



**HAL**  
open science

## Description of the verbal morphology of Asama

Dimitri Lévêque, Thomas Pellard

► **To cite this version:**

Dimitri Lévêque, Thomas Pellard. Description of the verbal morphology of Asama: A realizational and implemented approach. International Symposium of Morphology 2019, Sep 2019, Paris, France. hal-02295412

**HAL Id: hal-02295412**

**<https://hal.science/hal-02295412>**

Submitted on 25 Sep 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Description of the verbal morphology of Asama

## A realizational and implemented approach

<https://hal.archives-ouvertes.fr/hal-02295412>

Dimitri Lévêque

INALCO-EHESS-CNRS, CRLAO  
leveque.dimitri@gmail.com

Thomas Pellard

CNRS-EHESS-INALCO, CRLAO  
thomas.pellard@cnrs.fr

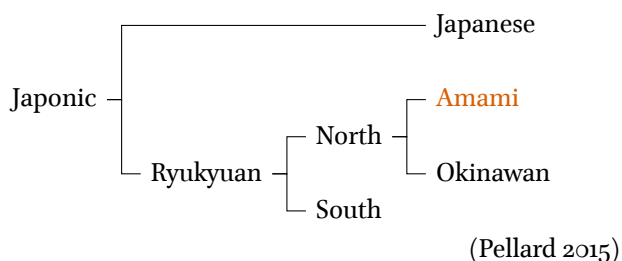
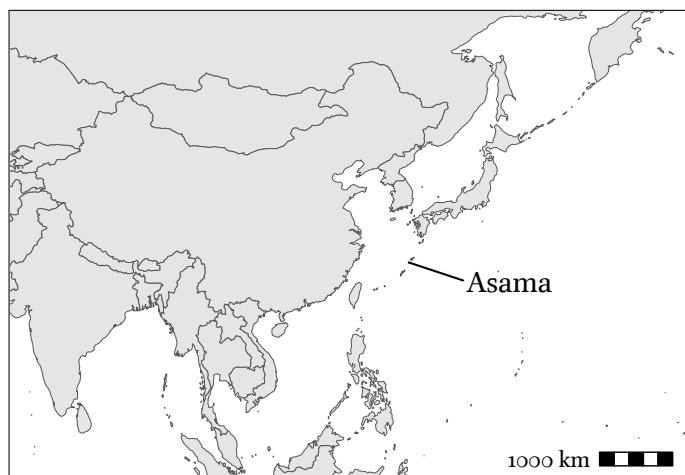
### [1] Outline

1. overview of the verb inflectional morphology of Asama, with a focus on non-canonical phenomena
2. computational implementation
3. complexity measures of implicative structure

## Introduction

### [2] Asama

- endangered variety of Amami Ryukyuan
- spoken in the Asama village of Tokunoshima Island, Japan
- a few hundred of speakers, most > 70 years old
- SOV, dependent-marking
- word-tone, light vs. heavy syllables (CVV, CVC)



### [3] Japonic verb morphology

- Japanese has a rather simple and almost canonical agglutinative morphology.
- some other Japonic languages are much more complex and opaque (Pellard & Yamada 2017; Lévêque 2017)

### [4] Asama verb morphology exhibits several non-canonical phenomena

- stem allomorphy: segmental & suprasegmental (tone & vowel length)
- suffix allomorphy
- systematic overabundance
- multi-functional exponents

## Data & methods

### [5] Data collection

- 50 full + 400 near-full inflectional verb paradigms
- data from published sources (Okamura et al. 2009; Uwano 2001)
- supplemented by data collected in the field by D. Lévêque (2018–2019)
- elicitation and natural texts

### [6] Methods

- Formal description* Paradigm Function Morphology (PFM; Bonami & Stump 2016; Stump 2001; 2015; 2018)
- Computational implementation* finite-state transducers (FSTs, Beesley & Karttunen 2003; Hulden 2009)
- Quantitative analysis* information-theoretical complexity measures (Ackerman et al. 2009; Ackerman & Malouf 2013; Blevins 2013; Bonami & Beniamine 2016)

