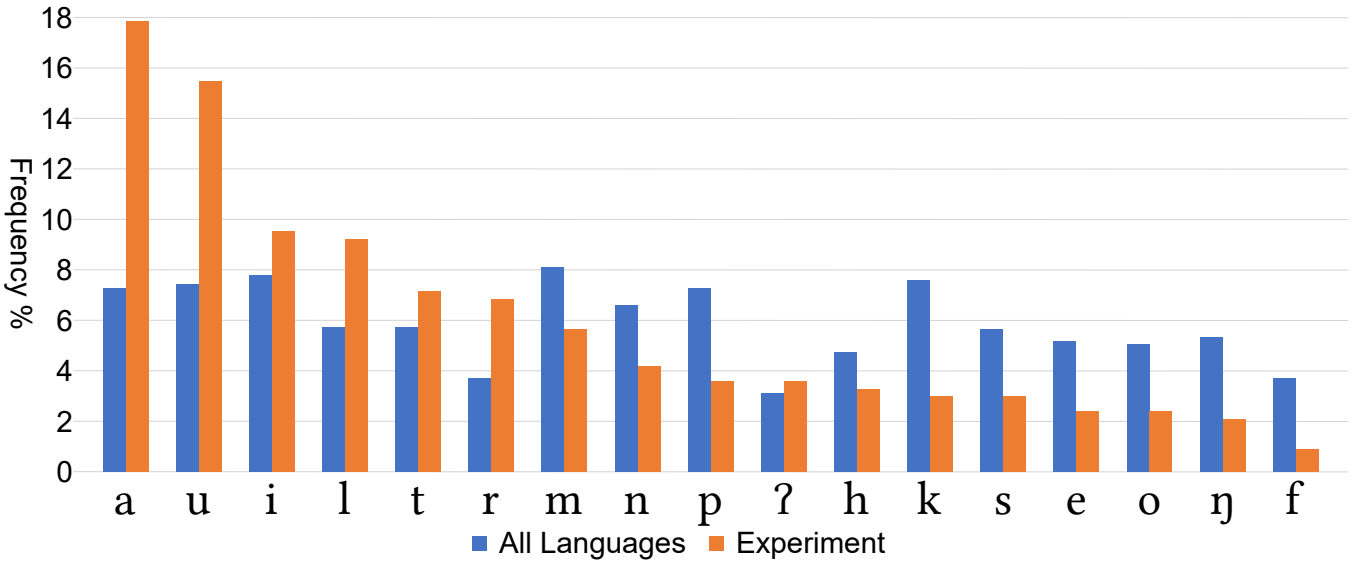
Appendix 1 - Prior Segment Frequencies



Appendix 2 - Prior Frequencies

	e	i	a	u	o	m	n	ŋ	l	r	t	p	ʔ	h	s	k	f
e									3					3			
i									4	1	4	3		4	2		
a				1			2	1	1	5			6	2	4	2	3
u			1						5	5	8		7	1	2	6	
o								3	1	2							
m																	
n			2					5									
ŋ			1		3		5										
l	3	4	1	5	1					21	7						
r		1	5	5	2				21		7						
t		4		8					7	7			6				
p		3															6
ʔ			6	7							6					8	
h	3	4	2	1											10		
s		2	4	2										10			
k			2	6									8				
f			3									6					

