lɐl–\ɾɹɪɥɔ–ɒɪ ɹcl lɐl–ɒɪ ɹcl ɹɐᵓɾ(e–\ɥcᵊɒɪlɔ

aaaaaaaaaA, the language of *Rymako*

uruwi

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aaaaaaaaaaaaaaaa

A complete grammar

October 20, 2017

Dedicated to Isoraḳatheð.

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Branch: canon
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Contents

0.1 | Introduction

1 | Phonology and orthography

1.1 | Phoneme inventory

Table 1.1: The consonants of aaaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	m	n	ɲ	ŋ	
Plosive	p b	t d	c ɟ	k g	ʔ
Fricative	f	s	ʃ	x	
(coarticulated)	θx	fx		fʃ	
Affricate		ts	tʃ		
Lateral fricative		ɬ			
Approximant		ɹ	j	w	
Lateral approximant		l			
Trill		r			

Table 1.2: The vowels of aaaaaaaaaaA.

Spread	Half-rounded	Rounded
i	y̨	y
ɯ	u̜	u
ɛ		œ
ʌ		ɔ
ä		

In addition to consonants and vowels, aaaaaaaaaaA has rod signals, represented by numbers. Rod A is blue and held by one's dominant hand and B is red and held by one's non-dominant hand.

1. Rod A is raised to one's chest, while B is pointed down.
2. Rods A and B are crossed in the front.
3. Rod B is raised upwards in front of the nondominant arm, while rod A is lowered.

4. Rod A is pointed sideways near one's nondominant arm, while rod B is lowered.
5. Rods A and B are extended to the sides.
6. Rods A and B are extended, facing forward.
7. Rod A is raised forward, while B is pointed to the side.
8. Rod B is raised forward, while A is pointed to the side.

Lowering both rods is interpreted as an absence of a rod signal.
If the use of rods are unavailable, the numerals of the positions may be pronounced.

1.2 | Hacmisation

aaaaaaaaaA uses the hacm script with superscript letters to indicate phonemes not found in Arka. The transcriptions can be found in Tables 1.3 and 1.4.

Table 1.3: The consonants of aaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	ᴅ	ɳ	ɳʱ	ɳᵠ	
Plosive	d b	ɾ ɑ	ɾʱ ɑʱ	ɭ ᵩ	.
Fricative	ɑ	ɻ	ɭ	ɦ	
(coarticulated)	ɻʰ	ɑʰ		ɑˡ	
Affricate		ɾɻ	ɾɭ		
Lateral fricative		s			
Approximant		ᵨ	ʱ	o	
Lateral approximant		l			
Trill		ɳ			

Table 1.4: The vowels of aaaaaaaaaA.

Spread	Half-rounded	Rounded
c	cᵊ	cᵓ
əᶜ	ə	əᵓ
e		eᵓ
ɔᵉ		ɔ
ɪ		

Rod signs are represented by the hacm digits ⟨𞣇 𞣅 𞣈 𞣉 𞣊 𞣋 𞣌 𞣍⟩ attached to the end of the verbs they encompass. Proper words are preceded by a backslash ⟨\⟩.

Vowels that are inferrable from context are sometimes omitted. For example, /ɹɛfan/ (to speak) is written ⟨ᵨeɑn⟩, but /ɹɛfin/ (to spread), which is less common, is written ⟨ᵨeɑcn⟩, with the second vowel. Most of this grammar will leave all vowels written.

1.3 | Phonotactics

An onset consists of one of the following:

- any single consonant other than /l/ (the exceptions are ⟨lel⟩ [lɛk] and related words),
- any obstruent followed by an approximant other than /l/,
- or any plosive followed by /r/,
- or any nasal followed by /j/ or /w/.

A nucleus consists of one vowel.
A coda consists of one of the following:

- nothing,
- a nasal,
- a voiceless plosive (excluding /ʔ/),
- /ɹ/, /s/ or /l/

1.4 | Stress

Stress falls on the last syllable with a coda, or otherwise the second-to-last syllable. See table 1.5 for examples.

Table 1.5: Examples of stress locations.

Orthography	Location of stress (# from last)
ᴅɪjɪ	2
nɪ.cn	1
.əᶹʃəlɔ	2
lɪɲnedcᵊ	3

1.5 | Vowel harmony

For the purposes of vowel harmony, vowels are divided into front and back vowels. /a/ is neutral. A root with neither front nor back vowels acts as if it has front vowels.

2 | Syntax

2.1 | Basic word order

The basic word order is VSO. Descriptors follow what they modify.

2.2 | Questions

Binary questions have the interrogative polarity marker and no change to syntax.

In wh-questions, the wh-word is pulled to the front (i. e. before the verb). This requires case marking for the wh-word:

ɾlen ɲeɑcᵊʝhɪ nc͡ɔɣ
who-ACC speak-FAR.PAST-Q PR.FAR.SG
Whom did you speak to?

This applies only to questions, not interrogative-mood clauses that act as relative clauses:

ɲeɑcᵊʝhɪ nc͡ɔ ɾlel, ɥɪɾ ɲɔ.
speak-FAR.PAST-Q PR.FAR.SG who, see-NEAR.PAST PR.ANAPH_OBJ.INT
I saw the person whom you talked to.

2.3 | Multiple clauses

A sentence might have multiple clauses. Each clause in a sentence follows the basic VSO order, and clauses are separated with commas.

3 | Nouns

Nouns are declined for number, case and definiteness.

3.1 | Number

aaaaaaaaaaA has many grammatical numbers:

Table 3.1: The discrete grammatical numbers of aaaaaaaaaaA.

Number	Constraint on $x \in \mathbb{Z}$
Integral	none
Nullary	$x = 0$
Singular	$\lvert x \rvert = 1$
Dual	$\lvert x \rvert = 2$

Table 3.2: The continuous grammatical numbers of aaaaaaaaaaA.

Number	Constraint on $x \in \mathbb{R}$
Nullary	$x = 0$
Subsingular	$\lvert x \rvert < 1$
Supersingular	$1 \leq \lvert x \rvert < 2$
Plural	$\lvert x \rvert \geq 2$ or x is unknown

3.2 | Case

In a clause with both the subject and object directly expressed in that order, both the subject and object are declined in the nominative case (and their roles are inferred through word order). In a clause where only one is present, or where both are expressed in the opposite order, the subject will receive the nominative case and the object will receive the accusative case.

3.3 | Noun classes

There are three overarching groups of noun classes.

3.3.1 | Countable

Nouns in these classes are declined for a discrete number.

1. Sentient – such as humans, AIs, deities.
2. Animate – nonsentient animals.
3. Inanimate – anything else.

3.3.2 | Measurable

Nouns in this class are declined for a continuous number.

4. Measure – all measurable nouns, especially units of measurement.

3.3.3 | Uncountable

Nouns in these classes are not declined for number, and require compounding with a countable or measurable noun in order to be quantified.

5. Fluid – liquids and gases.
6. Edible – edible (to humans) non-fluids.
7. Inedible – inedible (to humans) non-fluids.
8. Abstract – abstract ideas.

3.4 | Definiteness

The definite form of a noun is formed regularly by reduplicating the first syllable (without the coda): ⟨ᴅɪjɪj⟩ “a person” becomes ⟨ᴅɪᴅɪjɪj⟩ “the person”.

3.5 | Declension table

3.5.1 | Countable classes

Note that noun declensions respect vowel harmony. For nouns with back vowels, replace the front vowels with the back vowels of the same height and rounding, and vice versa.

Table 3.3: Declensions for countable nouns.

	Integral	Nullary	Singular	Dual

	Integral	Nullary	Singular	Dual
Sentient: ⟨ᴅɪjɪ⟩ “person”				
Nominative	ᴅɪjɪ	ᴅɪjɪlе	ᴅɪjɪj	ᴅɪjɪl
Accusative	ᴅɪjɪn	ᴅɪjɪnᵠlе	ᴅɪjɪnᴄj	ᴅɪjɪnɪl
Sentient: ⟨ʲʰɪ.en⟩ “magician”				
Nominative	ʲʰɪ.en	ʲʰɪ.eɾе	ʲʰɪ.eȷ	ʲʰɪ.el
Accusative	ʲʰɪ.eɥᴄn	ʲʰɪ.enᵠlе	ʲʰɪ.eɥᴄj	ʲʰɪ.eɥᴄl
(Note that the final consonant is preserved only in the integral nominative form.)				
Animate: ⟨ᴅənᵠɔ⟩ “rabbit”				
Nominative	ᴅənᵠɔ	ᴅənᵠɔlɔᵉ	ᴅənᵠɔj	ᴅənᵠɔ.əᶜ
Accusative	ᴅənᵠɔn	ᴅənᵠɔnɾɔᵉ	ᴅənᵠɔn	ᴅənᵠɔnəᶜ
Animate: ⟨ȷcᵊl⟩ “fox”				
Nominative	ȷcᵊl	ȷcᵊɾе	ȷcᵊȷ	ȷcᵊ.c
Accusative	ȷcᵊɥᴄn	ȷcᵊnᵠlе	ȷcᵊɥᴄj	ȷcᵊɥc
Inanimate: ⟨hɪɾdəᵓ⟩ “statue”				
Nominative	hɪɾdəᵓ	hɪɾdəᵓlɔᵉ	hɪɾdəᵓl	hɪɾdəᵓj
Accusative	hɪɾdəᵓᴅ	hɪɾdəᵓᴅdɔᵉ	hɪɾdəᵓdɔᵉ	hɪɾdəᵓɑəᶜ
Inanimate: ⟨.cᴅen⟩ “house”				
Nominative	.cᴅen	.cᴅeɾе	.cᴅel	.cᴅeȷ
Accusative	.cᴅeɥcᴅ	.cᴅeɥcᴅde	.cᴅeɥcde	.cᴅeɥcɑc

3.5.2 | Measurable classes

Table 3.4: Declensions for measurable nouns.

