

# Decomposing cardinal numerals: Cross-linguistic evidence

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## Introduction

Simplex numerals

Complex numerals

Structures

Spellout

# Two functions

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Bultinck (2005), Rothstein (2013, 2017)

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▶ **object counting**  $\Rightarrow$  quantification over entities

- (2) a. **five** cats
- b. the **five** girls

# The main claim

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## Data

- ▶ we look at morphological relations between the two types of numerals



# Distinguishing the two functions

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- (3)
- Five** times two equals ten.
  - #Five** things times two things equals ten things.

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- (3) a. Five times two equals ten.  
b. #Five things times two things equals ten things.
- (4) a. Five is a Fibonacci number.  
b. #Five things are a Fibonacci number.
- (5) a. All five cats who live in the barn are crazy.  
b. #All five is odd.

# Morphological marking patterns

## Meaning/form correspondences

cf. Greenberg (1978), Hurford (1998, 2001)

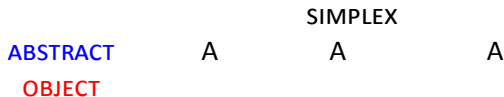
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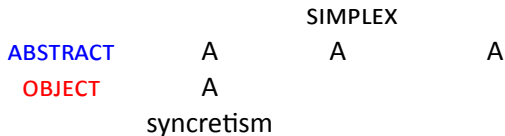


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OBJECT	A	A+C	
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		COMPLEX		
ABSTRACT	A+B	A+B	A+B	A+B
OBJECT				

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# Syncretism

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- (6) a. **five** cats  
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- (7) a. bal **ayoku**  
ball two  
'two balls'  
b. Yeting nu **ayoku** mi-a maiye sua  
five SPEC two take-DUR if three  
'If two is taken from five, it is three.'

Abui

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- (8) a. \*go-no ringo  
five-GEN apple
- b. go-ko-no ringo  
five-CL-GEN apple  
'five apples'

Japanese

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Japanese

- (9) a. juu waru go-wa ni-da.  
ten divide.by five-TOP two-COP  
'Ten divided by five is two.'  
b. #juu-ko waru go-ko-wa ni-ko-da.  
ten-CL divide.by five-CL-TOP two-CL-COP

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(10) **dalawa-ng** aklát  
two-LIG book  
'two books'

(11) **Dalawa** dagdagan ng apat ay anim.  
two plus GEN four TOP/LNK six  
'Two plus four equals six.'

Tagalog

# Suppletion

**Suppletivism**: object counting  $\neq$  abstract counting

cf. Greenberg (1978), A. Borg (1974), A. J. Borg (1987), Hurford (1998, 2001)

- ▶ morphologically independent forms for 2 in Maltese

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- (12) a. \***tnejn** nisa  
two women
- b. **żewġ** nisa  
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- (13) a. **Tnejn** u **tnejn** jagħmlu erbgħa.  
two and two they-make four  
'Two and two make four.'  
b. \***Żewġ** u **żewġ** jagħmlu erbgħa.  
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Numeral 5 in Puyuma (Formosan)

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NUMBER	SERIAL	OBJECT
1	sa	mia-sa
2	drua	mia-drua
3	telru	mia-telru
4	pat	mia-pat
5	lrima	mia-luwatr

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5	lrima	mia-luwatr

- (14) mi-walak dra mia-pat dra walak  
have-child ID.OBL CL-four ID.OBL child  
'They have four children.'

Puyuma

- (15) na mia-luwatr i, m-inatray a lalak=driyan  
DEF.NOM CL-five TOP ITR-die ID.OBL child=IMPF  
'The five (brothers and sisters) died when they were only children.'

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NUMBER	CARDINAL	DISTRIBUTIVE
2	'e-lua	pā-lua
3	'e-kolu	pā-kolu
4	'e-hā	pā-hā
5	'e-lima	pā-lima
6	'e-ono	pā-ono

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6	‘e-ono	pā-ono

- (16) ‘e-lua i‘a  
PRFX-two fish  
‘two fish’

Hawaiian

- (17) ‘e-lua ā me ‘e-lua, ‘e-hā  
PRFX-two and with PRFX-two PRFX-four  
‘Two plus two is four.’