Appendix 2 - Prior Frequencies

o → l

Sleep.Primary					
u	r	o	ŋ	-
k	u	l	o	m

ŋ → a

White.Primary				
t	i	a	ŋ	-
t	i	ʔ	a	n

r → i

Fish.Primary				
k	u	r	i	l
u	t	i	l	-

u → h

Walk.Primary					
u	t	u	ʔ	-
h	u	t	u	p

u → a

Black.Primary			
a	u	-	-
ʔ	a	ʔ	u

l → o

Sleep.Primary					
k	u	l	o	m
u	r	o	ŋ	-

a → l

Water.Primary				
i	a	r	a	-
i	s	a	l	a

a → ŋ

White.Primary					
t	i	ʔ	a	n
t	i	a	ŋ	-

l → a

Water.Primary					
i	s	a	l	a
i	a	r	a	-

i → r

Fish.Primary					
u	t	i	l	-
k	u	r	i	l

h → u

Walk.Primary					
h	u	t	u	p
u	t	u	ʔ	-

Appendix 2 - Prior Frequencies

a → u

Black.Primary			
ʔ	a	ʔ	u
a	u	-	-

s → u

Walk.Primary				
s	u	r	u	p
u	t	u	ʔ	-

Walk.Primary				
s	u	l	u	p
u	t	u	ʔ	-

n → a

White.Primary				
t	i	a	n	-
t	i	ʔ	a	n

White.Primary				
t	i	a	n	-
t	i	ʔ	a	n

o → r

Sleep.Primary				
u	r	o	ŋ	-
ʔ	u	r	o	m

Sleep.Primary				
u	r	o	ŋ	-
k	u	r	o	m

k → a

Black.Primary			
a	k	u	-
ʔ	a	ʔ	u

Black.Primary			
a	k	u	-
ʔ	a	ʔ	u

s → i

Wind.Primary			
s	i	r	u
i	t	u	-

Wind.Primary			
s	i	l	u
i	t	u	-

u → s

Walk.Primary				
u	t	u	ʔ	-
s	u	r	u	p

Walk.Primary				
u	t	u	ʔ	-
s	u	l	u	p

a → n

White.Primary				
t	i	ʔ	a	n
t	i	a	n	-

White.Primary				
t	i	ʔ	a	n
t	i	a	n	-

a → k

Black.Primary			
ʔ	a	ʔ	u
a	k	u	-

Black.Primary			
ʔ	a	ʔ	u
a	k	u	-

h → a

Water.Primary				
i	h	a	r	a
i	a	r	a	-

Grass.Primary				
h	a	p	i	ʔ
a	f	i	-	-

i → s

Wind.Primary			
i	t	u	-
s	i	r	u

Wind.Primary			
i	t	u	-
s	i	l	u

Appendix 2 - Prior Frequencies

r → o

Sleep.Primary				
ʔ	u	r	o	m
u	r	o	ŋ	-

Sleep.Primary				
k	u	r	o	m
u	r	o	ŋ	-

a → h

Water.Primary				
i	a	r	a	-
i	h	a	r	a

Grass.Primary				
a	f	i	-	-
h	a	p	i	ʔ

p → i

Grass.Primary				
h	a	p	i	ʔ
a	f	i	-	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

h → e

Child.Primary			
h	e	l	u
e	l	u	-

Child.Primary			
h	e	l	u
e	l	u	-

Child.Primary			
h	e	l	u
e	l	u	-

e → l

Child.Primary			
h	e	l	u
e	l	u	-

Child.Primary			
h	e	l	u
e	l	u	-

Child.Primary			
h	e	l	u
e	l	u	-

l → e

Child.Primary			
e	l	u	-
h	e	l	u

Child.Primary			
e	l	u	-
h	e	l	u

Child.Primary			
e	l	u	-
h	e	l	u

ŋ → o

Sleep.Primary				
u	r	o	ŋ	-
ʔ	u	r	o	m

Sleep.Primary				
u	r	o	ŋ	-
k	u	r	o	m

Sleep.Primary				
u	r	o	ŋ	-
k	u	l	o	m

o → ŋ

Sleep.Primary				
ʔ	u	r	o	m
u	r	o	ŋ	-

Sleep.Primary				
k	u	r	o	m
u	r	o	ŋ	-

Sleep.Primary				
k	u	l	o	m
u	r	o	ŋ	-

a → f

Grass.Primary				
h	a	p	i	ʔ
a	f	i	-	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