## The verb morphology of Asama

### Non-canonical phenomena

### [7] Systematic overabundance

	PROG.PST	
	#1	#2
'to begin'	<i>hazimiitutan</i> H	<i>hazimituutan</i> H
'to be born'	<i>m'aariitutan</i> H	<i>m'aarituutan</i> H

### [8] Multi-functional exponents

	IIMP	SEQ
'to read'	<i>juum-i</i> LH	<i>juud-i</i> LH
'to meet'	<i>oor-i</i> H	<i>oot-i</i> H

## [9] Overview of alternations

	'to sell'	'to knit'	'to take in charge'
NPST	<i>ujui</i> H	<i>amjui</i> H	<i>acikajui</i> LH
CVB2	<i>urug99si</i> H	<i>amjug99si</i> H	<i>acikarug99si</i> LH
NEG	<i>uran</i> H	<i>aman</i> H	<i>acikaran</i> LH
DIMP	<i>uroo</i> H	<i>amoo</i> H	<i>acikaroo</i> LH
IIMP	<i>urii</i> H	<i>aami</i> HL	<i>acikaari</i> LH
CVB	<i>ui</i> H	<i>amii</i> H	<i>acikai</i> LH
DES	<i>uicjaahai</i> H	<i>amicjaahai</i> H	<i>acikaicjaahai</i> LH
PST	<i>utan</i> H	<i>adan</i> LH	<i>acikatan</i> LH
SEQ	<i>utti</i> H	<i>aadi</i> HL	<i>acikaati</i> LH
PROG	<i>utui</i> LHL	<i>aadui</i> HL	<i>acikaatui</i> LHL
PROG.NEG	<i>utuuran</i> LHL	<i>aaduran</i> HL	<i>acikaaturan</i> LHL

## [10] Segmental alternations

	'to laugh'	'to knit'	'to die'
NPST	<i>warojui</i> H	<i>amjui</i> H	<i>moisjui</i> H
CVB2	<i>warorug99si</i> H	<i>amjug99si</i> H	<i>moisjug99si</i> H
NEG	<i>waroran</i> H	<i>aman</i> H	<i>moisjan</i> H
DIMP	<i>waroroo</i> H	<i>amoo</i> H	<i>moisjoo</i> H
IIMP	<i>waroori</i> H	<i>aami</i> H	<i>moisjii</i> H
CVB	<i>waroi</i> H	<i>amii</i> H	<i>moisii</i> H
DES	<i>waroicjaahai</i> H	<i>amicjaahai</i> H	<i>moisicjaahai</i> H
PST	<i>warotan</i> H	<i>adan</i> LH	<i>moisjan</i> H
SEQ	<i>warooti</i> H	<i>aadi</i> HL	<i>moisjii</i> H
PROG	<i>warotui</i> H	<i>aadui</i> HL	<i>moisjui</i> H
PROG.NEG	<i>warotuuran</i> H	<i>aaduran</i> HL	<i>moisjuran</i> H

## [11] Vowel length alternations

	'to laugh'	'to knit'	'to take in charge'
NPST	<i>warojui</i> H	<i>amjui</i> H	<i>acikajui</i> LH
NEG	<i>waroran</i> H	<i>aman</i> H	<i>acikaran</i> LH
DIMP	<i>waroroo</i> H	<i>amoo</i> H	<i>acikaroo</i> LH
IIMP	<i>waroori</i> H	<i>aami</i> HL	<i>acikaari</i> LH
CVB	<i>waroi</i> H	<i>amii</i> H	<i>acikai</i>
DES	<i>waroicjaahai</i> H	<i>amicjaahai</i> H	<i>acikaicjaahai</i> LH
SEQ	<i>warooti</i> H	<i>aadi</i> HL	<i>acikaati</i> LH
PROG	<i>warotui</i> H	<i>aadui</i> HL	<i>acikaatui</i> LHL
PROG.NEG	<i>warotuuran</i> H	<i>aaduran</i> HL	<i>acikaaturan</i> LHL

