Towards polytomous mixed effects regression analysis and modeling

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The PROBLEM

- *Mixed effects* modeling is not explicitly implemented (in *R*) for *polytomous* (>2) *nominal* (unordered categorical) outcomes

One solution

- Apply the **Poisson** (loglinear/count) equivalent of the **multinomial** logit [logistic] model
  - Yields one simultaneously fit model
- Agresti 2002: 330-332 (cf. Faraway 2006: 101-102)
  - "*Loglinear* models treat categorical response variables symmetrically, focusing on associations and interactions in their joint distribution. *Logit* models [e.g. multinomial logistic], by contrast, describe how a single categorical response depends on explanatory variables. ... **Moreover, logit models with *categorical* explanatory variables have equivalent loglinear [count] models.**"

Alternative approach

- Apply the *one-vs-rest* heuristic using a set of *binary* mixed effects models (with the *lmer(…, family=binomial)* function in the *lme4* package)
  - Requires and yields *many & separately fit* models
- Agresti 2002: 515
  - Section 12.4.4 *Baseline-Category Logit Models with Random [Mixed] Effects*: "This requires using a vector or cluster-specific random effects $u_{j,j}$, one for each logit [model]. ... With nominal responses there is not reason to expect effects to be similar for different [outcomes] *j*.

Formal specification of multinomial and Poisson models

- Multinomial
  - $\text{logit}[P(Y)] = \log[P(Y)/P(\neg Y)] = \ = \alpha + \beta X$
- Poisson
  - $\log[n(Y)] = \alpha + \beta X$

Poisson-multinomial link – first with only *linguistic* predictor variables

- From multinomial variable representation to outcome-wise *counts* for each unique multinomial variable combination (context)

#	Proportion	Count	Lexeme	Person	Number	Agent	Observation
1	0.59598214	267	ajatella	First	NIL	Individual	1
2	0.08482143	38	harkita	First	NIL	Individual	1
3	0.27008929	121	miettiä	First	NIL	Individual	1
4	0.04910714	22	pohtia	First	NIL	Individual	1
5	1.00000000	1	ajatella	First	NIL	NIL	2
6	0.00000000	0	harkita	First	NIL	NIL	2
7	0.00000000	0	miettiä	First	NIL	NIL	2
8	0.00000000	0	pohtia	First	NIL	NIL	2

Comparing the equivalent multinomial/Poisson models

- Person=THIRD & Number=PLURAL & Agent=GROUP (altogether 23 cases in the data)

#	Proportion	Count	Lexeme	Person	Number	Agent	Observation
65	0.13043478	3	ajatella	Third	Plural	Group	17
66	0.26086957	6	harkita	Third	Plural	Group	17
67	0.08695652	2	miettiä	Third	Plural	Group	17
68	0.52173913	12	pohtia	Third	Plural	Group	17

Specifying and fitting equivalent multinomial/Poisson models

- Multinomial model (*baseline category*)
  - THINK.model_multinom.Person_Number_Agent.demo

    <- multinom(**Lexeme ~ Person + Number + Agent**, data=THINK.Lexeme_Person_Number_Agent_Section.multinomial_data_demo)
- Polytomous one-vs-rest
  - THINK.model_ovr.Person_Number_Agent.demo <- plr("Lexeme","Person + Number + Agent", data=THINK.Lexeme_Person_Number_Agent_Section.multinomial_data_demo, heuristic="one.vs.rest", …)
- Poisson model
  - THINK.model_poisson.Person_Number_Agent.demo

    <- glm(***Count ~ Observation*** **+ Lexeme + Lexeme:Person + Lexeme:Number + Lexeme:Agent**, data=THINK.Lexeme_Person_Number_Agent.counts_demo, family=**poisson**)

Comparing the equivalent multinomial/Poisson models

- Person=THIRD & Number=PLURAL & Agent=GROUP (altogether 23 cases in the data)

#	Proportion	Count	Lexeme	Person	Number	Agent	Observation
65	0.13043478	3	ajatella	Third	Plural	Group	17
66	0.26086957	6	harkita	Third	Plural	Group	17
67	0.08695652	2	miettiä	Third	Plural	Group	17
68	0.52173913	12	pohtia	Third	Plural	Group	17

Comparing the equivalent **multinomial**/Poisson models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
3	6	2	12	23

- Original proportions

ajatella	*harkita*	*miettiä*	*pohtia*
0.13043478	0.26086957	0.08695652	0.52173913

