructing the lexicon for L15 (and L31) in (18).

(18) Lexicon for L15 with phonotactically contrastive features set

r5 must be set to both [-long] and [+long] at once (shaded red)

		S	L		S	L		S	L		S	L		S	L
	r1	?	-	**r3**	?	-	**r2**	?	+	**r4**	?	+	**r5**	?	- and +
	s1	?	-	**s3**	?	-	**s2**	?	+	**s4**	?	+			

Before discussing the setting of [length] features via Inconsistency Detection, a side note about the [stress] features being unset: as Tesar (2013:300-305) discusses, it is not possible for the learner to set the [stress] feature of any morpheme using a single form.

In (19), the ranking is consistent when r5 is [-stress]; i.e. /paká:/[paká:] as well as when r5 is [+stress], just in case the suffix vowel s2 is [+stress]; i.e. /páká:/[paká:]. Therefore, the learner requires Contrast Pairs for the setting of [stress] feature of all morphemes, including the r5 allomorphs; for this stage, refer to Section 9.

(19) Testing the [stress] features of r5 via Inconsistency Detection:

a. In r5s2 [paká:] r5 as [-stress] is consistent with IDENT[stress] or WSP or MR » ML

b. In r5s2 [paká:] r5 as [+stress] and s2 as [-stress] is consistent Phonotactic I and III

c. In r5s2 [paká:] r5 as [+stress] and s2 as [+stress] is consistent with WSP or MR » ML

	Input	Winner	Loser	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
		Phonotactic I			W		L	L	
		Phonotactic III		L		W			L
a.	r5s2 /pa.ka:/	[pa.ká:]	[pá.ka:]	W	W		L	W	
b.	r5s2 /pá.ka:/	[pa.ká:]	[pá.ka:]	W	L		L	W	
c.	r5s2 /pá.ká:/	[pa.ká:]	[pá.ka:]	W	e		L	W	

The construction of the lexicon with [length] features set for each morpheme proceeds as follows:

a. Each word {r1s1…r5s4} is matched up with a surface form from the phonotactic inventory {páka…paká:} in the table in (16). This step is shown in (20).

b. The learner tests the values of root based on the features using those that were set for the the first syllable of the surface form it matches; likewise, the learner tests the values of a suffix based on the features that were set for the second syllable it matches. This step is shown in the table in (21).[1]

For example, given the surface form [páka] and its mapping onto the word *r1s1* [páka]*:*

a. the first syllable of [páka] is /?, -/ and so the root *r1* is tested with the input /?, -/

b. the second syllable of [páka] is /?, -/ and so the suffix s1 is tested with the input /?, -/

c. The learner uses Inconsistency Detection to detect any errors in the [length] feature of each morpheme. It is in this stage of the construction of the lexicon that the learner detects an error when processing those words containing r5; for details, see the discussion of (23)-(26):

i. Say *r5* is tested as [+long], in accordance with the forms [**pá:**ka] and [**pá:**ka:] being set to [+long] prior to morphemic analysis. When the learner processes *r5s1* [.pá:.ka.] or *r5s2* [.pá:.ka:.], it will not detect any errors: each word will be faithful to the [+long] specification of the vowel in accordance with the Phonotactic Ranking information IDENT[long] »WSP & NOLONG.

ii. When r5 is [+long], the ranking is inconsistent for the words *r5s3* [.pa.ká.] and *r5s4* [.pa.ká:.], which *cannot* be underlingly [+long].

d. To resolve the error, the learner applies MRCD to the ranking: For r5 to be underlyingly [+long] and surface as short in the words r5s3 [.pa.ká.] and r5s4 [.pa.ká:.], IDENT[long] must rank below WSP or NOLONG. The learner applies MRCD, ranking IDENT[long] below WSP and NOLONG.

i. The ranking after the application of MRCD, however, gives rise to another error: When r5 is [+long], this ranking is inconsistent for the words r5s3 [.pá:.ka.] and r5s4 [.pá:.ka:.], which *do* surface with [+long] vowels.

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[1] Bruce Tesar (p.c.) notes that it is not necessary to re-test the forms at this point: Inconsistency occurs when one surface form (e.g. r5s1) has a root feature set to one value [+long] while another surface form (e.g. r5s3) has the same feature set to the opposite value [-long]. Testing *r5s1* again is computationally redundant.

The learner has detected a true contradiction in the processing of words containing r5. There is no ranking where r5 is underlyingly [+long], allowing *r5s1* [.pá:.ka.] and *r5s2* [.pá:.ka:.] to surface with [+long] vowels while *r5s3* [.pa.ká.] and *r5s4* [.pa.ká:.] surface with [-long] vowels.

e. The learner responds by positing input allomorphs for r5: $r5_1$ is set to [-long] and $r5_2$ is set to [+long]. In processing each word with r5, both allomorphs are listed in the input and the length features of r5 are tested once again via Inconsistency Detection. The learner does not detect any inconsistencies and the [length] features are now set for r5, as shown in (30).

(20) *L15 and L31: setting of phonotactically contrastive features in surface forms*

	Syllable 1		**Syllable 2**		
	Root		**Suffix**		*Words that match this surface form*
Surface	**S**	**L**	**S**	**L**	
[páka]		-		**-**	r1s1, r3s1, r3s3
[pá:ka]		+		-	r2s1, r4s1, r4s3, r5s1
[pá.ka:]		-		**+**	r1s2, r3s2, r3s4
[pá:.ka:]		+		+	r2s2, r4s2, r4s4
[.pa:.ká]		+		-	r2s3, r5s4
[paká]		-		-	r1s3, r5s3
[paká:]		-		+	r1s4
[pá:ka:]		+		+	r2s4, r5s2

(21) L15: testing the [length] features of morphemes based on features in (20):

Phonotactic Inventory: {.pá.ka., .pá.ka:., .pá:.ka., .pá:.ka:., .pa.ká., .pa.ká:.}

r1=/ʔ-/ [pá]~[pa]	r3=/ʔ-/ [pá]	r2=/ʔ-/ [pá:]	r4=/ʔ-/ [pá:]	r5= /ʔ-/ [pá:]~[pa]	
.pá.|ka.	.pá.|ka.	.pá:.|ka.	.pá:.|ka.	.pá:.|ka.	s1=/ka/ [ka]
.pa.|ká.	.pá.|ka.	.pa:.|ká.	.pá:.|ka.	.pa.|ká.	s3=/ká/ [ka]~[ká]
.pá.|ka:.	.pá.|ka:.	.pá:.|ka:.	.pá:.|ka:.	.pá:.|ka:.	s2=/ka:/ [ka:]
.pa.|ká:.	.pá.|ka:.	.pa:.|ká:.	.pá:.|ka:.	.pa.|ká:.	s4=/ká:/ [ká:]~ [ka:]

In the tableaux in (23) and (25), the learner tests the [length] feature of r5 with opposite values: in (23), the learner is testing r5 as [+long], based on the words *r5s1* [**pá:**ka] and *r5s2* [**pá:**ka:] being matched up with their surface forms, which were each set to [+long] in the first syllable; in (25), the learner is testing r5 as [-long], based on the words *r5s3* [**pa**ká] and *r5s4* [**pa**ká:] being matched up with their surface forms, which have a [-long] vowel.

In (23), the learner attempts to set r5 to [+long]; all inputs that contain r5 are tested with r5 as [+long]. The learner constructs an input for the words r5s1 /pá:.ka/ and r5s2 /pá:ka/; each reflects the values for length and stress based on their outputs [pá:ka] and [pá:ka:]; the learner constructs an input for *r5s3* /pa:ká/ and *r5s2* /pá:ka:/; each of these inputs has a [+long] vowel in the input for r5, which is unfaithfully mapped to an output with a [-long] vowel.

