Analogy in the Plural System of Maltese

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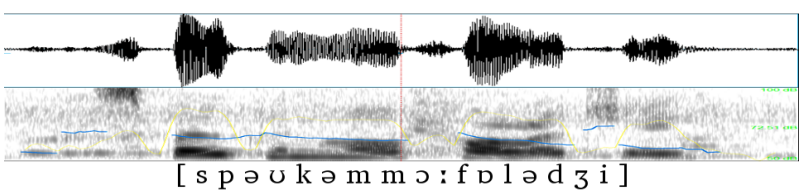


Maltese


Bari
Naples
Pompeii
Matera
Taranto
Lecce
Sardegna
Tyrrhenian Sea
Cagliari
Reggio
Calabria
Palermo
Trapani
Marsala
Sicilia
Catania
Syracuse
Ionian Sea
Tunis
تونس
Sousse
سوسه
Malta
Sfax
صفاقس
Mediterranean S
Tunisia
Tripoli
طرابلس
Abu Kammash
ابو كماش
Misrata

Maltese

- It is a semitic language, with characteristics of Maghrebi Arabic and traces of Levantine Arabic.
- National language of Malta.
- Spoken by about 400.000 people in Malta (Malta, Gozo and 1 family in Comino).
- Another 100.000 people speak it around the world (Australia, the US, Canada, Belgium, Luxembourg, Italy and the UK.)

Maltese

- It has been influenced by Italian (Sicilian) and English.
- The lexicon consists of 32% Arabic, 52% Italian and 6% English items. (And a rest of obscure origin (Brincat, 1996).)
  - ħabib 'friend'
  - furketta 'fork'
  - xawer 'shower'
- The Arabic words are most frequently used.

Sound and broken plurals

sound add a suffix: sptar – sptar-ijiet 'hospital'

broken change the prosody: ktieb – kotba 'book'

Sound plurals

Singular	Plural	Suffix	Gloss
arlogġ	arlogġi	-i	watch, clock
omm	ommijiːt	-ijiːt	mother
ħaddiːm	ħaddiːma	-a	worker
bniːdem	bnedmiːn	-iːn	lazy
film	films	-s	movie
saltna	saltniːt	-aːt, -iːt	kingdom

Mayer, Spagnol & Schönhuber (2013)

Broken plurals

Type	Singular	Plural	Gloss
A	bandiːra	bnaːdar	flag
B	balla	balal	bundle
C	borġ	braːġ	heap
D	xmara	xmajjar	river
E	xatba	xtaːbi	gate
F	baħar	ibħra	sea
G	ġdid	ġdodda	new
H	għarbi [arbi]	għarab [arap]	Arab
I	wiċċ	uċuħ	face
J	għaref [aref] [aref]	għoriːf [oriːf]	wise man
K	għama [ama]	għomja [omja]	blind person

Schembri (2012)

Several sound plurals for one singular

Singular	Plural	Gloss
werqa	werq-at	leaf
werqa	werq-iːt	leaf

Both sound and broken forms

for one singular

Singular	Broken plural	Sound plural	gloss
bandiːra	bnaːdar	bandiːri	flag
tapit	twapet	tapiti	carpet
ħaxix	ħxejjex	ħaxixiːt	vegetables

Sound? Broken? Bround!

Some forms seem to have both a suffix and a changed prosody:

Singular	Plural	Gloss
bniːdem	bnedm-iːn	lazy
giddiːb	giddɪb-in	liar (bround)

Borġ & Azzopardi-Alexander (1997)

Maltese

Great deal of variation

There is a great deal of variation. It is difficult to pinpoint the rules for sound plurals (Borġ & Azzopardi-Alexander, 1997), and broken plurals drive scholars of Maltese to despair: *"Dwar il-plural miksur m'hemmx regoli". (There are no rules governing the broken plural.* (L-Għaqda Tal-Kittieba Maltin. Cited in: Schembri, 2012)

Maltese

- If it is indeed the case tat there are no rules governing the broken plural, this means that there is no – linguistic or statistical – structure in the data that allows native speakers to generalize.
- Broken plurals should not be productive.

