Appendix A

Results for Neutralize 1 (chapter 3)

A.1 Input forms

The Neutralize 1 language has palatalization of k before i, resulting in neutralization of k and $\widehat{t\int}$ in the ergative.

a. Forms ending in segments other than k

absolutive		ergative
dap	∼	dapi
lot	∼	loti
gub	∼	gubi
sat͡ʃ	∼	sat͡ʃi
rut͡ʃ	∼	rut͡ʃi
lag	∼	lagi
ban	∼	bani
yul	∼	yuli

b. Forms ending in k

absolutive		ergative
ʔak	∼	ʔat͡ʃi
muk	∼	mut͡ʃi
lok	∼	lot͡ʃi

A.2 Absolutive to ergative direction

A.2.1 Grammar for the *absolutive→ergative* direction

The following table lists all of the rules created in the process of learning the mapping from the absolutive form to the ergative form, in order of discovery. The "parents" column lists the two rules which were compared to yield the generalization (or, in the case of word-specific rules, a '*', indicating that the learner has just received a new input pair). The right three columns list the reliability statistics of the rule; its *hits* (the number of forms it can derive correctly), its *scope* (the number of forms it could potentially apply to in the lexicon) and its *confidence* (the ratio

of the hits to scope, adjusted with lower confidence limit statistics). The confidence value for a word-specific rule is undefined.

Note that the feature specifications discovered by the minimal generalization learner do not use contrastive underspecification (e.g., Steriade 1995), but rather define natural classes using *all* of the features that the segments have in common. Thus, the set of features that define the natural class {*o,u*} includes not only [+syllabic], [−consonantal], [+back],[−low] and [+tense], but also features like [+voice], [−nasal], and so on.

The best rule in the grammar is rule number 59, which attaches -*i* after any consonant. This rule correctly accounts for all of the forms in the input data, achieving a confidence of .916.

a. Morphological rules in the absolute to ergative direction

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
1	*	∅ → i /			dap	___#	1	1	*undef*
2	*	∅ → i /			lot	___#	1	1	*undef*
3	1,2	∅ → i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {p,t}		___#	2	2	0.570
4	*	∅ → i /	=		gub	___#	1	1	*undef*
5	1,4	∅ → i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{lab} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ = {b,p}		___#	2	2	0.570
6	3,4	∅ → i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,p,t}		___#	3	3	0.718
7	*	∅ → i /	=		satʃ	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
8	1,7	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{t\textesh}},\text{p}\}$		___#	3	3	0.718
9	2,7	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{lab} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{t\textesh}},\text{t}\}$		___#	3	3	0.718
10	3,7	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{t\textesh}},\text{p},\text{t}\}$		___#	4	4	0.786
11	4,7	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{t\textesh}},\widehat{\text{d\textyogh}},\text{b},\text{p}\}$		___#	4	4	0.786
12	6,7	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{t\textesh}},\widehat{\text{d\textyogh}},\text{b},\text{d},\text{p},\text{t}\}$		___#	5	5	0.825
13	*	$\varnothing \to i$ /	=		rut$\widehat{\text{\textesh}}$	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
14	7,13	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{rnd} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{front} \\ +\text{tense} \end{bmatrix}$ = {a,o,u}	t͡ʃ	___#	2	2	0.570
15	*	$\varnothing \rightarrow$ i /	=		lag	___#	1	1	*undef*
16	1,15	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \end{bmatrix}$ = {b,g,k,p}		___#	6	6	0.852
17	2,15	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ = {d,g,k,t}		___#	5	5	0.825
18	3,15	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{ant} \end{bmatrix}$ = {b,d,g,k,p,t}		___#	7	7	0.872
19	4,15	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \end{bmatrix}$ = {b,g}		___#	2	2	0.570