## [12] Tone alternations

	'to sell'	'to knit'	'to take in charge'
NPST	<i>ujui</i> H	<i>amjui</i> H	<i>acikajui</i> LH
NEG	<i>uran</i> H	<i>aman</i> H	<i>acikaran</i> LH
DIMP	<i>uroo</i> H	<i>amoo</i> H	<i>acikaroo</i> LH
IIMP	<i>urii</i> H	<i>aami</i> HL	<i>acikaari</i> LH
CVB	<i>ui</i> H	<i>amii</i> H	<i>acikai</i> LH
DES	<i>uicjaahai</i> H	<i>amicjaahai</i> H	<i>acikaicjaahai</i> LH
SEQ	<i>utti</i> H	<i>aadi</i> HL	<i>acikaati</i> LH
PROG	<i>utui</i> LHL	<i>aadui</i> HL	<i>acikaatui</i> LHL
PROG.NEG	<i>utuuran</i> LHL	<i>aaduran</i> HL	<i>acikaaturan</i> LHL

## A Paradigm Function Morphology (PFM) analysis

## [13] Non-canonical phenomena

- problematic for morpheme-based approaches  
→ Word-and-Paradigm approach
- Paradigm Function Morphology (PFM)
  - one of the most carefully articulated and formalised theoretical frameworks of morphology
  - readily handles various non-canonical morphological phenomena
  - readily implementable (Karttunen 2003)
  - good empirical coverage of typologically diverse morphological systems
  - not committed to a particular syntactic framework

## [14] Data sample

	'to laugh'	'to knit'	'to take in charge'
NPST	<i>warojui</i> H	<i>amjui</i> H	<i>acikajui</i> LH
CVB2	<i>warorug99si</i> H	<i>amjug99si</i> H	<i>acikarug99si</i> LH
NEG	<i>waroran</i> H	<i>aman</i> H	<i>acikaran</i> LH
IIMP	<i>waroori</i> H	<i>aami</i> HL	<i>acikaari</i> LH
CVB	<i>waroi</i> H	<i>amii</i> H	<i>acikai</i> LH
SEQ	<i>warooti</i> H	<i>aadi</i> HL	<i>acikaati</i> LH
PROG	<i>warotui</i> H	<i>aadui</i> HL	<i>acikaatui</i> LHL

## [15] PFM analysis

Rules of stem choice:	$X_V, \{\}$	→ $X$
	$X_V, \{\text{IIMP, SEQ}\}$	→ $X$
	$X_V, \text{class } 2,3, \{\text{PROG}\}$	→ $X$
Block 1:	$X_V, \{\text{NPST, CVB2}\}$	→ $XT_1$
	$X_V, \text{class } 1,3, \{\text{CVB2}\}$	→ $XT_4$
	$X_V, \{\text{CVB}\}$	→ $XT_3$
	$X_V, \{\text{NEG, HORT, IIMP}\}$	→ $XT_4$
	$X_V, \{\text{SEQ, PROG NPST}\}$	→ $XT_5$
Block 2:	$X_V, \{\text{NPST}\}$	→ $XT_{ui}$
	$X_V, \{\text{NEG}\}$	→ $X_{an}$
	$X_V, \{\text{CVB}\}$	→ $X_{ii}$
	$X_V, \{\text{SEQ, IIMP}\}$	→ $X_i$
Block 3:	$X_V, \text{class } 1,2, \{\}$	→ $X_H$
	$X_V, \text{class } 2, \{\text{IIMP, SEQ, PROG}\}$	→ $X_{HL}$
	$X_V, \text{class } 3, \{\}$	→ $X_{LH}$
	$X_V, \text{class } 3, \{\text{PROG}\}$	→ $X_{LHL}$

## [16] Two types of inflectional classes

- PFM analysis → segmental and suprasegmental alternations can be treated separately
- vowel length and tone assumed to be on an autosegmental tier
- behave independently from segmental alternations

## [17] Segmental alternations

$T_1$	$T_2$	$T_3$	$T_4$	$T_5$
<i>bj</i>	—	<i>b</i>	<i>b</i>	<i>d</i>
<i>mj</i>	—	<i>m</i>	<i>m</i>	<i>d</i>
<i>gj</i>	—	<i>g</i>	<i>g</i>	<i>zj</i>
<i>kj</i>	—	<i>k</i>	<i>k</i>	<i>cj</i>
<i>kj</i>	—	<i>k</i>	<i>k</i>	<i>ccj</i>
<i>sj</i>	—	<i>s</i>	<i>sj</i>	<i>cj</i>
<i>sj</i>	—	<i>s</i>	<i>sj</i>	<i>sj</i>
<i>cj</i>	—	<i>c</i>	<i>t</i>	<i>ccj</i>
<i>j</i>	∅	∅	<i>r</i>	<i>t</i>
<i>j</i>	∅	<i>r</i>	<i>r</i>	<i>cj</i>
<i>j</i>	∅	<i>r</i>	<i>r</i>	<i>ccj</i>
<i>j</i>	∅	∅	<i>r</i>	<i>tt</i>