Maltese

No unmarked shapes

The first syllable of many broken plurals have this shape:

CCVV

(for example: bnaːdar, braːġ.) This is not, as far as we know, an unmarked prosodic shape.

Maltese

Extant accounts

- prosodic morphology
  - Plural forms are not prosodically optimizing, nor are they prosodically unmarked.
- CV-skeleton mapping
  - What skeletons are chosen when?

Maltese

Extant accounts

- prosodic morphology
  - Plural forms are not prosodically optimizing, nor are they prosodically unmarked.
- CV-skeleton mapping
  - What skeletons are chosen when?

- The general idea behind these theories: the phonotactics of the singular determines the shape of the plural. This is a good idea.

Maltese

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

Corpus and experiment

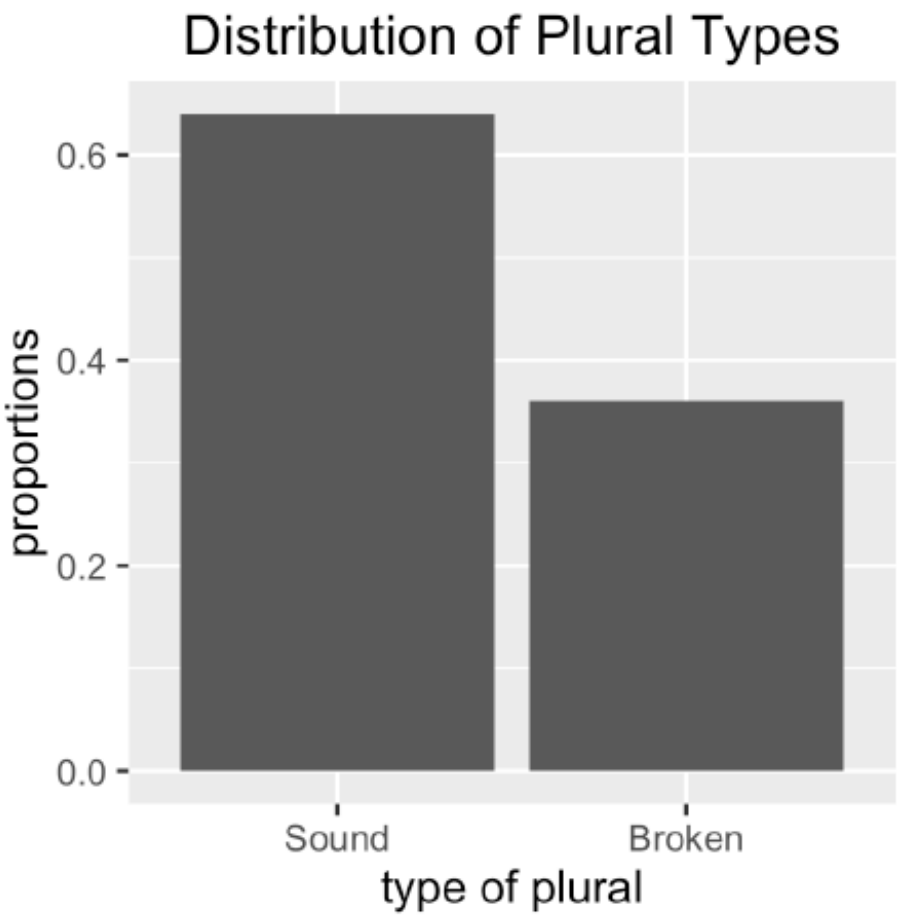
To test these hypotheses we created a corpus and we did a production experiment.

Maltese

Corpus

- We created a corpus of 2369 Maltese nouns
  - Taken from the online corpus MLRS Corpus Malti.
  - The corpus was checked by means of the online dictionary ġabra.