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
20	7,15	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \\ +\text{distr} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,g,k}		___#	6	6	0.852
21	8,15	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{distr} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,g,k,p}		___#	8	8	0.887
22	9,15	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,d,g,k,t}		___#	7	7	0.872
23	10,15	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,d,g,k,p,t}		___#	9	9	0.898
24	*	$\emptyset \to i$ /	=		ban	___#	1	1	*undef*
25	1,24	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,m,n,p,t}		___#	4	4	0.786
26	2,24	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{strid} \\ -\text{dors} \end{bmatrix}$ = {d,n,t}		___#	2	2	0.570
27	3,24	$\emptyset \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,m,n}		___#	2	2	0.570

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
28	7,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ $= \{t͡ʃ,d͡ʒ,d,n,t\}$		___#	4	4	0.786
29	8,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{dors} \end{bmatrix}$ $= \{t͡ʃ,d͡ʒ,b,d,m,n,p,t\}$		___#	6	6	0.852
30	15,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{ŋ,d,g,n\}$		___#	2	2	0.570
31	16,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{ant} \end{bmatrix}$ $= \{ŋ,b,d,g,k,m,n,p,t\}$		___#	8	8	0.887
32	17,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{ŋ,d,g,k,n,t\}$		___#	6	6	0.852
33	19,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ +\text{ant} \end{bmatrix}$ $= \{ŋ,b,d,g,m,n\}$		___#	3	3	0.718
34	20,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \end{bmatrix}$ $= \{t͡ʃ,d͡ʒ,ŋ,d,g,k,n,t\}$		___#	8	8	0.887
35	21,24	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \end{bmatrix}$ $= \{t͡ʃ,d͡ʒ,ŋ,b,d,g,k,m,n,p,t\}$		___#	10	10	0.908
36	*	$\varnothing \to i$ /	=		yul	___#	1	1	*undef*
37	1,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ $= \{ð,θ,b,d,f,l,p,r,s,t,v,z\}$		___#	4	4	0.786

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
38	2,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ $= \{\text{d,l,r,t}\}$		___#	2	2	0.570
39	4,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ $= \{\text{ð,b,d,l,r,v,z}\}$		___#	2	2	0.570
40	7,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{tʃ}},\text{ð},\widehat{\text{dʒ}},\text{ʃ},\text{θ},\text{ʒ},\text{d,l,r,s,t,z}\}$		___#	4	4	0.786
41	8,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{\text{tʃ}},\text{ð},\widehat{\text{dʒ}},\text{ʃ},\text{θ},\text{ʒ},\text{b,d,f,l,p,r,s,t,v,z}\}$		___#	6	6	0.852
42	15,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{\text{ð,d,g,l,r,z,}\}$		___#	2	2	0.570
43	16,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{ant} \end{bmatrix}$ $= \{\text{ð,θ,b,d,f,g,k,l,p,r,s,t,v,x,z,}\}$		___#	8	8	0.887
44	17,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{\text{ð,θ,d,g,k,l,r,s,t,x,z,}\}$		___#	6	6	0.852
45	19,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ +\text{ant} \end{bmatrix}$ $= \{\text{ð,b,d,g,l,r,v,z,}\}$		___#	3	3	0.718

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
46	20,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \end{bmatrix}$ $= \{\widehat{tʃ},ð,\widehat{dʒ},ʃ,θ,ʒ,d,g,k,l,r,s,t,x,z,\}$		___#	8	8	0.887
47	21,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \end{bmatrix}$ $= \{\widehat{tʃ},ð,\widehat{dʒ},ʃ,θ,ʒ,b,d,f,g,k,l,p,r,s,t,v,x,z,\}$		___#	10	10	0.908
48	24,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{son} \\ +\text{voi} \\ -\text{lab} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ $= \{l,n,r\}$		___#	2	2	0.570
49	25,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ $= \{ð,θ,b,d,f,l,m,n,p,r,s,t,v,z\}$		___#	5	5	0.825
50	26,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ $= \{d,l,n,r,t\}$		___#	3	3	0.718
51	27,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ $= \{ð,b,d,l,m,n,r,v,z\}$		___#	3	3	0.718
52	28,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{tʃ},ð,\widehat{dʒ},ʃ,θ,ʒ,d,l,n,r,s,t,z\}$		___#	5	5	0.825
53	29,36	$\varnothing \rightarrow$ i /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{dors} \end{bmatrix}$ $= \{\widehat{tʃ},ð,\widehat{dʒ},ʃ,θ,ʒ,b,d,f,l,m,n,p,r,s,t,v,z\}$		___#	7	7	0.872