In (23), the learner tests for consistency when r5 is [+long]:

a. The winner-loser pair /pá:ka/→[pá:ka]~[páka] is consistent with r5 being [+long] in the word *r5s1*. The winner is faithful to the [+long] value of r5; the loser realizes the r5 vowel as [-long]. The winner wins on IDENT[length], in accordance with the phonotactic ranking information of Phonotactic III.
b. The winner-loser pair /pá:ka:/→[pá:ka]~[páka] is consistent with r5 being [+long] in the word *r5s2*. The winner is faithful to the [+long] value of r5; the loser realizes the r5 vowel as [-long]. Again, the winner wins on IDENT[length], which is consistent with Phonotactic III.
c. The winner-loser pair /pa:ká/→[paká]~[pa:ká] is not consistent with r5 being [+long] in the word *r5s3* (inconsistency is shown by pink shading). The winner shows the shortening of the r5 vowel in IO-mapping; the loser is faithful to its [+long] value in the input. The loser does better on IDENT[length], which the learner detects as a conflict that needs to be resolved.
d. Likewise, the winner-loser pair /pa:ká:/→[paká:]~[pa:ká:] is not consistent with r5 being [+long] in the word *r5s4*. Again, the winner shows the shortening of the r5 vowel in the unstressed syllable whereas the loser is faithful to the [+long] feature in the input. The loser does better on IDENT[length], which the learner detects as the same conflict as in (c) that needs to be resolved.

In (24), the learner has performed MRCD to attempt to resolve the conflict in (25): IDENT[length] ranks below WSP and NOLONG.

c. For the word *r5s3* in (c), the winner-loser pair /pa:ká/→[paká]~[pa:ká] is now consistent with r5 being [+long] in the input. The winner realizes the r5 vowel as [-long]; the loser is faithful to the [+long]. The loser does better on NOLONG and WSP and the loser does better on IDENT[length] which is now dominated by NOLONG and WSP.

d. For the word *r5s4*, the winner-loser pair /pa:ká:/→[paká:]~[pa:ká:] is also now consistent with r5 being [+long] in the input. As in the winning candidate in (c), the winner shows the shortening of the r5 vowel in the unstressed syllable, and wins on WSP or NOLONG.

The ranking WSP or NOLONG » IDENT[length] is now inconsistent for the words *r5s1* [pá:ka] and *r5s2* [pá:ka:] which *do* surface with long vowels. This ranking also contradicts Phonotactic Ranking III: IDENT[length] » WSP & NOLONG.

a. For *r5s1* [pá:ka], the winning candidate /pá:ka/→[pá:ka] is inconsistent with the word containing $r5_1$, which is [-long]. The winner is faithful to the [-long] value of r5; the loser realizes the $r5_1$ vowel unfaithfully as [+long]. The winner is preferred on IDENT[length].

b. For *r5s2* [pá:ka:], the winner-loser pair /pá:ka:/→[pá:ka:]~[páka:] is also inconsistent with r5 being [+long] in the input. The winner is faithful to the [+long] value of r5; the loser realizes the r5 vowel as [-long]. Again, the dominant constraints WSP and NOLONG prefer the loser.

The learner is faced with a true contradiction for the ranking of WSP or NOLONG with respect to IDENT[length] and under the analysis where r5 has a single underlying form.

a. WSP or NOLONG » IDENT[length] is required for the mapping of *r5s1* /pa:ká/→[paká] and *r5s2* /pa:ká:/→[paká:].

b. IDENT[length] » WSP & NOLONG is required for r5s3 /pá:ka:/→[pá:ka] and r5s4 /pá:ka:/→[pá:ka:] (in addition for length to be contrastive in stressed and unstressed positions).

(22) Attempting to set the length feature of r5 to [+long] by Inconsistency Detection:

a. In r5s1 [pá:ka], r5 must be underlyingly [+long]

b. In r5s2 [pá:ka:], r5 must be underlyingly [+long]

c. In r5s3 [paká], r5 *cannot* be underlyingly [+long]

d. In r5s4 [paká:], r5 *cannot* be underlyingly [+long]

(23) L15 BCD after Phonotactic Learning:

{IDENT[stress]} » {ML, MR} » **{IDENT[length]} » {WSP, NOLONG}**

		Winner	Loser	Ident[stress]	ML	MR	IDENT[length]	WSP	NOLONG
	Phonotactic I	páka	páka	W	L	L			
	Phonotactic III	páka	páka:				W	L	L
a.	r5s1 /pá:.ka/	[pá:ka]	[páka]				W		L
b.	r5s2 /pá:.ka:/	[pá:ka:]	[páka:]				W	W	L
c.	r5s3/**pa:**ká/	[paká]	[pa:ká]				L	W	W
d.	r5s4/**pa:**ká:/	[paká:]	[pa:ká:]				L	W	W

(24) L15 MRCD yields the ranking:

{IDENT[stress]} » {ML, MR} » **{WSP, NOLONG} » {IDENT[length]}**

		Winner	Loser	Ident[stress]	ML	MR	WSP	NOLONG	IDENT[length]
	Phonotactic I	páka	páka	W	L	L			
	Phonotactic III	páka	páka:				L	L	W
a.	r5s1 /pá:.ka/	[pá:ka]	[páka]					L	W
b.	r5s2 /pá:.ka:/	[pá:ka:]	[páka:]				W	L	W
c.	r5s3/**pa:**ká/	[paká]	[pa:ká]				W	W	L
d.	r5s4/**pa:**ká:/	[paká:]	[pa:ká:]				W	W	L

In (25), the learner tests for consistency when r5 is [-long]. This test gives the same result as the tests where r5 is [+long] in (22)-(23), namely that no ranking exists that allows vowel length to be contrastive everywhere while still allowing r5 to show an alternation in [length].

c. In the word *r5s1,* the winner-loser pair /pá:ka/→[pá:ka]~[páka] is inconsistent with r5 being [-long]. The winner is unfaithful to the [-long] value of r5; the loser realizes the r5 vowel as [-long]. The winner wins on IDENT[length], in accordance with the phonotactic ranking information of Phonotactic III.
d. In the word *r5s2,* the winner-loser pair /pá:ka:/→[pá:ka]~[páka] is again inconsistent with r5 being [-long]. The winner is unfaithful to the [-long] value of r5; the loser realizes the r5 vowel as [-long]. Again, the loser is preferred on the constraint IDENT[length] which is dominant in the current grammar, which prompts the learner to again perform MRCD to resolve this conflict.

The ranking in (26), WSP or NOLONG » IDENT[length], resolves the conflict for the words *r5s1* and *r5s2*. However, this ranking is now inconsistent for everything else in the language, in particular:

a. For *r5s1* [pá:ka], the winning candidate /pá:ka/→[pá:ka] is inconsistent with the word containing $r5_1$, which is [-long]. The winner is faithful to the [+long] and should win on IDENT[length] in accordance with Phonotactic III; and,
b. For *r5s2* [pá:ka:], the winner-loser pair /pá:ka:/→[pá:ka:]~[páka:] is also inconsistent with r5 being [-long] in the input. The winner is faithful to the [+long] value of r5 and should win on IDENT[length].

In each test for the [length] feature of r5, a true contradicion arises because the ranking information for Language L15—Phonotactic III: IDENT[length] » WSP, NOLONG—requires that length is constrastive in stressed and unstressed positions and yet r5 shows an alternation in [length], which must involve one unfaithful mapping under the assumption that there is a single underlying form for r5. Therefore, in this system, the only way for the root r5 to surface as [+long] in *r1s1* [pá:ka] while surfacing as [-long] in *r2s1* [.pa.ká.], for example, is when there are input allomorphs.

(25) Attempting to set the length feature of r5 to [-long] via Inconsistency Detection:

a. In r5s3 [paká], r5 must be underlyingly [-long]

b. In r5s4 [paká:], r5 must be underlyingly [-long]

c. In r5s1 [pá:ka], r5 *cannot* be underlyingly [-long]

d. In r5s2 [pá:ka:], r5 *cannot* be underlyingly [-long]

(26) L15 and L31:

BCD after Phonotactic Learning:

{IDENT[length]} » {ML, MR} » {IDENT[stress]} » {WSP, NOLONG}

		Input	Output	Ident[stress]	ML	MR	IDENT[length]	WSP	NOLONG
	Phonotactic I	páka	páka	W	L	L			
	Phonotactic III	páka	páka:				W	L	L
a.	r5s3/paká/	[paká]	[pa:ká]				W		W
b.	r5s4/paká:/	[paká:]	[pa:ká:]				W	W	W
c.	r5s1/**pa:**ká/	[paká]	[pa:ká]				L	W	W
d.	r5s2/**pa:**ká:/	[páka:]	[pa:ká:]				L	W	W

(27) L15 and L31:

MRCD yields the ranking:

{IDENT[length]} » {ML, MR} » {IDENT[stress]} » {WSP, NOLONG}

		Input	Output	Ident[stress]	ML	MR	WSP	NOLONG	IDENT[length]
	Phonotactic I	páka	páka	W	L	L			
	Phonotactic III	páka	páka:				L	L	W
a.	r5s3/paká/	[paká]	[pa:ká]					W	W
b.	r5s4/paká:/	[paká:]	[pa:ká:]				L	W	W
c.	r5s1/**pa:**ká/	[paká]	[pa:ká]				W	W	L
d.	r5s2/**pa:**ká:/	[páka:]	[pa:ká:]				W	W	L

In (29), the learner then posits two input allomorphs for r5: $r5_1$ is arbitrarily tested as [-long] and $r5_2$ is tested with the opposite value, [+long]; the learner tests every r5 word again with both input allomorphs listed in the input and given the support for the ranking in Phonotactic Learning, Phonotactic III: IDENT[length] » WSP & NOLONG. All winners are now faithful to the length of the input for r5, with r5 vowels reflecting the [length] of the input allomorph that is selected.

a. In *r5s3* [paká], the winner /{pa, pa:}ká/→[paká] is now consistent with r5 being [-long] in the input. The winner is faithful to the [-long] feature of $r5_1$ in mapping; the loser realizes the r5 value as long and it is unfaithful to the [-long] value in the input when it selects the $r5_1$ allomorph. The winner does better on IDENT[length].
b. Note that the analyst can also consider another winner-loser pair where each output has a different [long] specification for the r5 vowel, but different input allomorphs are selected in each output. In the winner-loser pair /{pa, pa:}ká/→[paká]~ [pa:ká], the winner is faithful to the [-long] value of $r5_1$ and the loser is faithful to the [+long] value of $r5_2$. Both candidates are equal on IDENT[length], but the winner does not contain a long, unstressed vowel and so it wins on WSP or NOLONG.
c. In the word *r5s4*, the winner-loser pair /pa:ká:/→[paká:]~[pa:ká:] is consistent with $r5_1$ being selected as the input allomorph and being faithfully mapped to an output with a [-long] vowel. The loser shows lengthening of the [-long] $r5_1$ vowel and so it is dispreferred on IDENT[length].
d. In the word *r5s1,* the winning candidate /{pá:, pá}ka/→[pá:ka] is consistent with r5 being [+long] in the input; in other words, this time the winning candidate contains the $r5_2$ input allomorph, which is [+long]. The winner is therefore faithful to the [+long] value of $r5_1$; the loser realizes the $r5_1$ vowel as [-long]. The winner wins on IDENT[length].
e. As in (d), in the word *r5s2,* the winner /pá:ka:/→[pá:ka:] is consistent r5 being [+long] when $r5_2$ is selected as the input allomorph. The winner is faithful to the [+long] value of r5; the loser is unfaithful to the [+long] vowel. The winner wins on IDENT[length].

The learner has now tested the [length] values of r5 and does not detect any inconsistencies in the ranking with there being two input allomorphs for r5, $r5_1$ and $r5_2$, with each having opposite values for [length].

(28) r5 in L15

Word		Syllable 1		Syllable 2	
		Root		Suffix	
		S	L	S	L
a. r5s1	[.pá:.ka.]	?	+	?	-
b. r5s3	[.pa.ká.]	?	-	?	-
c. r5s2	[.pá:.ka:.]	?	+	?	+
d. r5s4	[.pa.ká:.]	?	-	?	+

Setting the length feature of r5 to [+long] by Inconsistency Detection:a. In r5s3 [paká], r5 must be be underlyingly [-long]

c. In r5s4 [paká:], r5 must be be underlyingly [-long]

d. In r5s1 [pá:ka], r5 must be underlyingly [+long]

e. In r5s2 [pá:ka:], r5 must be underlyingly [+long]

(29) L15 and L31: Testing [length] of r5 via Inconsistency Detection

{IDENT[length]} » {ML, MR} » {IDENT[stress]} » {WSP, NOLONG}

		Input	Output	IDENT[stress]	ML	MR	IDENT[length]	WSP	NOLONG
	Phonotactic I	páka	páka	W	L	L			
	Phonotactic III	páka	páka:				W	L	L
a.	r5s3/{pa, pa:}ká/	[paká] (/pa/)	[pa:ká] (/pa/)				W		W
b.	r5s3/{pa, pa:}ká/	[paká] (/pa/)	[pa:ká] (/pa:/)					W	W
c.	r5s4{pa, pa:}ká:/	[paká:]	[pa:ká:]				W	L	W
d.	r5s1 /{pá, pá:}.ka/	[pá:ka]	[páka]				W		L
e.	r5s2 /{pá, pá:}.ka:/	[pá:ka:]	[páka:]				W	W	L

The lexicon after the setting of [length] features for all morphemes is given in (30). The root r5 has two input allomorphs: $r5_1$ is set to [-long] and $r5_2$ is set to [+long]. Again note that in L15, only the [length] values and not the [stress] values can be set via Inconsistency Detection, hence both inputs for r5 remain unset for stress, as in the other morphemes.

(30) Lexicon for Language 15 with phonotactically contrastive features set

r5 has two allormorphs. $r5_1$ is set to [-long] and $r5_2$ is set to [+long]

		S	**L**		**S**	**L**		**S**	**L**		**S**	**L**		**S**	**L**		**S**	**L**
	r1	?	-	**r3**	?	-	**r2**	?	+	**r4**	?	+	**$r5_1$**	?	-	**$r5_2$**	?	+
	s1	?	-	**s3**	?	-	**s2**	?	+	**s4**	?	+						

In L14, the learner does not detect a contradiction in the length values of r5: in all environments the vowel is [-long] and so there is just one root with a vowel that cannot be underlyingly [+long].

(31) r5 in L14

Word		Syllable 1		Syllable 2	
		Root		Suffix	
		S	L	S	L
a. r5s1	[.pá.ka.]	?	+	?	-
b. r5s3	[.pa.ká.]	?	-	?	-
c. r5s2	[.pá.ka:.]	?	+	?	+
d. r5s4	[.pa.ká:.]	?	-	?	+

(32) Lexicon for Language 14 with phonotactically contrastive features set

r5 is set to [-long]

		S	**L**		**S**	**L**		**S**	**L**		**S**	**L**		**S**	**L**
	r1	?	-	**r3**	?	-	**r2**	?	+	**r4**	?	+	**r5**	?	-
	s1	?	-	**s3**	?	-	**s2**	?	+	**s4**	?	+			

7.1 General Procedure for Input Allomorphs

Before outlining the rest of the learning procedure for the Language L15, we will consider the learning procedure for more general cases where more than just a single feature is contradictory, while allowing for multiple input allomorphs of the same morpheme to have the same value for other features. The general procedure for learning the features of input allomorphs is given in (33).

The number of input allomorphs posited by the learner depends on the number of surface forms that exhibit contradictory behavior for a particular feature.

In L15, only two input allomorphs are required for r5, with one set to [+long] and the other set to [-long].

In another case considered here, there is a Language L15A with a morpheme r6 that shows an alternation between [pé:~pi]. Still only two input allomorphs are required but they contradict each other in terms of *two* features: [long] and [high] (but not [low]).

Given a system with four suffixes, there are maximally four morpheme alternates of a root morpheme *rM* that will have contradictory behavior and so the maximum number of input allomorphs that the learner will ever posit is four.

(33) Learning Input Allomorphs

Stage	*Example from System* *Paka$_2$+Vowel_Height_C*	
Phonotactic Ranking Information: F1 or F2 » M1 & M2 &….&M*n*	Ident[low] or Ident [high] » **e, *i, *a* Language has a three way vowel height contrast.	In L15A [p**á**ka], [p**i**ká], [p**é**:ka]
Construction of the lexicon: Two or more surface allomorphs for a single morpheme.	In the construction of the lexicon, the learner requires two input allomorphs for r6 since r6 surfaces as [pé:] sometimes and [pi] in others.	In L15A: r6 must be [-long, +high, -low] in [p**i**ká], and r6 must be [+long, -high, -low] in [p**é**:ka]
For each contradictory morpheme, one allomorph requires F1» M1	Ident[low] | Ident[high]» **i, *e* [pé:] requires faithfulness to [+long] and [-low, -high].	In L15A, r61 must be [-long, +high, -low] in [piká].
The other allomorph requires the contra-ERC: M1» F1 under the analysis that there is a single UR.	Requires: **e* » Ident[low] [pi] requires faithfulness to [-long] and [-low, +high].	In L15A, r6 must be [+long, -high, -low] in [p**é**:ka]

Consider the system *paka2+Vowel_Height_C*, which contains the *paka* constraints in addition to the constraints in (34)-(38). These constraints make the system sensitive to unfaithful mappings of vowel height: in a language that has a three-way height contrast, one of the F.Ident[height] dominates all of the M banning particular vowels {**a*, **e*, **i*}.