	Plural	Nullary	Subingular	Supersingular
Measure: ⟨ɥəᴅəᶜ⟩ “day (continuous)”				
Nominative	ɥəᴅəᶜ	ɥəᴅəᶜɥəᵓ	ɥəᴅəᶜɾ	ɥəᴅəᶜn
Accusative	ɥəᴅəᶜn	ɥəᴅəᶜɥəᵓn	ɥəᴅəᶜnɾɔᵉ	ɥəᴅəᶜnəᶜn
Measure: ⟨ᴅel⟩ “volume” (in expressions such as ⟨ᴅel–ɥəȷɔᵉ⟩ “cupful”)				
Nominative	ᴅel	ᴅeɥcᵓ	ᴅeɥcɾ	ᴅeɥcn
Accusative	ᴅeɥcn	ᴅeɥcᵓn	ᴅeɥcnɾе	ᴅeɥcncn
(Note that the final consonant is preserved only in the plural nominative form.)				

3.5.3 | Uncountable classes

Notably, uncountable-class noun declensions do not respect vowel harmony.

Table 3.5: Declensions for measurable nouns.

	Mass
Fluid: ⟨ɑˡəɥəᵓ⟩ “water”	
Nominative	ɑᵉɥəᵓ
Accusative	ɑᵉɥəᵓn
Fluid: ⟨ɲelᴇᴅ⟩ “nitrogen”	

	Mass
Nominative	ɑɐlɐɒ
Accusative	ɑɐlɐɒcn
(Here, the coda is preserved in the accusative as well.)	
Edible: ⟨ʃɐɥ.cᵓ⟩ “beef”	
Nominative	ʃɐɥ.cᵓ
Accusative	ʃɐɥ.cᵓn
Edible: ⟨ɒɪn⟩ “rice”	
Nominative	ɒɪn
Accusative	ɒɪncn
Inedible: ⟨ɥəᵓʃɔ⟩ “gold”	
Nominative	ɥəᵓʃɔ
Accusative	ɥəᵓʃɔbe
Inedible: ⟨lɪɾlɪȷ⟩ “stone”	
Nominative	lɪɾlɪȷ
Accusative	lɪɾlɪȷde
Abstract: ⟨ɑʰəᵓɒɔ⟩ “empathy”	
Nominative	ɑʰəᵓɒɔ
Accusative	ɑʰəᵓɒɔnᵠ
Abstract: ⟨ɸcȷ⟩ “[the number] five”	
Nominative	ɸcȷ
Accusative	ɸcȷcnᵠ

3.6 | Pronouns

Personal pronouns are not divided into first, second and third persons as in most languages. Instead, they fall into four categories which exhibit different behaviour depending on whether they occur as the first or second noun in the clause:

Table 3.6: Pronoun persons and their functions.

Person	Role in first position	Role in second position
Near	The speaker.	The first argument of the sentence.
Far	The listener.	If the first argument is the speaker, then the listener. Otherwise, the speaker.
Other	A third entity.	An entity that is neither the speaker, the listener nor the first argument.
Generic	A generic entity (akin to “one”).	
Anaphoric Subject	The subject of the previous clause.	
Anaphoric Object	The object of the previous clause.	

In wh-questions, the wh-word assumes the second position and the other argu-

ment becomes the first.

If a clause has no explicit arguments, the first argument is understood to be the subject.

Table 3.7: Personal pronouns. ⟨–n⟩, ⟨–en⟩ or ⟨–ɔᵉn⟩ is suffixed for the accusative case.

(continuous) (discrete)	Pl. / Sub. / Sup. Integral	Nullary Nullary	Singular	Dual
Near	ʃɪ	˩leʃɪ	ɒe	ɑcɥc
Far	dɔ	˩ɔᵉdɔ	nəᶜ	bɥɪ
Other	nc	˩enc	scᵓ	˩ɪɥc
Anaph. Sub.	ɥɪ	˩eɥɪ	.cɒ	nᵠcɥc
Anaph. Obj.	ɥɔ	˩ɔᵉɥɔ	.əᶜɒ	nᵠəᶜɥɔ
Generic	.əᵓ			

(For the observant readers: notice the similarity to Kavinan's system.)

3.6.1 | Last-clause pronouns

The anaphoric pronoun ⟨bej⟩ (accusative: ⟨bejen⟩) is grammatically an other pronoun, and it refers to the previous clause said. Likewise, ⟨bedcj⟩ (accusative: ⟨bedcn⟩) refers to the clause before the previous one.

3.7 | Compounding

Nouns can be compounded together in a head-initial manner. When that happens, only the leftmost noun is the one to be declined.

ɒel–ɥəjɔᵉ–ɑˡəɥəᵓ–ɸcj
volume-cup-water-five
five cupfuls of water

Note that integral pronouns can modify other nouns, in which personal possession is indicated:

ɒel–ɥəjɔᵉ–ɑˡəɥəᵓ–ɸcj–ʃɪ
volume-cup-water-five-PR.NEAR.INTEGRAL
(arg1)'s five cupfuls of water

Descriptors can also compound on nouns. This compounding is productive in aaaaaaaaaA.

ɒɪjɪ–˩əᵓʃɪ
person-old
old people
(Compare to ɒɪjɪ ˩əᵓʃɪ "person old-SENTIENT".)

3.8 | Possession

“X’s Y” is translated as ⟨Y=ᴅɪ ɟcl X⟩. The possessive construction is also used to create appositives.

Observe that possession marks the head, and ⟨–ᴅɪ⟩ is a clitic, not an affix, as in the following example:

ᴅəᴅənᵠɔɟ–ɑˈəɻəᵓ–ᴅɪ ɟcl ɟʰɪ.eɟ
DEF~rabbit-SING-water=GEN POS magician-SING
the magician’s water rabbit

In more casual speech, ⟨ɟcl⟩ may be dropped.

4 | Verbs

Verbs are conjugated for person of the subject, tense, polarity and tellicity, in two paradigms. Conjugation respects vowel harmony.

Table 4.1: Person-tense conjugations for verbs, using ⟨ɒɪl̀ɪn⟩ "(S) eats (O)".

	Nonpast	Past
Near	ɒɪl̀ɪn	ɒɪl̀ɪɾ
Far	ɒɪl̀ɪn	ɒɪlcᵊȷ
Other	ɒɪl̀ɪ	ɒɪlcᵊ
Anaph. Sub.	ɒɪl̀e	ɒɪlel
Anaph. Obj.	ɒɪlc.e	ɒɪlc.el
Generic	ɒɪlcↄ	ɒɪlcↄ

Table 4.2: Person-tense conjugations for verbs, using ⟨ɥeɑcn⟩ "(S) spreads (O)".

	Nonpast	Past
Near	ɥeɑcn	ɥeɑcɾ
Far	ɥeɑɪn	ɥeɑcᵊȷ
Other	ɥeɑɪ	ɥeɑcᵊ
Anaph. Sub.	ɥeɑe	ɥeɑel
Anaph. Obj.	ɥeɑc.e	ɥeɑc.el
Generic	ɥeɑcᵊ	ɥeɑcᵊ

to which a suffix is added:

Table 4.3: Polarity-tellicity suffixes for verbs. The interrogative affix can also follow a negative affix.

	Positive	Negative	Interrogative
Telic	–˙	–l̀e / –l̀ↄᵉ	–ɦɪ
Atelic	–ɒc / –ɒəᶜ	–ȷɪ	–lcᵊ / –lə

Notes:

- "Negative atelic" means something akin to "unsuccessfully tried to avoid doing X".
- The interrogative polarity, in addition to marking questions, is used to mark clauses that may or may not be true but are referred to later in the sentence.

Some examples:

ɒɪlɪn sɪɾe ɾlɔɥɔ.
eat-NEAR.NONPAST fish flower
Fish eat flowers.

ɒɪlɪn sɪɾe ɾlɔɥɔ, ɒɪlɪn nɥɪɥɪ ɥɪ.
eat-NEAR.NONPAST fish flower, eat-NEAR.NONPAST cat PR.ANAPH_SUB
Fish eat flowers, and cats eat fish.

ɒɪlɪn sɪɾe ɾlɔɥɔ, ɒɪle ɥɪɾíbe.
eat-NEAR.NONPAST fish flower, eat-ANAPH_SUB.NONPAST grass-ACC
Fish eat flowers, and they eat grass.
(Grass is inedible to humans, but edible to fish.)

ɒɪlɪnle ɾlɔɥɔ sɪɾe.
eat-NEAR.NONPAST-NEG flower fish
Flowers don't eat fish.

dɥɪ sc^{ɔ} hɥchɥcɑel, ɟenɪn ɾɪ beɟ.
carry-OTHER.NONPAST PR.OTHER.SG DEF~book-SG, worry-NEAR.NONPAST PR.NEAR.INT PR.LAST_CLAUSE
He has the book; that worries me.
or: That he has the book worries me.

dɥɪhɪ sc^{ɔ} hɥchɥcɑel, ɟenɪn ɾɪ beɟ.
carry-OTHER.NONPAST-INTERROGATIVE PR.OTHER.SG DEF~book-SG, worry-NEAR.NONPAST PR.NEAR.INT PR.LAST_CLAUSE
He might have the book; that worries me.
or: That he might have the book worries me.

