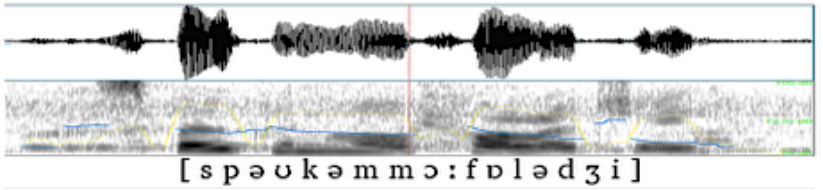
HEINRICH HEINE
UNIVERSITÄT DÜSSELDORF

philGRAD
Faculty of Arts and Humanities
Graduate Academy Düsseldorf



Maltese Plurals: Evidence from a Nonce Word Experiment

Jessica Nieder & Ruben van de Vijver

nieder@phil.hhu.de Ruben.Vijver@hhu.de

DFG Research Unit FOR 2373: Project MALT

6th Lingwistika Maltija, Comenius University Bratislava, 08 June 2017

Maltese Plurals

- 2 main strategies to build the plural of a noun:
  - **Sound Plural** *sptar – sptarijiet* 'hospital(s)'
  - **Broken Plural** *ballun – blalen* 'ball(s)'

- There is variation within the two different plural forms:
  - a number of sound plural suffixes, between 4 and 39 different broken plural patterns

- There is also variation in the choice of the plural forms:
  - *bandiera* (sg.) *bnadar* (broken pl.) vs. *bandieri* (sound pl.) 'flag'

Maltese Plurals: Learnability

- Is it possible to predict pluralisation of novel words?
- If there are no rules governing the plural formation (Sutcliffe, 1924 cited in Schembri, 2012), this means that there is no – linguistic or statistical – structure in the data that allows native speakers to generalize

Maltese Plurals: Previous accounts

Prosodic Morphology (McCarthy & Prince, 1990a, 1990b, 1994)

Plural forms are mapped on prosodic templates or shape-invariant patterns

- What happens in a system that shows a lot of variation?
- We find marked prosodic patterns: CCVV
- How to account for these patterns?
- Dawdy-Hesterberg & Pierrehumbert (2014):
  - Ernestus & Baayen (2003) have shown that phonological features play a role for morphological generalization

Maltese Plurals: Previous accounts

CV-skeleton mapping

Has been used as description of different broken plural types in Maltese (e.g. Schembri, 2012)

- How to account for sound plural forms?
- What skeletons trigger choice of plural forms?

Maltese Plurals: Previous accounts

- Common idea of these accounts: the phonotactics of the singular determines the shape of the (broken) plural

➢ good starting point

Maltese Plurals: Hypothesis

- The phonotactics of the singular determines the shape of the plural
- More frequent items are more likely to be generalized than infrequent items.

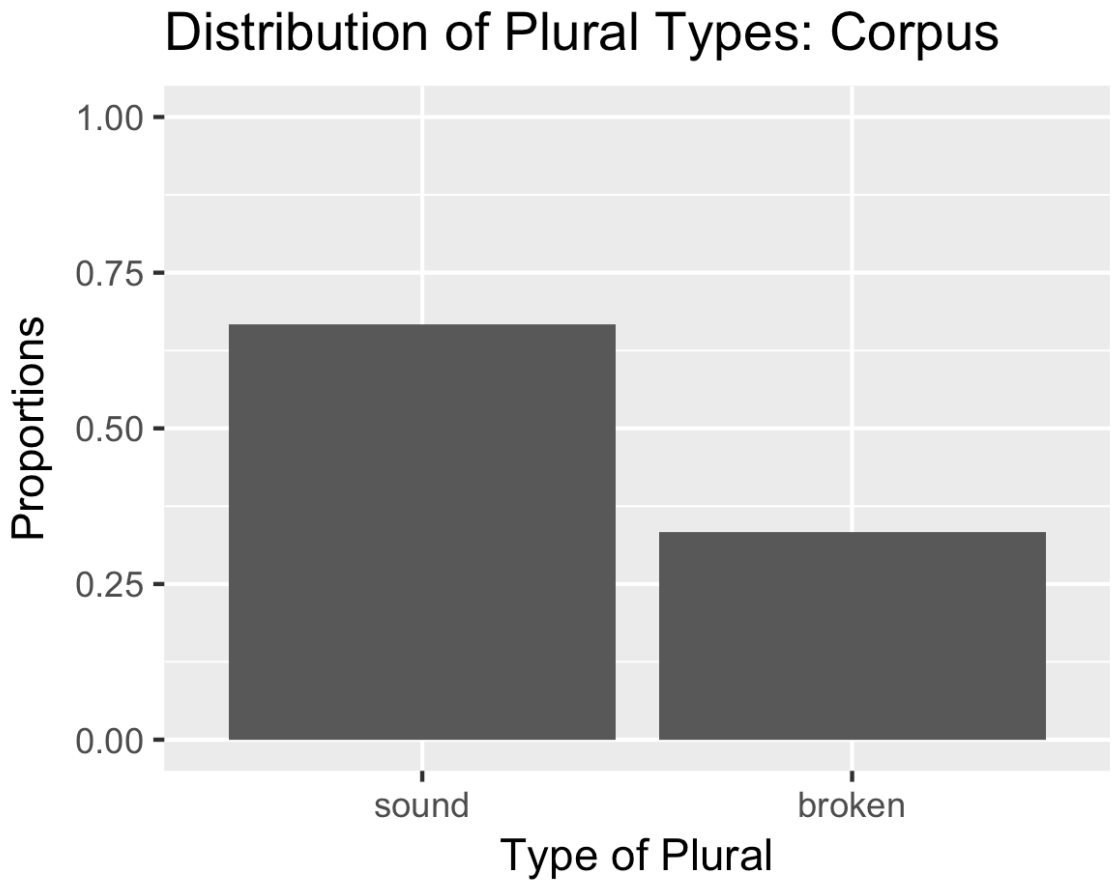
Maltese Plurals: Our work

- To test the hypotheses we created a corpus and conducted a production experiment
- We modeled our experimental data with the Naive Discriminative Learner, a cognitive learning algorithm (Baayen et al., 2011) that does not rely on abstract representations like CV-structure: are generalizations possible?