i → p

Grass.Primary				
a	f	i	-	-
h	a	p	i	ʔ

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

e → h

Child.Primary			
e	l	u	-
h	e	l	u

Child.Primary			
e	l	u	-
h	e	l	u

Child.Primary			
e	l	u	-
h	e	l	u

Appendix 2 - Prior Frequencies

f → a

Grass.Primary				
a	f	i	-	-
h	a	p	i	ʔ

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

t → i

Fish.Primary				
ʔ	u	t	i	l
u	t	i	l	-

Wind.Primary			
i	t	u	-
h	i	t	u

Wind.Primary			
i	t	u	-
s	i	r	u

Wind.Primary			
i	t	u	-
s	i	l	u

a → s

Water.Primary				
i	a	r	a	-
i	s	a	r	a

Water.Primary				
i	a	r	a	-
i	s	a	l	a

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

Grass.Primary				
a	f	i	-	-
s	a	p	i	-

i → h

Wind.Primary				
i	t	u	-	
h	i	t	u	

Green.Primary					
l	a	i	-	-	
l	a	h	i	ʔ	

Green.Primary					
l	a	i	-	-	
l	a	h	i	k	

Green.Primary					
l	a	i	-	-	
l	a	h	i	k	

h → i

Wind.Primary				
h	i	t	u	
i	t	u	-	

Green.Primary					
l	a	h	i	ʔ	
l	a	i	-	-	

Green.Primary					
l	a	h	i	k	
l	a	i	-	-	

Green.Primary					
l	a	h	i	k	
l	a	i	-	-	

i → t

Fish.Primary				
u	t	i	l	-
ʔ	u	t	i	l

Wind.Primary			
h	i	t	u
i	t	u	-

Wind.Primary			
s	i	r	u
i	t	u	-

Wind.Primary			
s	i	l	u
i	t	u	-

i → l

Fish.Primary					
ʔ	u	t	i	l	
u	t	i	l	-	

Fish.Primary					
u	t	i	l	-	
k	u	l	i	l	

Fish.Primary					
k	u	r	i	l	
u	t	i	l	-	

Fish.Primary					
k	u	l	i	l	
u	t	i	l	-	

s → a

Water.Primary				
i	s	a	r	a
i	a	r	a	-

Water.Primary				
i	s	a	l	a
i	a	r	a	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

Grass.Primary				
s	a	p	i	-
a	f	i	-	-

l → i

Fish.Primary					
u	t	i	l	-	
ʔ	u	t	i	l	

Fish.Primary					
u	t	i	l	-	
k	u	r	i	l	

Fish.Primary					
u	t	i	l	-	
k	u	l	i	l	

Fish.Primary					
k	u	l	i	l	
u	t	i	l	-	

Appendix 3 - Symbols

Ψ Phylogeny
The (possibly unknown) relationship between entities resulting from an evolutionary tree

τ Tree topology
Information on the relationships of the languages

μ Substitution rate
the rate at which the language changes

N Sampled languages
The number of languages in a sample

ν Expected events
The expected number of evolutionary events that occurred between two languages

t Past times
Times of branch events

$\mathscr{B}$ Possible rooted trees

$\mathbf{A}$ Segmental alignment
Constructed by combining the word segment information for the languages of interest with information on the homology of the segments

$\mathbf{S}$ Segmental information
Information on the homology of the segments

$\mathbf{s}$ Segment
Linguistic segment

$\mathbf{s}_i$ ith segment

$\mathbf{H}$ Homology map
The map describing the alignment of the segments

$\mathbf{Q}$ Rate Matrix

β Rate matrix scaling factor
Scales the rate matrix such that the average rate of segmental substitution is one

$\mathbf{P}$ Probability
The probability the process ends in certain state

P Marginal Likelihood
The probability of an event ocurring

π Equilibrium distribution

λ Rate of segment insertion

μ Rate of segment deletion

n Word length

Number of segments in a word

r Rate parameter

θ Rate parameters

Parameters associated with the rate matrix

θ' Proposal

New value proposal

q Proposal probability

Probability of new proposal

u Random number

R Acceptance probability

Probability of accepting a proposed value

$\mathscr{M}$ Model

Mathematical model for linguistic parameters

BF Bayes Factor

A numerical factor related to the quality of the model fit

X Unknown

Appendix 4 - Words containing each segment

a 0061 8

ihara iara isara isala naʔ na nak nak popat fofaʔ popat popat lami lami lami lami narit nariʔ narit nalit mumaŋ mumaŋ mumaŋ mumaŋ alah ala alas alas atar atar arar alal ʔaʔu au aku aku tiʔan tiaŋ tian tian lahiʔ lai lahik lahik hapiʔ afi sapi sapi