4.1 | Aspect

Verbs can also be marked for aspect, either using a rod sign directly on the verb, or a particle with a rod sign, placed anywhere between the verb it modifies and the next verb.

Table 4.4: Aspect markers. Those with hyphens are attached to verb. Those without hyphens are placed as separate particles anywhere after the verb.

Aspect name	Marking	Meaning
Imperfect	–ɬ	An action that is currently going on. Also used to distinguish static actions as opposed to dynamic (e. g. *wear* as opposed to *put on*).
Interrupted	ɭcɬ	An action that was interrupted.
Perfect	–ɻ	An action that has already finished. Changes present tense to immediate past. Also used to distinguish dynamic actions as opposed to static (e. g. *put on* as opposed to *wear*).
Gnomic	–ʔ	A general truth or aphorism, or an action done habitually.
Gnomic dubitative	ɭcʔ	A general truth or aphorism that the speaker considers to be false.
Deontic necessity	–ɱ	An action that the speaker insists on happening.
Epistemic necessity	ɲəᶜɒɱ	An action that the speaker infers that is happening.
Deontic potential	–ɬ	An action that the speaker permits to occur.
Epistemic potential	ɲəᶜɒɬ	An action that the speaker infers that might happen.
Unexpected	–ʕ	An action that is unexpected (akin to using “but”).
Comparative	deʕ	Indicates an action of greater intensity than what was described in the previous clause.
Nonexclusive subject	ɲcɬ	Indicates that the subject comprises not only of what is explicitly mentioned, but also other things.
Nonexclusive object	ɲcʔ	Indicates that the object comprises not only of what is explicitly mentioned, but also other things.
Nonexclusive argument	ɲcɱ	Combination of both nonexclusive subject and nonexclusive object.

An example:

ɭɻɱɾɒcɬ ɒe nc, ɭcnc.elʕ dənᵠɪdɔᵉ–ɥɪ.
fight-NEAR.PAST-ATELIC-IMPERFECT PR.NEAR.SG PR.OTHER.INT, shoot-ANAPH_OBJ.PAST-UNEXPECTED knee-SG.ACC-PR.ANAPH_SUB.INT
I tried to fight them, but they shot my knee.

4.2 | Obliques

aaaaaaaaaA lacks oblique arguments. Instead, equivalent expressions employ serial verb constructions. For instance, “he ate soup with a spoon” would be reduced to “he held a spoon and ate soup”:

dɥcᵊ sc͡ɔ ɑɔᵉlɔᵉl, ɒɪlel sɪdjcn.
INST-OTHER.PAST PR.OTHER.SG spoon-SG, eat-ANAPH_SUB.PAST soup-ACC
He held a spoon and ate soup.
or: He ate soup with a spoon.

Likewise:

nɪ.ɪ nc jəjəl–hɪ.ɪɥ, ncɒe hɪhɪrdəᵓdɔᵉ.
TEMPORAL-OTHER PR.OTHER.INT DEF~day-SG-spring, dance-ANAPH_SUB DEF~statue-SG.ACC
They will wait until the spring equinox and dance around the statue.
or: They will dance around the statue on the spring equinox.

A similar construction can be used for the negation of obliques:

dɥcᵊle sc͡ɔ ɑɔᵉlɔᵉl, ɒɪlelʕ sɪdjcn.
INST-OTHER.PAST-NEG PR.OTHER.SG spoon-SG, eat-ANAPH_SUB.PAST-UNEXPECTED soup-ACC
He did not hold a spoon, but ate soup.
or: He ate soup without a spoon.

4.3 | Conjunctions

Conjunctions such as “and” are treated like obliques. For instance, “and” is represented by the verb ⟨ɑcn⟩, and precedes the clause in which the two are used:

ɑcᵊ \ɥcᵊje \ɾɪɥəl, ɒɪlel ɾeɥ.cᵓn.
and-OTHER.PAST Ryse Tarul, eat-ANAPH_SUB.PAST beef-ACC
Ryse and Tarul ate beef.

Sufficiently complex nesting may be unrepresentable using only anaphoric referents. The easiest way to resolve this issue is to use definite nouns in place of anaphoric referents.

ɑcᵊ \ɥcᵊje \ɾɪɥəl, ɑcᵊ ɾeɥ.cᵓ sɪdjc, ɒɪlcᵊ ɒɪɒɪjɪl ɥɪ.
and-OTHER.PAST Ryuse Tarul, and-OTHER.PAST beef soup, eat-OTHER.PAST DEF~person-DU PR.ANAPH_SUB.CONT
[They,] Ryse and Tarul ate beef and soup.

4.4 | Subordinate clauses

Ideas such as “if” or “because” are also expressed with verbs. For example, ⟨ɲɪ.cn⟩ “wait, when” is also used for “if”:

ʃɐɲɪlehɪ, ɲɪ.cn ʃɪ bɐj, ɑehcn.
rain-OTHER-NEG-Q, wait-NEAR PR.NEAR.INT ANAPH_CLAUSE, play-NEAR
If it doesn’t rain, we will play.

Note the clausal argument to ⟨ɲɪ.cn⟩, since our condition is an entire clause instead of a noun.

4.4.1 | Conditions

Conditional ideas whose English translations contain “if” can also be expressed in a more concise way, but this usage can sometimes sound colloquial:

ʃɐɲɪlehɪ, ɑehcn.
rain-OTHER-NEG-Q, play-NEAR
If it doesn’t rain, we will play.

4.5 | Comparatives

The comparative is a function $\mathrm{cmp} : A \times A \times (A \to \mathbb{R}) \times (A \times A \to \{0,1\}) \to \{0,1\}$, where $\mathrm{cmp}(a, b, f, \sqsupset) = f(a) \sqsupset f(b)$.

Consider the following sentences:

Fish eat flowers more than cats.
More fish eat flowers than cats.

Semantically, they can be translated to:

$$\mathrm{cmp}(\text{fish}, \text{cats}, a \mapsto (\#\text{ of flowers eaten by } a), >) \tag{4.1}$$
$$\mathrm{cmp}(\text{fish}, \text{cats}, a \mapsto (\#\text{ of } a \text{ that eat flowers}), >) \tag{4.2}$$

The heart of comparatives in aaaaaaaaaaA is the quadrivalent verb ⟨ɑɔɲɪn a b f $\sqsupset$⟩. Thus:

ɒilcʔhɪ ʃlɔɲɔɒ–jʰcn, ɑɔɲɪn sɪɾde nɥɪɲɪ ɲɔ neʃ.
eat-GENERIC-Q flower-ACC.INT-how_many, CMP-NEAR fish cat PR.ANAPH_OBJ.INT >
Fish eat more flowers than cats.

ɒilcʔhɪ .əʔ–jʰcn ʃlɔɲɔ, ɑɔɲɪn sɪɾde nɥɪɲɪ ɲɪ neʃ.
eat-GENERIC-Q PR.GENERIC-how_many flower, CMP-NEAR fish cat PR.ANAPH_SUB.INT
>

More fish eat flowers than cats.

Note that we place a clause whose argument is the generic pronoun before the comparative clause. From the doran-clause, we refer to the function using the anaphoric pronoun referring to the position of the return value.

Table 4.5: Comparators in aaaaaaaaaA.

⊐	Comparator
$>$	neɾ
$<$	ɑɔᵉɭ
$=$	ɾeᶟnᵠ
$\geq$	ɾɥıl
$\leq$	ɒcɹ
$\neq$	.cᵊɹ
$\approx$	ɥeɹ
$\gg$	ɑʰe
$\ll$	ɾlın

4.6 | Ditransitive-like constructions

In English, some verbs such as *give* take two objects: the item being given and the recipient of the item. Since clauses in aaaaaaaaaA can take only one object, translating such verbs requires multiple clauses:

ɾıφıɾ ɒe hɥchɥcɷen, nebel \ɥcᵊɹjen.
lose-NEAR.PAST PR.NEAR.SG DEF~book, give_to-ANAPH_SUB.PAST Riᵘse-ACC
I gave the book to Ryse.

4.7 | Transitivisation

Verbs that are intransitively (i. e. have no object passed at this time) can be turned into a causative form with the prefix ⟨φc–⟩:

ɾlcɾlcɾ ɑɥeɑɥenʰe.
fall-NEAR.PAST DEF~coin
The coins fell.

ɒe φcɾlcɾlcᵊ ɑɥeɑɥenʰe
PR.NEAR.SG TRANS-fall-OTHER.PAST DEF~coin
I dropped the coins.

Note that the word order changes to SVO. In addition, the verb is conjugated for its object, rather than the subject as expected. If the following clause uses an anaphoric

subject, it refers to the object of the current clause.

Moreover, the verb does not need to be one that can never take an object. In the above example, ⟨ɾlcɾdcn⟩ means "(S) falls on (O)". However, if the verb in question is taking an object, it cannot be transitivised directly and a more roundabout way is required:

ɾlcɾdcɾ qɥeqɥenʸe ɥıɾı.
fall-NEAR.PAST DEF~coin grass
The coins fell on the grass.

