A cognitively-motivated computational model of language interaction and change

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Natural-language meaning can be modeled in a relatively valid way. Using an abstract lexicon, I have developed an artificial-intelligence computational model in which the emergence of grammar from general cognitive and communicative principles is simulated.

General principles

Activation: influence of frequency and recency:
(Balota and Chumbley 1985)

(1) DODGE COLT: CAR ≺ DODGE COLT

Check: make sure you're understood:
(Grice 1975, Levelt 1983; Aristar 1997, de Swart 2011, Lestrade 2010)

(2) a. {BOOK, **PEN**, SCREEN, PENCIL, ...}
b. {*ballpoint, **pen**, it, fountain pen*, ...}

(3) Apatani (after Abraham 1985: 38-40)
a. *mó sɨhɨnɨ pabɨne*
3SG cow killed
'He killed the cow.'
b. *sɨhɨnɨ mó **mi** alitubɨne*
cow 3SG **DAT** kicked
'The cow kicked him.'

Proximity: stand together, belong together:
(Givón 1995)

(4) *book yellow and man big*
'yellow book and big man' (not other way around)

Reduction: shortening of automatized forms:
(Jurasky et al. 2001, Heine and Kuteva 2007)

(5) *eigenlijk* → *eik* 'actually'

Erosion: actual storage of shortened forms & ***Bleaching***: loss of meaning specificity:
(Nettle 1999; Bybee 2010, Heine and Kuteva 2007)

(6) *ēwa-haft* 'century-like' → *echt* 'real'
(van der Sijs 2010)

Fusion: attachment of attenuated forms:
(Bybee 1985)

(7) *ik loop* → *'k=loop* 'I walk'

Recruitment: use of supporting expression:
(Ariel 1999)

(8) French (after Heine & Kuteva, 2002, 234)
a. *La jeune [...]. Elle est danseuse.*
'The girl [...]. She is a dancer.'
b. ***Ma femme** il=est venu.*
my:F wife 3=is come
'My wife has come.'

FirstInFirstOut: incremental production:
(van Bergen 2011)

(9) {BALL, TAKE, I}: *I* ≺ *ball* ≺ *take*

Generalize: assumption of (self-fulfilling) rules:

(10) $n_{exceptions} \ll n_{instances}/ln(n_{instances})$
(Yang 2005)

Abbreviations

123 person; *D1:9* meaning dimensions, *Ext1:9* ∼ external role, *Int1:9* ∼ internal role; DAT dative; SG singular; *tgt* target event; *V1:V9* qualities of actions, *A1:A9* ∼ actors, *U1:U9* ∼ undergoers.

Modeling meaning

CAT: entity=T, animate=T, ..., covering=fur, legs=4.
(Guiraud 1968, Wierzbicka 1996, Gärdenfors 2000)

D1	D2	D3	D4	D5	D6	D7	D8	D9	form
1.00	0.00	1.00	1.00	0.00	0.75	0.25	1.00	1.00	*atadoso*
1.00	1.00	0.00	1.00	1.00	0.38	0.38	0.62	0.88	*nimator*
1.00	1.00	0.00	0.00	0.00	0.62	0.50	0.25	0.62	*umimota*
1.00	0.00	1.00	0.00	1.00	1.00	0.12	1.00	0.62	*isomera*
0.00	0.00	1.00	1.00	1.00	0.00	0.25	0.75	0.00	*enolate*

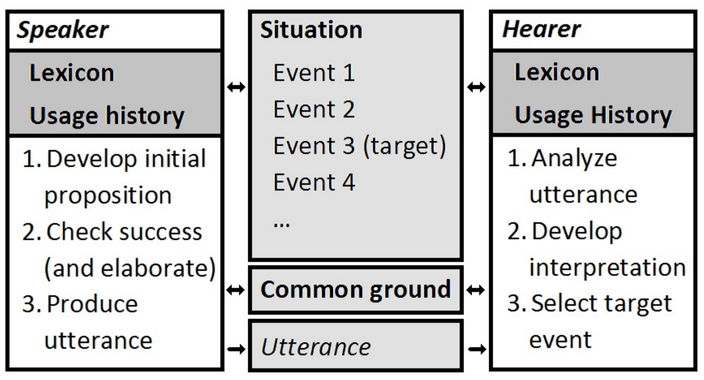
Table 1: *First entries of noun lexicon (abbreviated)*

HIT: activity=T, duration=F, ..., participants=2;
external: cause=T, volitional=T, ..., means=hands;
internal: affected=T, control=F, ..., result=pain.