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
54	30,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{ð,ŋ,d,g,l,n,r,z,\}$		___#	3	3	0.718
55	31,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{ant} \end{bmatrix}$ $= \{ð,ŋ,θ,b,d,f,g,k,l,m,n,p,r,s,t,v,x,z,\}$		___#	9	9	0.898
56	32,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ +\text{ant} \end{bmatrix}$ $= \{ð,ŋ,θ,d,g,k,l,n,r,s,t,x,z,\}$		___#	7	7	0.872
57	33,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ +\text{ant} \end{bmatrix}$ $= \{ð,ŋ,b,d,g,l,m,n,r,v,z,\}$		___#	4	4	0.786
58	34,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \end{bmatrix}$ $= \{t͡ʃ,ð,d͡ʒ,ŋ,ʃ,θ,ʒ,d,g,k,l,n,r,s,t,x,z,\}$		___#	9	9	0.898
59	35,36	$\varnothing \to i$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \end{bmatrix}$ $= \{t͡ʃ,ð,d͡ʒ,ŋ,ʃ,θ,ʒ,b,d,f,g,k,l,m,n,p,r,s,t,v,x,z,\}$		___#	11	11	0.916
60	*	$k \to t͡ʃi$ /	=		ʔa	___#	1	1	*undef*
61	*	$k \to t͡ʃi$ /	=		mu	___#	1	1	*undef*
62	60,61	$k \to t͡ʃi$ /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{front} \\ +\text{tense} \end{bmatrix}$ $= \{a,o,u\}$		___#	3	3	0.718
63	*	$k \to t͡ʃi$ /	=		lo	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
64	60,63	$k \to \widehat{t\int}i$ /	X	$\begin{bmatrix} +syl \\ -cons \\ +son \\ +cont \\ -nas \\ +voi \\ -cor \\ +ant \\ +distr \\ +dors \\ -hi \\ -front \\ +tense \end{bmatrix}$ = {a,o}		___#	2	2	0.570
65	61,63	$k \to \widehat{t\int}i$ /	X	$\begin{bmatrix} +syl \\ -cons \\ +son \\ +cont \\ -nas \\ +voi \\ +lab \\ +rnd \\ -cor \\ +ant \\ +distr \\ +dors \\ -low \\ -front \\ +back \\ +tense \end{bmatrix}$ = {o,u}		___#	2	2	0.570

b. Phonological rule: /k/ → [$\widehat{t\int}$] / ___i

A.2.2   Using the grammar to derive ergatives for each word

The highest confidence rule in the grammar (number 59) applies to all 11 words in this hypothetical language; therefore, if we were to use the grammar to derive ergatives for each known absolute, this rule could always be used to attach *-i* with a confidence of .916. For words that end in *k* in the absolute, the phonological rule $k \to \widehat{t\int}$ / ___i would automatically change the *k* into a $\widehat{t\int}$.

A.2.3   Calculation of metrics in the *absolutive→ergative* direction

Accuracy

Rule 59, together with the phonological rule $k \to \widehat{t\int}$ / ___*i*, productively generates the correct output for all 11 words of the language. Therefore, the accuracy of this grammar is 100%.

Mean confidence of rules in the grammar

The mean confidence of the rules in the grammar is found by averaging the *confidence* values of the grammar; this value is .762.

Mean confidence of winning outputs

When the grammar is used to derive outputs productively for each known word, the same rule (number 59) is used in all cases; its confidence is .916, so the mean confidence of winning outputs in this direction is .916.

Average winning margin

This grammar yields just one output per form (attaching *-i*, along with palatalization in the case of *k*). Thus, there are no other competing outputs, so I will assume that the confidence in the second best output using this grammar is 0 (no second choice). This means that the average difference between the best form and the second form is, in this case, identical with the average confidence of the winning form: .916.