ɒe ɸcɾlcɾdcᵊ qɥeqɥenʸe, ɾlcɾdel ɥıɾıbe.
PR.NEAR.SG TRANS-fall-OTHER.PAST DEF~coin, fall-ANAPH_SUB.PAST grass-ACC
I dropped the coins; they fell on grass.
or: I dropped the coins on grass.

4.8 | Clauses with nullary arguments

A clause with one or more arguments that are nullary or modified by nullary-number nouns (either through compounding or possession) will have a negative verb as well:

ɒəɾınɭe ɒıjıɭe.
recall-NEAR-NEG person-NULL
No one knows.

ɾjclɾınɭe ɒe jıɥɾıɒı jcl jʰı.eɭe.
want-NEAR-NEG PR.NEAR.SG ring=GEN POS magician-NULL
I don't want the rings of any magician.

4.9 | The copula

The copula ⟨jcn⟩ can take a noun as an object, in which case it can mean identity or membership. (Location is expressed with ⟨lın⟩ "be at".) With no object at all, it is used to denote existence.

It can also accept a descriptor, in which case the descriptor is attached before ⟨jcn⟩ in the dictionary form.

5 | Descriptors

Descriptors act as adjectives or adverbs. They follow what they modify, and are inflected for the noun class or verbal person of their antecedents.

Table 5.1: Descriptor declensions, using the descriptors ⟨hɐɒʃɪ⟩ “large” and ⟨lɘˤʃɪ⟩ “old”.

Class or person	Declined form	
Sentient	hɐɒʃɪ	lɘˤʃɪ
Animate	hɐɒʃɪ	lɘˤʃɪ
Inanimate	hɐɒʃe	lɘˤʃɔᵉ
Measure	hɐɒʃɪȷ	lɘˤʃɪȷ
Fluid	hɐɒʃeȷ	lɘˤʃɔᵉȷ
Edible	hɐɒʃc	lɘˤʃəᶜ
Inedible	hɐɒʃeᵓ	lɘˤʃɔ
Abstract	hɐɒʃcᵊ	lɘˤʃə
Near	hɐɒʃɪɻ	lɘˤʃɪɻ
Far	hɐɒʃɪɻ	lɘˤʃɪɻ
Other	hɐɒʃeɻ	lɘˤʃeɻ
Anaph. Sub.	hɐɒʃɪɻ	lɘˤʃɪɻ
Anaph. Obj.	hɐɒʃeɻ	lɘˤʃeɻ
Generic	hɐɒʃcᵓɻ	lɘˤʃəᵓɻ

5.1 | Conversion

A noun can be converted to a descriptor by appending ⟨–ɹɪ⟩.

A descriptor can be converted to an abstract noun meaning “the nature of being ~” by replacing the final ⟨–ɪ⟩ with ⟨–cnel⟩.

6 | Tree mode

As mentioned in section 4.3, anaphoric referents in a linked-list sentence are sometimes insufficient for expressing even simple sentence structures. While the easiest method of resolving this issue is using definite nouns, aaaaaaaaaaA also provides a mode where sentences are not linked lists of clauses, but rather (binary) trees.

6.1 | Activation

Tree mode is enabled automatically when the treeing particle <nᵘᵎ9> is used, and disabled at the end of a sentence.

6.2 | Branch-switching

The aforementioned particle <nᵘᵎ9> marks the beginning of the right branch of the tree. The right branch is ended by the particle <nᵘᵎΔ>, which causes the next clause to join the left and right branches.

(N. B. <nᵘᵎ9> and <nᵘᵎΔ> can occur only between clauses. If the particles are represented by left and right brackets, respectively, then the brackets should match.)

6.3 | Anaphoric pronouns in joiner clauses

In clauses that join two branches, anaphoric pronouns require marking whether the antecedent occurs in the left predecessor <nᵘᵎ9> or the right predecessor <nᵘᵎΔ>. This is done by marking the pronoun with <–9> or <–Δ>.

Likewise, verbs can be modified with <–9> or <–Δ> to indicate which branch the subject came from.

6.4 | Errors

The following are ungrammatical:

- Using the particle <nᵘᵎΔ> or the branched anaphoric pronouns when tree mode is disabled

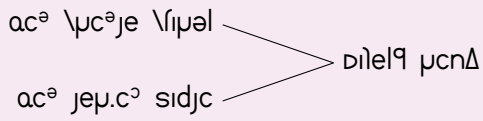
- Using the particle ⟨nʸɪΔ⟩ other than to close a corresponding ⟨nʸɪϥ⟩
- Using the unbranched anaphoric pronouns in clauses with two predecessors
- Using the branched anaphoric pronouns in clauses with one predecessor
- Starting a new branch with ⟨nʸɪϥ⟩ when the current branch is empty

6.5 | Example

The second example in section 4.3 can be expressed as follows:

ɑcᵊ \ɥcᵊɟe \ɾɪɥəl, nʸɪϥ ɑcᵊ ɟeɥ.cᵓ sɪdjc, nʸɪΔ ɒɪlelϥ ɥcnΔ.

The resulting tree is shown below:



7 | Numerals

aaaaaaaaaA uses a mixed-base system for its numerals. Numerals are abstract nouns. A Perl 6 program to convert numerals can be found in Section A.3.

7.1 | Single-digit numerals

Here are the numerals for $n < 17$:

Table 7.1: The cardinal numbers from 0 – 16.

base 10	base v	word
0	0	ɻəɒ
1	1	ɑcᵊl
2	ɹ	ʃɪȷ
3	ʔ	ɷʸeᵓn
4	𝍌	ɑˡɪɻ
5	ϟ	ɸcȷ
6	ʕ	ɒɥe
7	ϥ	ʃȷcȷ
8	Δ	dəᵓn
9	L	hed
10	F	bənᵠ
11	ⅎ	nəᶜ
12	ⅇ	leᵓ
13	♯	jʰcd
14	A	ɥɪn
15	∀	ɭel
16	Ψ	.ɪɻ

Note that digits above 9 use capital hacm letters.

7.2 | Numerals up to $19 \cdot 17$

These are represented by two digits. The multiples of 17 are shown below:

Table 7.2: Multiples of 17, up to $18 \cdot 17$.

base 10	base v	word
17	10	selcᵊ
34	J0	ɒɪlcᵊ
51	ʔ0	ɷʰeᶝlcᵊ
68	ℳ0	ɾɪɒlcᵊ
85	Ⱶ0	ɸcjʃcᵊ
102	ʕ0	ɒɥelcᵊ
119	ϙ0	ʃjcjʃcᵊ
136	Δ0	dəᶝnə
153	L0	helcᵊ
170	F0	bənᵠə
187	ⱷ0	nəᶜlə
204	Ⱡ0	leᶝlcᵊ
221	Ⱶ0	jʰcdlcᵊ
238	A0	ɥɪnᶜᵊ
255	∀0	ɭelɥcᵊ
272	Ψ0	.ɪlɥcᵊ
289	Ð0	jɪlscᵊ
306	Ψ0	heɒdcᵊ

Thus $y \cdot 17 + x$ is written ⟨x-y⟩.

7.3 | Numerals up to $13 \cdot 19 \cdot 17 = 4199$

These are represented by three digits. The multiples of $19 \cdot 17$ are listed below:

Table 7.3: Multiples of $19 \cdot 17$, up to $12 \cdot 19 \cdot 17$.

base 10	base v	word
323	100	hɪjɪʃɪn
646	J00	ɾɪjɪʃɪn
969	ʔ00	ɷʰeᶝjeʃɪn
1292	ℳ00	ɑˡɪɲɪʃɪn
1615	Ⱶ00	ɸcjɪʃɪn
1938	ʕ00	ɒɥejɪʃɪn
2261	ϙ00	ʃjcjɪʃɪn
2584	Δ00	dəᶝnɪɪʃɪn
2907	L00	heɑɪʃɪn
3230	F00	bənᵠɪʃɪn

base 10	base v	word
3553	ⅎ00	nəᶜɹɪɾɪn
3876	⅁00	lɐᵓɹɪɾɪn

Thus $(z \cdot 19 \cdot 17) + (y \cdot 17) + x$ is written ⟨z-x-y⟩.

7.4 | Numerals up to and including $4199 \cdot (4199+1)/2 = 8817900$

The numeral for 4199 is ⟨lə.ɔləᶜ⟩, written as ⟨1:000⟩.

Likewise, two ⟨lə.ɔləᶜ⟩ is written as ⟨Ꞗ:000⟩ and pronounced ⟨lə.ɔləᶜ–ɾɪɹ⟩, but the second ⟨lə.ɔləᶜ⟩ is one smaller than the first. In other words, ⟨Ꞗ:000⟩ = $4199 + (4199 - 1) = 8397$.

Table 7.4: "Multiples" of ⟨lə.ɔləᶜ⟩.

"Multiple"	Difference from last	Total
(0)		0
1:000	4199	4199
Ꞗ:000	4198	8397
ʔ:000	4197	12594
Ø:000	4196	16790
ᛋ:000	4195	20985
...		
⅁ㅍ∀:000	3	8817897
⅁ㅍψ:000	2	8817899
1::000:000	1	8817900

Thus the nth "multiple" differs from the $(n-1)$th multiple by $(4199+1-n)$ (given $1 \leq n \leq 4199$), and the sum of the first n "multiples" is

$$\begin{aligned} y(n) &= \sum_{i=1}^{n} (4200 - n) \\ &= \frac{1}{2} \cdot (8399 \cdot n - n^2) \end{aligned} \tag{7.1}$$

And likewise, for some given y, the largest "multiple" of ⟨lə.ɔləᶜ⟩ not smaller than y has the index

$$N(y) = \left\lfloor \frac{1}{2} \cdot \left(8399 - \sqrt{70543201 - 8 \cdot y}\right) \right\rfloor \tag{7.2}$$

In other words, for any numeral $\langle n_1{:}n_2 \rangle$, $n_1 + n_2$ must be less than 4199.