- Multinomial model (with *multinom/nnet*)

```
predict(THINK.model_multinom.Person_Number_Agent.demo,
newdata=data.frame(matrix(c("Third", "Plural", "Group"),1,,
dimnames=list(NULL,c("Person","Number","Agent")))),type="probs")
```

ajatella	*harkita*	*miettiä*	*pohtia*
0.1479454	0.2196239	0.1082725	0.5241583

Comparing the equivalent **polytomous** models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
3	6	2	12	23

- Original proportions

ajatella	*harkita*	*miettiä*	*pohtia*
0.13043478	0.26086957	0.08695652	0.52173913

- One-vs-rest

```
predict.plr(THINK.model_ovr.Person_Number_Agent.demo,
newdata=data.frame(matrix(c("Third","Plural","Group"),
1,,dimnames=list(NULL,c("Person","Number","Agent")))),type="response")
```

ajatella	*harkita*	*miettiä*	*pohtia*
0.1620709	0.2316961	0.1084190	0.5158476

Comparing the equivalent multinomial/**Poisson** models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
3	6	2	12	23

- Poisson model count estimates

fitted(THINK.model_poisson.Person_Number_Agent.demo)[65:68]

65	66	67	68	Σ
3.402750	5.051696	2.490234	12.055320	23

- Corresponding proportion estimates

fitted(THINK.model_poisson.Person_Number_Agent.demo)[65:68]/23

[ajatella]	*[harkita]*	*[miettiä]*	*[pohtia]*
0.1479456	0.2196390	0.1082711	0.5241444

Comparing the equivalent multinomial/ Poisson models – estimated probabilities

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
3	6	2	12	23

- Original proportions

ajatella	*harkita*	*miettiä*	*pohtia*
0.13043478	0.26086957	0.08695652	0.52173913

- Multinomial (baseline category) probability estimates

ajatella	*harkita*	*miettiä*	*pohtia*
0.1479454	0.2196239	0.1082725	0.5241583

- One-vs-rest probability estimates

ajatella	*harkita*	*miettiä*	*pohtia*
0.1620709	0.2316961	0.1084190	0.5158476

- Poisson-count based proportion estimates

ajatella	*harkita*	*miettiä*	*pohtia*
0.1479456	0.2196390	0.1082711	0.5241444

Comparing model odds – *multinomial* vs. *one-vs-rest*

Multinomial (Baseline category)

VariableLevel	*harkita*	*miettiä*	*pohtia*
(Intercept)	0.35	0.29	0.32
PersonFirst	0.72	1.35	0.20
PersonSecond	0.28	2.34	0.38
PersonThird	1.05	1.91	1.15
NumberPassive	0.74	1.41	2.51
NumberPlural	0.82	0.62	1.06
AgentGroup	**4.96**	2.09	**9.03**
AgentIndividual	0.67	1.25	1.44

Polytomous one-vs-rest

VariableLevel	*ajatella*	*harkita*	*miettiä*	*pohtia*
(Intercept)	1.04	0.21	0.18	0.20
PersonFirst	1.46	0.84	1.82	0.19
PersonSecond	1.01	0.26	3.20	0.32
PersonThird	0.74	0.87	1.83	0.95
NumberPassive	0.65	0.53	1.13	2.47
NumberPlural	1.28	0.92	0.63	1.26
AgentGroup	0.20	**1.76**	0.60	**4.49**
AgentIndividual	0.88	0.59	1.22	1.46

Multinomial model in comparison to the one-vs-rest exaggerates impact of variables – due to comparison with only baseline category (*ajatella)* instead all the three other categories (1 vs. 3) – though the effect directions are similar

Comparing model odds – *multinomial* vs. *Poisson*

Multinomial (Baseline category)

VariableLevel	*harkita*	*miettiä*	*pohtia*
(Intercept)	0.35	0.29	0.32
PersonFirst	0.72	1.35	0.20
PersonSecond	0.28	2.34	0.38
PersonThird	1.05	1.91	1.15
NumberPassive	0.74	1.41	2.51
NumberPlural	0.82	0.62	1.06
AgentGroup	**4.96**	**2.09**	**9.03**
AgentIndividual	0.67	1.25	1.44

Poisson equivalent

Variable	*ajatella*	*harkita*	*miettiä*	*pohtia*
(Intercept)	4.30	-	-	-
Lexeme	-	0.35	0.29	0.32
PersonFirst	4.99	3.59	6.71	NA
PersonSecond	2.65	0.75	6.21	NA
PersonThird	0.87	0.92	1.67	NA
NumberPassive	0.40	0.29	0.56	NA
NumberPlural	0.94	0.78	0.59	NA
AgentGroup	**0.11**	**0.55**	**0.23**	NA
AgentIndividual	0.70	0.47	0.87	NA