Maltese Experiment: Corpus

- We created a corpus of 2369 Maltese nominals
- Words were taken from Schembri (2012) and an online corpus (MLRS Corpus Malti v. 2.0)
- Checked with *Ġabra:* online lexicon for Maltese (Camilleri, 2013)
- CV structure
- Corpus frequency number for each word

Maltese Experiment: Plurals in Corpus



Maltese Experiment: Method

- **Production task with visual presentation**
- Maltese native speakers were asked to produce plural forms for existing Maltese singulars and phonotactically legal nonce singulars (Berko-Gleason, 1958)
- Nonce forms were constructed from words of our corpus of 2369 Maltese nominals by changing either the consonants or the vowels or both systematically, e.g.: sema ‚sky‘ —> fera soma fora
- The results are three lists of wug words: C, V, CV
- The words of our corpus used as base had either a sound plural form, a broken plural form or both plural forms: SP, BP, BOTH

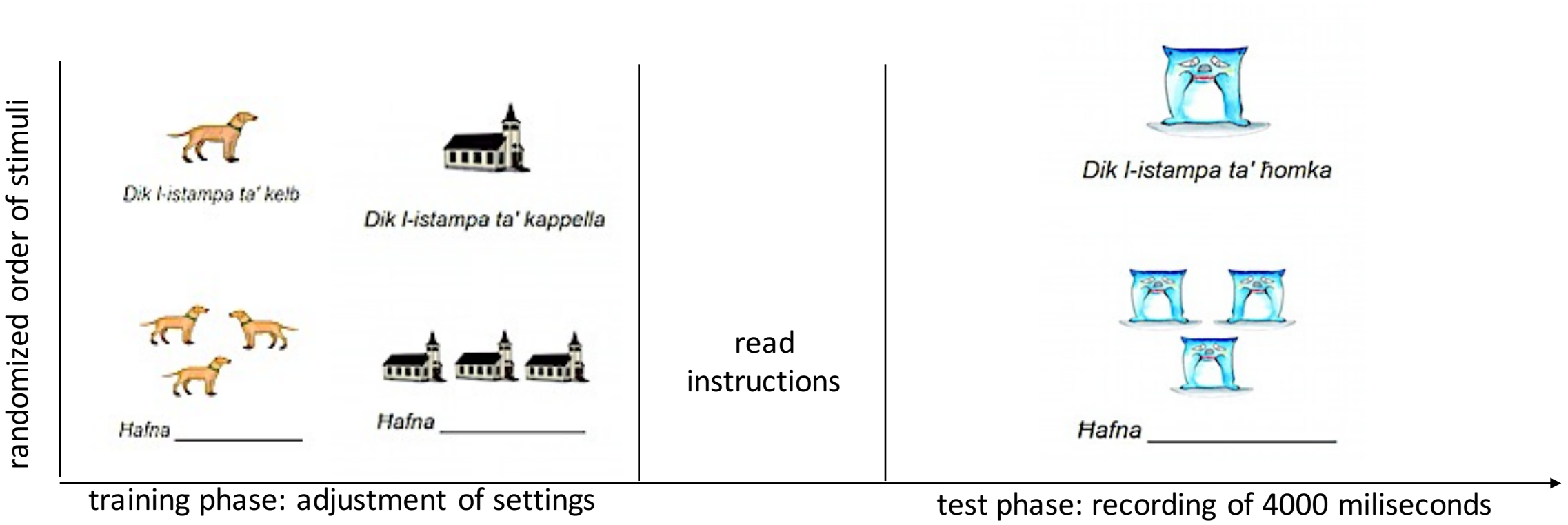
Maltese Experiment: Stimuli

- We chose **90 nonce words**:
  - 30 from list C
    - 10 Base Broken Plural
    - 10 Base Sound Plural
    - 10 Base Both
  - 30 from list V
    - 10 Base Broken Plural
    - 10 Base Sound Plural
    - 10 Base Both
  - 30 from list CV
    - 10 Base Broken Plural
    - 10 Base Sound Plural
    - 10 Base Both
- And **22 existing nouns**:
  - 5 frequent sound plural words, 5 infrequent sound plural words
  - 5 frequent broken plural words, 5 infrequent broken plural words
  - 2 training items (1 sound plural, 1 broken plural)

Maltese Experiment: Procedure

- Participants: 80 adult native speakers of Maltese: 50 female, 30 male (mean age 24.6), recruited at the University of Malta
- We recorded the plural answers of the participants