Hawaiian



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Numerals 1–5 in Vera'a (Vanuatu)

Schnell (2011)

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Schnell (2011)

NUMBER	CARDINAL	MULTIPLICATIVE
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2	vō-ruō	vag-ruō
3	vō-'ōl	vag-'ōl
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- (18) vēvē-gi      ne lukun ēn naw, din    ēn vō-'ōl...  
mother-3SG TAM count ART wave reach ART NBR-three  
'Then his mother counted the waves reaching (the number)  
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Vera'a

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Vera'a

- (19) ēn woqe'enge ne vō-ru  
ART tree           LIG NBR-two  
'two trees'

Vera'a

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- ▶ suffix **-w** ⇒ abstract counting
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- ▶ twist: **-w** also on numerals used to count inanimate objects

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- (20) a. puk **pah-w**  
book four-CL  
'four books'
- b. doahk **pah-men**  
dog four-CL.ANIM  
'four dogs'

Mokilese

- (21) Ria-pak **pah-w** walu-w.  
two-times four-CL eight-CL  
'Two times four is eight.'

Mokilese

# Summary

	TYPE	LANGUAGE	NUMBER	ABSTRACT	OBJECT
SIMPLEX	SYNCRETISM	English	5	five	five
	STACKING	Japanese	5	go	go-ko
	SUPPLETION	Maltese	2	tnejn	żewġ



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	SUPPLETION	Maltese	2	tnejn	żewġ
COMPLEX	SYNCRETISM	Hawaiian	2	'e-lua	'e-lua
	STACKING	Vera'a	2	vō-ruō	ne-vō-ruō
	SUPPLETION	Mokilese	4	pah-w	pah-men

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# Universal semantic features

Key intuition concerning numerals

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- above five
  - between five and eight

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- ▶ interval-based semantics of degree

- (23)
- Anne is taller than everybody else is.
  - Anne has more cats than everybody else.



# Universal semantic features

## Standard approach to classifiers

e.g., Borer (2005), Chierchia (1998, 2010), Rothstein (2010), Li (2011), Scontras (2013)

- ▶ mass-like semantics of nouns in classifier languages
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## Counting via measure functions

Krifka (1989)

- ▶ natural unit/object unit operation
- ▶  $\#(P)$  maps a plurality to a number of individuals

# Universal semantic features

Three semantic primitives

- ▶ closed interval  $\Rightarrow$  set of numbers

- (24)
- $\llbracket \text{SCALE}_m \rrbracket_{\langle n,t \rangle} = \lambda n_n [0 \leq n \leq m]$
  - $\llbracket \text{SCALE}_5 \rrbracket = [0, 5]$

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- ▶ maximization operator  $\Rightarrow$  name of a **number concept**

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- ▶ classifier semantics  $\Rightarrow$  shift to a **predicate modifier**

(26) a.  $\llbracket \text{CL} \rrbracket_{\langle n, \langle \langle e,t \rangle, \langle e,t \rangle \rangle \rangle} = \lambda n_n \lambda P_{\langle e,t \rangle} \lambda x_e [*P(x) \wedge \#(P)(x) = n]$   
b.  $\llbracket \text{CL} \rrbracket(\llbracket \text{NUM} \rrbracket(\llbracket \text{SCALE}_5 \rrbracket)) = \lambda P_{\langle e,t \rangle} \lambda x_e [*P(x) \wedge \#(P)(x) = 5]$

# Universal semantic features

## Structures

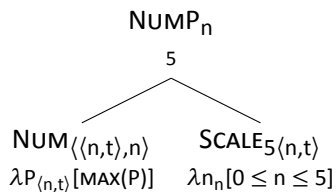
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(27)





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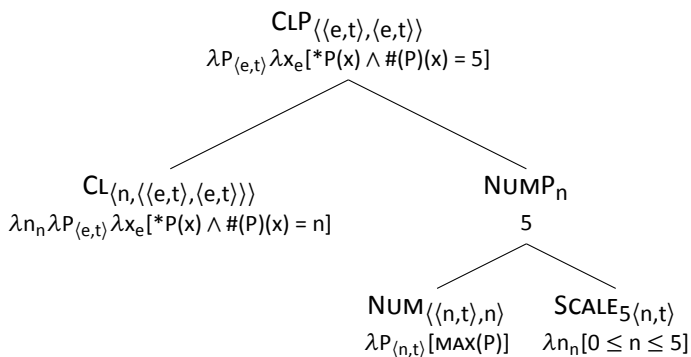
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(28)



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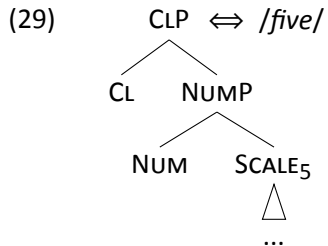
- ▶ realizational model of morphology
- ▶ maps structures to their pronunciation using lexical entries
- ▶ cyclic phrasal spellout
- ▶ spellout driven movement
- ▶ deriving different lexicalizations  $\Rightarrow$  account for the typology