Plurals in our corpus



Maltese experiment

- We created nonce forms based on the forms found in our 2369 word corpus
  - We changed C or V or both systematically:
  - sema 'sky' $\rightarrow$ fera, soma, fora.
- We divided the words op in frequent ($>$ 50 per million) and infrequent ($<$ 50 per million).
- We chose 90 nonces (30 C-changed words, 30 V-changed words and 30 CV-words.)
- and 22 existing nouns:
  - 5 frequent sound plural words, 5 infrequent ones
  - 5 frequent broken plurals, 5 infrequent ones
  - 2 training items (1 sound, 1 broken.)

Experiment

- Production test with visual presentation
- Software SpeechRecorder
- 38 native speakers of Maltese tested in Malta.
- First one item: *Dik l-stampa ta' X. This is a picture of X*
- Then 3 items: *ħafna X? Many X?*

Results

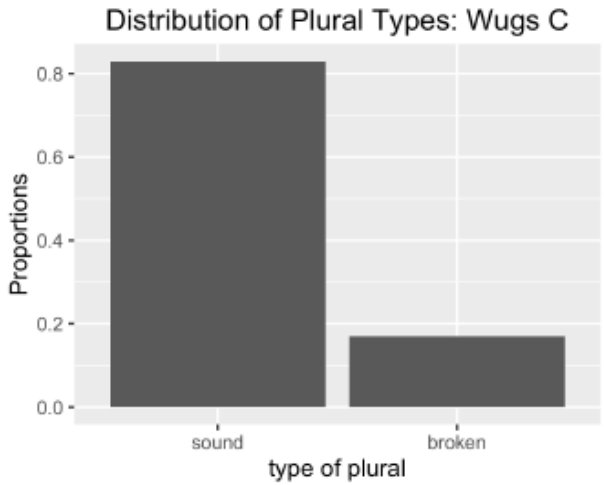
Qualitative

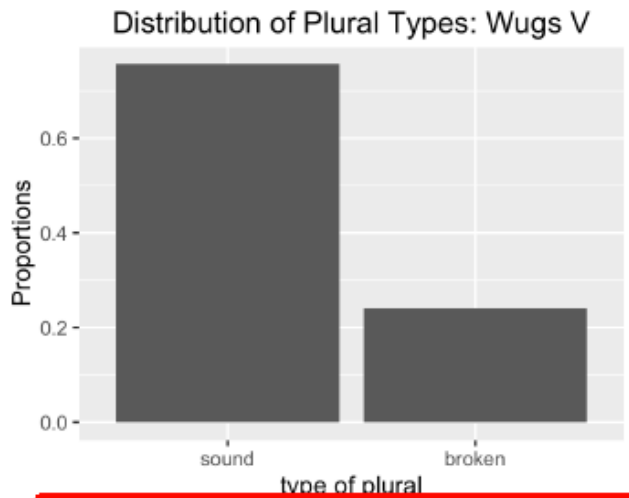
There is lots a variation in the data:

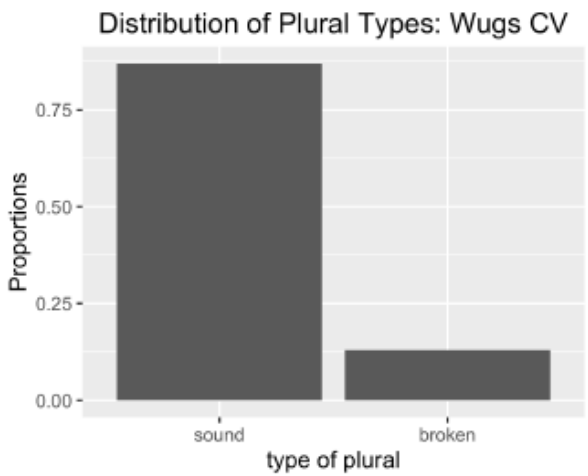
Nonce	Speaker A	Speaker B	Speaker C	Speaker D
xogol	xgiːgel	xogolijiːt	xogliːt	xogoli
tolluq	tliːlaq	tolluqijiːt	tliːqi	tolluqi
żepelp	żepelpijiːt	żpiːpel	żepelpi	
follu	folol	folli	follijiːt	folliːt