Maltese Experiment: Procedure



Maltese Experiment: Results - Variation

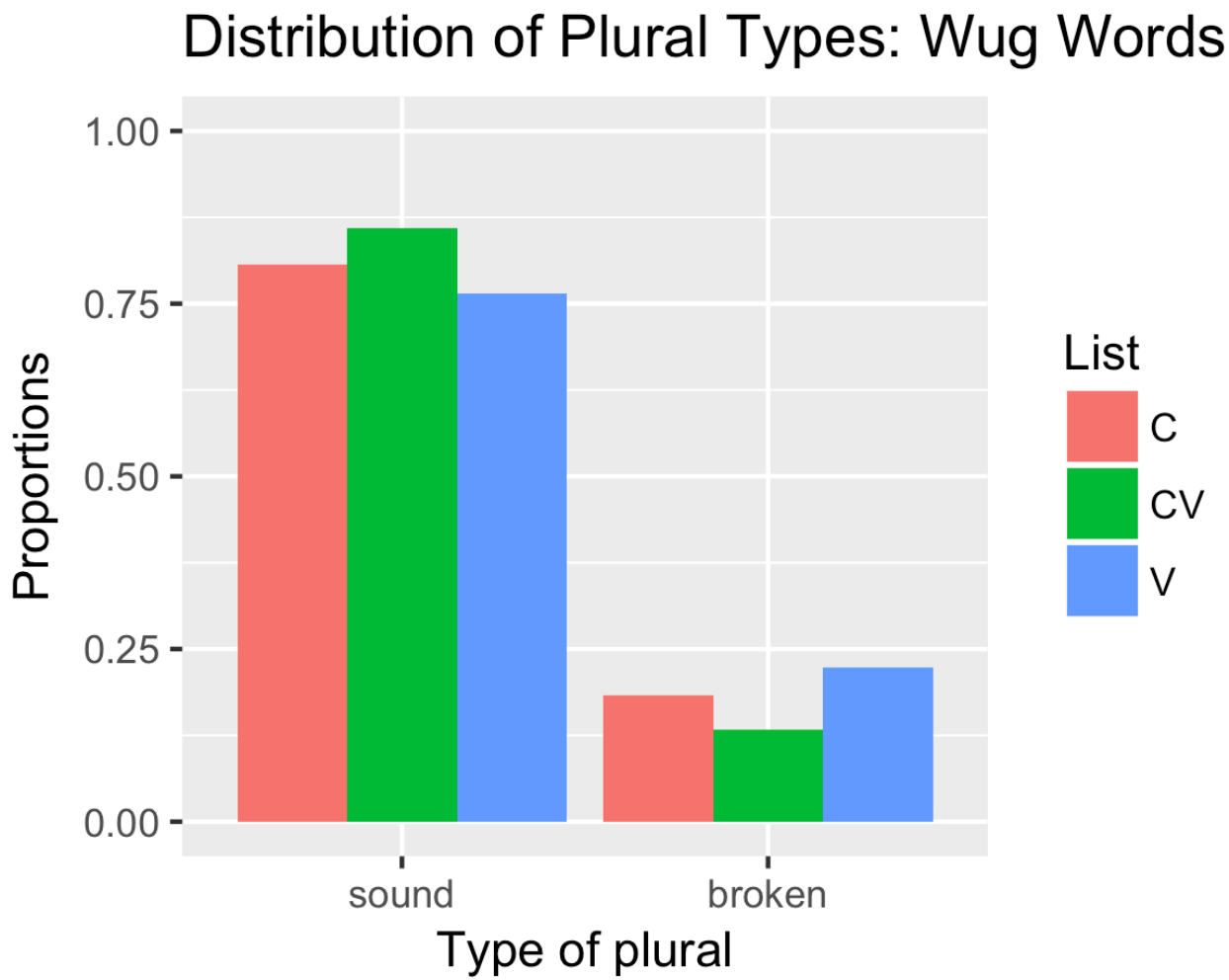
	Plurals Forms given by Participants			
Nonce Singular	Speaker A	Speaker B	Speaker C	Speaker D
xogol	*xgiegel*	*xogolijiet*	*xogliet*	*xogoli*
tolluq	*tlielaq*	*tolluqijiet*	*tlieqi*	*tolluqi*
żepelp	*żepelpijiet*	*żepelpi*	*żpiepel*	*zepelpi*
follu	*folol*	*folli*	*follijiet*	*folliet*

- There is a lot of variation in our data: different plural forms per item (broken plural, sound plural)

Maltese Experiment: Results – List

Does the change of consonants, vowels or both to build nonce words have an effect on the produced plural type of the nonce words?

Maltese Experiment: Results – List



Maltese Experiment: Results – List

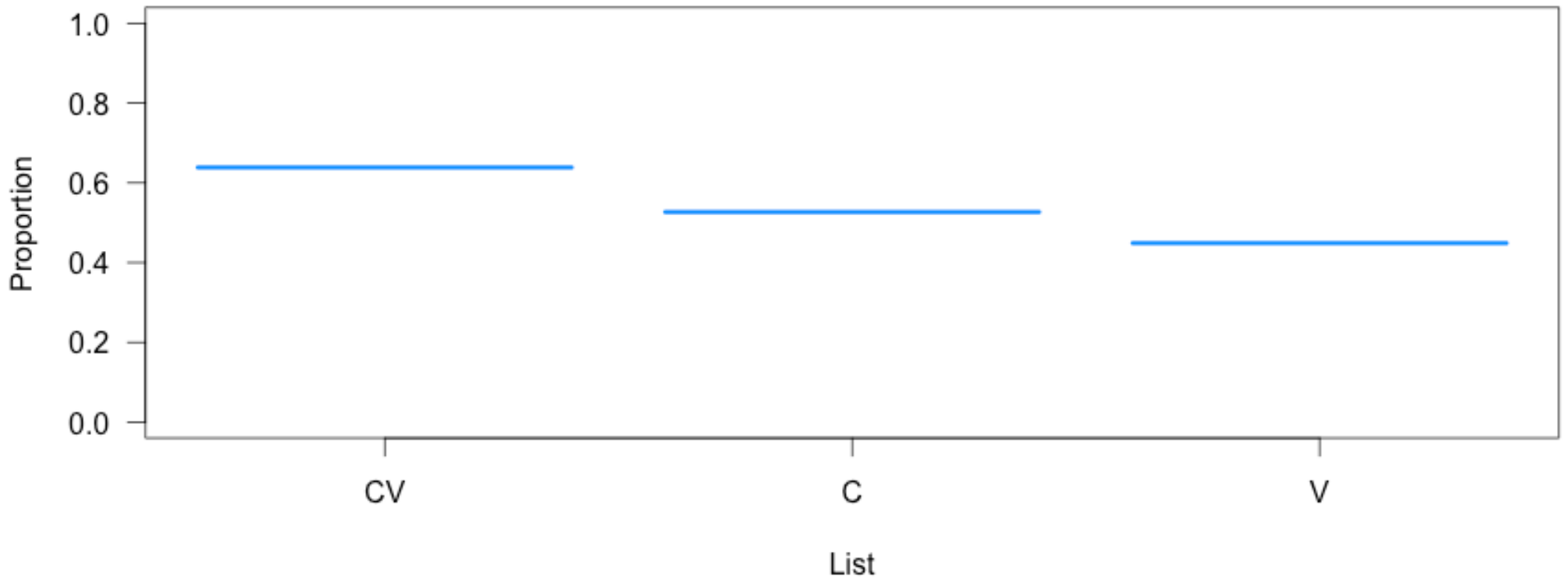
glmer with lme4 package (Bates, Maechler, Bolker & Walker, 2015)