A.3 Ergative to absolutive direction

A.3.1 Grammar for the *ergative→absolutive* direction

a. Morphological rules in the ergative to absolutive direction

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
1	*	$i \rightarrow \emptyset$ /			dap	___#	1	1	*undef*
2	*	$i \rightarrow \emptyset$ /			lot	___#	1	1	*undef*
3	1,2	$i \rightarrow \emptyset$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {p,t}		___#	2	2	0.570
4	*	$i \rightarrow \emptyset$ /			gub	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
5	1,4	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{lab} \\ -\text{rd} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ = {b,p}		___#	2	2	0.570
6	2,4	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,p,t}		___#	3	3	0.718
7	*	i → ∅ /			sat͡ʃ	___#	1	1	*undef*
8	1,7	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{rd} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,p}		___#	3	6	0.351
9	2,7	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,t}		___#	3	6	0.351
10	3,7	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{voi} \\ -\text{rd} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,p,t}		___#	4	7	0.428

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
11	4,7	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ +\text{distr} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,p}		___#	4	7	0.428
12	6,7	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,d,p,t}		___#	5	8	0.489
13	*	i → ∅ /			rut͡ʃ	___#	1	1	*undef*
14	7,13	i → ∅ /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{front} \\ +\text{tense} \end{bmatrix}$ = {a,o,u}	t͡ʃ	___#	2	5	0.254
15	*	i → ∅ /			lag	___#	1	1	*undef*
16	1,15	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \end{bmatrix}$ = {b,g,k,p}		___#	3	3	0.718
17	2,15	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {d,g,k,t}		___#	2	2	0.570

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
18	3,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {b,d,g,k,p,t}		___#	4	4	0.786
19	4,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{rd} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \end{bmatrix}$ = {b,g}		___#	2	2	0.570
20	7,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \\ +\text{distr} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,g,k}		___#	3	6	0.351
21	8,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \\ +\text{distr} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,g,k,p}		___#	5	8	0.489
22	9,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,d,g,k,t}		___#	4	7	0.428
23	10,15	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{son} \\ -\text{cont} \\ -\text{nas} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,d,g,k,p,t}		___#	6	9	0.537
24	*	$i \rightarrow \varnothing$ /			ban	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
25	1,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,m,n,p,t}		___#	4	4	0.786
26	2,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ = {d,n,t}		___#	2	2	0.570
27	4,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {b,d,m,n}		___#	2	2	0.570
28	7,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,d,n,t}		___#	4	7	0.428
29	8,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{rd} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,b,d,m,n,p,t}		___#	6	9	0.537
30	15,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ŋ,d,g,n}		___#	2	2	0.570
31	16,24	$i \rightarrow \varnothing$ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ŋ,b,d,g,k,m,n,p,t}		___#	5	5	0.825

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
32	17,24	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ŋ,d,g,k,n,t}		___#	3	3	0.718
33	19,24	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ŋ,b,d,g,m,n}		___#	3	3	0.718
34	20,24	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{lab} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,ŋ,d,g,k,n,t}		___#	5	8	0.489
35	21,24	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{cont} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,d͡ʒ,ŋ,b,d,g,k,m,n,p,t}		___#	7	10	0.579
36	*	i → ∅ /			yul	___#	1	1	*undef*
37	1,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {ð,θ,b,d,f,l,p,r,s,t,v,z}		___#	4	4	0.786
38	2,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ = {d,l,r,t}		___#	2	2	0.570
39	4,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {ð,b,d,l,r,v,z}		___#	2	2	0.570

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
40	7,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,d,l,r,s,t,z}		___#	4	7	0.428
41	8,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{rd} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,b,d,f,l,p,r,s,t,v,z}		___#	6	9	0.537
42	15,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,d,g,l,r,z,}		___#	2	2	0.570
43	16,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,θ,b,d,f,g,k,l,p,r,s,t,v,x,z,}		___#	5	5	0.825
44	17,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,θ,d,g,k,l,r,s,t,x,z,}		___#	3	3	0.718
45	19,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,b,d,g,l,r,v,z,}		___#	3	3	0.718
46	20,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{lab} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,d,g,k,l,r,s,t,x,z,}		___#	5	8	0.489