## Morphomic sets of forms (Aronoff 1994):

- $T_1$ : NPST, NPST2, ...
- $T_2$ : PROH
- $T_3$ : CVB, DES, ...
- $T_4$ : NEG, HORT, IIMP, ...
- $T_5$ : SEQ, PST, PROG, ...

## [18] Suprasegmental alternations

Class	A	B	C
I1	$RT_1X$ H	$RT_5X$ H	$RT_5X:Y$ H
I2	$RT_1X$ H	$RT_5X$ H	$RT_5X$ H, $RT_5X:Y$ H
II1	$RT_1X$ H	$RT_5X$ : H	$RT_5X:Y$ LHL
II2	$RT_1X$ H	$RT_5X$ H	$RT_5X:Y$ LHL
III	$RT_1X$ LH	$RT_5X$ HL	$RT_5X$ HL
IV	$RT_1X$ LH	$RT_5X$ LH	$RT_5X$ LHL
V	$RT_1X$ HL	$RT_5X$ HL	$RT_5X$ HL

## [19] Suprasegmental alternations (example)

Class	A: {NPST}	B: {SEQ}	C: {PROG}
I1	$RT_1ui$ H	$RT_5i$ H	$RT_5ui$ H
I2	$RT_1ui$ H	$RT_5i$ H	$RT_5ui$ H, $RT_5X:Y$ H
II1	$RT_1ui$ H	$RT_5i$ : H	$RT_5ui$ LHL
II2	$RT_1ui$ H	$RT_5i$ H	$RT_5ui$ LHL
III	$RT_1ui$ LH	$RT_5i$ HL	$RT_5ui$ HL
IV	$RT_1ui$ LH	$RT_5i$ LH	$RT_5ui$ LHL
V	$RT_1ui$ HL	$RT_5i$ HL	$RT_5ui$ HL

## Computational implementation

## [20] Why an implemented description?

- “the insufficiency of paper-and-pencil linguistics” (Karttunen 2006)
- provide a maximally precise and explicit description
- helpful for testing hypotheses and for verifying the accuracy of the description
- allow to compute complexity measures

## [21] Why FSTs?

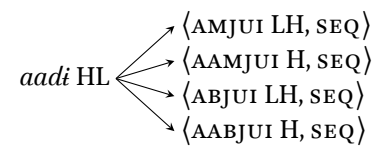
- standard NLP tools
- can handle almost any morphological process (Koskeniemi 1983; Karttunen et al. 1992; Aksënova et al. 2016)
- bidirectional:
  - production* lexeme/root → inflected form
  - recognition* inflected form → lexeme/root
- many free, open-source and well documented implementations
- Foma free software (Hulden 2009)

## [22] FSTs

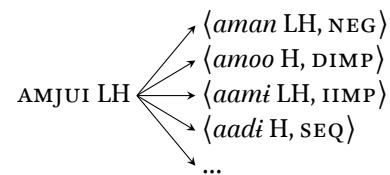
1. content paradigm cell  $\langle L, \sigma \rangle \rightarrow$  realised cell  $w$

$$\langle \text{AMJUI LH, SEQ} \rangle \rightarrow \text{aadi HL}$$

2. unlabeled form  $w \rightarrow$  all possible morphological analyses  $\langle L, \sigma \rangle$

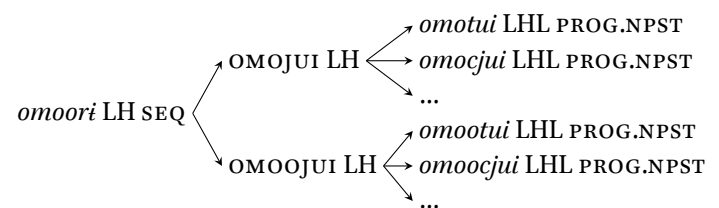


3.  $L \rightarrow$  full realised paradigm, i.e. a set of cells  $\{\langle w, \sigma \rangle, \langle w', \sigma' \rangle, \dots\}$