dependent variable:
Answers of participants (binary, Sound or Broken Plural)

independent variables:
List = C, V, CV
Base =SP, BP, BOTH

random effects: Singular, Speaker

Maltese Experiment: Results – List

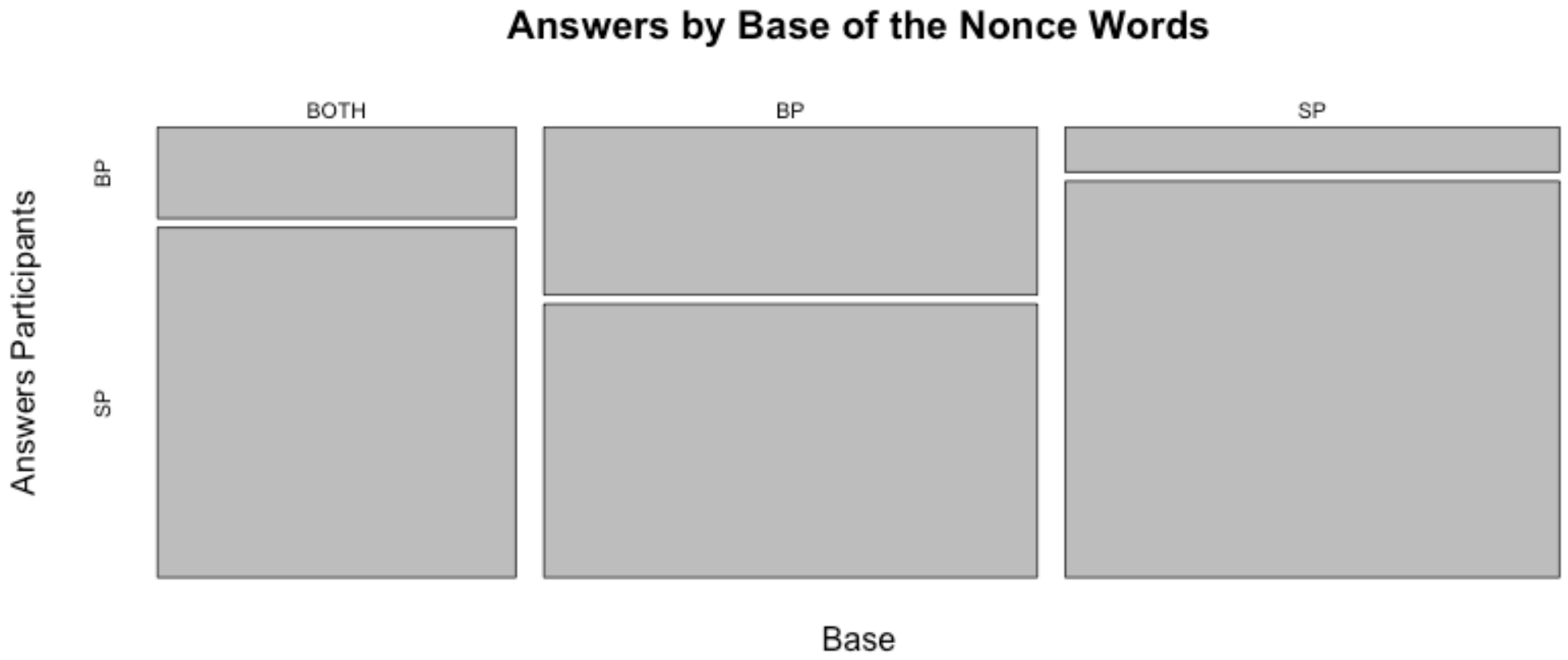


Significant difference between List CV and List V ($p<0.001$)