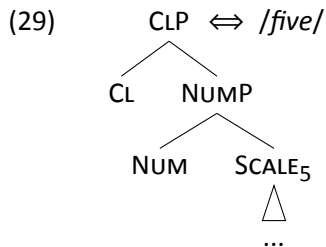
# Simplex numerals: Syncretism

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5		<i>five</i>	

## Simplex numerals: Syncretism

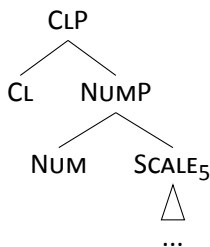
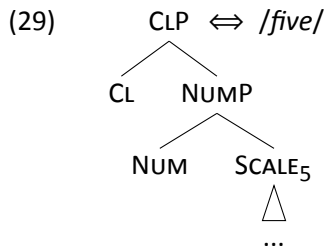


## Simplex numerals: Syncretism



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A lexically stored tree L matches a syntactic node S iff L contains the syntactic tree dominated by S as a subtree.

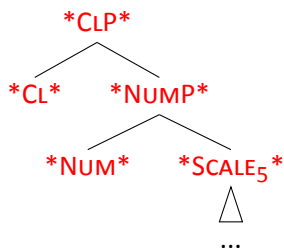
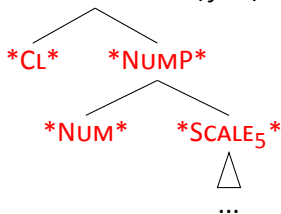
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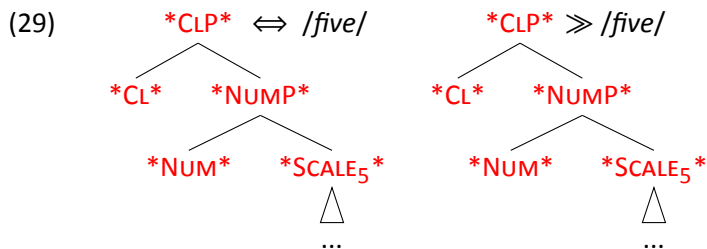
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(29) \*CLP\*  $\Leftrightarrow$  /five/



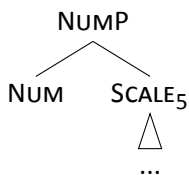
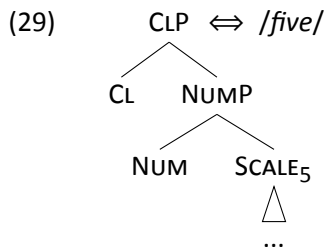
- (30) THE SUPERSET PRINCIPLE (Starke 2009):  
A lexically stored tree L matches a syntactic node S iff L contains the syntactic tree dominated by S as a subtree.

# Simplex numerals: Syncretism



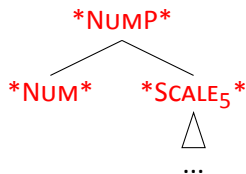
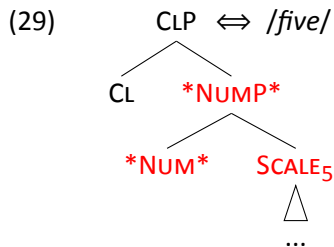
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## Simplex numerals: Syncretism



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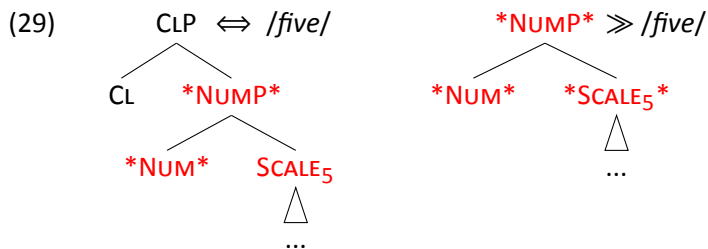
# Simplex numerals: Syncretism



- (30) THE SUPERSET PRINCIPLE (Starke 2009):  
A lexically stored tree L matches a syntactic node S iff L contains the syntactic tree dominated by S as a subtree.

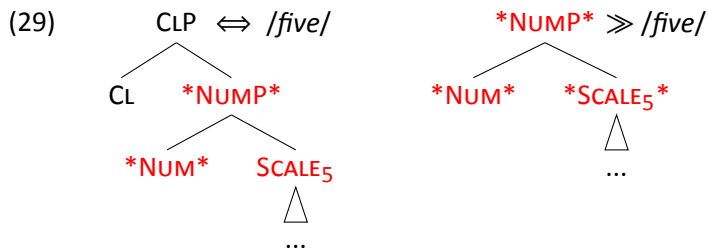


## Simplex numerals: Syncretism



- (30) THE SUPERSET PRINCIPLE (Starke 2009):  
A lexically stored tree L matches a syntactic node S iff L contains the syntactic tree dominated by S as a subtree.