e 0065 15

helu elu helu helu tetu tetu teru telu

f 0066 13

fofaʔ afi

h 0068 7

ihara hitu helu helu helu alah hutup lahiʔ lahik lahik hapiʔ

i 0069 3

ʔutil util kuril kulil ihara iara isara isala hitu itu siru silu lami lami lami lami narit nariʔ narit nalit tiʔan tiaŋ tian tian lahiʔ lai lahik lahik hapiʔ afi sapi sapi

k 006B 5

kuril kulil nak nak kurom kulom aku aku lahik lahik

l 006C 4

ʔutil util kuril kulil isala ulu silu lami lami lami lami nalit helu elu helu helu alah ala alas alas sulup lumun kulom alal telu lahiʔ lai lahik lahik

m 006D 14

lami lami lami lami mumaŋ mumaŋ mumaŋ mumaŋ rumun rumuŋ rumun lumun ʔurom kurom kulom

n 006E 10

naʔ na nak nak narit nariʔ narit nalit rumun rumun lumun tiʔan tian tian

o 006F 12

popat fofaʔ popat popat ʔurom uroŋ kurom kulom

p 0070 11

popat popat popat hutup surup sulup hapiʔ sapi sapi

r 0072 6

kuril ihara iara isara uruʔ uru uru siru narit nariʔ narit surup rumun rumuŋ rumun ʔurom uroŋ kurom atar atar arar teru

s 0073 9

isara isala siru silu alas alas surup sulup sapi sapi

t 0074 2

ʔutil util popat popat popat hitu itu narit narit nalit hutup utuʔ atar atar tiʔan tiaŋ tian tian tetu tetu teru telu

Appendix 4 - Words containing each segment

u 0075 1

ʔutil util kuril kulil uruʔ uru uru ulu hitu itu siru silu helu elu helu helu mumaŋ mumaŋ mumaŋ mumaŋ hutup utuʔ surup sulup rumun rumuŋ rumun lumun ʔurom uroŋ kurom kulom ʔaʔu au aku aku tetu tetu teru telu

ŋ 014B 16

mumaŋ mumaŋ mumaŋ mumaŋ rumuŋ uroŋ tiaŋ

ʔ 0294 0

ʔutil naʔ fofaʔ uruʔ nariʔ utuʔ ʔurom ʔaʔu tiʔan lahiʔ hapiʔ

Appendix 5 - Word Lists by Language

Language A

Cognate	IPA	Sounds
Fish-Primary	ʔutil	GlottalStop-u-t-e-l
Water-Primary	ihara	e-h-ah-r-ah
Earth-Primary	naʔ	n-ah-GlottalStop
Rain-Primary	popat	p-oh-p-ah-t
Cloud-Primary	uruʔ	u-r-u-GlottalStop
Wind-Primary	hitu	h-e-t-u
Man-Primary	lami	l-ah-m-e
Woman-Primary	narit	n-ah-r-e-t
Child-Primary	helu	h-ay-l-u
House-Primary	mumaŋ	m-u-m-ah-nya
Forest-Primary	alah	ah-l-ah-h
Walk-Primary	hutup	h-u-t-u-p
Speak-Primary	rumun	r-u-m-u-n
Sleep-Primary	ʔurom	GlottalStop-u-r-oh-m
Bathe-Primary	atar	ah-t-ah-r
Black-Primary	ʔaʔu	GlottalStop-ah-GlottalStop-u
White-Primary	tiʔan	t-e-GlottalStop-ah-n
Red-Primary	tetu	t-ay-t-u
Green-Primary	lahiʔ	l-ah-h-e-GlottalStop
Grass-Primary	hapiʔ	h-ah-p-e-GlottalStop