## [23] FST composition

- composition of 2 FSTs
- any (existing) given realised form  $\rightarrow$  list of all possible realised forms of any other paradigm cell



## Implicative structure &amp; complexity measures

## [24] Implicative structure

- PFM: segmentation between stem and affixes
- implicative structure: no need to segment, whole forms are taken into account (Bonami 2014; Bonami & Luís 2015)
- including non-alternating parts helps reducing the uncertainty

## [25] Segmental information reduces uncertainty

- segmental information:

$$X_1 = X_{\{a,o,u\}}$$

$$X_2 = X_{\{i\}}$$

$$X_3 = X_{\{\{s,z,c\}i\}}$$

$$X_4 = X_{\{\{C-\{s,z,c\}i\}\}}$$

- without knowledge:  $\left\{ \begin{array}{l} X_i \\ X_{r_{ii}} \end{array} \right\}$

- with knowledge:  $[NPST : X_j jui \Rightarrow CVB : X_i]$   
 $[NPST : X_j jui \Rightarrow CVB : X_i r_{ii}]$

[26] Length & syllable structure information reduce uncertainty

Class	Length	Structure	Example
I1	$2\mu$	(C)V <sub>i</sub> V <sub>i</sub> , (C)VCV	<i>warojui</i> H 'to laugh'
I2	$\geq 3\mu$	—	<i>m<sup>?</sup>aar<sup>?</sup>ijui</i> H 'to be born'
II1	$\leq 2\mu$	(C)V, (C)VC] <sub><math>\sigma</math></sub> , (C)Vi	<i>tubjui</i> H 'to fly'
II2	$2\mu$	(C)VCV, (C)VN] <sub><math>\sigma</math></sub>	<i>asibjui</i> H 'to play'
III	$\leq 2\mu$	(C)V(N $\cup$ C)] <sub><math>\sigma</math></sub>	<i>umjui</i> LH 'to ripen'
IV	—	$\neq$ (C <sup>?</sup> )V(N $\cup$ C)] <sub><math>\sigma</math></sub>	<i>tuijui</i> LH 'to go through'
V	$2\mu$	(C)V <sub>i</sub> V <sub>i</sub>	<i>m<sup>?</sup>oojui</i> HL 'to be' (honor.)

- without knowledge:  $\left\{ \begin{array}{l} X : T_5 i H \\ X T_5 i i H \end{array} \right\}$

- with knowledge:  $X = (C)V \Rightarrow [NPST : X_j jui H \Rightarrow SEQ : X T_5 i i H]$   
 $X = (C)V C V \Rightarrow [NPST : X_j jui H \Rightarrow SEQ : X : T_5 i H]$

[27] Entropy calculations & sources of uncertainty

*Paradigm Cell Filling Problem* "What licenses reliable inferences about the inflected (and derived) surface forms of a lexical item?" (Ackerman et al. 2009: 54)

*Shannon entropy* information quantity delivered by the source, used as a measure of uncertainty

$$H(X) = - \sum_{x \in X} P(x) \log_2(P(x))$$

*conditional Shannon entropy* how much does knowing a cell help predicting another?

$$H(X|Y) = - \sum_{x \in X} \sum_{y \in Y} P(x, y) \log_2(P(x|y))$$

[28] Distillation of 5 cells (areas of interpredictability; Stump & Finkel 2013)