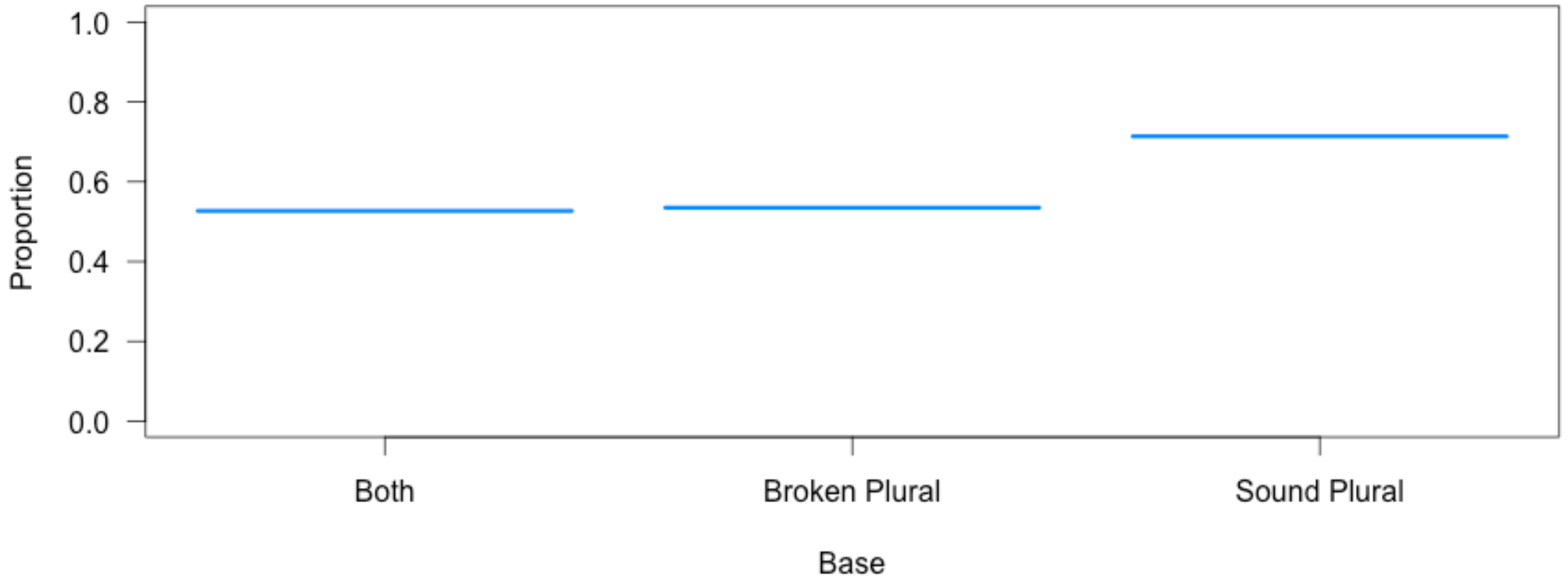
Maltese Experiment: Results - Base

Does the plural form of the existing word that has been used as a base for the nonce word have an effect on the produced plural type of the nonce words?

Maltese Experiment: Results - Base

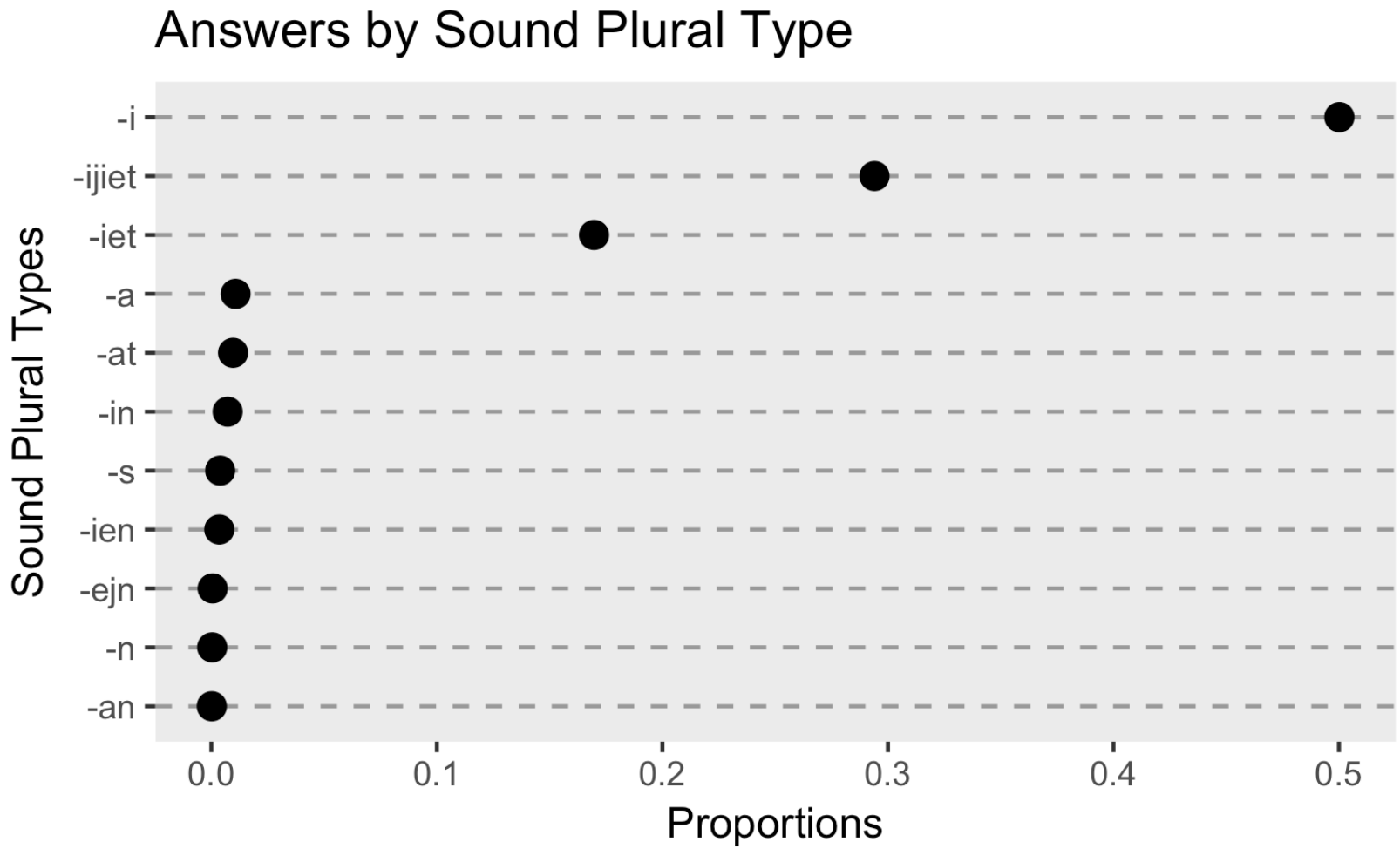


Maltese Experiment: Results - Base



Significant difference between Base Broken and Base Sound ($p<0.001$)