7.5 | Higher numerals

The *bases* of higher numerals b_i can be derived from the recurrence relation

$$b_i = \begin{cases} 4199 & \text{if } i = 1 \\ \dfrac{b_{i-1} \cdot (b_{i-1} + 1)}{2} & \text{otherwise} \end{cases} \tag{7.3}$$

Then b_i acts as a new triangular base. Equations 7.1 and 7.2 can be generalised to the following:

$$y(n, b_i) = \sum_{i=1}^{n} (b_i + 1 - n) \tag{7.4}$$

$$= \frac{1}{2} \cdot (n \cdot (2 \cdot b_i + 1 - n)) \tag{7.5}$$

$$N(y, b_i) = \left\lfloor \frac{1}{2} \cdot \left(2 \cdot b_i - \sqrt{4 \cdot b_i^2 + 4 \cdot b_i + 1 - 8 \cdot y} \right) \right\rfloor \tag{7.6}$$

It follows that $y(n_1, b_i) + n_2$ is represented as $\langle n_1 :^i n_2 \rangle$ (i colons), and such a numeral must satisfy $n_1 + n_2 < b_i$.

Here are the names of the bases themselves:

Table 7.5: Names of higher bases.

Base	base v	word
b_1	1:000	ɭəˌɔləᶜ
b_2	1::000:000	ɒɐɥcᵓʃɪ
b_3	1:::000:000::000:000	ʃɪlɥəᵓ
b_4		ɷencoɪ

7.6 | Cardinal and ordinal numerals

Cardinal numerals compound to their antecedents; ordinal numerals use the possessive ⟨–ɒɪ ɟcl⟩ construction:

ɒcɑɪ–ɷʰeᵓn
child-three
three children

ɒcɑɪjɒɪ ɟcl ɷʰeᵓn
child-SG=GEN POS three
the third child

8 | Derivational morphology

The following methods are used to derive related terms from existing ones.

8.1 | Abstraction

Abstraction is a derivation that takes a non-abstract noun and returns the abstract noun representing the concept of the argument. This formation appends ⟨–ne⟩ or ⟨–nɔᵉ⟩ to the noun.

Examples:

- ⟨hɥcɑen⟩ *book* → ⟨hɥcɑene⟩ *literature*
- ⟨hɔlı⟩ *cart* → ⟨hɔlınɔᵉ⟩ *transportation*

Note that any double letters collapse into a single.

8.2 | Dematuration

Dematuration is a derivation that takes a noun and returns a noun of the same class that represents an immature form of the argument (not necessarily a diminuitive). ⟨ʃc–⟩ or ⟨ʃəᶜ–⟩ are prepended to nouns that begin in ⟨j⟩ or ⟨l⟩, or ⟨jc–⟩ or ⟨jəᶜ–⟩ otherwise.

Examples:

- ⟨ɒıjı⟩ *person* → ⟨jcɒıjı⟩ *child*
- ⟨ʃjɔɥəɔ⟩ *fruit* → ⟨jəᶜʃjɔɥəɔ⟩ *unripe fruit*
- ⟨jeɾlılcn⟩ *essay* → ⟨ʃcjeɾlılcn⟩ *draft*

8.3 | Verb-to-noun conversions

Verb-to-noun conversions involve an operation called *inversion*; this operation swaps certain phonemes of a word:

- front vowels ↔ back vowels
- voiceless plosives ↔ voiced plosives
- ɑ ↔ ɟʰ
- ɟ ↔ ɑʰ (in any position other than in a coda)
- h ↔ ɑˡ
- ɻ ↔ ɳ (in any position other than after a fricative in an onset)
- s ↔ l (in any position other than in a coda)
- ɥ ↔ o

For instance, ⟨ɻɪ.cʃɪn⟩ would be inverted to ⟨ɳɪ.əᶜɷɪn⟩.
All other phonemes are unchanged.
Since all of the conversions below are straightforward, only their names will be mentioned.

Table 8.1: Verb-to-noun conversions, from the inversion of the verb stem.

Name	Affix
Agent	–eᶽnᵠ / –ɔnᵠ
Patient	–eᶽd / –ɔd
Location	–eᶽɻ / –ɔɻ
Instrument	–ɪʃɟ

Table 8.2: An example with ⟨nəᶽbɪn⟩ *to steal*.

Name	Derivation	Meaning
Agent	ncᶽdeᶽnᵠ	thief
Patient	ncᶽdeᶽd	stolen goods
Location	ncᶽdeᶽɻ	site of theft
Instrument	ncᶽdɪʃɟ	tool used for theft

9 | Names

Names fall into two grammatical categories:

- *Nominal names* act as nouns. They are usually single words.
- *Clausal names* are entire clauses. These names usually refer to places, although a few people have clausal names. In extreme cases, such a name can span multiple clauses.

9.1 | Nominal names

These names act as nouns, and they are preceded by a backslash ⟨\⟩. If the name spans multiple words (as common in foreign names), spaces are escaped by backslashes. No distinction is made between native and foreign names.

Only personal names can stand on their own, and even then, only given or full names. Other names must modify a common noun describing the nature of what is named, in the integral number without definiteness.

Table 9.1: Some examples of nominal names.

Name	Type
\ɥcᵊje	Personal (native)
\ʃɪɥəl	Personal (native)
\ɥɐɒcn	Personal (foreign)
dɥeᵊɒe–\oɪlɪ.c	Place (foreign)

Native names will usually respect vowel harmony. Children of parents who work in professions demanding physical labour (e. g. bricklaying) will usually have names with back vowels. In contrast, those born to parents of professions that do not demand physical strength (e. g. computer programming) will usually bear names with front vowels.

9.2 | Clausal names

These names comprise of one or more clauses. Due to the nature of clausal names, they are all considered native. Most of these names refer to places; personal clausal names are almost always nicknames or such. Orthographically, they are put into square brackets ⟨[]⟩.

Clausal names are used by saying them as their own clauses, then using an anaphoric pronoun to backreference the entity described by the name in question. The type of anaphoric pronoun used varies from name to name. It might be the anaphoric subject pronoun, the object pronoun or the last-clause pronoun.

We call the *referent* the subject, the object or the verb of the last clause, respectively depending on the type of anaphoric pronoun used to refer to the name. If the referent is a noun, it must be declined in the integral number without definiteness.

Here, as common in maps and such, the referent will be capitalised. However, other contexts that make the type of anaphoric pronoun to use clear do not use this type of capitalisation.

Table 9.2: Some examples of clausal names.

Name	Type	Literal meaning
[AEɤΨϵᵌ dɳlʃɹ ʃɔɑɔl]	Place	The trees *covered* the ground
[ɒəʃɪ ɸɤEᵌÐE ɥcᵊl–\\leɷɥcᵓ]	Place	The *city* remembers the Šedrŷ star
[ɑcᵊ ɭɥɪʃə–ɒɪ ɟcl ɟəɥ ɟʰɪ.en–ɒɪ ɟcl ɭɪɷcᵓ, ɸoeɟc.el ɸɤEᵌÐEÐ]	Place	The *city* was founded by the warrior of the sun and the wizard of the moon
[ɒeɟɹ \Ψ∃TF϶ ɟcᵊl–selcᵊ]	Personal	*Gulto* takes care of 17 foxes

An example of usage:

ɲɪ.ɪ bɪnen–bəɟ, [ɒəʃɪ dɥeᵓɒe ɥcᵊl–\leɷɥcᵓ], ɟʰɪ ɒɪdɪjɪj .cɒ.
wait-OTHER year-future, (name), go-OTHER DEF~person-SG PR.ANAPH_SUB.SG
He will go to Muta Pröme Ryk-Šedrŷ next year.

10 | Calendar

Domain II, which contains *Rymako*, has a day that is 26.99410 hours long. Other figures are given in terms of local days:

Table 10.1: Astronomical measures for Domain II.

Period	Length in local days
Local (synodic) day	1.00000
Sidereal day	0.99699
Tropical year (l_y)	301.94714
Sidereal year	302.03719
Synodic month (l_m)	30.80152
Sidereal month	27.95032

10.1 | Tides

In Domain II, the offset of the sea level due to the tide can be modeled by the following equations:

$$y = y_s + y_m \tag{10.1}$$

$$y_s = A_s \cdot (1 + A_{sa} \cdot \cos(\tau \cdot t)) \cdot \cos(2 \cdot \tau \cdot t) \tag{10.2}$$

$$y_m = A_m \cdot \left(1 + A_{ma} \cdot \cos\left(\frac{\tau \cdot t}{l_m}\right)\right) \cdot \cos\left(\frac{2 \cdot \tau \cdot (1 - l_m) \cdot t}{l_m}\right) \tag{10.3}$$

where:

$$\begin{aligned}
\tau &= 2 \cdot \pi \\
A_s &\approx 0.675 \\
A_{sa} &\approx 0.0532 \\
A_m &\approx 1.267 \\
A_{ma} &\approx 0.176 \\
y &= \text{offset of sea level in metres} \\
t &= \text{time since HAT in local synodic days}
\end{aligned}$$

An exact solution to $dy/dt = 0$ is not known to exist. However, the solutions to this equation can be found numerically. Consult Section A.1 for a Sage program to do so.