NPST	CVB	IIMP	SEQ	PROG.NPST
<i>RT<sub>1</sub>ui</i> H	<i>RT<sub>3</sub>ii</i> H, <i>RT<sub>4</sub>ii</i> H	<i>R:T<sub>4</sub>i</i> H	<i>R:T<sub>5</sub>i</i> H	<i>RT<sub>5</sub>ui</i> H
<i>RT<sub>1</sub>ui</i> H	<i>RT<sub>3</sub>ii</i> H, <i>RT<sub>4</sub>ii</i> H	<i>R:T<sub>4</sub>i</i> H	<i>R:T<sub>5</sub>i</i> H	<i>RT<sub>5</sub>ui</i> H, <i>RT<sub>5</sub>ui</i> H
<i>RT<sub>1</sub>ui</i> H	<i>RT<sub>3</sub>ii</i> H, <i>RT<sub>4</sub>ii</i> H	<i>RT<sub>4</sub>ii</i> H	<i>RT<sub>5</sub>ii</i> H	<i>RT<sub>5</sub>ui</i> LHL
<i>RT<sub>1</sub>ui</i> H	<i>RT<sub>3</sub>ii</i> H, <i>RT<sub>4</sub>ii</i> H	<i>RT<sub>4</sub>i</i> H	<i>R:T<sub>5</sub>i</i> H	<i>RT<sub>5</sub>ui</i> LHL
<i>RT<sub>1</sub>ui</i> LH	<i>RT<sub>3</sub>ii</i> LH, <i>RT<sub>4</sub>ii</i> LH	<i>R:T<sub>4</sub>i</i> HL	<i>R:T<sub>5</sub>i</i> HL	<i>RT<sub>5</sub>ui</i> HL
<i>RT<sub>1</sub>ui</i> LH	<i>RT<sub>3</sub>ii</i> LH, <i>RT<sub>4</sub>ii</i> LH	<i>R:T<sub>4</sub>i</i> LH	<i>R:T<sub>5</sub>i</i> LH	<i>RT<sub>5</sub>ui</i> LHL
<i>RT<sub>1</sub>ui</i> HL	<i>RT<sub>3</sub>ii</i> HL, <i>RT<sub>4</sub>ii</i> HL	<i>RT<sub>4</sub>i</i> HL	<i>RT<sub>5</sub>i</i> HL	<i>RT<sub>5</sub>ui</i> HL

[29] Unary implications

- knowledge of only one cell
- type frequencies of classes taken into account

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.244
CVB	0.928		0.085	0.300	0.559
IIMP	0.951	0.206		0.222	0.529
SEQ	1.360	1.007	0.423		0.322
PROG.NPST	1.244	0.942	0.421	0.000	

[30] Segmental alternations & uncertainty

- unary implications for segmental alternations
- full interpredictability between 2 zones
- entropy remains low because of the uneven frequencies of the segmental classes

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.222
CVB	0.000		0.000	0.222	0.222
IIMP	0.000	0.000		0.222	0.222
SEQ	0.419	0.419	0.419		0.000
PROG.NPST	0.419	0.419	0.419	0.000	

[31] Unpredictable segmental alternations

- $H(SEQ|NPST)$ :  $\left\{ \begin{array}{l} Xti \\ Xtii \\ Xcji \end{array} \right\}$
- $H(CVB|PROG.NPST)$ :  $\left\{ \begin{array}{l} Xmii \\ Xbii \end{array} \right\}$

[32] Neutralisation of vowel length

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.244
CVB	0.928		0.085	0.300	0.559
IIMP	0.951	0.206		0.222	0.529
SEQ	1.360	1.007	0.423		0.322
PROG.NPST	1.244	0.942	0.421	0.000	

- $H(NPST|CVB)$ :  $[CVB : wari (*warooi) H \Rightarrow NPST : \left\{ \begin{array}{l} warojui H \\ waroojui H \end{array} \right\}]$
- $H(NPST|IIMP)$ :  $[IIMP : acitki LH \Rightarrow \left\{ \begin{array}{l} NPST : acitkjui LH \\ NPST : acikjui LH \end{array} \right\}]$

[33] Neutralisation of tonal oppositions

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.244
CVB	0.928		0.085	0.300	0.559
IIMP	0.951	0.206		0.222	0.529
SEQ	1.360	1.007	0.423		0.322
PROG.NPST	1.244	0.942	0.421	0.000	

- $H(\text{NPST}|\text{IIMP})$ :  
 $[\text{IIMP} : \text{uuti} (\text{H}=\text{HL}) \Rightarrow \text{NPST} : \left\{ \begin{array}{l} \text{ucjui LH} \\ \text{uucjui H} \end{array} \right\}]$
- $H(\text{PROG.NPST}|\text{SEQ})$ :  
 $[\text{SEQ} : \text{aadi} (\text{H}=\text{HL}) \Rightarrow \text{PROG.NPST} : \left\{ \begin{array}{l} \text{aadui H} \\ \text{aadui HL} \end{array} \right\}]$