# Simplex numerals: Syncretism



(30)

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5		<i>five</i>	

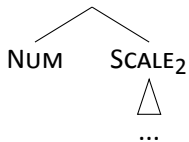
## Simplex numerals: Suppletion

(31)

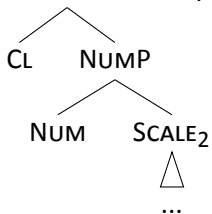
ABSTRACT		OBJECT		
SCALE	NUM	SCALE	NUM	CL
	<i>five</i>	ENG 5	<i>five</i>	
	<i>tnejn</i>	MLT 2	<i>zewġ</i>	

## Simplex numerals: Suppletion

(32) NUMP  $\Leftrightarrow$  /tnejn/

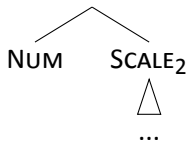


(33) CLP  $\Leftrightarrow$  /zewǵ/

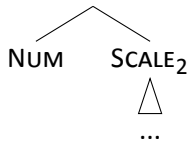


## Simplex numerals: Suppletion

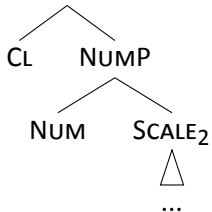
(32) NUMP  $\Leftrightarrow$  /tnejn/



NUMP

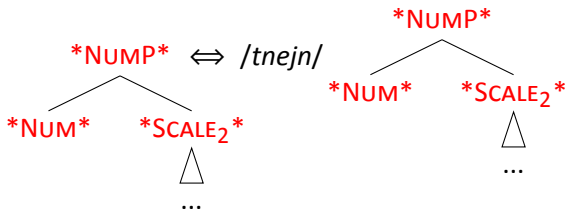


(33) CLP  $\Leftrightarrow$  /zewǵ/

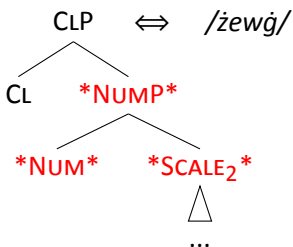


# Simplex numerals: Suppletion

(32)



(33)



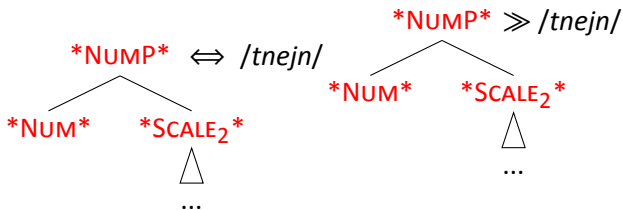
(34)

THE ELSEWHERE CONDITION (Kiparsky 1973):

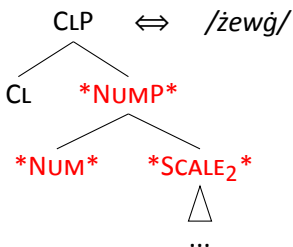
When multiple items match, choose the more specific one (it has fewer superfluous features).

# Simplex numerals: Suppletion

(32)



(33)



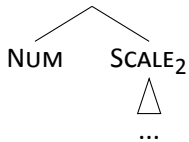
(34)

THE ELSEWHERE CONDITION (Kiparsky 1973):

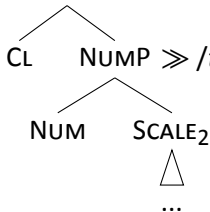
When multiple items match, choose the more specific one (it has fewer superfluous features).

## Simplex numerals: Suppletion

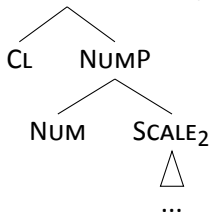
(32) NUMP  $\Leftrightarrow$  /tnejn/



CLP  $\gg$  /tnejn/



(33) CLP  $\Leftrightarrow$  /zewǵ/

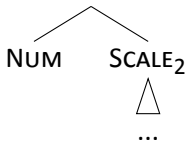


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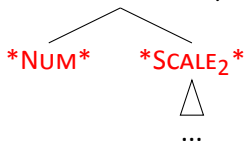


## Simplex numerals: Suppletion

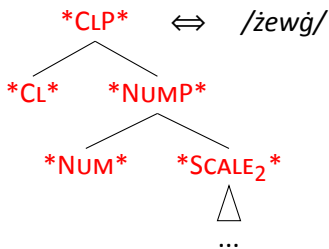
(32) NUMP  $\Leftrightarrow$  /tnejn/



\*CLP\*  $\gg$  /tnejn/



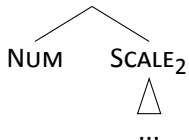
(33)



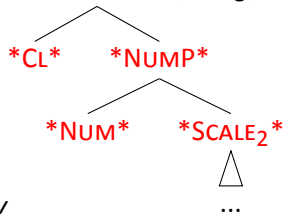
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When multiple items match, chose the more specific one (it has fewer superfluous features).