Maltese Experiment: Results – Sound Plurals

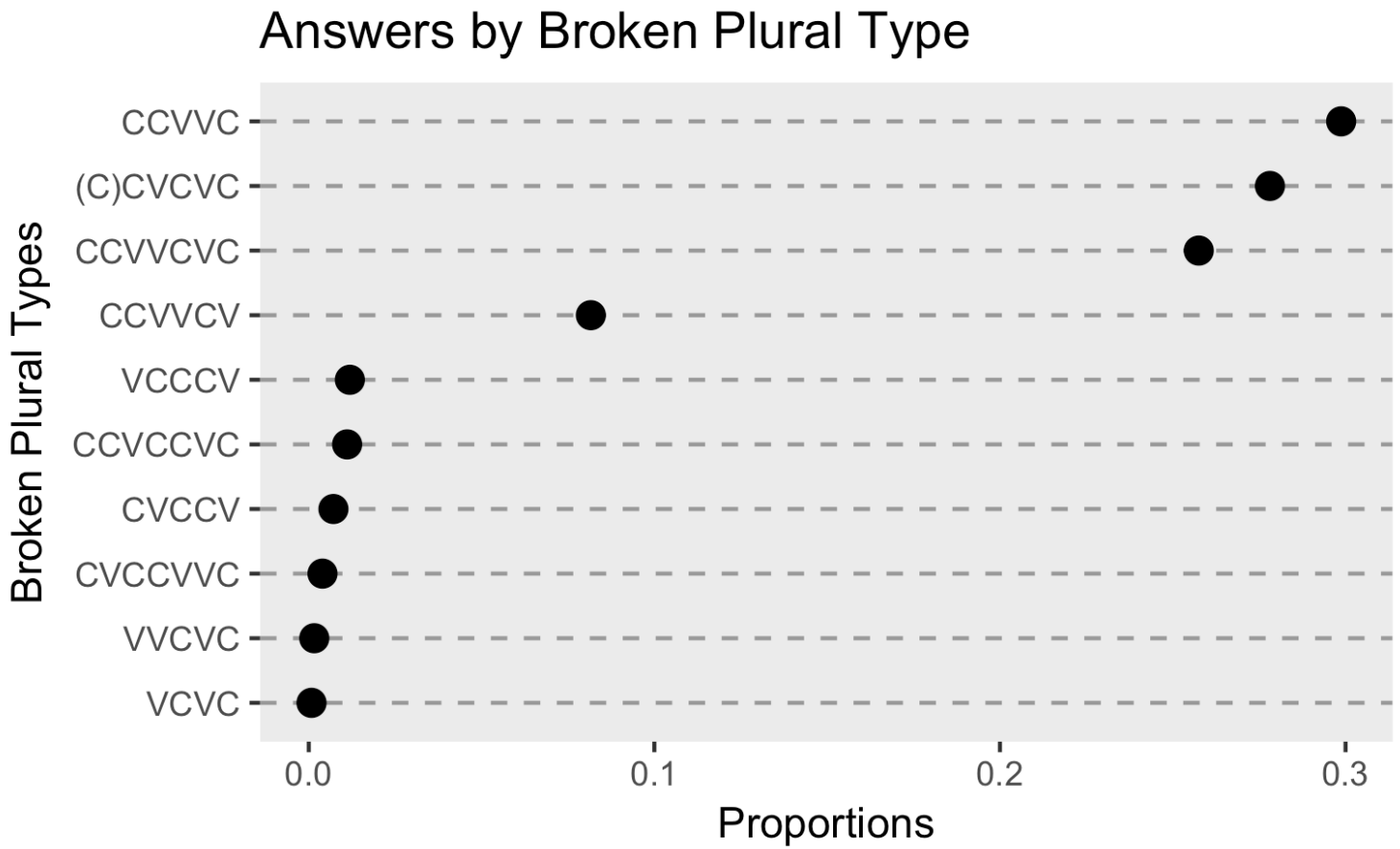


Maltese Experiment: Results – Sound Plurals

- -i and –ijiet are the most common suffixes in our corpus, too
- One participant of the experiment said

„When we [=the Maltese native speakers] do not know the word, we just put an –i or –ijiet on it. That will leave the word as it is and we avoid mistakes.“

Maltese Experiment: Results – Broken Plurals



Maltese Experiment: Results – Broken Plurals

- Most frequent broken plural patterns in our data:

patterns	**wug words (sg.-pl.)**
CCVVC	*telleb – tlieb*
CCVVCVC	*peżna - pżieżen*
CVCVC	*baċċa - baċeċ*

- According to Schembri (2012) these patterns are highly productive in Maltese

Maltese Experiment: Results – Existing Words

Non-canonical frequent		Non-canonical infrequent	
Sound	Broken	Sound	Broken
5 (of 400)	1 (of 400)	14 (of 400)	177 (of 400)
1,3%	0,3%	3,5%	44,3%

Table: Proportion of non-canonical plural forms for existing singular nouns

- Non-canonical plural forms = forms we do not find in the dictionary

Summary: Results so far

- Changing consonants and vowels influenced the choice of plural forms
- The plural form of the existing word used as base for nonce words influenced the choice of plural
- Participants produced broken plurals for nonce words with the most frequent CV structure, sound plurals for nonce words with most common suffixes

Naive Discriminative Learning

Baayen (2011), Baayen et al. (2011)