D1	...	D9	Ext1	...	Int1	...	Int9	type	form
1.00	...	0.50	1.00	...	0.00	...	0.00	twoPlace	*rirunes*
1.00	...	0.50	1.00	...	0.00	...	1.00	twoPlace	*amumali*
1.00	...	0.75	0.00	...	1.00	...	0.62	twoPlace	*emimano*
0.00	...	0.75	0.00	...				onePlace	*litaril*
1.00	...	1.00	1.00	...	0.00	...	0.25	twoPlace	*adasumu*

Table 2: *First entries of verb lexicon (abbreviated)*

Communication procedure



(Grice 70s, Levelt 80s, Steels 90s)

Situation

V1	...	V9	A1	...	A9	123	U1	...	U9	123	tgt
1	...	0.625	0	...	0.375	3					0
1	...	0.000	1	...	0.875	3	1	...	0.375	3	0
0	...	0.625	1	...	0.375	3	1	...	0.250	3	0
0	**...**	**0.875**	**1**	**...**	**0.000**	**3**	**1**	**...**	**0.750**	**1**	**1**
1	...	0.375	1	...	0.250	3	0	...	0.375	3	0

Table 3: *First events of a situation (abbreviated)*

Step 1: initial proposition

U: D1 D2 D3 D4 D5 D6 D7 D8 D9 person ID form **freq**
1 1 1 1 1 0.25 1 1 1 697 *nosonen* **444**
arg NM VM **recency** prodEffort weight **match coll** typing
444 0 0 **0** 24 0.889 **0.598** **0** 0.622

V: D1 ... D9 Ext1 ... Ext9 Int1 ... Int9 type ID form
0 ... 1 1 ... 1 1 ... 0 twoPlace 335 *naronol*
freq **recency** prodEffort weight **match coll**
1 **781** 18 1 **0.986** **0**

A: D1 D2 D3 D4 D5 D6 D7 D8 D9 person ID form **freq**
1 1 0 1 0 0.25 0.625 0.5 0 3 575 *otesere* **0**
arg NM VM **recency** prodEffort weight **match coll** typing
0 0 0 **1013** 24 1 **0.986** **0** 0.664

Step 2: check and elaborate

(11) *nosonen naronol otesere*
1 naronol.V otesere
#'I naronol otesere.'

Best marker available for either verb role: *emomene* 'naronoler'

Step 3: produce utterance

First generations: random word order, lexical ad-hoc marking, no verb agreement:
(Bickerton 1981, Jackendoff 2002)

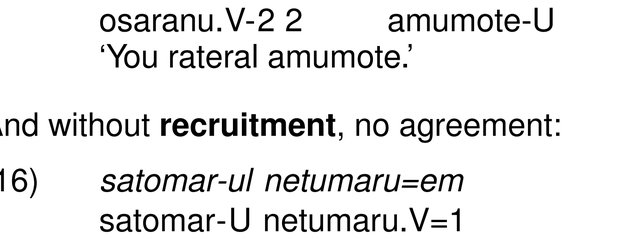
(12) *nosonen naronol otesere **emomene***
1 naronol.V otesere **naronoler**
'Otesere naronols me.'

Results

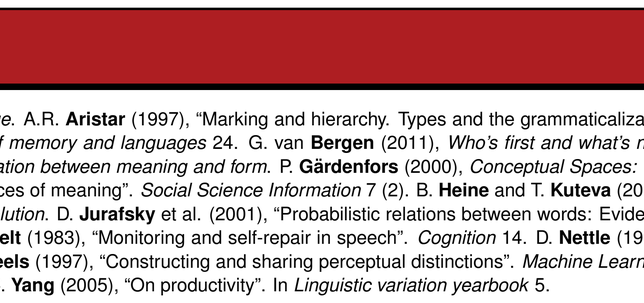
Because of grammaticalization, emergence of **pronouns** (*momel*), **verb agreement** (*-ma*), **case marking** (*-ol*), and grammatical **word order** (SOV):

(13) ***momel** arelom-**ol** sosolal-**ma***
2 arelomol-U sosolal.V-2
'You sosolal arelomol.'

... without loss/gain of communicative success:



The **less predictable** the world, the more often role marking is necessary:



... but without **check success**, no role marking is used and hence no case marking develops:

(14) *ulena elesulo-ra nomonot*
2 elesulo.V-2 nomonot
#'Nomonot elesuloes you.'

No grammatical word order without **activation**, **incremental production**, and **generalization**:

(15) *osaranu-es rateral amumote-om*
osaranu.V-2 2 amumote-U
'You rateral amumote.'

And without **recruitment**, no agreement:

(16) *satomar-ul netumaru=em*
satomar-U netumaru.V=1
'I netumaru satomar.'

References

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