Not directly comparable odds → need to reorder baseline lexeme category for one of the two models

Comparing model odds – *multinomial* vs. *Poisson*

Multinomial (Baseline category)

VariableLevel	*ajatella*	*harkita*	*miettiä*
(Intercept)	3.10	1.07	0.91
PersonFirst	4.99	3.59	6.71
PersonSecond	2.65	0.75	6.21
PersonThird	0.87	0.92	1.67
NumberPassive	0.40	0.29	0.56
NumberPlural	0.94	0.78	0.59
AgentGroup	**0.11**	**0.55**	**0.23**
AgentIndividual	0.70	0.47	0.87

Poisson equivalent

Variable	*ajatella*	*harkita*	*miettiä*	*pohtia*
(Intercept)	4.30	-	-	-
Lexeme	-	0.35	0.29	0.32
PersonFirst	4.99	3.59	6.71	NA
PersonSecond	2.65	0.75	6.21	NA
PersonThird	0.87	0.92	1.67	NA
NumberPassive	0.40	0.29	0.56	NA
NumberPlural	0.94	0.78	0.59	NA
AgentGroup	**0.11**	**0.55**	**0.23**	NA
AgentIndividual	0.70	0.47	0.87	NA

AgentGroup	*ajatella*	*harkita*	*pohtia*
Multinomial	0.1107492	0.5492622	0.2308943
Poisson	0.1107363	0.5492630	0.2309020

Interim conclusion of the comparisons

- For all practical purposes, the multinomial and Poisson models of the same polytomous outcome setting are equivalent
  - (though the fitted coefficients/odds and outcome values are not *exactly* the same)

Adding an *extralinguistic* predictor variable – *Section*

- 23 sections in Helsingin Sanomat (1995)
  - Politics, letters to the editor, sports, economy/ business, etc.
  - Where the article was printed
- 2 sections in SFNET (2002-2003)
  - Where the author decided to post the contributions
  - *sfnet.keskustelu.ihmissuhteet*: personal relationships
  - *sfnet.keskustelu.politiikka*: politics

Adding an *extralinguistic* predictor variable

- From a binary (dummy-coded logical TRUE/FALSE) to a multinomial variable representation
  - Person (1ST, 2ND, 3RD)
  - Number ([SINGULAR], PLURAL, PASSIVE)
  - Agent/Subject (INDIVIDUAL, GROUP)
  - Section (Newspaper departments, Newsgroups)

#	Lexeme	Person	Number	Agent	Section
1	pohtia	NIL	Passive	NIL	hs95_MN [opinion/excerpts ← other newspapers]
2	harkita	Third	NIL	Group	hs95_YO [letters to the editor]
3	miettiä	Third	NIL	Individual	hs95_SP [sports]
4	miettiä	Third	NIL	Individual	hs95_PO [(Finnish) domestic politics]
5	ajatella	Third	NIL	Individual	sfnet_politiikka [newsgroup on politics]
6	ajatella	Third	NIL	Individual	hs95_SP

Poisson-multinomial link with *linguistic* and *extralinguistic* predictor variables

- From multinomial variable representation to outcome-wise *counts* for each *unique* multinomial variable combination (*context*)

#	Proportion	Count	Lexeme	Person	Number	Agent	Section	Observation
1	0.5	1	ajatella	First	NIL	Individual	hs95_AE	1
2	0.0	0	harkita	First	NIL	Individual	hs95_AE	1
3	0.5	1	miettiä	First	NIL	Individual	hs95_AE	1
4	0.0	0	pohtia	First	NIL	Individual	hs95_AE	1
5	0.8	4	ajatella	First	NIL	Individual	hs95_AK	2
6	0.0	0	harkita	First	NIL	Individual	hs95_AK	2
7	0.2	1	miettiä	First	NIL	Individual	hs95_AK	2
8	0.0	0	pohtia	First	NIL	Individual	hs95_AK	2

Specifying and fitting equivalent multinomial/Poisson models

- Multinomial model (*baseline category*)
  - THINK.model_multinom.Person_Number_Agent_Section.demo

    <- multinom(**Lexeme ~ Person + Number + Agent + Section**, data=THINK.Lexeme_Person_Number_Agent_Section.multinomial_data_demo)