Language B

Cognate	IPA	Sounds
Fish-Primary	util	u-t-e-l
Water-Primary	iara	e-ah-r-ah
Earth-Primary	na	n-ah
Rain-Primary	fofaʔ	f-oh-f-ah-GlottalStop
Cloud-Primary	uru	u-r-u
Wind-Primary	itu	e-t-u
Man-Primary	lami	l-ah-m-e
Woman-Primary	nariʔ	n-ah-r-e-GlottalStop
Child-Primary	elu	ay-l-u
House-Primary	mumaŋ	m-u-m-ah-nya
Forest-Primary	ala	ah-l-ah
Walk-Primary	utuʔ	u-t-u-GlottalStop
Speak-Primary	rumuŋ	r-u-m-u-nya
Sleep-Primary	uroŋ	u-r-oh-nya
Bathe-Primary	atar	ah-t-ah-r
Black-Primary	au	ah-u
White-Primary	tiaŋ	t-e-ah-nya
Red-Primary	tetu	t-ay-t-u
Green-Primary	lai	l-ah-e
Grass-Primary	afi	ah-f-e

Language C

Cognate	IPA	Sounds
Fish-Primary	kuril	k-u-r-e-l
Water-Primary	isara	e-s-ah-r-ah
Earth-Primary	nak	n-ah-k

Rain-Primary	popat	p-oh-p-ah-t
Cloud-Primary	uru	u-r-u
Wind-Primary	siru	s-e-r-u
Man-Primary	lami	l-ah-m-e
Woman-Primary	narit	n-ah-r-e-t
Child-Primary	helu	h-ay-l-u
House-Primary	mumaŋ	m-u-m-ah-nya
Forest-Primary	alas	ah-l-ah-s
Walk-Primary	surup	s-u-r-u-p
Speak-Primary	rumun	r-u-m-u-n
Sleep-Primary	kurom	k-u-r-oh-m
Bathe-Primary	arar	ah-r-ah-r
Black-Primary	aku	ah-k-u
White-Primary	tian	t-e-ah-n
Red-Primary	teru	t-ay-r-u
Green-Primary	lahik	l-ah-h-e-k
Grass-Primary	sapi	s-ah-p-e

Language D

Cognate	IPA	Sounds
Fish-Primary	kulil	k-u-l-e-l
Water-Primary	isala	e-s-ah-l-ah
Earth-Primary	nak	n-ah-k
Rain-Primary	popat	p-oh-p-ah-t
Cloud-Primary	ulu	u-l-u
Wind-Primary	silu	s-e-l-u
Man-Primary	lami	l-ah-m-e
Woman-Primary	nalit	n-ah-l-e-t
Child-Primary	helu	h-ay-l-u
House-Primary	mumaŋ	m-u-m-ah-nya
Forest-Primary	alas	ah-l-ah-s
Walk-Primary	sulup	s-u-l-u-p
Speak-Primary	lumun	l-u-m-u-n
Sleep-Primary	kulom	k-u-l-oh-m
Bathe-Primary	alal	ah-l-ah-l
Black-Primary	aku	ah-k-u
White-Primary	tian	t-e-ah-n
Red-Primary	telu	t-ay-l-u
Green-Primary	lahik	l-ah-h-e-k
Grass-Primary	sapi	s-ah-p-e

Appendix 6 - Segment Groups

Where symbols appear in pairs, the one to the right represents a rounded vowel.

Vowel

	Front	Near-Front	Central	Near-Back	Back
Close	i				u
Near-close					
Close-mid	e				o
Mid					
Open-mid					
Near-open					
Open		a			

Long-Vowel

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					
Open-mid					
Near-open					
Open					

Nasal-Vowel

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					
Open-mid					
Near-open					
Open					

Long-Nasal-Vowel

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					

Open-mid					
Near-open					
Open					

Vowel-Diphthong

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					
Open-mid					
Near-open					
Open					

Nasal-Vowel-Diphthong

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					
Open-mid					
Near-open					
Open					

Vowel-Non-Sylabic

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					
Mid					
Open-mid					
Near-open					
Open					

Vowel-Diphthong-Non-Sylabic

	Front	Near-Front	Central	Near-Back	Back
Close					
Near-close					
Close-mid					

Mid					
Open-mid					
Near-open					
Open					

Pulmonic Consonants

Manner	Bilabial	Labio-Dental	Alveolar	Velar	Glottal
Nasal, Stop					
Nasal	m		n	ŋ	
Stop	p		t	k	ʔ
Sibilant, Fricative			s		
Fricative		f			h
Approximant					
Tap/Flap					
Trill			r		
Lateral, Fricative					
Lateral, Approximant			l		
Lateral, Tap/Flap					

Shaded areas denote articulations judged to be impossible. Where symbols appear in pairs, the one to the right represents a modally voiced consonant.