## Simplex numerals: Suppletion

(32) NUMP  $\Leftrightarrow$  /tnejn/

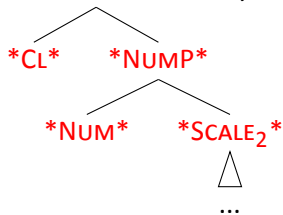


\*CLP\*  $\gg$  /zewǵ/



(33)

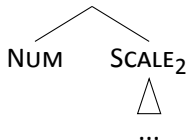
\*CLP\*  $\Leftrightarrow$  /zewǵ/



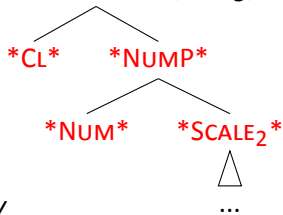
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When multiple items match, chose the more specific one (it has fewer superfluous features).

# Simplex numerals: Suppletion

(32) NUMP  $\Leftrightarrow$  /tnejn/

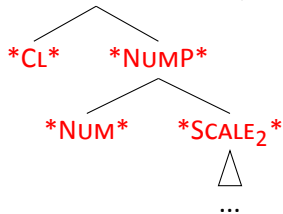


\*CLP\*  $\gg$  /zewǫg/



(33)

\*CLP\*  $\Leftrightarrow$  /zewǫg/



(34)

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>	ENG 5		<i>five</i>		
<i>tnejn</i>	MLT 2		<i>zewǫg</i>		

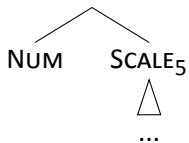
## Simplex numerals: Stacking

(35)

ABSTRACT		OBJECT		
SCALE	NUM	SCALE	NUM	CL
<i>five</i>	ENG 5	<i>five</i>		
<i>tnejn</i>	MLT 2	<i>zewǵ</i>		
<i>go</i>	JPN 5	<i>go</i>		<i>ko</i>

## Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/

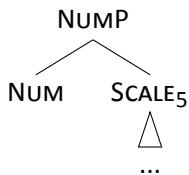
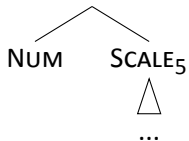


(37) CLP  $\Leftrightarrow$  /ko/



# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



(37) CLP  $\Leftrightarrow$  /ko/

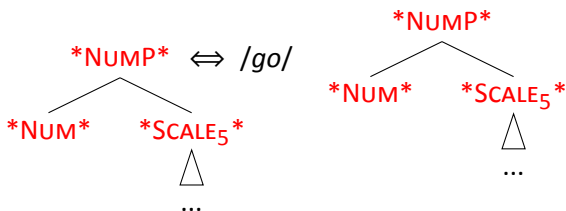


(38) Merge F and

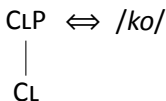
- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

# Simplex numerals: Stacking

(36)



(37)



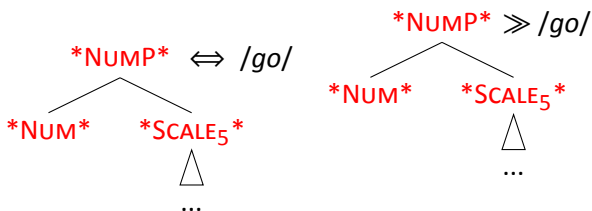
(38)

Merge F and

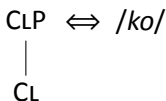
- Spell out FP
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# Simplex numerals: Stacking

(36)



(37)



(38)

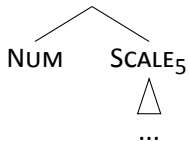
Merge F and

- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

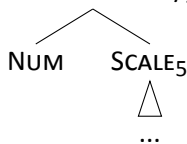


# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



CLP  $\gg$  /go/



(37) CLP  $\Leftrightarrow$  /ko/

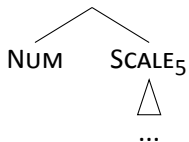


(38) Merge F and

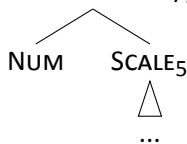
- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