- Poisson model
  - THINK.model_poisson.Person_Number_Agent_Section.demo

    <- glm(***Count ~ Observation*** **+ Lexeme + Lexeme:Person + Lexeme:Number + Lexeme:Agent + Lexeme:Section**, data=THINK.Lexeme_Person_Number_Agent_Section.counts_demo, family=**poisson**)

Comparing the equivalent multinomial/Poisson models

- Person=THIRD & Number=PLURAL & Agent=INDIVIDUAL & Section=sfnet_politiikka (altogether 41 cases in the data)

#	Proportion	Count	Lex.	Person	Number	Agent	Section	Obs.
973	0.78048780	32	ajatella	Third	Plural	Individual	sfnet_politiikka	244
974	0.04878049	2	harkita	Third	Plural	Individual	sfnet_politiikka	244
975	0.14634146	6	miettiä	Third	Plural	Individual	sfnet_politiikka	244
976	0.02439024	1	pohtia	Third	Plural	Individual	sfnet_politiikka	244

Comparing the equivalent multinomial/Poisson models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
32	2	6	1	41

- Original proportions

ajatella	*harkita*	*miettiä*	*pohtia*
0.78048780	0.04878049	0.14634146	**0.02439024**

- Multinomial model (with *multinom/nnet*)

```
predict(THINK.model_multinom.Person_Number_Agent_Section.demo,
newdata=data.frame(matrix(c("Third", "Plural", "Individual", "sfnet_politiikka"),1,,
dimnames=list(NULL,c("Person","Number","Agent","Section")))), type="probs")
```

ajatella	*harkita*	*miettiä*	*pohtia*
0.59814562	0.05051883	0.19773692	**0.15359864**

Comparing the equivalent multinomial/Poisson models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
32	2	6	1	41

- Poisson model count estimates

```
fitted(THINK.model_poisson.Person_Number_Agent_Section.demo)[973:976]
      973       974       975       976
24.525218  2.070774  8.107170  6.296838
```

Corresponding proportion estimates

```
fitted(THINK.model_poisson.Person_Number_Agent_Section.demo)[973:976]/41
   [ajatella]    [harkita]    [miettiä]     [pohtia]
0.59817606   0.05050668   0.19773584   0.15358142
```

Specifying and fitting a Poisson equivalent mixed effects model

- *lmer*(Count ~ ***(1|Observation)*** **+ Lexeme + Lexeme:Person + Lexeme:Number + Lexeme:Agent +** ***(1|Section)***, data=THINK.Lexeme_Person_Number_Agent_Section.counts_demo, **family=poisson**)
  - Observation as mixed effect in order to get coefficients properly estimated

Comparing overall fits between *fixed* and *mixed* poisson equivalent multinomial models

- Fixed model
  - Section as fixed predictor (without interactions)

Residual Deviance	AIC
890.2	3237

- Mixed model
  - Section (and Observation) as random predictor

AIC	BIC	logLik	Deviance
2131	2298	-1032	2063

- Conclusion
  - Fixed → Mixed: Deviance:↑ – AIC:↓

Comparing the equivalent *fixed/mixed* Poisson models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
32	2	6	1	41

- Poisson model count estimates

fitted(THINK.model_poisson_lmer.Person_Number_Agent_Section.demo)[973:976]

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
18.234855	3.621799	8.009096	10.226739	40.09249

- Corresponding proportion estimates

fitted(THINK.model_poisson.Person_Number_Agent_Section.demo)[973:976]/40.092

ajatella	*harkita*	*miettiä*	*pohtia*
0.4548197	0.0903361	0.1997655	**0.2550787**

- Original observed proportions

0.78048780	0.04878049	0.14634146	**0.02439024**

Comparing the equivalent *fixed/mixed* Poisson models

- Original counts

ajatella	*harkita*	*miettiä*	*pohtia*	Σ
32	2	6	1	41

- Original observed proportions

ajatella	*harkita*	*miettiä*	*pohtia*
0.78048780	0.04878049	0.14634146	0.02439024

- Fixed-model Poisson-count based proportion estimates

ajatella	*harkita*	*miettiä*	*pohtia*
0.59817606	0.05050668	0.19773584	0.15358142