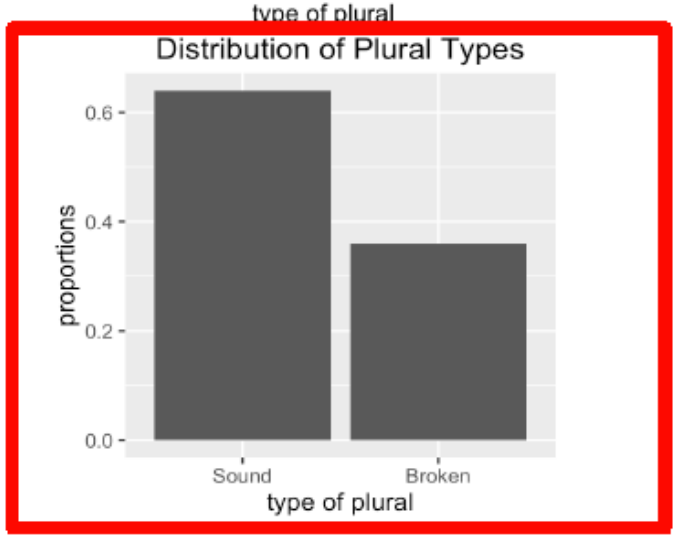
Results

Sound and broken plurals in nonces and corpus





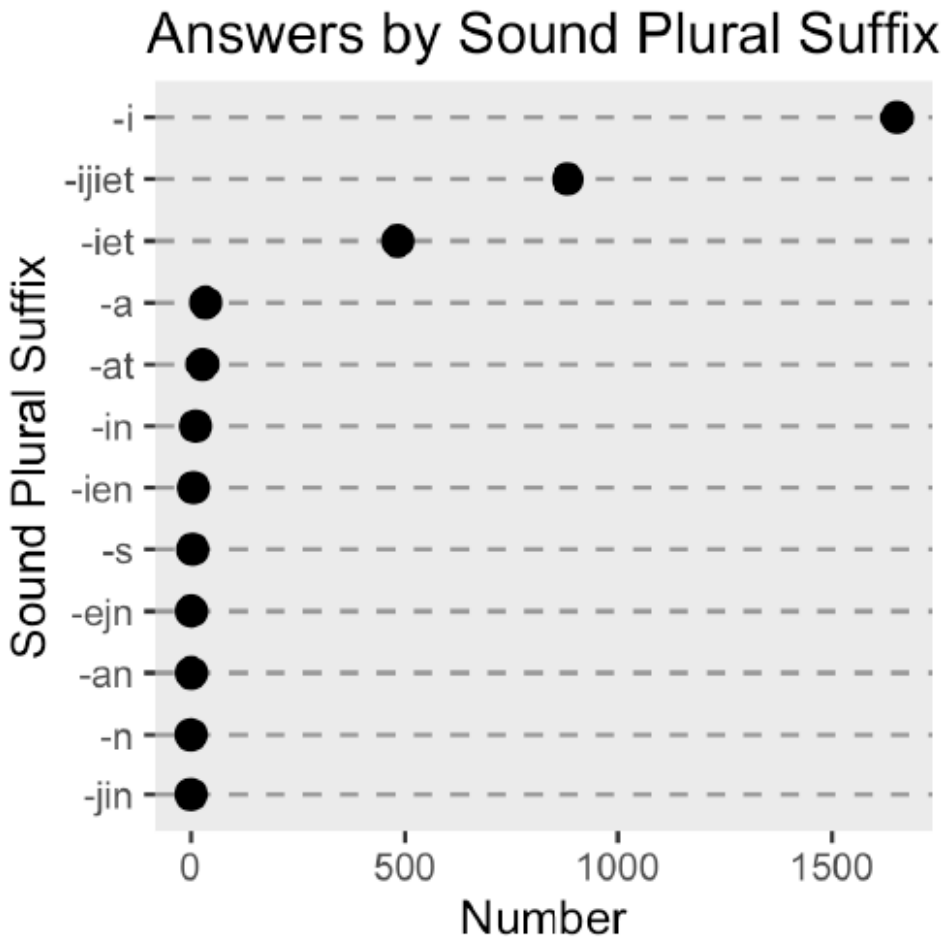




Corpus results

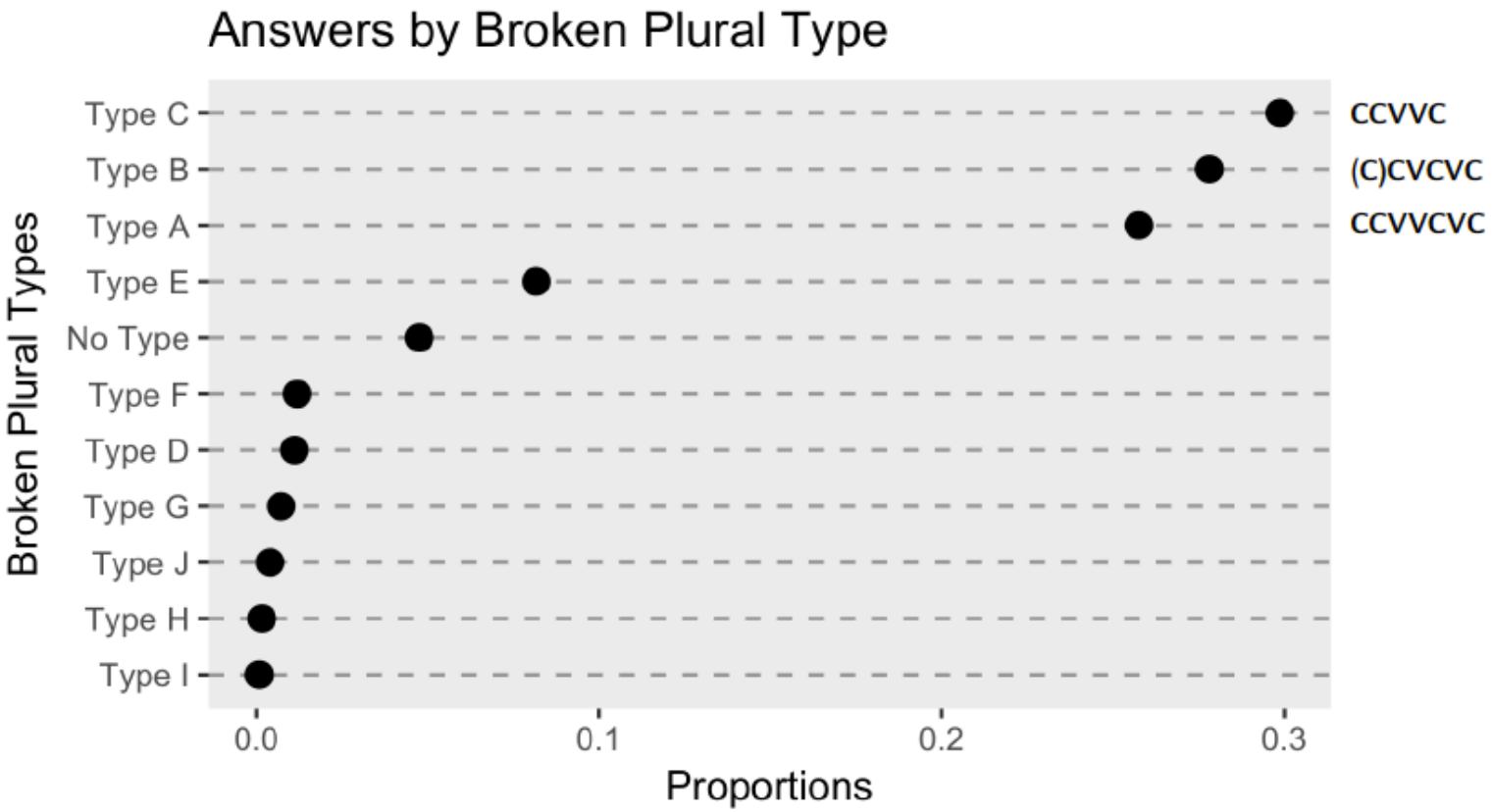
Results