[34] Summary of the sources of uncertainty

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST				V, S	V, S
CVB	V		V	V, S	V, S
IIMP	V, T	V, T		V, S	V, T, S
SEQ	V, T, S	V, T, S	V, S		V, T
PROG.NPST	V, S	V, S	V, S		

(V = vowel length, T = tone, S = segment)

[35] Binary implications

- knowledge of two cells
- $\rightarrow$  identifying the principal parts of the system, i.e. the set of forms from which all the paradigm is predictable (Finkel & Stump 2007; Stump & Finkel 2013).

[36] Principal parts

H(C R)	NPST	CVB	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.244
{NPST, CVB}	0.000		0.000	0.222	0.250
{NPST, IIMP}	0.000	0.000		0.222	0.250
{NPST, SEQ}	0.000	0.000	0.000		0.023
{NPST, PROG.NPST}	0.000	0.000	0.000	0.000	

## Conclusions

[37] Conclusions

- PFM: clear framework for morphological description
- computational implementation with FSTs
  - explicitness and accuracy
  - enables complexity measures
- implicative structure with conditional entropy measures
  - identify phonological factors of uncertainty
  - identify the principal parts of the system
- future directions
  - more data for more coverage
  - Information-based Morphology (Crysmann & Bonami 2015): no need to introduce a radical, no need for rigid blocks of rules

## Abbreviations

CVB = converb, DES = desiderative, DIMP = direct imperative, HORT = hortative, IIMP = indirect imperative, IMP = imperative, NEG = negative, NPST = non-past, PROG = progressive, PROH = prohibitive, PST = past, SEQ = sequential.

## References

- Ackerman, Farrell & Blevins, James P. & Malouf, Robert. 2009. Parts and wholes: Implicative patterns in inflectional paradigms. In Blevins, James P. & Blevins, Juliette (eds.), *Analogy in grammar: Form and acquisition*, 54–81. Oxford: Oxford University Press. <https://doi.org/10.1093/acprof:oso/9780199547548.003.0003>.
- Ackerman, Farrell & Malouf, Robert. 2013. Morphological organization: The low conditional entropy conjecture. *Language* 89(3). 429–464. <https://doi.org/10.1353/lan.2013.0054>.
- Aksënova, Alëna & Graf, Thomas & Moradi, Sedigheh. 2016. Morphotactics as tier-based strictly local dependencies. In *Proceedings of the 14th Annual SIGMORPHON Workshop on Computational Research in Phonetics, Phonology, and Morphology*, 121–130. Berlin: Association for Computational Linguistics. <https://doi.org/10.18653/v1/W16-2019>.
- Aronoff, Mark. 1994. *Morphology by itself: Stems and inflectional classes*. Cambridge: MIT Press.
- Beesley, Kenneth & Karttunen, Lauri. 2003. *Finite state morphology*. Stanford: Center for the Study of Language and Information Publications.
- Blevins, James P. 2013. The information-theoretic turn. *Psychologia* 46(4). 355–375. <https://doi.org/10.2298/psi1304355b>.
- Bonami, Olivier. 2014. *La structure fine des paradigmes de flexion: Études de morphologie descriptive, théorique et formelle*. Paris: Université Paris Diderot. (Habilitation dissertation). <https://tel.archives-ouvertes.fr/tel-01531860>.
- Bonami, Olivier & Beniamine, Sarah. 2016. Joint predictiveness in inflectional paradigms. *Word Structure* 9(2). 156–182. <https://doi.org/10.3366/word.2016.0092>.
- Bonami, Olivier & Luís, Ana R. 2015. Sur la morphologie implicative dans la conjugaison du portugais: Une étude quantitative. In Léonard, Jean Léo (ed.), *Morphologie flexionnelle et dialectologie romane*, 111–151. Leuven: Peeters.
- Bonami, Olivier & Stump, Gregory. 2016. Paradigm function morphology. In Hippisley, Andrew & Stump, Gregory (eds.), *The Cambridge handbook of morphology*, 449–481. Cambridge: Cambridge University Press.
- Crysmann, Berthold & Bonami, Olivier. 2015. Variable morphotactics in Information-based Morphology. *Journal of Linguistics* 52(2). 311–374. <https://doi.org/10.1017/S0022226715000018>.
- Finkel, Raphael & Stump, Gregory. 2007. Principal parts and morphological typology. *Morphology* 17. 39–75. <https://doi.org/10.1007/s11525-007-9115-9>.
- Hulden, Mans. 2009. Foma: A finite-state compiler and library. In *Proceedings of the Demonstrations Session at EACL 2009*, 29–32. <https://www.aclweb.org/anthology/E09-2008>.
- Karttunen, Lauri. 2003. Computing with realizational morphology. In Gelbukh, Alexander (ed.), *Computational linguistics and intelligent text processing*, 203–214. Berlin: Springer. [https://doi.org/10.1007/3-540-36456-0\\_20](https://doi.org/10.1007/3-540-36456-0_20).
- Karttunen, Lauri. 2006. The insufficiency of paper-and-pencil linguistics: The case of Finnish prosody. In Butt, Miriam