- Mixed-model Poisson-count based proportion estimates

ajatella	*harkita*	*miettiä*	*pohtia*
0.4548197	0.0903361	0.1997655	0.2550787

Coefficients/odds for mixed effects model

VariableLevel	Estimate	Odds	Pr(>|z|)	Sign.
(Intercept)	1.02370	2.78	1.86e-05	***
Lexemeajatella:AgentGroup	-2.13995	**0.12**	6.22e-13	***
Lexemeajatella:AgentIndividual	0.11058	1.12	0.640741	
Lexemeajatella:NumberPassive	-0.06815	0.93	0.800813	
Lexemeajatella:NumberPlural	-0.85629	0.42	1.49e-05	***
Lexemeajatella:PersonFirst	-0.05036	0.95	0.856623	
Lexemeajatella:PersonSecond	-0.59566	0.55	0.086161	.
Lexemeajatella:PersonThird	0.43142	1.54	0.061095	.
Lexemeharkita	-1.05886	0.35	4.41e-16	***
Lexemeharkita:AgentGroup	-0.51877	0.60	0.088230	.
Lexemeharkita:AgentIndividual	-0.26797	0.76	0.350980	
Lexemeharkita:NumberPassive	-0.37416	0.69	0.227556	
Lexemeharkita:NumberPlural	-1.06220	0.35	3.19e-05	***
Lexemeharkita:PersonFirst	-0.39981	0.67	0.236232	
Lexemeharkita:PersonSecond	-1.87581	0.15	0.000111	***
Lexemeharkita:PersonThird	0.45837	1.58	0.085692	.
VariableLevel	**Estimate**	**Odds**	**Pr(>|z|)**	**Sign.**

Coefficients/odds for mixed effects model

VariableLevel	Estimate	Odds	Pr(>|z|)	Sign.
Lexememiettiä	-1.23528	0.29	<2e-16	***
Lexememiettiä:AgentGroup	-1.38180	0.25	2.05e-05	***
Lexememiettiä:AgentIndividual	0.35441	1.43	0.192578	
Lexememiettiä:NumberPassive	0.27640	1.32	0.354561	
Lexememiettiä:NumberPlural	-1.32633	0.27	9.29e-10	***
Lexememiettiä:PersonFirst	0.23689	1.27	0.446195	
Lexememiettiä:PersonSecond	0.24092	1.27	0.516394	
Lexememiettiä:PersonThird	1.07016	2.92	3.87e-05	***
Lexemepohtia	-1.08468	0.34	<2e-16	***
Lexemepohtia:AgentGroup	-0.05414	**0.95**	0.845087	
Lexemepohtia:AgentIndividual	0.35307	1.42	0.173795	
Lexemepohtia:NumberPassive	0.79151	**2.21**	0.004750	**
Lexemepohtia:NumberPlural	-0.80661	0.45	0.000211	***
Lexemepohtia:PersonFirst	-1.58039	0.21	3.59e-06	***
Lexemepohtia:PersonSecond	-1.49522	0.22	0.000158	***
Lexemepohtia:PersonThird	0.64560	**1.91**	0.007427	**

What about the full-scale model?

Variant of the prior model selected on the basis of extensive univariate analysis

→ Altogether 48 contextual feature variables:

- Morphological features pertaining to the node-verb or the entire verb-chain they are components of (10)
- semantic characterizations of verb-chains (6)
- syntactic argument types, without any subtypes (10)
- Syntactic arguments combined with their semantic and structural subtypes (20)
- extra-linguistic features (2)