(34) **IDENT[±low]**

Assign a violation for each [-low] input vowel that has a [+low] output correspondent.

Assign a violation for each [+low] input vowel that has a [-low] output correspondent.

(35) **IDENT[±high]**

Assign a violation for each [-high] input vowel that has a [+low] output correspondent.

Assign a violation for each [+high] input vowel that has a [-low] output correspondent.

(36) ***a***

Assign a violation for each [a].

(37) ***e***

Assign a violation for each [e].

(38) ***i***

Assign a violation for each [i].

This system also differs from *paka2* in that, instead of *r5*, it contains the morpheme *r6,* which has two input allomorphs: /{pé:, pi}/. In language L15A, the first input allomorph $r6_1$ /pé:/ is [-long, -stress, -high, -low]; the second input allomorph $r6_2$ /pi/ is [+long, +stress, +high, -low].

(39) L15A

Phonotactic Inventory: {.pá.ka., .pá.ka:., .pá:.ka., .pá:.ka:., .pa.ká., .pa.ká:., pé:ka, pi.ká}

r1=/pa/[pá]	r3=/pá/[pá]	r2=/pa:/[pá:]	r4=/pá:/[pá:]	r6= /{pé:, pi}/ [pé:]~[pi]	
.pá.ka.	.pá.ka.	.pá:.ka.	.pá:.ka.	.pé:.ka.	s1=/ka/[ka]
.pa.ká.	.pá.ka.	.pa:.k.	.pá:.ka.	.pi.ká.	s3=/ká/[ka]~[ká]
.pá.ka:.	.pá.ka:.	.pá:.ka:.	.pá:.ka:.	.pé:.ka:.	s2=/ka:/[ka:]
.pa.ká:.	.pá.ka:.	.pa:.ká:.	.pá:.ka:.	.pi.ká:.	s4=/ká:/[ká:]~ [ka:]

In phonotactic learning of Language L15A, the learner learns that vowel height is contrastive along both [high] and [low]. The learner stores the WL pairs for Phonotactic 2-I and Phonotactic 2-I in (40).

(40) Phonotactic Learning of L15A

a. Phonotactic 2-I: IDENT[±low] » *a, *e & NOLONG

b. Phonotactic 2-II: IDENT[±high] » *e, *i & NOLONG

	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG	IDENT[±high]	IDENT[±low]	*a	*e	*i
Phonotactic I	Fusion			W		L	L						
Phonotactic III	Fusion		L		W			L					
	[páka]	[pé:ka]						W		W	L	W	
	[pé:ka]	[páka]						L		W	W	L	
Phonotactic 2-I	Fusion							L		W	L	L	
	[pé:ka]	[piká]						L	W			L	W
	[piká]	[pé:ka]						W	W			W	L
Phonotactic 2-II	Fusion							L	W			L	L

As before, the surface forms are matched up with the words that have this surface form and the morphemes inherit the vowel height, length and stress features of the surface form as in (41).

(41) *Feature setting of L15A surface forms*

	Syllable 1				**Syllable 2**				
	Root				**Suffix**				*Words that match this surface form*
Surface	**S**	**L**	**High (H)**	**Low (Lo)**	**S**	**L**	**H**	**Lo**	
[páka]		-	-	+		**-**	-	+	r1s1, r3s1, r3s3
[pá:ka]		+	-	+		-	-	+	r2s1, r4s1, r4s3
[pá.ka:]		-	-	+		**+**	-	+	r1s2, r3s2, r3s4
[pá:.ka:]		+	-	+		+	-	+	r2s2, r4s2, r4s4
[.pa:.ká]		+	-	+		-	-	+	r2s3
[paká]						-	-	+	r1s3
[paká:]						+	-	+	r1s4
[pá:ka:]						+	-	+	r2s4
[pé:ka]		**+**	-	-					r6s1
[piká]		**-**	+	-					r6s3
[pé:ka:]		**+**	-	-					r6s2
[piká:]		-	+	-					r6s4

In the construction of the lexicon, the learner will arrive at a contradiction in both the [length] and [high] values of r6, but not in its [low] value: the surface forms that have been matched with r6 always have a [-low] vowel, either *e* or *i* (note that the stress features remain unset, as in the *paka*$_2$ system). No ranking of the constraints allows vowel length to be contrastive while having an alternation in the [length] value of r6. The contradiction that arises is due to the ranking of IDENT[length] with respect to NOLONG and

WSP, as in *paka*$_2$. Also, no ranking of the constraints will allow the vowel height alternation [e~i] for *r6*. The contradiction that arises is due to the ranking of the constraints IDENT[high] with respect to **e* and **i*.

The contradiction in the [length] and [high] values co-occur with one another: one morpheme alternate of r6 [pi] inherits the values [-long, +high] from words like [piká] and the other alternate of r6 ,[pé:] inherits [+long, -high] from words like [pé:ka]. Since these contradictions co-occur with each other, only two input allomorphs will be required that have the opposite values for both [long] and [high] to resolve the contradiction.

As shown in the tableau in (44), in the word *r6s1* [.pé:.ka.] (and also in *r6s2* [.pé:.ka:.]), r6 cannot be underlyingly [-long] and thus it must be [+long]. Also, based on the surface form [.pé:.ka.], r6 cannot be underlying [+high] and so it is set to [-high] if it is encountered as the first allomorph of r6 in the construction of the lexicon.

With Inconsistency Detection, the learner learns that no ranking in Language L15A is possible where r6 has a single underlying form for *r6s2* [.pi.ká.] and *r6s2* [.pi.ká:.]. In r6, the vowel cannot be underlyingly [+long]—it must be [-long]. This contradiction is resolved by introducing the second input allomorph in the lexicon for L15 which is [-long]. As for the other input allomorph for r6, the vowel cannot be underlyingly [+low], rather, it must be underlyingly [-low]. If the learner adopts the [-high] setting from the other vowel, there will still be inconsistency in the [high] value of the input allomorph r6$_2$. The learner does not find any inconsistencies with this second allormorph being set to [-high].

(42) Lexicon for L15 with phonotactically contrastive features attempting to be set:
r6 must be set to both [-long] and [+long] at once; likewise it must be both [+high] and [-high] (it is not necessary to have more than two allomorphs to resolve inconsistency since [-high] co-occurs with [+long] and [+high] co-occurs with [-long]).

		S	**L**	**H**	**Lo**
	r6	?	- and +	- and +	-
Surface alternate:	r6$_1$		-	+	
	r6$_2$		+	-	

In (43), r6 has two input allomorphs: $r6_1$ is set to [-long, +high, -low] and $r6_2$ is set to [+long, -high, -low]. Note that each input allomorph has the feature [+low].

(43) Lexicon for Language 15A with vowel length and height features set

		S	**L**	**H**	**Lo**		**S**	**L**	**H**	**Lo**		**S**	**L**	**H**	**Lo**		**S**	**L**	**H**	**Lo**		**S**	**L**	**H**	**Lo**
	r1	?	-	-	+	**r3**	?	-	-	+	**r2**	?	+	-	+	**r4**	?	+	-	+	$r6_1$	?	-	+	-
	s1	?	-	-	+	**s3**	?	-	-	+	**s2**	?	+	-	+	**s4**	?	+	-	+	$r6_2$	?	+	-	-

The tableau in (44) applies Inconsistency Detection to show why both input allomorphs of r6 must be set to [+low]. From this we can see how certain features must be constant across input allomorphs.