Non-Pulmonic Consonants

Manner
Stop
Ejective, Stop
Ejective, Fricative
Ejective, Lateral, Fricative
Tenuis, Click
Nasal, Click
Tenuis, Lateral, Click
Implosive
Lateral, Approximant

Shaded areas denote articulations judged to be impossible. Where symbols appear in pairs, the one to the right represents a modally voiced consonant.

Pulmonic Affricates

Manner
Sibilant
Lateral
Voiced
Non-Sibilant

Shaded areas denote articulations judged to be impossible.

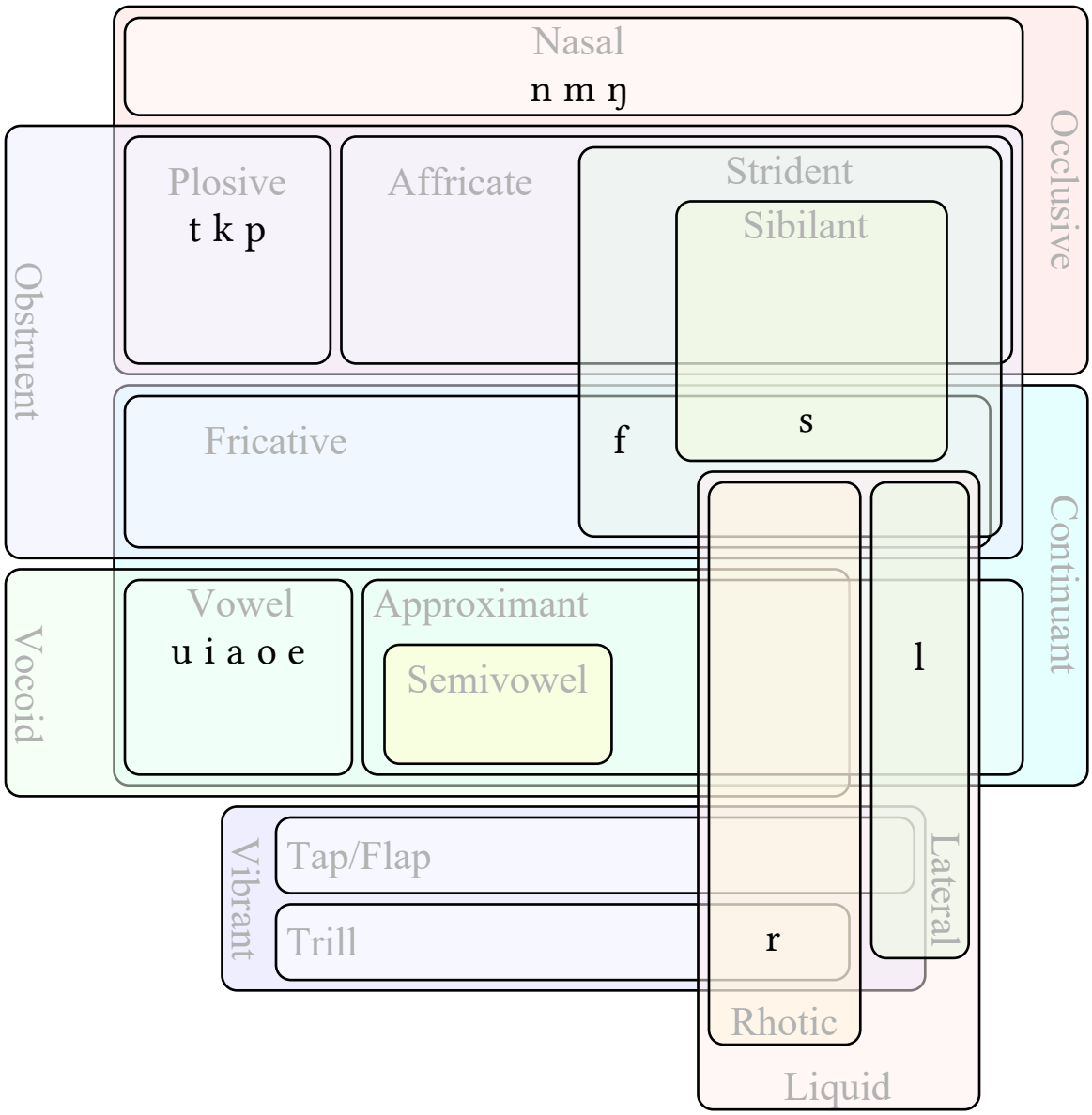
Ejective Affricates

Manner
Central
Lateral

Shaded areas denote articulations judged to be impossible.

Other Segments

Appendix 7 - Euler Feature Diagram



IPA Segments

a 0061 Open Near-Front Vocoid Vowel Continuant Parent Vowel	e 0065 Close-mid Front Vocoid Vowel Continuant Parent Vowel	f 0066 Labio-Dental Pulmonic Fricative Strident Obstruent Continuant Labial Dental	h 0068 Glottal Pulmonic Fricative
i 0069 Close Front Vocoid Vowel Continuant Parent Vowel	k 006B Velar Pulmonic Stop Occlusive	l 006C Alveolar Vocoid Voiced Pulmonic Lateral Approximant Rhotic Liquid	m 006D Bilabial Voiced Pulmonic Nasal Occlusive
n 006E Alveolar Voiced Pulmonic Nasal Occlusive	o 006F Close-mid Back Rounded Vocoid Vowel Continuant Parent Vowel	p 0070 Bilabial Pulmonic Stop Occlusive	r 0072 Alveolar Voiced Pulmonic Trill Rhotic Vibrant Liquid