- Computational model of morphological processing
- NDL simulates a learning process
- Supervised learning
- Has been used successfully to model language acquisition (Ramscar, Yarlett, Dye, Denny & Thorpe, 2010)
- Central idea:

  learning = exploring how events are inter-related, they become associated (see also Plag & Balling, 2016)
- inter-related events: *Cues* and *Outcomes*

Naive Discriminative Learning

Baayen (2011), Baayen et al. (2011)

- Based on Rescorla-Wagner equations that are well established in cognitive psychology (Rescorla & Wagner, 1972)
- Associations between cues and outcomes at a given time, whereas the strength of an association, the association weight, is defined as follows (Evert&Arppe, 2015):

  - No change if a cue is not present in the input
  - Increased if the cue and outcome co-occur
  - Decreased if the cue occurs without the outcome

- Danks (2003) equilibrium equations: define association strength when a stable state is reached → „adult state of the learner“ (Baayen, 2011)
- Implementation as R package *ndl*

Naive Discriminative Learning

Baayen (2011), Baayen et al. (2011)

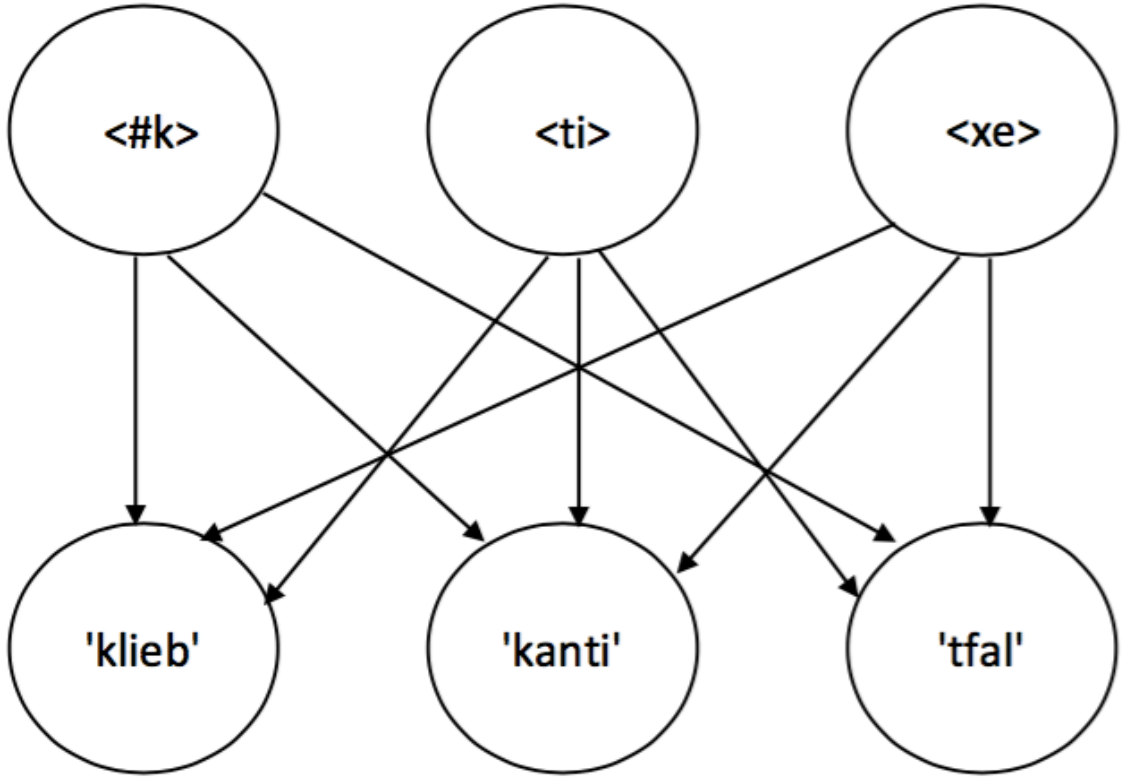


Figure: Association between Cues and Outcomes

Modeling our Data: Naive Discriminative Learning

- We trained the NDL model on our corpus
- We formulated our singular nonce words in bigrams and calculated how the NDL learner would classify them

  - Cues: singulars in bigrams, #k – ke - el - lb - b#
  - Outcome: plural types, #k → sound, ke → broken...

- The associations between cue and outcome are weighted
- We used NDL to predict classification of nonce words

Modeling our Data: Naive Discriminative Learning

Cue	Broken Plural	Sound Plural
#k	-0.1228488034	0.6212695562
ke	0.4219441264	-0.4219441264
el	0.1686745205	-0.1690560897
lb	0.1667921396	-0.1638825484
b#	0.4240803967	0.0749708285
sum	1,05864238	-0,05864238

Table: Example for NDL association weights predicting outcome „broken“ for singular *kelb*

Modeling our Data: Naive Discriminative Learning – Results

- We compared the classification of participants with NDL
- NDL correctly classified 65,3 % of our observations

	broken	sound
broken	0.6045667	0.3954333
sound	0.3319242	0.6680758

Table: Classification of nonce words by NDL

Modeling our Data: Naive Discriminative Learning

- Let´s compare our results with other models that have been used with Arabic broken plural nouns:

➢Dawdy-Hesterberg & Pierrehumbert (2014) used modified versions of the Generalised Context Model (Nakisa, Plunkett & Hahn, 2001, Albright & Hayes, 2003)