Sound plural suffixes



Results

Broken plural forms



Results

Errors in infrequent forms

Errors frequent		Errors 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%

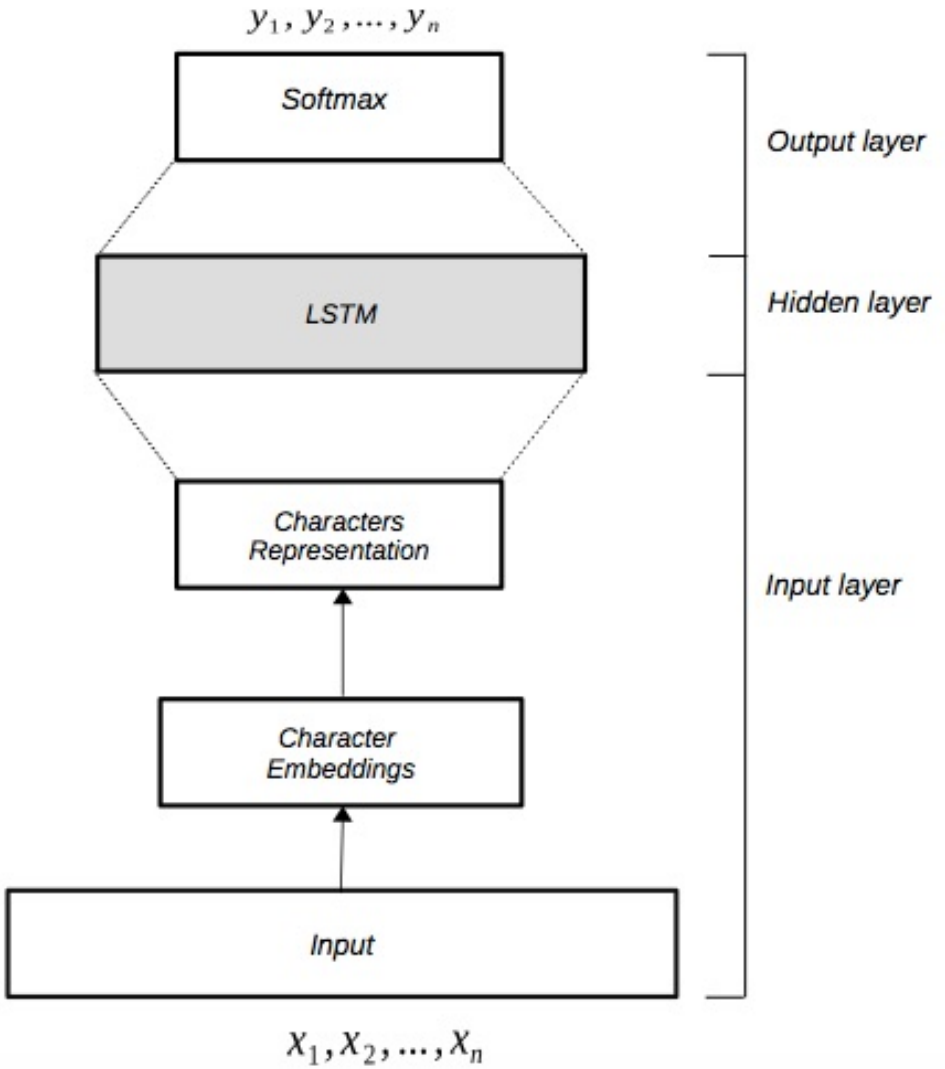
Models

Long Short-Term Memory (with the help of Samih Younes)

- Recurrent neural network which we trained to classify Maltese plurals.
  - If there really is no structure at all in the data this should fail.