- The ranking **a* » IDENT[low] & **e* is required for *a* to raise to *e*. The winner-loser pair in (a.) is /pá:ka/→[pé:ka]~[páka:]; this pair is used to test the [low] value of the r6 vowel in [pé:ka]. The winner does better on **a*; the loser does better on IDENT[low] and **e*. This ranking is inconsistent with Phonotactic 2-II (40). From this inconsistency, the learner determines that the length value of the r6 vowel in [pé:ka] cannot be [+low], and thus it sets it to [-low].
- The ranking **a* | ** e* » IDENT[low], IDENT[high] & **i* is required for *a* to raise to *i*.
    - The winner-loser pair in (b.) is /paká/→[piká]~[paká]; this pair is used to test the [low] and [high] value of the r6 vowel in [piká]. The winner does better on **a*.
    - The winner-loser pair in (c.) /peká/→[piká]~[peká]; this pair is used to test the [high] value of the r6 vowel in [piká]. The winner does better on **e*.

  The ranking information from the fusion of the two ERCs (b.) and (c) contradicts Phonotactic 2-I or Phonotactic 2-II in (40). Again, trom this inconsistency, the learner determines that the length value of the r6 vowel in [piká] cannot be [+low], and thus it sets it to [-low], as in the other input allomorph.

(44) Setting the [long] and [high] features of r6 via Inconsistency Detection:

a. $r6_2$ cannot be underlyingly [+low] in the word [pé:ka]: contradicts Phonotactic 2-I

b. $r6_1$ cannot be underlyingly [+low] in the word [piká]: contradicts Phonotactic 2-I

c. $r6_2$ cannot be underlyingly [+high] in the word [pé:ka]: contradicts Phonotactic 2-II

d. $r6_1$ must be underlyingly [+high] in the word [piká], as per Phonotactic 2-II

e. $r6_2$ must be underlyingly [-high] in the word [pé:ka], as per Phonotactic 2-II

f. $r6_1$ cannot be underlyingly [-high] in the word [piká] : contradicts Phonotactic 2-II

g. $r6_2$ cannot be underlyingly [-long] in the word [pé:ka]:contradicts Phonotactic III

h. $r6_1$ must be underlyingly [-long] in the word [piká], as per Phonotactic III

i. $r6_2$ must be underlyingly [+long] in the word [pé:ka], as per Phonotactic III

j. $r6_1$ cannot be underlyingly [+long] in the word [piká]: contradicts Phonotactic III

Input	Output		IDENT[stress]	ML	MR	Ident[Length]	WSP	NOLONG	IDENT[±high]	IDENT[±low]	*a	*e	*i
Phonotactic I	Fusion		W	L	L								
Phonotactic III	Fusion					W	L	L					
Phonotactic 2-I	Fusion									W	L	L	
Phonotactic 2-II	Fusion								W			L	L
a. $r6_2$s1 /**pá:**ka/	[pé:ka]	[pá:ka]								L	W		L
b. $r6_1$s3 /**pa**ká/	[piká]	[paká]							L	L	W		L
c. $r6_2$s1 /**pí:**ka/	[piká]	[peká]							L			W	L
d. $r6_1$s3 /**pi**ká/	[piká]	[peká]							L				
e. $r6_2$s1 /**pé:**ka/	[pé:ka]	[pí:ka]							W			L	W
f. $r6_1$s3 /**pe**ká/	[piká]	[peká]							L			W	L
g. $r6_2$s1 /**pé**ka/	[pé:ka]	[péka]				L		L					
h. $r6_1$s3 /**pi**ka/	[piká]	[pi:ká]				W	W	W					
i. $r6_2$s1 /**pé:**ka/	[pé:ka]	[péka]				W		L					
j. $r6_1$s3 /**pi:**ka/	[piká]	[pi:ká]				L	W	W					

8 Input Allomorph Phonotactic Ranking Information

Going back to Language L15 in the *paka*$_2$ system, once the learner posits two input allomorphs for r5, further ranking information will be obtained in the stage called *Input Allomorph Phonotactic Learning*. This new ranking information is called *Input Allomorph Phonotactic I* in (45).

In the r5 paradigm of L15 and L31, r5s1 [pá:ka] and r5s2 [paká] contrast in the stress value of r5, with r5 surfacing as stressed [pá:] before s1 and unstressed [pa] before s2.

As we shall see, it is possible to compare two candidates that differ in stress but appear to have a length disparity because r5's input allomorphs differ in their [length] values.

The learner constructs an input that consists of both r5 input allomorphs plus as suffix vowel that has the same value for stress and length as in the ouput. For example, in r5s1 [pá:ka], the suffix vowel in r5 is unstressed and so it is tested with a [-stress] value (/{pá:, pá}ka/→[pá:ka]); in r5s2 [paká], the learner constructs an input that contains the two input allomorphs for r5 and tests the suffix vowel as [+stress] (/{pa:, pa}ká/→[paká]).

This process is analagous to determine what ranking(s) must exist for the surface forms [pá:ka] and [paká] to be contrastive in the language (c.f. *Phonotactic I* in (13)), with the only difference being that *r5s1* [pá:ka] and *r5s2* [paká] must be tested after the learner has obtained the necessary information for input allomorphs to be required for r5.

- As shown in the tableau in (45), the learner obtains the support for the ranking information IDENT[stress] or ML » MR and NOLONG.
- In (a) the winner has selected r5$_2$ which has a [+long] vowel as the input (/{**pá:**, pá}ka//→[pá:ka]); in the loser, the other allomorph r5$_1$ which has a [-long] vowel as the input (/{pá:, **pá**}ka/→[paká]). Since the candidates select different input allomorphs, neither the winner nor the loser is unfaithful to the [length] value of the root vowel, and so both candidates are equal on IDENT[length]. The winner does better on IDENT[stress], since it is faithful to the [-stress] value of the suffix vowel in mapping. It also does better on ML since it has initial stress.
- The learner obtains the support for the ranking information IDENT[stress] for the ranking IDENT[stress] or MR or NOLONG » ML.

- In the winner, the input allomorph is $r5_1$ which has a [-long] vowel plus a suffix which is stressed. In the loser, the the input allomorph is $r5_2$, which has a [+long] vowel. The winner is faithful to the [+stress] value of the suffix and so it does better on ML.
- The fusion of these two ERCs is IDENT[stress] » ML & MR & NOLONG.

Finally, note that the Input Allomorph Ranking information is stronger ranking information that obtained from the fusion of Normal Phonotactic Ranking information where either IDENT[stress] *or* IDENT[length] dominates ML & MR & NOLONG.

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(45)

New Ranking Information:

IDENT[stress] » {ML, MR, NOLONG}

Input Allomorph Phonotactic Learning	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
a.	{pá,pá:}ka	pá:ka					*	*
b.	{pá,pá:}ka	paká		**		*		
c.	pá:ka~	paká		W		W	L	L
	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
d.	{pa,pa:}ká	paká				*		
e.	{pa,pa:}ká	pá:ka		**			*	*
f.	paká~	pá:ka		W		L	W	W
	Fusion			**W**		**L**	**L**	**L**
c.f. Normal Phonotactic Learning	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
a.	pá:ka	pá:ka					*	*
b.	pá:ka	paká		**	*	*		
c.	pá:ka~	paká		W	W	W	L	L
	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
d.	paká	paká				*		
e.	paká	pá:ka		**	*		*	*
f.	paká~	pá:ka		W	W	L	W	W
	Fusion			**W**	**W**	**L**	**L**	**L**

9 Contrast Pairs for setting [stress] features

Contrast Pairs are pairs of words that differ by one morpheme and differ in their surface forms. As in the *paka* system, in the *paka2* system, the learner uses contrast pairs to set the [stress] features of all morphemes.

9.1 Contrast pairs in L15: Using r1s1 and r1s3 for setting the [stress] value of s1

The argument that follows draws heavily on Section 7.6.2 *A Disjunction of disparities* (Tesar 2013:310-317).

The pair of words r1s1 and r1s3 tests the underlying value of stress for s1 with the value [+stress].

(46) r1s1 contrasts for stress with r1s3

	r1**s1**	[pá.ka]	r1: /ʔ, -/; s1:/ʔ, -/
	r1**s3**	[.pa.ká]	r3: /ʔ, -/; s3:/ʔ, -/

As shown in the tableau in (48), every pair where s1 is tested as [+stress] is inconsistent. This prompts the learner to set s1 to [-stress] through Inconsistency Detection.