- & Dalrymple, Mary & Holloway King, Tracy (eds.), *Intelligent linguistic architectures: Variations on themes by Ronald M. Kaplan*, 287–300. Stanford: Center for the Study of Language and Information Publications. <http://roa.rutgers.edu/article/view/828>.
- Karttunen, Lauri & Kaplan, Ronald M. & Zaenen, Annie. 1992. Two-level morphology with composition. In *Proceedings of COLING-92*, 141–148. <https://www.aclweb.org/anthology/C92-1025>.
- Koskenniemi, Kimmo. 1983. *Two-level morphology: A general computational model for word-form recognition and production*. Helsinki: University of Helsinki. <http://www.ling.helsinki.fi/~koskenni/doc/Two-LevelMorphology.pdf>.
- Lévêque, Dimitri. 2017. *Description implémentée de la phonologie et de la morphologie verbale du dialecte des langues ryukyū parlé à Asama, Tokunoshima*. Paris: Université Sorbonne Nouvelle Paris 3. (Master 2's dissertation).
- Okamura, Takahiro & Sawaki, Motoei & Nakajima, Yumi & Fukushima, Chitsuko & Kikuchi, Satoru (eds.). 2009. *Tokunoshima hōgen nisen bun jiten*. Revised edn. Matsumoto: Tokunoshima Hōgen no Kai.
- Pellard, Thomas. 2015. The linguistic archeology of the Ryukyu Islands. In Heinrich, Patrick & Miyara, Shinsho & Shimoji, Michinori (eds.), *Handbook of the Ryukyuan languages: History, structure, and use*, 13–37. Berlin: De Gruyter Mouton. <https://doi.org/10.1515/9781614511151.13>. <https://hal.archives-ouvertes.fr/hal-01289257>.
- Pellard, Thomas & Yamada, Masahiro. 2017. Verb morphology and conjugation classes in Dunan (Yonaguni). In Kiefer, Ferenc & Blevins, James P. & Bartos, Huba (eds.), *Perspectives on morphological organization*, 31–49. Leiden: Brill. [https://doi.org/10.1163/9789004342934\\_004](https://doi.org/10.1163/9789004342934_004). <https://hal.archives-ouvertes.fr/hal-01493096>.
- Stump, Gregory T. 2001. *Inflectional morphology: A theory of paradigm structure*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CB09780511486333>.
- Stump, Gregory. 2015. *Inflectional paradigms*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/cbo9781316105290>.
- Stump, Gregory. 2018. Paradigm Function Morphology. In Audring, Jenny & Masini, Francesca (eds.), *The Oxford handbook of morphological theory*, 285–304. Oxford: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199668984.013.23>.
- Stump, Gregory & Finkel, Raphael. A. 2013. *Morphological typology: From word to paradigm*. Cambridge: Cambridge University Press.
- Uwano, Zendō. 2001. Tokunoshima Asama hōgen no kat-suyōkei akusento shiryō. *Ryūkyū no Hōgen* 25. 1–61. <http://hdl.handle.net/10114/11893>.