Models

Long Short-Term Memory (with the help of Samih Younes)



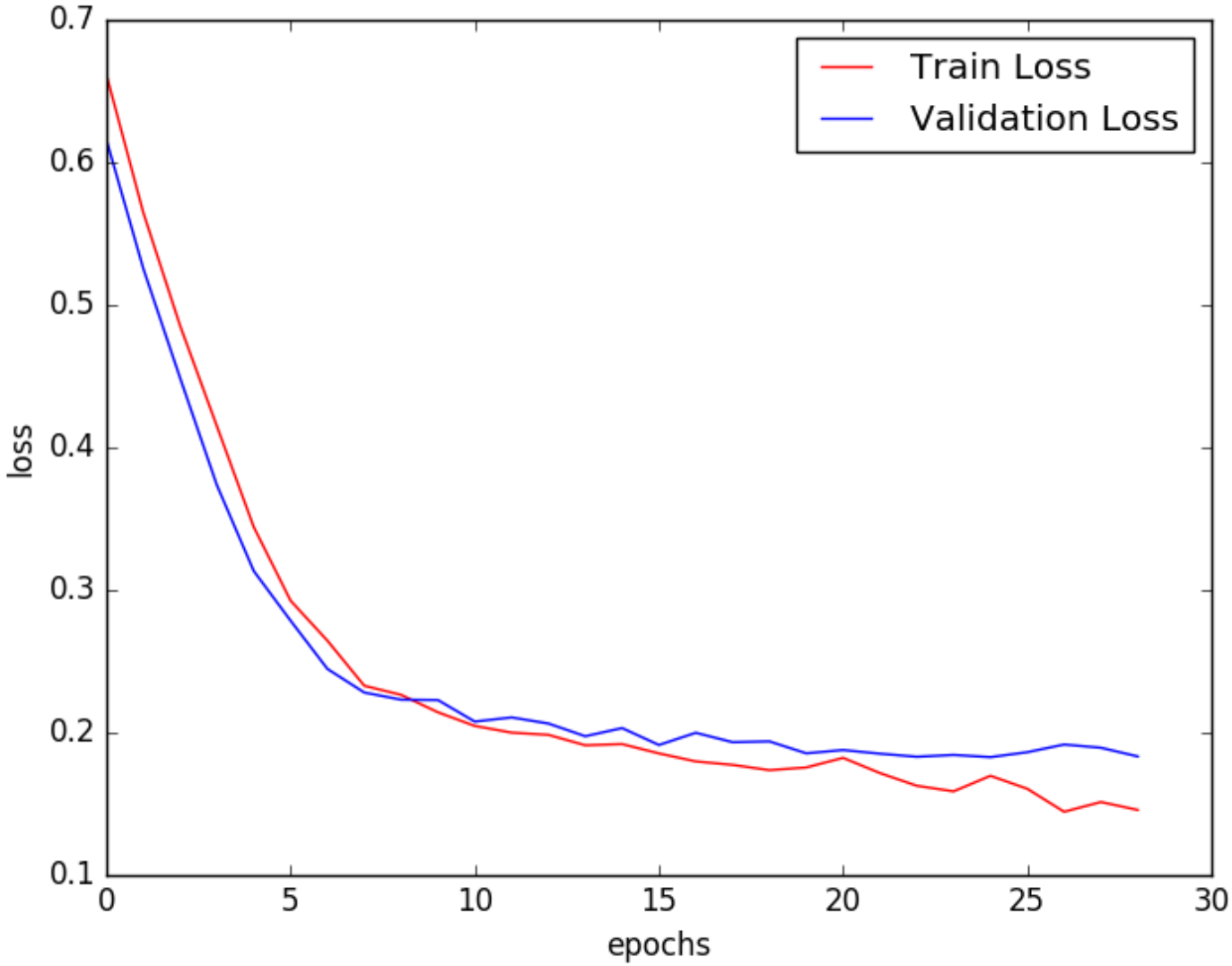
Models

Long Short-Term Memory

- data: 2337 word forms (this is based on a version not chacked by ġabra. It contains a few non-nouns.)
- Training: 1869 (broken and sound)
- Validation: 468 (186 broken, 282 sound)