**!CLP!**  
CL NUMP  $\gg$  /go/



(37) CLP  $\Leftrightarrow$  /ko/

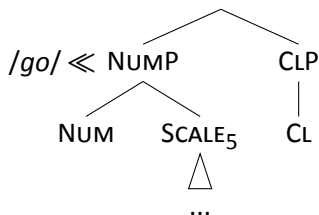
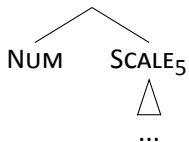


(38) Merge F and

- Spell out FP
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# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



(37) CLP  $\Leftrightarrow$  /ko/

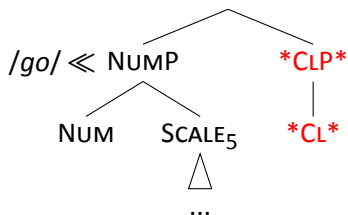
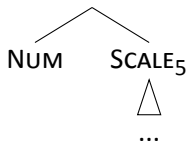


(38) Merge F and

- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



(37) \*CLP\*  $\Leftrightarrow$  /ko/

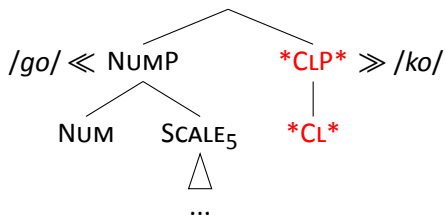
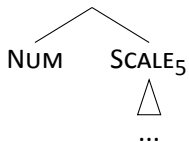


(38) Merge F and

- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



(37) \*CLP\*  $\Leftrightarrow$  /ko/

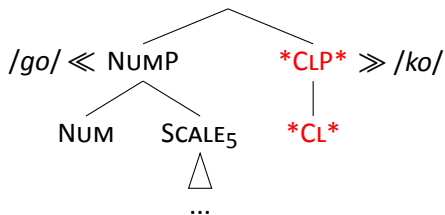
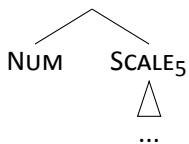


(38) Merge F and

- Spell out FP
- If (a) fails, move the complement of F, and retry (a)

# Simplex numerals: Stacking

(36) NUMP  $\Leftrightarrow$  /go/



(37) CLP  $\Leftrightarrow$  /ko/



(38)

ABSTRACT		OBJECT		
SCALE	NUM	SCALE	NUM	CL
<i>five</i>	ENG 5	<i>five</i>		
<i>tnejn</i>	MLT 2	<i>zewg</i>		
<i>go</i>	JPN 5	<i>go</i>	<i>ko</i>	

# Complex numerals: Suppletion

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5	<i>five</i>		
<i>tnejn</i>		MLT 2	<i>zewǵ</i>		
<i>go</i>		JPN 5	<i>go</i>		<i>ko</i>
<i>pah</i>	<i>w</i>	MOK 4	<i>pah</i>	men	

## Complex numerals: Suppletion

(39) SCALE<sub>1</sub> ⇔ /pah /  
△  
...

(40) NUMP ⇔ /w /  
/ NUM

(41) CLP ⇔ /men /  
/ CL NUMP  
/ NUM



## Complex numerals: Suppletion

(39) SCALE<sub>1</sub> ⇔ /pah /  
△  
...

SCALE<sub>1</sub>  
△  
...

(40) NUMP ⇔ /w /  
/ NUM

(41) CLP ⇔ /men /  
/ CL NUMP  
/ NUM

- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)



# Complex numerals: Suppletion

(39) \*SCALE<sub>1</sub>\* ⇔ /pah/  
△  
...

\*SCALE<sub>1</sub>\* ≫ /pah/  
△  
...

(40) NUMP ⇔ /w/  
/ NUM

(41) CLP ⇔ /men/  
/ CL NUMP  
/ NUM

- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)

## Complex numerals: Suppletion

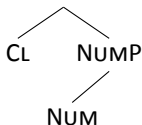
(39) SCALE<sub>1</sub> ⇔ /pah/



(40) NUMP ⇔ /w/



(41) CLP ⇔ /men/



- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)

## Complex numerals: Suppletion

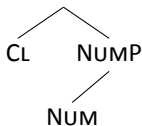
(39) SCALE<sub>1</sub> ⇔ /pah/



(40) NUMP ⇔ /w/



(41) CLP ⇔ /men/



- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
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# Complex numerals: Suppletion