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
47	21,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{nas} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,b,d,f,g,k,l,p,r,s,t,v,x,z,}		___#	7	10	0.579
48	24,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{son} \\ +\text{voi} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ = {l,n,r}		___#	2	2	0.570
49	25,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {ð,θ,b,d,f,l,m,n,p,r,s,t,v,z}		___#	5	5	0.825
50	26,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ +\text{ant} \\ -\text{distr} \\ -\text{dors} \end{bmatrix}$ = {d,l,n,r,t}		___#	3	3	0.718
51	27,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \\ -\text{dors} \end{bmatrix}$ = {ð,b,d,l,m,n,r,v,z}		___#	3	3	0.718
52	28,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ -\text{rd} \\ +\text{cor} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,d,l,n,r,s,t,z}		___#	5	8	0.489
53	29,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{rd} \\ -\text{dors} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ʃ,θ,Z,b,d,f,l,m,n,p,r,s,t,v,z}		___#	7	10	0.579

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
54	30,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,ŋ,d,g,l,n,r,z,}		___#	3	3	0.718
55	31,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,ŋ,θ,b,d,f,g,k,l,m,n,p,r,s,t,v,x,z,}		___#	6	6	0.852
56	32,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,ŋ,θ,d,g,k,l,n,r,s,t,x,z,}		___#	4	4	0.786
57	33,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ +\text{voi} \\ -\text{rd} \\ +\text{ant} \end{bmatrix}$ = {ð,ŋ,b,d,g,l,m,n,r,v,z,}		___#	4	4	0.786
58	34,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{lab} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ŋ,ʃ,θ,Z,d,g,k,l,n,r,s,t,x,z,}		___#	6	9	0.537
59	35,36	i → ∅ /	X	$\begin{bmatrix} -\text{syl} \\ +\text{cons} \\ -\text{rd} \end{bmatrix}$ = {t͡ʃ,ð,d͡ʒ,ŋ,ʃ,θ,Z,b,d,f,g,k,l,m,n,p,r,s,t,v,x,z,}		___#	8	11	0.612
60	*	t͡ʃi → k /			ʔa	___#	1	1	*undef*
61	*	t͡ʃi → k /			mu	___#	1	1	*undef*
62	60,61	t͡ʃi → k /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{front} \\ +\text{tense} \end{bmatrix}$ = {a,o,u}		___#	3	5	0.420
63	*	t͡ʃi → k /			lo	___#	1	1	*undef*

no.	parents	change	residue	shared features	shared segments	change location	hits	scope	confidence
64	60,63	$\widehat{t\int}i \to k$ /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{hi} \\ -\text{front} \\ +\text{tense} \end{bmatrix}$ = {a,o}		___#	2	3	0.396
65	61,63	$\widehat{t\int}i \to k$ /	X	$\begin{bmatrix} +\text{syl} \\ -\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{nas} \\ +\text{voi} \\ +\text{lab} \\ +\text{rd} \\ -\text{cor} \\ +\text{ant} \\ +\text{distr} \\ +\text{dors} \\ -\text{low} \\ -\text{front} \\ +\text{back} \\ +\text{tense} \end{bmatrix}$ = {o,u}		___#	2	3	0.396

b. Phonological rules: *none*

A.3.2 Using the grammar to derive absolutives for each word

In this direction, the grammar can potentially produce multiple outputs, because there are some rules that simply remove the final *i* of the ergative, and other rules simultaneously remove the *i* and change the *k* to a $\widehat{t\int}$. When the grammar is used to derive absolutives for each word in the ergative form, two patterns emerge:

- Words ending in sequences other than -$\widehat{t\int}i$ have only one possible absolutive, which is the ergative minus the final -*i*—e.g., *dapi* → *dap*, *loti* → *lot*, and so on. (There are 6 such words in this hypothetical language.) The best way to derive these words is with a rule removing -*i* after anything other than an affricate (rule 55), with a confidence of .852.