As the calendar used by aaaaaaaaaaA uses the high and low tides to count time, it is not synchronised even with days. The basic unit of time in the calendar is the *tidal day* ⟨ᒧᘿᗡᘿᶜ⟩ (l_t) – the amount of time between a high tide and the second high tide thereafter, which is, on average, 1.03356 local synodic days, but can vary considerably. Thus:

$$\begin{aligned}
l_m/l_t &\approx 29.80148 && (10.4)\\
&\approx 4053/136 && (10.5)\\
l_y/l_m &\approx 9.80299 && (10.6)\\
&\approx 7215/736 && (10.7)
\end{aligned}$$

This suggests that:

1. most months will have 30 days, but every 136 months, 27 months will have only 29.

2. most years will have 10 months, but every 736 years, 145 years will have only 9.

10.2 | Months

Months follow a 136-month cycle wherein the $5n+2$-numbered months (zero-indexed, $n \in \mathbb{N}$) have 29 days and the other months have 30.

The names of months, on the other hand, are determined from their positions relative to the first month of the year:

Table 10.2: The months of the year.

#	Name
0	ɑəᵓbəᵓ
1	ɥcᵊ.eᴅ
2	ʃʝɪφɔl
3	ᴅəɥəʝɪ
4	ʅɗeɥɪᴅ
5	ʃɔᵉᴅəʃ
6	nᵠəɥəᶜʃ
7	ʅcbclı
8	bɔᴅəᵓʅ
9*	.cʝeᵓɥɪ

Days within a month are indexed from one.

10.3 | Years

The lengths of the year follow a 736-year cycle as specified in Figure 10.1. The code used to generate this table can be found in Section A.2.

10.4 | Eras

Years are grouped further into *eras* ⟨ʅɪɥɪ⟩, which change on major historical events. The start of a new era resets the month and year cycle. Eras can also start in the middle of a year of the previous era; thus, the start of the year is different for each era. The *crossover date* of an era is the date of the era that coincides with the first day of the next; in other words, it is the date immediately after the last day of the era.

Table 10.3: The months of the year.

Name	Crossover date	Days between	Cumulative
ʅɪɥɪ–ɥəʅɔᵉ	ɱ ʅɗeɥɪᴅ ⅃Δ⅃	889726	889726
ʅɪɥɪ–ʅəᵓʃı	1⅃ ʃʝɪφɔl ʕ∀ʕ	642508	1532234
ʅɪɥɪ–ʅɪʝnedcᵊ	Δ ʅcbclı ⅃ʔ£	207366	1739600
ʅɪɥɪ–nchel	(to present)		

The first day of ⟨ʅɪɥɪ–nchel⟩ coincides with the founding of the (not yet named).

Figure 10.1: Table of year lengths in a cycle.

```
   0123456789 |     0123456789 |     0123456789 |     0123456789
 0 XXXXX9XXXX |  19 XX9XXXX9XX |  38 9XXXX9XXXX |  57 XXX9XXXX9X
 1 9XXXX9XXXX |  20 XXX9XXXX9X |  39 9XXXX9XXXX |  58 XXX9XXXX9X
 2 9XXXX9XXXX |  21 XXX9XXXX9X |  40 9XXXXX9XXX |  59 XXX9XXXX9X
 3 9XXXX9XXXX |  22 XXX9XXXX9X |  41 X9XXXX9XXX |  60 XXXX9XXXX9
 4 9XXXX9XXXX |  23 XXX9XXXX9X |  42 X9XXXX9XXX |  61 XXXX9XXXX9
 5 9XXXX9XXXX |  24 XXX9XXXX9X |  43 X9XXXX9XXX |  62 XXXX9XXXX9
 6 9XXXX9XXXX |  25 XXX9XXXX9X |  44 X9XXXX9XXX |  63 XXXX9XXXX9
 7 X9XXXX9XXX |  26 XXX9XXXXX9 |  45 X9XXXX9XXX |  64 XXXX9XXXX9
 8 X9XXXX9XXX |  27 XXXX9XXXX9 |  46 X9XXXX9XXX |  65 XXXX9XXXX9
 9 X9XXXX9XXX |  28 XXXX9XXXX9 |  47 XX9XXXX9XX |  66 XXXX9XXXXX
10 X9XXXX9XXX |  29 XXXX9XXXX9 |  48 XX9XXXX9XX |  67 9XXXX9XXXX
11 X9XXXX9XXX |  30 XXXX9XXXX9 |  49 XX9XXXX9XX |  68 9XXXX9XXXX
12 X9XXXX9XXX |  31 XXXX9XXXX9 |  50 XX9XXXX9XX |  69 9XXXX9XXXX
13 X9XXXXX9XX |  32 XXXX9XXXX9 |  51 XX9XXXX9XX |  70 9XXXX9XXXX
14 XX9XXXX9XX |  33 XXXXX9XXXX |  52 XX9XXXX9XX |  71 9XXXX9XXXX
15 XX9XXXX9XX |  34 9XXXX9XXXX |  53 XX9XXXXX9X |  72 9XXXX9XXXX
16 XX9XXXX9XX |  35 9XXXX9XXXX |  54 XXX9XXXX9X |  73 9XXXX9
17 XX9XXXX9XX |  36 9XXXX9XXXX |  55 XXX9XXXX9X |
18 XX9XXXX9XX |  37 9XXXX9XXXX |  56 XXX9XXXX9X |

9: 9 months
X: 10 months
```

10.5 | Subdivisions of the day

Lek-Tsaro has two systems for subdividing the day.

10.5.1 | Traditional timekeeping

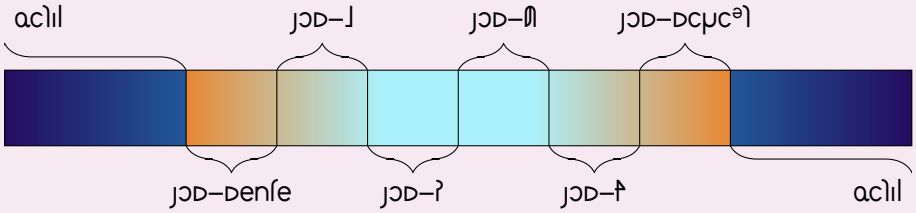
The traditional system of timekeeping relies on subdivisions of the solar day. As shown in Figure 10.2, the period between sunrise and sunset are divided into six equally-sized parts ⟨jɔd⟩, and the night is considered a separate category. This implies that the length of the "hours" depends on the seasons.

The traditional timekeeping system is vague – typically, the most precise interval used is a quarter or eighth of an "hour".

10.5.2 | Modern timekeeping

The need for precise schedules necessitated another standard for subdividing the day. The modern system is based on the tidal day, rather than the solar day. In theory, each

Figure 10.2: Hours in traditional timekeeping.



tidal day is divided into 23 equal parts ⟨lın⟩, each of which is divided into 80 equal parts ⟨ȷcne⟩, which are each divided into 40 equal parts ⟨bırdəl⟩.

Of course, having 23 ⟨lın⟩ per tidal day requires predicting the next two high tides. For that reason, each day's ⟨lın⟩ are based on the length of the *previous* tidal day, such that each day might have more or less than 23 ⟨lın⟩.

A | Listings of programs

A.1 | workfiles/7/tides.sage

```
# How many values to output

limit = int(sys.argv[1]) if len(sys.argv) > 1 else 1000

# :P

tau = 2 * pi

t = var("t")

# Constants

A_s = 0.675; A_sa = 0.0532; A_m = 1.267; A_ma = 0.176; l_m = 30.80152

# Solar component
y_s2 = A_s * (1 + A_sa * cos(tau * t)) * cos(2 * tau * t)
# Lunar component
y_m2 = A_m * (1 + A_ma * cos(tau * t / l_m)) * cos(2 * tau * t / l_m -
    2 * tau * t)
y = y_s2 + y_m2
yp = diff(y, t)

# High and low tides occur at values of t where dy/dt = 0.

i = 0
time = 0
print(0)
while i < limit:
  try:
    time2 = find_root(yp == 0, time + 0.000000001, time + 0.35)
    print(time2)
    time = time2
    i += 1
  except:
    time += 0.01
```

workfiles/7/tides.sage

A.2 | workfiles/7/bins.pl6

```
# CONSTANTS

constant \MONTHS_PER_YEAR_CYCLE = 7215;
constant \YEARS_PER_YEAR_CYCLE = 736;
constant \AVG_MONTHS_PER_YEAR = MONTHS_PER_YEAR_CYCLE /
    YEARS_PER_YEAR_CYCLE;

# COMPUTATION
# For each year, take as many months as are needed
# in order to cycle to the next.

my $c = 0;
my @k;

for 0 ..^ YEARS_PER_YEAR_CYCLE -> $i {
  my $need = 1 - ($c - floor($c));
  my $objs = ceiling($need * AVG_MONTHS_PER_YEAR);
  @k[$i] = $objs;
  $c += $objs / AVG_MONTHS_PER_YEAR;
}

# DISPLAY

my \cols = 4;
my $len = @k.elems;

say ("    0123456789" xx cols).join(" | ");

my \total-rows = ceiling($len / 10);
my \rows = ceiling(total-rows / cols);

for 0 ..^ rows -> $j {
  for 0 ..^ cols -> $p {
    print(" | ") if $p != 0;
    my $q = $j + rows * $p;
    next if $q >= total-rows;
    printf("%3d ", $q);
    for 0 ..^ 10 {
      my $i = 10 * $q + $_;
      if $i >= $len { print " "; }
      else {
        print "0123456789XE".substr(@k[$i], 1);
      }
    }
  }
  say "";
}
```