s 0073 Alveolar Pulmonic Sibilant Fricative Strident Obstruent Continuant	t 0074 Alveolar Pulmonic Stop Occlusive	u 0075 Close Back Rounded Vocoid Vowel Continuant Parent Vowel	ŋ 014B Velar Voiced Pulmonic Nasal Occlusive
ʔ 0294 Glottal Pulmonic Stop			

Appendix 9 - Feature Tree

Diacritics

	Undefined escape character	˜	Nasalized	¨	Centralized
˖	Advanced	˗	Retracted	ˇ	RisingTone
°	Voiceless		Implosive	ˈ	Syllabic
ʼ	Ejective	ˤ	Pharyngealized	˄	Falling tone
◠	Non-syllabic	˺	No audible release	˞	Rhotic hook
˧	Advanced tongue root	˼	Apical	˝	Extra low tone
˛	Less rounded	˽	Dental	˜	Velarized or Pharyngealized
↘	Global fall	ˠ	Velarized	ˊ	High tone
h	Aspirated	j	Palatalized	˜	Creaky voiced
ˋ	Low tone	l	Lateral release	ˉ	Mid tone
◻	Laminal	˓	Linguo-Labial	n	Nasal release
˒	More rounded	˕	Lowered	˦	Retracted tongue root
↗	Global rise	˔	Raised	˝	Extra high tone
¨	Breathy voiced	ˇ	Voiced	w	Labialized
˘	Extra short	ˣ	Mid-centralized	↓	Down-step
↑	Up-step	ˑ	Long	˙	Half-long
	Indeterminacy in french vowels		Begin Non-segmental notation		End non-segmental notation
ʢ	Voiced epiglottal fricative	!	Post-alveolar click	ǀ	Minor group
ǀ	Dental click	‖	Major group	‖	Alveolar lateral click
ǂ	Palatal click	°	Voiceless descender	‾	Combining macron
‿	Tie-bar below	⁀	Tie-bar above	ɫ	Ready made combination
→	Becomes		Separator		

Language A

A test language.

This language is not real

Language B

A test language.

This language is not real

Language C

A test language.

This language is not real

Language D

A test language.

This language is not real