- Words ending in -$\widehat{t\int}i$ have two possible outputs: one with -$\widehat{t\int}i$ (e.g., *lo$\widehat{t\int}i$* → *lo$\widehat{t\int}$*), derived by a rule removing -*i* after any consonant (rule 59) with a confidence of .612. The second, less preferred output is one with *k* (e.g., *loki*), using the -$\widehat{t\int}i$ → -*k* change (rule 62), which works for 3 out of 5 of the relevant words in the vocabulary, and has a confidence of .420.

A.3.3 Calculation of metrics in the *ergative→absolutive* direction

Accuracy

The productively preferred output is always the one in which -*i* has simply been removed; this is correct for 8 out of 11 of the words in this language, but incorrect for the three which end in *k* in the absolutive. Therefore, the accuracy of the grammar in this direction is 8/11 = 73%.

Mean confidence of rules in the grammar

Averaging the confidence scores in the table above yields a mean confidence of .585 for the rules in the ergative to absolutive direction.

Mean confidence of winning outputs

As described above, six of the winning outputs are derived with a confidence of .852, while the remaining five are derived with a confidence of .612. This yields a mean confidence of .743 in the winning outputs.

Average winning margin

Six of the outputs have no competitor at all, so win by their full confidence of .852. For the five words ending in -$\widehat{tʃ}i$, the outputs with $\widehat{tʃ}$ beat the outputs with *k* by only .612 − .420 = .192. Thus, the mean winning margin in this direction is .552.

Appendix B

Metrics for base selection in Latin

Table B.1 lists all of the effectiveness measures of each of the six candidates for base status, based on the 494 most frequent Latin nouns. Rows indicate the input forms, and columns indicate the output forms; for example, the average winner confidence for the *nom.→gen.* mapping is 0.76, in the upper left.

Table B.1: Base selection metrics for Latin noun paradigms

	↓In/Out→nom.sg.	gen.sg.	dat.sg.	acc.sg.	abl.sg.	nom.pl.	**sum**
Avg winner:	nom.sg.	0.76	0.70	0.86	0.82	0.76	**0.78**
Avg margin:		0.66	0.59	0.77	0.68	0.65	**0.67**
Percent correct:		0.82	0.77	0.87	0.85	0.80	**0.82**
Avg grammar:		0.35	0.31	0.45	0.33	0.33	**0.35**
Avg winner:	gen.sg.	0.88		0.97	0.94	0.96	0.95	**0.94**
Avg margin:		0.69		0.92	0.91	0.91	0.79	**0.84**
Percent correct:		0.93		0.97	0.96	0.96	0.94	**0.95**
Avg grammar:		0.45		0.70	0.67	0.69	0.53	**0.61**
Avg winner:	dat.sg.	0.86	0.97		0.94	0.96	0.95	**0.94**
Avg margin:		0.69	0.93		0.89	0.91	0.81	**0.85**
Percent correct:		0.92	0.98		0.96	0.97	0.96	**0.96**
Avg grammar:		0.43	0.81		0.59	0.65	0.43	**0.58**
Avg winner:	acc.sg.	0.89	0.91	0.90		0.91	0.90	**0.90**
Avg margin:		0.76	0.82	0.80		0.79	0.77	**0.79**
Percent correct:		0.95	0.94	0.92		0.93	0.92	**0.93**
Avg grammar:		0.55	0.73	0.60		0.60	0.53	**0.60**
Avg winner:	abl.sg.	0.86	0.96	0.96	0.95		0.94	**0.93**
Avg margin:		0.68	0.93	0.90	0.91		0.85	**0.85**
Percent correct:		0.92	0.97	0.97	0.97		0.95	**0.95**
Avg grammar:		0.45	0.78	0.72	0.72		0.56	**0.65**
Avg winner:	nom.pl	0.84	0.94	0.92	0.92	0.92		**0.91**
Avg margin:		0.69	0.76	0.81	0.86	0.81		**0.79**
Percent correct:		0.89	0.94	0.94	0.94	0.94		**0.93**
Avg grammar:		0.50	0.69	0.56	0.66	0.62		**0.61**