workfiles/7/bins.pl6

A.3 | workfiles/7/conno.pl6

```
my $digits-str = "0123456789TKXSNVFMD";
my @digits = $digits-str.comb;

sub convert-small-fwd($n, $pad = False) {
  die "$n must be < 4199" if $n >= 4199;
  my $a = $n div (19 * 17);
  my $b = ($n div 17) % 19;
  my $c = $n % 17;
  return
    (!$pad && $a == 0 ?? "" !! @digits[$a]) ~
    (!$pad && $b == 0 && $a == 0 ?? "" !! @digits[$b]) ~
    @digits[$c];
}

sub convert-small-back($s) {
  die "$s must be 3 chars or fewer" if $s.chars > 3;
  my $c = $digits-str.index($s.substr(* - 1, 1) // "0");
  my $b = $digits-str.index($s.substr(* - 2, 1) // "0");
  my $a = $digits-str.index($s.substr(* - 3, 1) // "0");
  return $c + 17 * ($b + 19 * $a);
}

sub triangle($n, $p) {
  return ($n * (2 * $p + 1 - $n)) div 2;
}

sub sqrt-floor($y) {
  die "$y is negative" if $y < 0;
  return $y if $y < 2;
  my $small = sqrt-floor($y +> 2) +< 1;
  my $large = $small + 1;
  return $small if $large * $large > $y;
  return $large;
}
sub sqrt-ceil($y) {
  my $n = sqrt-floor($y);
  return $n if $n * $n == $y;
  return $n + 1;
}

sub untriangle($y, $p) {
  return (2 * $p + 1 - sqrt-ceil(4 * $p * $p + 4 * $p - 8 * $y + 1))
    div 2;
}

my @powers = (4199);

for 0 .. 10 {
  my $p = @powers[* - 1];
  @powers.push: $p * ($p + 1) div 2;
}

sub convert-large-fwd-h($n, $i, $pad = False) {
```

```
  # base case
  if $i == 0 {
    return convert-small-fwd($n, $pad);
  }
  # recursive
  my $super = untriangle($n, @powers[$i - 1]);
  my $infra = $n - triangle($super, @powers[$i - 1]);
  if $super == 0 && !$pad {
    return convert-large-fwd-h($infra, $i - 1, False);
  }
  return
    convert-large-fwd-h($super, $i - 1, $pad) ~
    (":" x $i) ~
    convert-large-fwd-h($infra, $i - 1, True);
}

sub convert-large-fwd($n, $pad = False) {
  my $i = 0;
  ++$i while @powers[$i] <= $n;
  convert-large-fwd-h($n, $i, $pad);
}

sub convert-large-back($s) {
  # Find the longest run of colons
  my @matches = ($s ~~ m:g/":"+/); #/"
  if (!@matches) {
    return convert-small-back($s);
  }
  my $longest-match = @matches.max(*.chars);
  my $i = (~$longest-match).chars;
  my $left = $s.substr(0, $longest-match.from);
  my $right = $s.substr($longest-match.to);
  my $sup = convert-large-back($left);
  my $inf = convert-large-back($right);
  return triangle($sup, @powers[$i - 1]) + $inf;
}

multi MAIN(Int :$fwd) {
  say convert-large-fwd($fwd);
}
multi MAIN(Str :$back) {
  say convert-large-back($back);
}
```

workfiles/7/conno.pl6

A.4 | workfiles/7/count-days.pl6

```
# Count the number of days between 1/0/0 and D/M/Y, inclusive.

# CONSTANTS

constant \MONTHS_PER_YEAR_CYCLE = 7215;
constant \YEARS_PER_YEAR_CYCLE = 736;
```

```
constant \AVG_MONTHS_PER_YEAR = MONTHS_PER_YEAR_CYCLE /
    YEARS_PER_YEAR_CYCLE;
constant \MONTHS_PER_MONTH_CYCLE = 136;
constant \DAYS_PER_MONTH_CYCLE = 4053;

# COMPUTATION
# For each year, take as many months as are needed
# in order to cycle to the next.

my $c = 0;
my @k = (0);

for 0 ..^ YEARS_PER_YEAR_CYCLE -> $i {
  my $need = 1 - ($c - floor($c));
  my $objs = ceiling($need * AVG_MONTHS_PER_YEAR);
  @k[$i + 1] = $objs;
  $c += $objs / AVG_MONTHS_PER_YEAR;
}

my @cumk = [\+] @k;

sub months-before-year($year) {
  my $whole-cycles = $year div YEARS_PER_YEAR_CYCLE;
  my $remainder = $year % YEARS_PER_YEAR_CYCLE;
  return $whole-cycles * MONTHS_PER_YEAR_CYCLE + @cumk[$remainder];
}

my @m = (0);

for 0 ..^ MONTHS_PER_MONTH_CYCLE -> $i {
  @m.push: ($i % 5 == 2) ?? 29 !! 30;
}

my @cumm = [\+] @m;

sub days-before-month($month) {
  my $whole-cycles = $month div MONTHS_PER_MONTH_CYCLE;
  my $remainder = $month % MONTHS_PER_MONTH_CYCLE;
  return $whole-cycles * DAYS_PER_MONTH_CYCLE + @cumm[$remainder];
}

sub days-before-date($d2, $m, $y) {
  my $d = $d2 - 1; # d is 0-indexed
  my $bm = months-before-year($y) + $m;
  return days-before-month($bm) + $d;
}

sub MAIN($d2, $m, $y) {
  say days-before-date($d2, $m, $y);
}
```

workfiles/7/count-days.pl6

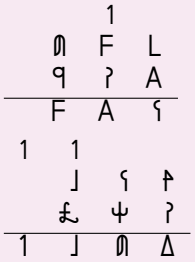
B | Arithmetic in base *v*

This chapter describes algorithms for performing arithmetic operations in Lek-Tsaro's number system.

B.1 | Operations on small numbers

B.1.1 | Additions

If both addends are smaller than 4199, then it is sufficient to use mixed-base addition:



B.1.2 | Subtraction

If both of the operands are smaller than 4199, then it is sufficient to use mixed-base subtraction.

B.1.3 | Determining parity

A number less than 4199 is even iff the sum of its digits in base *v* is even – that is, either none of its digits are odd, or if exactly two are.

B.1.4 | Dividing by two

If a number's base-v representation contains only even digits, then divide each digit by two.

If the representation has two odd digits, then take advantage of the identities

$$11_v/2 = 9_v$$
$$101_v/2 = 99_v$$
$$110_v/2 = T0_v$$

This operation is written as ⟨ᴅ⟩, short for ⟨ᴅʏɪɴᴇ⟩ "one half". Thus, in hacm:

- ᴅ11 = L
- ᴅ101 = LL
- ᴅ110 = F0

B.1.5 | Multiplication

With the previous two operations, it is now possible to use peasant multiplication to multiply small numbers.

B.2 | Operations on larger numbers

B.2.1 | Addition

For some $i \in \mathbb{N}$, and two numbers number $a = x_a :^i y_a$ and $b = x_b :^i y_b$, we take advantage of the fact that

$$x_a :^i y_a + x_b :^i y_b = (x_a + 1) :^i y_a + (x_b - 1) :^i y_b + (x_a - x_b + 1) \tag{B.1}$$
$$x_a :^i y_a + x_b :^i y_b = (x_a + x_b) :^i y_a + 0 :^i y_b + x_a \cdot x_b \tag{B.2}$$
$$= (x_a + x_b) :^i (y_a + y_b) + x_a \cdot x_b \tag{B.3}$$

Romanisation

In this text, the romanisation is used only to transcribe names into English. Whenever possible, the hacmisation should be used.

Table B.1: The consonants of aaaaaaaaaaA.

	Bilabial	Alveolar	Palatal	Velar	Glottal
Nasal	m	n	ñ	ŋ	
Plosive	p b	t d	ť ď	k g	’
Fricative	f	s	š	h	
(coarticulated)	þh	fh		fš	
Affricate		ts	tš		
Lateral fricative		ł			
Approximant		r	j	w	
Lateral approximant		l			
Trill		ř			

Table B.2: The vowels of aaaaaaaaaaA.

Spread	Half-rounded	Rounded
i	y	ŷ
ï	u	û
e		ö
ë		o
a		

Rod signs are represented by the Arabic digits ⟨1 2 3 4 5 6 7 8⟩ attached to the end of the verbs they encompass. Proper words are preceded by a backslash ⟨\⟩.

⟨ŋ⟩ should be capitalised as ⟨Ŋ⟩ only if one can depend on the majuscule glyph appearing like an N with a hook. Otherwise, it should be spelled ⟨Ng⟩.

C | Dictionary

.