Tentative overall mixed effects model

```
> summary(THINK.Lexeme_Person_Number_Agent_Patient_Manner_Location_Time_Modality_Section_Author.multinomial_data)
     Lexeme              Person           Number                      Agent                          Patient
 ajatella:1492   NIL          :1056   NIL       :2561   NIL                  : 897   NIL                          :1011
 harkita : 387   Z_ANL_FIRST  : 509   Z_ANL_PASS: 457   SX_AGE.SEM_GROUP     : 256   SX_PAT.SEM_ABSTRACTION       : 698
 miettiä : 812   Z_ANL_SECOND: 320   Z_ANL_PLUR: 386   SX_AGE.SEM_INDIVIDUAL:2251   SX_PAT.SEM_ACTIVITY          : 489
 pohtia  : 713   Z_ANL_THIRD :1519                                                  SX_PAT.INDIRECT_QUESTION     : 438
                                                                                    SX_LX_että_CS.SX_PAT         : 396
                                                                                    SX_PAT.SEM_INDIVIDUAL_GROUP: 109
                                                                                    (Other)                      : 263
                 Manner       Location                      Time                        Modality1                       Modality2
 NIL                 :2902   NIL   :3127   NIL                   :2763   NIL                    :2572   NIL                    :3107
 SX_MAN.SEM_AGREEMENT:  48   SX_LOC: 277   SX_TMP.SEM_DEFINITE   : 158   SX_VCH.SEM_NECESSITY   : 487   SX_VCH.SEM_ACCIDENTAL:  44
 SX_MAN.SEM_FRAME    :  64                 SX_TMP.SEM_INDEFINITE: 483   SX_VCH.SEM_POSSIBILITY: 345   SX_VCH.SEM_EXTERNAL  :  79
 SX_MAN.SEM_GENERIC  : 113                                                                            SX_VCH.SEM_TEMPORAL  : 119
 SX_MAN.SEM_JOINT    :  62                                                                            SX_VCH.SEM_VOLITION  :  55
 SX_MAN.SEM_NEGATIVE :  38
 SX_MAN.SEM_POSITIVE : 177
                  Section                                    Author
 Z_EXTRA_DE_ihmissuhteet:1028   Z_EXTRA_AU_sfnet_721                 : 146
 Z_EXTRA_DE_politiikka  : 626   Z_EXTRA_AU_hs95_latomon_käyttäjäprofiili: 100
 Z_EXTRA_DE_hs95_SP     : 243   Z_EXTRA_AU_sfnet_331                 :  99
 Z_EXTRA_DE_hs95_KU     : 224   Z_EXTRA_AU_sfnet_92                  :  79
 Z_EXTRA_DE_hs95_YO     : 189   Z_EXTRA_AU_sfnet_966                 :  77
 Z_EXTRA_DE_hs95_UL     : 114   Z_EXTRA_AU_sfnet_345                 :  73
 (Other)                : 980   (Other)                              :2830
```

Tentative overall mixed effects model

lmer(Count ~ (1|Observation) + Lexeme + Lexeme:Person + Lexeme:Number + Lexeme:Agent + Lexeme:Patient + Lexeme:Manner + Lexeme:Location + Lexeme:Time + Lexeme:Modality1 + Lexeme:Modality2 + (1|Section), data=THINK.Lexeme_Person_..._Section.counts, family=poisson)

Tentative fitted results

- AIC BIC logLik deviance

  5956 6857 -2848 5696

- Random effects:

Groups	Name	Variance	Std.Dev.
Observation	(Intercept)	0.150176	0.38753
Section	(Intercept)	0.075796	0.27531

- Number of obs: 7544, groups: Observation, 1886; Section, 25

Adjusted coefficients/odds

Predictor	Odds
(Intercept)	1.9
Lexemeharkita	0.12
Lexememiettiä	0.17
Lexemepohtia	0.12
Lexemeajatella:PersonZ_ANL_FIRST	(1.2)
Lexemeharkita:PersonZ_ANL_FIRST	(0.96)
Lexememiettiä:PersonZ_ANL_FIRST	1.6
Lexemepohtia:PersonZ_ANL_FIRST	0.24
Lexemeajatella:PersonZ_ANL_SECOND	(1.1)
Lexemeharkita:PersonZ_ANL_SECOND	0.39
Lexememiettiä:PersonZ_ANL_SECOND	2.5
Lexemepohtia:PersonZ_ANL_SECOND	0.47
Lexemeajatella:PersonZ_ANL_THIRD	1.3
Lexemeharkita:PersonZ_ANL_THIRD	(1.1)
Lexememiettiä:PersonZ_ANL_THIRD	1.7
Lexemepohtia:PersonZ_ANL_THIRD	(0.98)
Lexemeajatella:NumberZ_ANL_PASS	(0.86)
Lexemeharkita:NumberZ_ANL_PASS	0.64
Lexememiettiä:NumberZ_ANL_PASS	(1)
Lexemepohtia:NumberZ_ANL_PASS	(1.3)
Lexemeajatella:NumberZ_ANL_PLUR	0.66
Lexemeharkita:NumberZ_ANL_PLUR	(0.74)
Lexememiettiä:NumberZ_ANL_PLUR	0.5
Lexemepohtia:NumberZ_ANL_PLUR	(0.92)

Adjusted coefficients/odds …

Lexemeajatella:AgentSX_AGE.SEM_GROUP	0.25
Lexemeharkita:AgentSX_AGE.SEM_GROUP	(0.89)
Lexememiettiä:AgentSX_AGE.SEM_GROUP	0.45
Lexemepohtia:AgentSX_AGE.SEM_GROUP	1.8
Lexemeajatella:AgentSX_AGE.SEM_INDIVIDUAL	(0.79)
Lexemeharkita:AgentSX_AGE.SEM_INDIVIDUAL	(0.67)
Lexememiettiä:AgentSX_AGE.SEM_INDIVIDUAL	(1)
Lexemepohtia:AgentSX_AGE.SEM_INDIVIDUAL	(1.2)