(47) Inconsistency detected for contrast pair r1s1 and r1s3 when testing s1=[+stress]

	r1	**Word**	**Consistent?**
	[+stress]	r1s1: /páká/ [.pá.ka.] r1s3: /páká/ [.pa.ká.]	No
	[-stress]	r1s1: /paká/ [.pá.ka.] r1s3: /paká/ [.pa.ká.]	No

a. When r1 is tested with the value [+stress] this creates a disparity in r1s3 /páká/→[paká].

i. r1s3: /páká/→[paká] requires MR » ML. In the winner, the root is unfaithful to the [+stress] value of r1; in the loser, the suffix is unfaithful to the [+stress] value of r3. The winner and loser each have

one unfaithful mapping of a [+stress] value and so they are equal on IDENT[stress]. The winner does better on MR since it has final stress, or NOLONG since it does not have a [+long] vowel in the output.

ii. r1s1: /páká/→[páka] requires the opposite ranking: ML » MR. In the winner, the suffix is unfaithful to the [+stress] of s3. The winner does better on ML since it has inital stress. The loser does better on MR or NOLONG.

b. When r1 is tested with the value [-stress] this creates two disparities in r1s1 /paká/→[páka], and no disparities in in r1s3 /paká/→[paká].

i. r1s1: /paká/→[páka] requires MR » IDENT[stress] & ML. In the winner, r1 is unfaithful to the [-stress] value in the input and s1 is unfaithful to the [+stress] value in the input. In the loser, both the root and the suffix are fully faithful to the [stress] value in the input. The winner does better on MR since it has final stress; it also does better on NOLONG since it does not have a [+long] vowel in the output.

ii. r1s3: /paká/→[páka] requires the opposite ERC: IDENT[stress] or ML » MR. The winner is faithful to the [stress] values of the root and suffix; the loser is unfaithful to both. The winner does better on IDENT[stress] since it avoids unfaithful mappings of [stress] and ML since it has inital stress. The loser does better on MR and NOLONG.

(48) Setting s1 to [-stress] via Inconsistency Detection using *r1s1* and *r1s3*

		Winner	Loser	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
Input Allomorph Phonotactic I		Fusion			W		L	L	L
Phonotactic III		Fusion		L		W			L
a. i.	*r1 unfaithful* r1s3 /páká/	[paká]	[páka]				L	W	W
ii.	*s1 unfaithful* r1s1 /páká/	[páka]	[paká]				W	L	L
b. i.	*r1, s1 unfaithful* /paká/	[páka]	[paká]		L		L	W	W
ii.	*fully faithful* r1s3 /paká/	[paká]	[páka]		W		W	L	L

9.2 Contrast pairs in L15: Using r5s1 and r5s3 for setting the [stress] value of s1

In (48) we saw the learner set the underlying value of [stress] for s1 tableau using the pair *r1s1* and *r1s3*. Each word consisted of root and suffix, each of which consisted of a single underlying form.

In L15, r5s1 [pá:ka] and r5s3 [paká] also form a contrast pair that can be used to set the [stress] value of the suffix s1. In r5s1 [paká], r5 surfaces as [-stress] before s3 (and also [-long]); and, in r5s1 [pá:ka], r5 surfaces as [+stress] before s1 (and also [+long]). Each word consists of root and each suffix, with the roots having two input allomorphs. Unlike when using the contrast pair *r1s1* and *r1s3*, the learner will be required to test lexical hypotheses for each r5 input allomorph.

The lexical hypotheses that are being tested are summarized in the table in (49) . In the tableau in (50) , the learner tests the stress value for s1 as [+stress]. Since they are all inconsistenct, the learner sets s1 to [-stress] and s3 to [+stress].

A couple of comments on this test:

As mentioned, the learner treats the [stress] features of $r5_1$ [**?**, -] and $r5_2$ [**?**, +] as distinct alternating features. When the learner processes r5s1 and r5s3 together it must test both allomorphs of r5 with the same value for stress *within in each condition*—if r5 does not have the same underlying form in both words, e.g. if the ranking selects $r5_1$ which is tested as [-stress] and $r5_2$ [+stress], then this opens up the possibility of contrast between r5s1 and r5s3 being the result of r5.

All combinations of [stress] values are tested for inconsistency.

However, the learner has already obtained the support for vowel length to be contrastive: this ensures that $r5_1$ [**?**, -] cannot be the allomorph that is selected in *r5s1* [.pá:.ka.] nor in the word *r5s2* [.pá:.ka:.] and also that $r5_2$ [**?**, +] cannot be the allomorph that is selected *r5s3* [.pa.ká.] nor in *r5s4* [.pa.ká:.]. In L15 each word will be faithful to the [+long] specification of the vowel in accordance with the Phonotactic Ranking information IDENT[long] »WSP & NOLONG, predicting that the [length] value for every vowel is the same as the feature that was set in the input. Nevertheless, in the tableau in (50), combinations including $r5_1$ as [**+**, -] and [-, -] are tested for *r5s3* [.pa.ká.]; also, combinations including $r5_2$ is tested as [**+**, +] or [-, +] are tested for *r5s1* [.pá:.ka.]. These combinations have been shaded in (50) and will not be discussed beyond identifying the fact that they are inconsistent.

(49) Inconsistency detected for contrast pair r5s1 and r5s3 when testing s1=[+stress]

r5			**Consistent?**
[+stress]	a.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pá:/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pá:/)	No
	b.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pá/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pá/)	No
	c.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pá:/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pá/)	No
	d.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pá/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pá:/)	No
[-stress]	e.	r5s1: /{pa,pa:}ká/ [.pá:.ka.] (/pa:/) r5s3: /{pa,pa:}ká/ [.pa.ká.] (/pa:/)	No
	f.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pa/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pa/)	No
	g.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pa:/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pa/)	No
	h.	r5s1: /{pá,pá:}ká/ [.pá:.ka.](/pa/) r5s3: /{pá,pá:}ká/ [.pa.ká.] (/pa:/)	No

As shown in (51d), when both r5 input allomorphs are tested with [+stress] this creates a single [stress] disparity the word *r5s3* (in /{pá, pá:}ká/→[paká], $r5_1$ /pá/→ [pa] involves a disparity in [stress]).

i. r5s3: /{pá, pá:}ká/→[paká] requires NOLONG or MR » ML. In the winner, the root is unfaithful to the [+stress] value of r5; in the loser, the suffix is unfaithful to the [+stress] value of r3. The winner and loser each have one unfaithful mapping of a [+stress] value and so they are equal on IDENT[stress]. The winner does better on MR since it has final stress or NOLONG since it does not have a [+long] vowel in the output.

ii. r5s1: /{pá, pá:}ká/→[pá:ka] requires the contra-ERC: ML » MR & NOLONG. In the winner, the suffix is unfaithful to the [+stress] of s3. The winner does better on ML since it has initial stress. The loser does better on MR or NOLONG.

As shown in (51g), when both r5 input allomorphs are tested with [-stress] this creates two disparities in [stress] for r5s1 /{pa, pa:}ká/→[pá:ka]: $r5_1$ /pa:/→ [pá:] involves 1 [stress] disparity and s1 /ká/→ [ka] is 1 [stress] disparity.

i. r5s1: /{pa, pa:}ká/→[pá:ka] requires NOLONG or MR » IDENT[stress] & ML. In the winner, r5 is unfaithful to the [-stress] value in the input and s1 is unfaithful to the [+stress] value in the input. In the loser, both the root and the suffix are fully faithful to the [stress] value in the input. The winner does better on MR since it has final stress or NOLONG since it does not have a [+long] vowel in the output.

ii. r5s3: /{pá:, pá:}ká/→[pá:ka] requires the opposite ERC: IDENT[stress] or ML » MR & NOLONG. The winner is faithful to the [stress] values of the root and suffix; the loser is unfaithful to both. The winner does better on Ident[stress] since it avoids unfaithful mappings of [stress] or ML since it has initial stress. The loser does better on MR and NOLONG.