.cɒɐn *ninanim* house
.əᵓʃəlɔ *nabst* sadness, grief

ʃ

ʃlɪpcɟ *ninanim* river
ʃlɪɬlɪn *v* (S) fights (O)
ʃlcɾdcn *v* (S) falls on (O)
ʃlɔɲɔ *ninanim* flower
ʃlɔᵉdɪ *desc* sufficient, wanted, wished-for
ʃleɭɪ *desc* complete, full, mature
ʃlel *nsent* who?
ʃɟɪdɔ *nabst* power, magic, motivation
ʃjcɭcn *v* (S) stabs, stings (O)
ʃjclʃɪn *v* (S) wants (O), benefactive
ʃjɔɲəᵓ *ninanim* fruit
ʃɾdɪjcn *v* (S) answers to (O)
ʃɪɸɪn *v* (S) loses, frees (O); (O) escapes
ʃɪbɲɪ *desc* heavy
ʃɔɑɔɭ *ninanim* tree
ʃɔɑɔɭ *nined* wood
ʃedcn *v* (S) buys (O)
ʃeɲ.cᵓ *nedib* beef
ʃeɲɪn *v* rain (S = other)
ʃəɬɪ *nsent* coward, knave
ʃəᶜɲɔ *nined* blood vessels

ɭ

ɭɲɪʃʰəᵓ *nsent* warrior
ɭɔɔᵉlɪ *desc* potent, powerful not in a physical sense
ɭɪ.cdɪ *nabst* south
ɭɪɭɪn *v* (S) makes a loud noise
ɭɪɲedcᵊ *ninanim* mirror
ɭɪn *v* (S) is at (O), locational verb
ɭɪn *nmeas* subdivision of the day cf Grammar / Calendar / Subdivisions of the day / Modern timekeeping
ɭɪɑcᵓ *ninanim* moon
ɭɪɥɪ *ninanim* era
ɭɪɾdɪj *nined* stone
ɭcɭɪ *desc* all, every
ɭɔn *desc* whole, entire
ɭəᵓ.ɪn *v* (S) needs (O)
ɭəᵓʃɪ *desc* old

ɭ

ɭɸeᵓncn *v* (S) hunts for (O)
ɭcnɪn *v* (S) shoots an arrow to (O)
ɭcl *nabst* nature, disposition

ɾ

ɾɪɸʃɪ *ninanim* ring
ɾcn *v* (S) is (O)
ɾcncn *v* (S) attaches to, loves (O)
ɾcne *nmeas* subdivision of the day cf Grammar / Calendar / Subdivisions of the day / Modern timekeeping
ɾcᵊl *nanim* fox
ɾcɒ *nmeas* subdivision of the day cf Grammar / Calendar / Subdivisions of the day / Traditional timekeeping
ɾcᵉɑɸɪ *ninanim* table
ɾe.ɪn *v* (S) knows (O) answers (last clause)
ɾenɪn *v* (S) is worried by (O)
ɾeɑˡc *nabst* daytime
ɾeɾlʲlcn *ninanim* essay
ɾeᵊʃɭe *ninanim* land, country
ɾəʃɪ *desc* many, again
ɾəɸ *ninanim* day, sun

ɾʰ

ɾʰɪ.en *nsent* magician
ɾʰɪn *v* (S) goes toward (O)
ɾʰɪɸcn *v* (S) creates (O)
ɾʰcn *nabst* how many?
ɾʰeᵊncn *v* (S) befriends (O)

n

nɥɪɸɪ *nanim* cat
nɪ.cn *v* (S) waits for/until (O), temporal verb, if
nɪ.eɸcn *v* (S) covers, spans (O)
ncɒcn *v* (S) dances around (O)
nchel *ninanim* group, organisation, order
ncᵊ *ninanim* point ncᵊ–ɒɥɪne halfway point
nelcn *v* (S) swims in (O)
neɒ *desc* male
nebɪn *v* (S) gives something to (O)
neɸɑcn *v* (S) hides from (O)
neɸcʃɪ *desc* sudden
nel *nabst* nature, temperament, disposition
neldɪ *nsent* mind, brain
nəᵊnɪn *v* (S) kills (O), (O) dies
nəᵊbɪn *v* (S) steals from (O)
nəᵊbɪɸɔᵉn *nsent* thief

nᵠ

nᵠɔɸɪn *v* (S) thinks, ponders about (O)

u

uɔᵉɸɔ *nfluid* poison

ɑ

ɑɸenᶣe *ninanim* coin
ɑcɾcn *v* (S) obeys (O)
ɑcn *v* (S) joins (O), and
ɑcnɑɪ *desc* early
ɑcɸcn *v* touch
ɑcɸe *nabst* what
ɑcᵊl *desc* female
ɑɔᵉlɔᵉ *ninanim* spoon
ɑehcn *v* (S) plays with (O)
ɑəᵊ *ninanim* event, occurrence

ɑˡ

ɑˡɪɸe *nabst* quote, words, speech
ɑˡe *ninanim* what
ɑˡəɸəᵊ *nfluid* water

ɑʰ

ɑʰəᵊɒɔ *nabst* empathy

ɒ

ɒɥɪnɐ *nabst* one half
ɒɪl̀ɪn *v* (S) eats (O)
ɒɪjɪ *nsent* person
ɒɪn *nedib* rice
ɒcɑɪ *nsent* child (offspring)
ɒcɥɒɐᵓ *nanim* tongue
ɒcɥcᵊl̀ *nabst* evening
ɒɔʃɪn *v* (S) produces (O)
ɒɔʃɪn *v* (S) is destroyed to make, for (O)
ɒɔᵉɥəɒ *nanim* scorpion
ɒɐlcn *v* (S) gives birth to (O), (O) is born (S) is not necessarily the mother; this can be either parent
ɒɐjcn *v* (S) raises, takes care of, tends to (O)
ɒɐnʃɐ *nabst* morning
ɒɐɑɥɪn *v* (S) stands on, is on (O)
ɒɐɸɪn *v* (S) drowns in (O), (O) fills (S)
ɒɐdɪ *desc* in return
ɒɐdcn *v* (S) succeeds at (O), (S) does something to (O)
ɒɐɥcᵊ *ninam* opposite side
ɒɐl *nmeas* volume in expressions such as ɒɐl–ɥəjɔᵉ “cupful”
ɒɐl̀ɪ *desc* similar
ɒɐl̀cn *v* (S) imitates (O)
ɒəʃɪn *v* (S) recalls (O)
ɒənᵠɔ *nanim* rabbit

ɑ

ɑɪnʃɪn *v* (S) is inside (O)
ɑɪɑɔ *ninanim* back (body part)
ɑɪbə *nabst* life, existence
ɑɐlɐɒ *nfluid* nitrogen
ɑɐɒɪn *v* (S) sleeps
ɑəᵓɥɔ *ninanim* pathway

ɸ

ɸɥəᵓnɪn *v* (S) laughs at (O)
ɸoɐjɪn *v* (S) founds (O)
ɸcʃɩ *desc* well (not sick)
ɸcj *nabst* five

d

dɦɪʃjɪ *nabst* ground, floor
dɦɐn *nanim* owl
dɥcn *v* hold, carry, instrumental verb
dɥɐᵓɒɐ *ninanim* city
dɪʃɥɪn *v* (S) sits at (O)
dɪʃɪn *v* (S) dislikes, objects to, disapproves of (O)
dɪɾɐ *ninanim* landmass, domain
dɐɥɪn *v* (S) wears, experiences (O)
dɐɥɐᵓ *nedib* noodles
də.ɔn *nanim* large animal
dənᵠɪ *ninanim* knee

b

bɪnɐ *ninanim* year
bɪɾəl̀ *nmeas* subdivision of the day cf Grammar / Calendar / Subdivisions of the day / Modern timekeeping
bcjcn *v* (S) walks to (O)
bəj *nabst* future, next (time period)
bəᵓnᵠɪn *v* (S) succumbs to their impulses

h

hɥcɑɐn *ninanim* book
hɪ.ɪɥ *nabst* spring (season)
hɪjnɔ *ninanim* nose
hɪjdɐ *ninanim* leaf
hɪɾdəᵓ *ninanim* statue
hcn *v* (S) claims that (O)
hcɥcn *v* (S) is named (O)
hcᵊɒɪ *nedib* food
hɔl̀ɪ *ninanim* cart
hɐɑɪn *v* (S) asks for, requests (O)
hɐɒʃɩ *desc* large
həᵓɒɪ *desc* evil, malicious

ʏ

ʏɪn *v* (S) sees (O), because ʏɪn[O=ɟəɸ] (“see the sun”) = “wish”

ɳ

ɳɪɟɪn *v* discipline, punish, constrain
ɳcn *v* (S) allows (O)

ɸ

ɸɪ.cʃɪn *v* (S) is beside (O)
ɸɪʃɪ *nined* grass
ɸɪʃɪbɪ *ninanim* blade of grass
ɸɪɭɪn *v* (S) climbs, rises in (O)
ɸcᵊɭ *ninanim* star
ɸeɑɪn *v* (S) speaks to (O), (S) asks (O)
ɸeɑcn *v* (S) spreads (O)
ɸeɭɪ *ninanim* place
ɸeᵓɟɪ *desc* friendly, kind, considerate, nice
ɸəɭɪ *desc* late
ɸəɭcᵉ *nabst* nighttime
ɸəɟcᵉ *ninanim* cup
ɸəɒəᶜ *nmeas* tidal day
ɸəᵓʃc *nined* gold

s

sɪdjc *nfluid* soup
sɪɳe *nanim* fish
seɷʏɪn *v* (S) perceives (O) non-visually

o

oelje *nined* forest

l

leɭ *nabst* language
leɭebɪ *ninanim* a language