Adjusted coefficients/odds …

Lexemeajatella:PatientSX_LX_että_CS.SX_PAT	(1.1)
Lexemeharkita:PatientSX_LX_että_CS.SX_PAT	0.27
Lexememiettiä:PatientSX_LX_että_CS.SX_PAT	0.51
Lexemepohtia:PatientSX_LX_että_CS.SX_PAT	0.54
Lexemeajatella:PatientSX_PAT.DIRECT_QUOTE	0.039
Lexemeharkita:PatientSX_PAT.DIRECT_QUOTE	(0)
Lexememiettiä:PatientSX_PAT.DIRECT_QUOTE	2.7
Lexemepohtia:PatientSX_PAT.DIRECT_QUOTE	7.7
Lexemeajatella:PatientSX_PAT.INDIRECT_QUESTION	0.13
Lexemeharkita:PatientSX_PAT.INDIRECT_QUESTION	(0.71)
Lexememiettiä:PatientSX_PAT.INDIRECT_QUESTION	1.9
Lexemepohtia:PatientSX_PAT.INDIRECT_QUESTION	2.1
Lexemeajatella:PatientSX_PAT.INFINITIVE	0.66
Lexemeharkita:PatientSX_PAT.INFINITIVE	(0.64)
Lexememiettiä:PatientSX_PAT.INFINITIVE	(0)
Lexemepohtia:PatientSX_PAT.INFINITIVE	(0.14)
Lexemeajatella:PatientSX_PAT.PARTICIPLE	(0.75)
Lexemeharkita:PatientSX_PAT.PARTICIPLE	(0.62)
Lexememiettiä:PatientSX_PAT.PARTICIPLE	(0)
Lexemepohtia:PatientSX_PAT.PARTICIPLE	0.23

Adjusted coefficients/odds …

Lexemeajatella:PatientSX_PAT.SEM_ABSTRACTION	0.41
Lexemeharkita:PatientSX_PAT.SEM_ABSTRACTION	(0.99)
Lexememiettiä:PatientSX_PAT.SEM_ABSTRACTION	(1.2)
Lexemepohtia:PatientSX_PAT.SEM_ABSTRACTION	2.6
Lexemeajatella:PatientSX_PAT.SEM_ACTIVITY	0.25
Lexemeharkita:PatientSX_PAT.SEM_ACTIVITY	4.7
Lexememiettiä:PatientSX_PAT.SEM_ACTIVITY	0.64
Lexemepohtia:PatientSX_PAT.SEM_ACTIVITY	1.5
Lexemeajatella:PatientSX_PAT.SEM_COMMUNICATION	0.11
Lexemeharkita:PatientSX_PAT.SEM_COMMUNICATION	(1)
Lexememiettiä:PatientSX_PAT.SEM_COMMUNICATION	(0.91)
Lexemepohtia:PatientSX_PAT.SEM_COMMUNICATION	(1.2)
Lexemeajatella:PatientSX_PAT.SEM_INDIVIDUAL_GROUP	0.71
Lexemeharkita:PatientSX_PAT.SEM_INDIVIDUAL_GROUP	(0.57)
Lexememiettiä:PatientSX_PAT.SEM_INDIVIDUAL_GROUP	0.28
Lexemepohtia:PatientSX_PAT.SEM_INDIVIDUAL_GROUP	0.22