(50) Setting s1 to [-stress] by Inconsistency Detection

		Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
	Input Allomorph Phonotactic I	Fusion			W		L	L	L
	Phonotactic III	Fusion		L		W			L
a. i.	*r5₂ unfaithful* r5₂s3 /{pá, pá:}ká/	[paká] (/pá:/)	[pá:ka] (/pá:/)			L	L	W	W
ii.	*s1 unfaithful* r5₂s1 /{pá, pá:}ká/	[pá:ka] (/pá:/)	[paká] (/pá:/)			W	W	L	L
b. *i.*	*r5₁ unfaithful* r5₁s3 /{pá, pá:}ká/	[paká] (/pá/)	[pá:ka] (/pá/)			W	L	W	W
ii.	*s1 unfaithful* r5₁s1 /{pá, pá:}ká/	[pá:ka] (/pá/)	[paká] (/pá/)			L	W	L	L
c. *i.*	*r5₂ unfaithful* r5₂s3 /{pá, pá:}ká/	[paká] (/pá:/)	[pá:ka] (/pá/)				L	W	L
ii.	*s1 unfaithful* r5₁s1 /{pá, pá:}ká/	[pá:ka] (/pá/)	[paká] (/pá:/)				W	L	L
d. *i.*	*r5₁ unfaithful* r5₁s3 /{pá, pá:}ká/	[paká] (/pá/)	[pá:ka] (/pá:/)				L	W	W
ii.	*s1 unfaithful* r5₂s1 /{pá, pá:}ká/	[pá:ka] (/pá:/)	[paká] (/pá/)				W	L	L
e. i.	*r5₂, s1 unfaithful* r5₁s1/{pa, pa:}ká/	[pá:ka] (/pa:/)	[paká] (/pa:/)		L	W	L	W	W
ii.	*fully faithful* r5₁s3 /{pa, pa:}ká/	[paká] (/pa:/)	[pá:ka] (/pa:/)		W	L	W	L	L
f. *i.*	*r5₁, s1 unfaithful* r5₂s1/{pa, pa:}ká/	[pá:ka] (/pa/)	[paká] (/pa/)		L	L	W	L	L
ii.	*fully faithful* r5₂s3 /{pa, pa:}ká/	[paká] (/pa/)	[pá:ka] (/pa/)		W	W	L	W	W
g. *i.*	*r5₂, s1 unfaithful* r5₂s1/{pa, pa:}ká/	[pá:ka] (/pa:/)	[paká] (/pa/)		L		W	L	W
ii.	*fully faithful* r5₁s3 /{pa, pa:}ká/	[paká] (/pa/)	[pá:ka] (/pa:/)		W		W	L	W
h. *i.*	*r5₁, s1 unfaithful* r5₁s3/{pa, pa:}ká/	[pá:ka] (/pa/)	[paká] (/pa:/)		L		W	L	L
ii.	*fully faithful* r5₂s3 /{pa, pa:}ká/	[paká] (/pa:/)	[pá:ka] (/pa/)		W		L	W	W

Once s3 is set to [+stress] the learner can set other features by looking for words where s3 surfaces unfaithfully.

For example, the word r3s3 [páka] has initital stress. In the tableau in (51), the learner tests the [stress] value for r3 when it surfaces before s3, with the learner having set s3 to [+stress] in (48). The input has stress on the root and suffix vowel; the winner does better on ML. In this step the learner learns that r3 cannot be [-stress], thus it must be [+stress]. It additionally acquires the support for the ranking of the stress positioning constraints: ML » MR.

9.3 Contrast pairs in L15: Using r5s1 and r5s3 for setting the [stress] value of $r5_1$ and $r5_2$

In (51), the learner tests all combinations of [stress] for each input allomorph of r5 in two environments: in r5s1 [pá:ka], r5 surfaces as [+stress] before s1, which has been set to [-stress]; and in r5s3 [paká], r5 surfaces as [-stress] before s3, which has been set to [+stress].

The word r5s1 can be used to set both the stress features of $r5_1$ and $r5_2$ at once. When using r5s1 [pá:ka], there is just one condition—when $r5_1$ is [-stress, -long] and $r5_2$ is [+stress, +long]—that is consistent. In the word r5s3, there is only one condition that is *not* consistent, and so it cannot be used to set the stress features of $r5_1$ and $r5_2$.

a. *r5s1* [pá:ka]. As just mentioned, the test where $r5_1$ is [-stress, -long] and $r5_2$ is [+stress, +long] is the only combination that is consistent. When both r5 input allomorphs are tested with [+stress], this test creates the same disparity in r5s1 /{pá, pá:}ka/→[pá:ka]; likewise when both are [-stress], this tests creates the same disparity in /{pa, pa:}ka/→[páka]. As shown in (51), the learner determines that $r5s_1$ cannot be [+stress] when $r5_2$ is [+stress]; the learner also determines that $r5s_1$ cannot be [-stress] when $r5_2$ is [-stress].

   i. *$r5_2$ faithful*: /{pa, pá:}ka/→[pá:ka]~[páka] is consistent. The winner is faithful to the [+stress] value of $r5_2$; the loser is unfaithful to the [-stress] value of $r5_1$. The winner does better on IDENT[stress].

   ii. *$r5_1$ and $r5_2$ unfaithful*: /{pa, pa:}ka/→[pá:ka]~[páka] is inconsistent. The winner and the loser are equal on IDENT[stress]. The loser does not contain a long vowel so it is preferred on NOLONG.

   iii. *$r5_1$ and $r5_2$ faithful*: /{pá, pá:}ka/→[pá:ka]~[páka] is inconsistent. The winner and the loser are equal on IDENT[stress]. The loser does not contain a long vowel so it is preferred on NOLONG.

iv. *r5₂ unfaithful*: /{pá, pa:}ka/→[pá:ka]~[páka] is inconsistent. In the winner, the root vowel is stressed, incurring a violation of IDENT[stress]. The loser wins on IDENT[stress].

b. *r5s3* [paká]. The test where r5₁ is [-stress, -long] and r5₂ is [+stress, +long] is not the only combination that is consistent. When both r5 input allomorphs are tested with [+stress] this creates the same disparity in r5s3 /{pá, pá:}ká/→[paká]; likewise when both are [-stress] this creates the same disparity in /{pa, pa:}ká/→[paká]. In each of these cases, the winner is [paká] because it is preferred on WSP or NOLONG. The learner determines only that r5s₁ cannot be [+stress] when r5₂ is [-stress].

i. *r5₂ faithful*: /{pa, pá:}ká/→[paká]~[pa:ká] is consistent. The winner is faithful to the [-stress] value of r5₁; the loser is unfaithful to [-stress] value of r5₁. The winner does better on IDENT[stress].

ii. *r5₁ and r5₂ unfaithful*: /{pa, pa:}ká/→[paká]~[pa:ká] is consistent. The winner and the loser are equal on IDENT[stress]. The winner does not contain a long, unstressed vowel and so it is preferred on NOLONG and WSP.

iii. *r5₁ and r5₂ faithful*: /{pá, pá:}ká/→[paká]~[pa:ká] is consistent. The winner and the loser are equal on IDENT[stress]. The winner does not contain a long, unstressed vowel and so it is preferred on NOLONG and WSP.

iv. *r5₂ unfaithful*: /{pá, pa:}ká/→[paká]~[pa:ká] is inconsistent. In the winner, the root vowel is [-stress] in the input and is unfaithfully mapped to [+stress], incurring a violation of IDENT[stress]. The loser is faithful to the [+stress] value in the input, and so it wins on IDENT[stress].

(51) Testing r5s1 and r5s3 where s1 has been set to [-stress]

		Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
Input Allomorph Phonotactic I		Fusion			W		L	L	
Phonotactic III		Fusion		L		W			L
a.	*r3 unfaithful* r3s3: páká	[páka]	[paká]				W	L	
b. i.	*fully faithful* r5s1:/{pa, pá:}ka/	[pá:ka] (/pá:/)	[páka] (/pa/)		W				L
ii.	*r5₁ and r5₂ faithful* r5s1:/{pá, pá:}ka/	[pá:ka] (/pá:/)	[páka] (/pá/)						L
iii.	*r5₁ and r5₂ unfaithful* r5s1:/{pa, pa:}ka/	[pá:ka] (/pa:/)	[páka] (/pa/)						L
iv.	*r5₂ unfaithful* r5s1:{pá, pa:}ka	[pá:ka] (/pa:/)	[páka] (pá)		L				L
c. i.	*r5₂ unfaithful* r5s3:{pa, pá:}ká	[paká] (/pa/)	[pa:ká] (/pá:/)	W	W				W
ii.	*r5₁, r5₂ unfaithful* r5₁s3:{pá, pá:}ká	[paká] (/pá/)	[pa:ká] (/pá:/)	W					W
iii.	*fully faithful* r5s3:/{pa, pa:}ká/	[paká] (/pa/)	[pa:ká] (/pa:/)	W					W
iv.	*r5₁ unfaithful* {pá, pa:}ká	[paká] (/pá/)	[pa:ká] (/pa:/)	W	L				W

Recall that in Languages L15 and L31, long vowels surface in unstressed position. Once it has set the [stress] features, the learner will also obtain support for the ranking of the dominant constraint for the positioning of stress with respect to WSP.