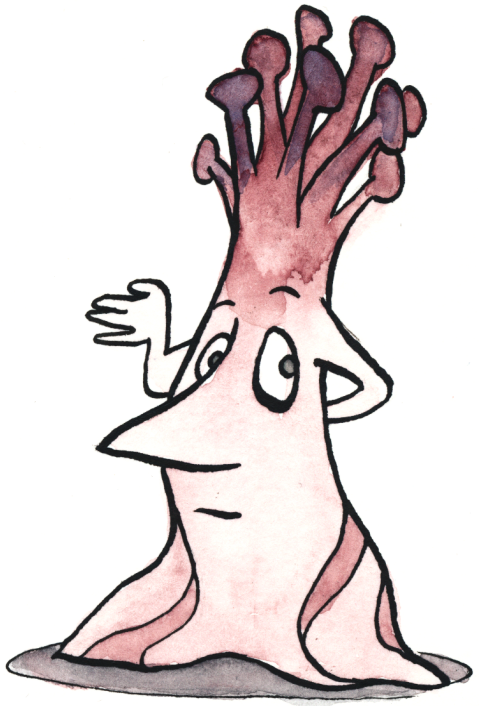
➢Accuracy of the models ranged between 55.31 – 65.97%

➢Our NDL analysis: 65.3%

Discussion

- There is structure in our data
- Native speakers are able to inflect novel nouns
- Participants produced more broken plural words when we just changed the vowels of existing singulars to create nonce words
  - When both, consonants and vowels, were changed, participants produced the highest number of sound plural forms
  - Consonants and vowels are important for the generalizations of broken plurals → evidence for tier separation
- Phonotactics of the singular determines the plural form
- Plurals are generalizable!
- (And, as always: much work still needs to be done.)

Grazzi ħafna!



References

Albright, A., & Hayes, B. (2003). Rules vs. analogy in English past tenses: a computational/experimental study. *Cognition*, *90*(2), 119–161.

Baayen, R. H. (2011). Corpus linguistics and naive discriminative learning. *Brazilian Journal of Applied Linguistics*, 11, 295-328.

Baayen, R. H., Milin, P., Filipovic Durdevic, D., Hendrix, P., and Marelli, M. (2011). An amorphous model for morphological processing in visual comprehension based on naive discriminative learning. *Psychological Review*, 118, 438-482.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1).

Berko, J. (1958). The Child's Learning of English Morphology. *WORD*, *14*(2-3), 150–177.

Camilleri, J. J. (2013). *A Computational Grammar and Lexicon for Maltese* (Master Thesis). University of Gothenburg, Gothenburg, Sweden.

Danks, D. (2003). Equilibria of the Rescorla-Wagner model. *Journal of Mathematical Psychology*, 47, 109–121.

Dawdy-Hesterberg, L. G., & Pierrehumbert, J. B. (2014). Learnability and generalisation of Arabic broken plural nouns. *Language, Cognition and Neuroscience*, *29*(10), 1268–1282.

Ernestus, M., & Baayen, R. H. (2003). Predicting the unpredictable: Interpreting neutralized segments in Dutch. *Language*, *79*, 5–38.

Evert, S., & Arppe, A. (2015). Some theoretical and experimental observations on naïve discriminative learning**.** In *Proceedings of the 6th Conference on Quantitative Investigations in Theoretical Linguistics (QITL-6)*, Tübingen, Germany.

McCarthy, J. J., & Prince, A. S. (1990a). Foot and word in prosodic morphology: The Arabic broken plural. *Natural Language & Linguistic Theory*, *8*(2), 209–283.

McCarthy, J. J. and Prince, A.S.(1990b).Prosodic morphology and templatic morphology. *Perspectives on Arabic Linguistics II*. 16.

McCarthy, J. J., & Prince, A. S. (1994). The Emergence of the Unmarked: Optimality in Prosodic Morphology. *Proceedings of the North East Linguistics Society 24*. 18.

Nakisa, R., Plunkett, K., & Hahn, U. (2001). Single- and dual- route models of inflectional morphology. In P. Broeder & J. Murre (Eds.), *Models of language acquisition: Inductive and deductive approaches* (pp. 201–222). Cambridge, MA: MIT Press.

Plag, I., & Balling, L.W. (2016). Derivational morphology: An integrative perspective on some fundamental issues. In Pirelli, Vito, Ingo Plag & Wolfgang U. Dressler (eds.), *Word knowledge and word usage: A cross-disciplinary guide to the mental lexicon*. Berlin, New York: De Gruyter.

Ramscar, M., Yarlett, D., Dye, M., Denny, K., & Thorpe, K. (2010). The Effects of Feature-Label-Order and Their Implications for Symbolic Learning. *Cognitive Science*, *34*(6), 909–957.

Rescorla, R.A., & Wagner, A.R.(1972). A theory of Pavlovian conditioning: variations in the effectiveness of reinforcement and nonreinforcement. In A.H. Black & W.F. Prokasy (eds.), Classical conditioning II: current research and theory (pp.64-99). New York: Appleton-Century-Crofts.

RStudio Team (2015). RStudio: Integrated Development for R. RStudio, Inc., Boston, MA URL http://www.rstudio.com/.

Schembri, T. (2012). *The Broken Plural in Maltese: A Description* (1. Aufl). Bochum: Univ.-Verl. Brockmeyer.

Sutcliffe, E. F. (1924). *A Grammar of the Maltese Language*. Valletta: Progress Press.

Rescorla-Wagner equations

Baayen et al. (2011)

The Rescorla-Wagner equations specify the association strength V_i^{t+1} of cue C_i with outcome O at time $t + 1$ as

$$V_i^{t+1} = V_i^t + \Delta V_i^t,$$

with the change in association strength $\triangle V_i^t$ defined as:

$$\Delta V_i^t = \begin{cases} 0 & \text{if } \textsc{absent}(C_i, t) \\ \alpha_i \beta_1 \left(\lambda - \sum_{\textsc{present}(C_j, t)} V_j \right) & \text{if } \textsc{present}(C_j, t) \ \& \ \textsc{present}(O, t) \\ \alpha_i \beta_2 \left(0 - \sum_{\textsc{present}(C_j, t)} V_j \right) & \text{if } \textsc{present}(C_j, t) \ \& \ \textsc{absent}(O, t) \end{cases}$$