Adjusted coefficients/odds …

Lexemeajatella:MannerSX_MAN.SEM_AGREEMENT	(0.73)
Lexemeharkita:MannerSX_MAN.SEM_AGREEMENT	(0)
Lexememiettiä:MannerSX_MAN.SEM_AGREEMENT	0.051
Lexemepohtia:MannerSX_MAN.SEM_AGREEMENT	0.16
Lexemeajatella:MannerSX_MAN.SEM_FRAME	0.63
Lexemeharkita:MannerSX_MAN.SEM_FRAME	0.16
Lexememiettiä:MannerSX_MAN.SEM_FRAME	0.15
Lexemepohtia:MannerSX_MAN.SEM_FRAME	0.53
Lexemeajatella:MannerSX_MAN.SEM_GENERIC	(0.88)
Lexemeharkita:MannerSX_MAN.SEM_GENERIC	(0)
Lexememiettiä:MannerSX_MAN.SEM_GENERIC	0.095
Lexemepohtia:MannerSX_MAN.SEM_GENERIC	(0)
Lexemeajatella:MannerSX_MAN.SEM_JOINT	0.27
Lexemeharkita:MannerSX_MAN.SEM_JOINT	(0.66)
Lexememiettiä:MannerSX_MAN.SEM_JOINT	(0.69)
Lexemepohtia:MannerSX_MAN.SEM_JOINT	0.42
Lexemeajatella:MannerSX_MAN.SEM_NEGATIVE	0.46
Lexemeharkita:MannerSX_MAN.SEM_NEGATIVE	0.25
Lexememiettiä:MannerSX_MAN.SEM_NEGATIVE	0.19
Lexemepohtia:MannerSX_MAN.SEM_NEGATIVE	0.12
Lexemeajatella:MannerSX_MAN.SEM_POSITIVE	0.45
Lexemeharkita:MannerSX_MAN.SEM_POSITIVE	(0.8)
Lexememiettiä:MannerSX_MAN.SEM_POSITIVE	0.48
Lexemepohtia:MannerSX_MAN.SEM_POSITIVE	0.49

Adjusted coefficients/odds …

Lexemeajatella:LocationSX_LOC	0.33
Lexemeharkita:LocationSX_LOC	0.4
Lexememiettiä:LocationSX_LOC	0.67
Lexemepohtia:LocationSX_LOC	1.5
Lexemeajatella:TimeSX_TMP.SEM_DEFINITE	0.37
Lexemeharkita:TimeSX_TMP.SEM_DEFINITE	0.46
Lexememiettiä:TimeSX_TMP.SEM_DEFINITE	0.57
Lexemepohtia:TimeSX_TMP.SEM_DEFINITE	(1.1)
Lexemeajatella:TimeSX_TMP.SEM_INDEFINITE	0.5
Lexemeharkita:TimeSX_TMP.SEM_INDEFINITE	0.67
Lexememiettiä:TimeSX_TMP.SEM_INDEFINITE	0.74
Lexemepohtia:TimeSX_TMP.SEM_INDEFINITE	0.58

Adjusted coefficients/odds …

Lexemeajatella:Modality1SX_VCH.SEM_NECESSITY	0.36
Lexemeharkita:Modality1SX_VCH.SEM_NECESSITY	(1.1)
Lexememiettiä:Modality1SX_VCH.SEM_NECESSITY	(1.1)
Lexemepohtia:Modality1SX_VCH.SEM_NECESSITY	0.64
Lexemeajatella:Modality1SX_VCH.SEM_POSSIBILITY	0.61
Lexemeharkita:Modality1SX_VCH.SEM_POSSIBILITY	(0.79)
Lexememiettiä:Modality1SX_VCH.SEM_POSSIBILITY	0.5
Lexemepohtia:Modality1SX_VCH.SEM_POSSIBILITY	0.43

Adjusted coefficients/odds …

Lexemeajatella:Modality2SX_VCH.SEM_ACCIDENTAL	0.66
Lexemeharkita:Modality2SX_VCH.SEM_ACCIDENTAL	(0)
Lexememiettiä:Modality2SX_VCH.SEM_ACCIDENTAL	0.19
Lexemepohtia:Modality2SX_VCH.SEM_ACCIDENTAL	0.17
Lexemeajatella:Modality2SX_VCH.SEM_EXTERNAL	(0.94)
Lexemeharkita:Modality2SX_VCH.SEM_EXTERNAL	(0.52)
Lexememiettiä:Modality2SX_VCH.SEM_EXTERNAL	0.53
Lexemepohtia:Modality2SX_VCH.SEM_EXTERNAL	(0.63)
Lexemeajatella:Modality2SX_VCH.SEM_TEMPORAL	0.25
Lexemeharkita:Modality2SX_VCH.SEM_TEMPORAL	0.12
Lexememiettiä:Modality2SX_VCH.SEM_TEMPORAL	(0.81)
Lexemepohtia:Modality2SX_VCH.SEM_TEMPORAL	(1)
Lexemeajatella:Modality2SX_VCH.SEM_VOLITION	0.32
Lexemeharkita:Modality2SX_VCH.SEM_VOLITION	0.36
Lexememiettiä:Modality2SX_VCH.SEM_VOLITION	0.53
Lexemepohtia:Modality2SX_VCH.SEM_VOLITION	0.48

The End – Everything you never wanted to know about Finnish verbs of thinking

- Thank you!
- Questions, comments, suggestions?!?