The tableau in (32) is after both r3 and s4 have been set to [+stress]. When stress is initial, this creates a single disparity in r3s4 /páká:/→[páka:] (words containing r5 cannot be used for this test since the input allomorph that allows stress to be faithfully realized is always selected: in r5s4 /{pa, pá:}ká:/→[**pa**ká:]~[pá:ka], the loser has an additional disparity in [stress]).

i. The learner learns that ML » MR & WSP. The winner is unfaithful to the [+stress] value of the suffix s3; the loser is unfaithful to the [+stress] value of r3. Each candidate has is one violation of IDENT[stress]. The winner does better on ML; the loser does better on MR and WSP, since it stresses the long vowel.

ii. Note that in L31, the learner uses a different pair to determine that the dominant constraint for the positioning of stress is MR and not ML; i.e. MR » ML & WSP. In L31, r3s4 /páká:/→[paká:], so either MR or WSP dominates ML. Another word is required where the initial vowel is [+long] and the suffix vowel is [-long] and the final vowel is stress; i.e. r4s3 /pá:ká/→[pa:ká]~[pá:ka].

(52) Testing r3s4 where s4 has been set to [+stress] and is unfaithfully mapped.

a. New ranking information obtained: ML » MR & WSP

	Input	Output	WSP	IDENT[stress]	IDENT[length]	ML	MR	NOLONG
Input Allomorph Phonotactic I	Fusion			W		L	L	
Phonotactic III	Fusion		L		W			L
s4 unfaithful páká:	[páka:]	[paká:]	L	e		W	L	
/{pá:, pa}ká:/	[paká:]	[pa:ká:]	W	W				W

10 Full Lexicon and Final Rankings for L15 and L31

In Languages L15 and L31, all stress and length features will be set for all roots and suffixes, as in (53). The final ranking information for L15 is in (54); when BCD applies it yields the ranking in (54). When all the ranking information is obtained for Language L31 and BCD applies, it yields the ranking for in (56). The ranking for L31 is given in (56) differs minimally from the ranking for L15 in that the dominant stress positioning constraint is MR rather than ML.

(53) Lexicon for Language 15 with stress features set in all roots and suffixes except for [stress] in $r5_1$ and $r5_2$.

		S	**L**		**S**	**L**		**S**	**L**		**S**	**L**		**S**	**L**		**S**	**L**
	r1	-	-	**r3**	+	-	**r2**	-	+	**r4**	+	+	**r5$_1$**	-	-	**r5$_2$**	+	+
	s1	-	-	**s3**	+	-	**s2**	-	+	**s4**	+	+						

(54) L15{Ident[stress], Ident[length]} » {ML} » {WSP, NOLONG, MR}

	IDENT[stress]	IDENT[length]	ML	NoLong	WSP	MR
Input Allomorph Phonotactic I	W		L	L		L
Phonotactic I	W		L			L
Phonotactic II		W		L		
Phonotactic III		W		L	L	L
(52)			W	L		
(52)a			W	`	L	L

(55) L15 after BCD: {Ident[stress]} » {ML} » {Ident[length]} » {WSP, NOLONG, MR}

	IDENT[stress]	ML	IDENT[length]	NoLong	WSP	MR
Input Allomorph Phonotactic I	W	L		L		L
Phonotactic I	W	L				L
Phonotactic II			W	L		
Phonotactic III			W	L	L	L
(52)		W		L		
(52)a		W		`	L	L

(56) L31 after BCD: {Ident[stress]} » {MR} » {Ident[length]} » {WSP, NOLONG, MR}

	IDENT[stress]	MR	IDENT[length]	NoLong	WSP	ML
Input Allomorph Phonotactic I	W	L		L		L
Phonotactic I	W	L				L
Phonotactic II			W	L		
Phonotactic III			W	L	L	L
c.f. (52)		W		L		
c.f. (52)a		W		`	L	L

11 Conclusion

This paper gave the procedure for learning multiple input allomorphs of a single morpheme in the Output Driven Learner of Tesar (2013), using Language L15 in the *paka*$_2$ system as the main example.

Language L15 is contrastive for [length] in stressed and unstressed positions and yet r5 shows a alternation in the length [pa~pá:]. Under the analysis that there is a single underlying form for r5, no ranking of the *paka* constraints allows vowel length to be contrastive while allowing r5 to have a length alternation. The learner is required to have input allomorphs in order for the r5 alternation to exist.

There are four stages of the procedure that apply only to the learning of input allomorphs, as summarized below.

i. The most significant stage is when the learner is required to posit multiple input allomorphs for r5. In *Phonotactic Learning* of L15, the learner obtains the support for the ranking information that allows vowel length to be contrastive in both stressed and unstressed positions. After morphological analysis, the [length] features of each morpheme can be set via *Inconsistency Detection*. This stage involves overlaying the input features that were set for surface forms onto the morphologically decomposed words. Given the word r5s1 [pá:ka],the learner then tests r5 as [+long] based on this form. However, the learner detects an error given the word r5s2 [paká], and the length feature of r5 as [+long]. MRCD is used to resolve this error, ranking IDENT[length] below WSP and NOLONG. However, the application of MRCD produces another error in the ranking, since all vowels are then predicted to neutralize in length. No ranking allows r5 to surface as [+long] in some environments while [-long] in other environments, assuming that r5 has a single underlying form: a true contradiction has occurred in the learning of Language L15. The learner resolves this contradiction by constructing two input allomorphs for r5: one input $r5_1$ contains a [-long] vowel and the other $r5_2$ a [+long] vowel and then does Inconsistency Detection again to test the [length] features of r5 with each input allomorph listed in the input for r5 words.

ii. A stage specific to languages with input allomorphs—proposed here—is *Input Allomorph Phonotactic Learning*. Within the r5 paradigm, r5s1 [pá:ka] and r5s2 [paká] show a contrast stress value of r5, with r5 surfacing as stressed [pá:] before s1 and unstressed [pa] before s2. The learner compares two candidates that differ in stress (but would also have a length disparity had they not been from a morpheme with input allomorphs): $r5_2$s1 /{pa,pá: }ka/→[pá:ka]~[paká] has a single disparity in the stress of the second vowel; $r5_1$s2 /{pa,pá:}ká/→[paká]~[pá:ka]. The learner obtains the support for the ranking IDENT[stress] » ML & MR & NOLONG.

iii. The final stage of learning uses *Contrast Pairs* to determine the value of [stress] features for all the roots and suffixes. Just as r1s3 [paká] and r1s1 [páka] form a contrast pair that can be used to set s1 to [-stress], r5s3 [paká] and r5s1 [pá:ka] form a contrast pair used to show that s1 is [-stress] too, although this procedure requires testing many more lexical hypotheses. The method involves testing

both input allomorphs for r5 with the same stress value; i.e. they are both [+stress] or they are both [-stress].

iv. To set the stress feature of each r5 input allomorph, the learner then constructs an input for r5s1 [pá:ka] where all the combinations of [stress] for $r5_1$ and $r5_2$ are tested. r5 surfaces as [+long] and [+stress] in the word $r5_2$s1 [pá:ka]; i.e. before s1, which was just set to [-stress]. The learner determines that the input allomorph $r5_1$ /ʔ, +/ cannot be [+stress] because this is inconsistent when $r5_2$ is both [+stress] and [-stress]. This information allows the learner to set the stress features of each r5 input allomorph at once, with $r5_1$ set to [-stress] and $r5_2$ set to [+stress].

With all features set, the learner may obtain the support for the dominant stress positioning constraint, as in the normal case of learning a language for the paka and $paka_2$ systems.

References

Mascaró, J. (1996). External allomorphy as emergence of the unmarked. Current Trends in Phonology: Models and Methods. Salford, Manchester, European Studies Research Institute, University of Salford**:** 473-483.

Mascaró, J. (2007). "External allomorphy and lexical representation." Linguistic Inquiry **38**(4): 715-735.

Merchant, N., A. Prince, and Tesar, B. (2014). OT Workplace. Version 68.

Tesar, B. (1997). "Multi-recursive constraint demotion."

Tesar, B. (2013). Output-Driven Phonology. Theory and Learning. Cambridge, Cambridge University Press.