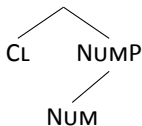
(39) SCALE<sub>1</sub> ⇔ /pah/



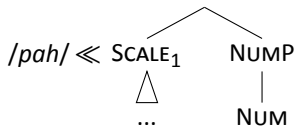
(40) NUMP ⇔ /w/



(41) CLP ⇔ /men/

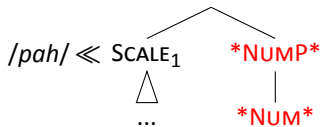


- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)



# Complex numerals: Suppletion

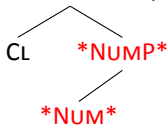
(39) SCALE<sub>1</sub> ⇔ /pah/



(40) \*NUMP\* ⇔ /w/



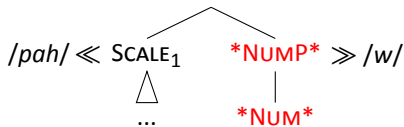
(41) CLP ⇔ /men/



- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)

# Complex numerals: Suppletion

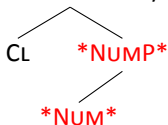
(39)  $SCALE_1 \Leftrightarrow /pah/$



(40)  $*NUMP* \Leftrightarrow /w/$



(41)  $CLP \Leftrightarrow /men/$



- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)



# Complex numerals: Suppletion

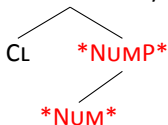
(39)  $SCALE_1 \Leftrightarrow /pah/$



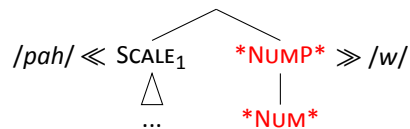
(40)  $*NUMP* \Leftrightarrow /w/$



(41)  $CLP \Leftrightarrow /men/$



- (42)
- Spell out FP
  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)



ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5	<i>five</i>		
<i>tnejn</i>		MLT 2	<i>zewġ</i>		
<i>go</i>		JPN 5	<i>go</i>		<i>ko</i>
<i>pah</i>	<i>w</i>	MOK 4			

# Complex numerals: Suppletion

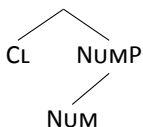
(39)  $SCALE_1 \Leftrightarrow /pah/$



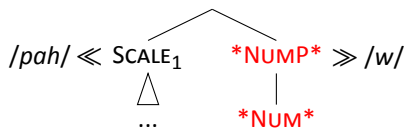
(40)  $NUMP \Leftrightarrow /w/$



(41)  $CLP \Leftrightarrow /men/$



- (42)
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  - If (a) fails, attempt movement of the spec of the complement of F, and retry (a)
  - If (b) fails, move the complement of F, and retry (a)



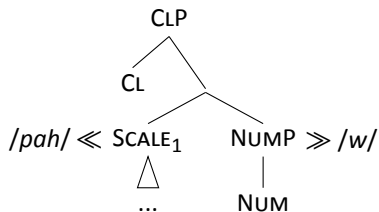
ABSTRACT		OBJECT		
SCALE	NUM	SCALE	NUM	CL
<i>five</i>	ENG 5	<i>five</i>		
<i>tnejn</i>	MLT 2	<i>zewǵ</i>		
<i>go</i>	JPN 5	<i>go</i>		<i>ko</i>
<i>pah</i>	<i>w</i>	MOK 4		???

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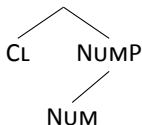
(39) SCALE<sub>1</sub> ⇔ /pah/



(40) NUMP ⇔ /w/



(41) CLP ⇔ /men/



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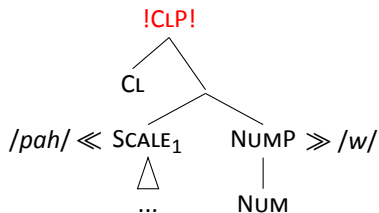
# Complex numerals: Suppletion

(39) SCALE<sub>1</sub> ⇔ /pah/

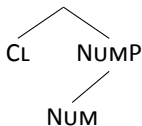


...

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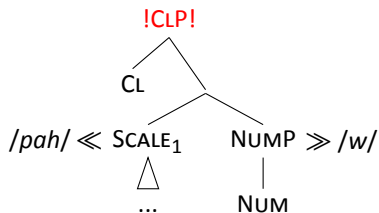
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(39) SCALE<sub>1</sub> ⇔ /pah/

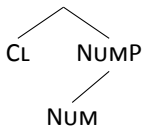


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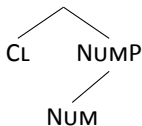
(39) SCALE<sub>1</sub> ⇔ /pah/



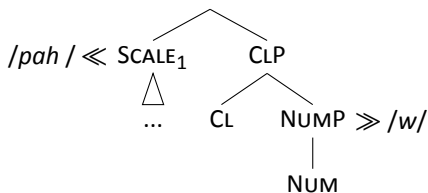
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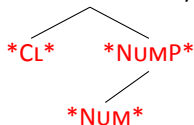
(39)  $SCALE_1 \Leftrightarrow /pah/$



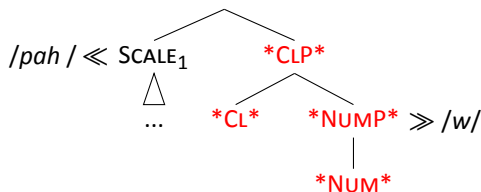
(40)  $NUMP \Leftrightarrow /w/$



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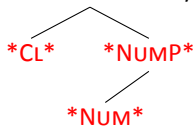
(39)  $SCALE_1 \Leftrightarrow /pah/$



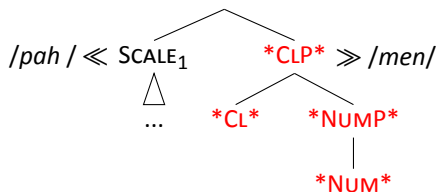
(40)  $NUMP \Leftrightarrow /w/$



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# Complex numerals: Suppletion

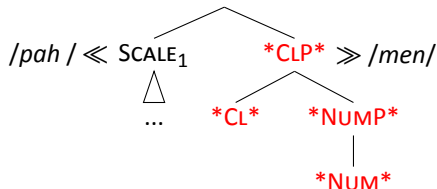
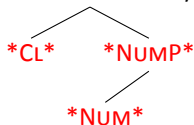
(39)  $SCALE_1 \Leftrightarrow /pah/$



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ABSTRACT		OBJECT		
SCALE	NUM	SCALE	NUM	CL
<i>five</i>	ENG 5	<i>five</i>		
<i>tnejn</i>	MLT 2	<i>zewg</i>		
<i>go</i>	JPN 5	<i>go</i>		<i>ko</i>
<i>pah</i>	<i>w</i>	MOK 4	<i>pah</i>	men

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# Complex numerals: Syncretism

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5	<i>five</i>		
<i>tnejn</i>		MLT 2	<i>żewġ</i>		
<i>go</i>		JPN 5	<i>go</i>	<i>ko</i>	
<i>pah</i>	<i>w</i>	MOK 4	<i>pah</i>	<i>men</i>	
<i>lua</i>	<i>‘e</i>	HAW 2	<i>lua</i>	<i>‘e</i>	

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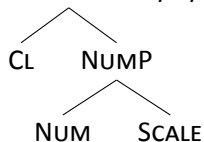
ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
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<i>tnejn</i>		MLT 2	<i>żewġ</i>		
<i>go</i>		JPN 5	<i>go</i>	<i>ko</i>	
<i>pah</i>	<i>w</i>	MOK 4	<i>pah</i>	<i>men</i>	
<i>lua</i>	<i>'e</i>	HAW 2	<i>lua</i>	<i>'e</i>	

(43) SCALE<sub>5</sub> ⇔ /lua/



...

(44) CLP ⇔ /'e/



# Complex numerals: Stacking

ABSTRACT			OBJECT		
SCALE	NUM		SCALE	NUM	CL
<i>five</i>		ENG 5	<i>five</i>		
<i>tnejn</i>		MLT 2	<i>zewġ</i>		
<i>go</i>		JPN 5	<i>go</i>	<i>ko</i>	
<i>lua</i>	<i>'e</i>	HAW 2	<i>lua</i>	<i>'e</i>	
<i>pah</i>	<i>w</i>	MOK 4	<i>pah</i>	<i>men</i>	
<i>ruō</i>	<i>vō</i>	VER 2	<i>ruō</i>	<i>vō</i>	<i>ne</i>

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## Typology

- ▶ variation in the complexity of numerals reduces to lexical items
- ▶ the crucial factor is how many meaning components each morpheme pronounces

# Thanks to

## Informants and consultants

- ▶ Mary Chimaobi Amaechi, Alan Bale, Albert J. Borg, Lisa Bylinina, Viacheslav Chirikba, Jessica Coon, Flóra Lili Donáti, Maia Duguine, Abdelkader Fassi Fehri, Andreas Haida, Nina Haslinger, Dominika Kuruncziová, Chang Liu, Catriona Malau, Roumyana Pancheva, Marina Pantcheva, Pittayawat Pittayaporn, Dolf Rami, Bridget Schvarcz, Yasu Sudo, Peter Sutton, Tue Trinh, Kazuko Yatsushiro

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# Thanks!