Models

Long Short-Term Memory: Learning



Models

Long Short-Term Memory: Learning

Label	precision	recall
broken	0.94	0.91
sound	0.94	0.96

Models

Long Short-Term Memory and experiment

LSTM	broken	sound
broken	170 (0.36)	16 (0.03)
sound	10 (0.02)	272 (0.58)

Experiment	broken	sound
broken	360 (0.5)	60 (0.08)
sound	0 (0.006)	300 (0.41)

Long Short-Term Memory and experiment

- There is structure in the data
- The classification is pretty good, broken plurals are underestimated and sound plurals overestimated.

Minimal Generalization Learner

Albright & Hayes (2003)

- Model that learns by comparing two inflected forms
- The difference between the forms is formulated as rule.
- The differences are generalized over.
  - [dɔg], [dɔgz]: $\emptyset \rightarrow$ [z]/[dɔg]+$_{[plural]}$.
  - [bæg], [bægz]: $\emptyset \rightarrow$ [z]/[bæg]$_{[plural]}$.
  - generalized: $\emptyset \rightarrow$ [z]/X[+voice,-cont]$_{[plural]}$.

Minimal Generalization Learner

- 2225 corpus pairs as input.
- Tested with 20 new words.

Minimal Generalization Learner

MGL	broken	sound
broken	3 (0.15)	7 (0.035)
sound	0 (0.0)	10 (0.5)

Experiment	broken	sound
broken	360 (0.5)	60 (0.08)
sound	0 (0.006)	300 (0.41)

Minimal Generalization Learner

- MGL is essentially a linear model.
- Nevertheless is does well.
- again broken plurals are underestimated and sound plurals a bit overestimated.

Naive Discriminative Learner

Baayen, Milin, Djurdjević, Hendrix & Marelli (2011)

- Learns associations between *cues* and *outcomes*.
- The cues are singular forms in bigrams
- the outcomes are plural types (sound, broken, bround).
- These associations are weighted.
- we trained the NDL on our corpus.
- We analyzed our nonce words in bigrams and calculated how the NDL learner would classify them.
- The NDL classified 63% the way our participants did.
    - Excluding frequency from the data, the correct classification dropped to 57%.

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, 2016):
  - 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 Learner

Baayen et al. (2011)

- Learns associations between *cues* and *outcomes*
- The cues are singular forms
  - Bigrams, trigrams, CV skeleton, segments
- Outcomes are plural types (sound, broken, bround)
  - Cue and Outcomes for ktieb $\sim$ kotba:

cue bigram: #k-kt-ti-ib-b#

outcome #k $\rightarrow$ broken, kt $\rightarrow$ broken, ti $\rightarrow$ broken, ib $\rightarrow$ broken, b# $\rightarrow$ broken

- The associations between cue and outcome are weighted
- Trained the NDL on our corpus
- Used NDL to predict the classification of our nonces

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#
  - Outcomes: 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*

Naive Discriminative Learner

Classification of words in corpus

- Trained on 90% of the corpus and tested with the rest

bigrams correctly classifies 73.6% of unseen singulars
trigrams correctly classifies 94.6% of unseen singulars
CV correctly classifies 63.3% of unseen singulars

Naive Discriminative Learner

Classification of wugs

- How well does the NDL model agree with the classification of wugs by our participants?
- We took the weight of the cues calculated on the basis of the trigram analysis of the corpus
- We pasted the cues together to find the cumulative weight for each wug to find the strongest association for each wug
- We compared the classification of participants with NDL

Table: Classification of wugs by NDL

	broken	bround	sound	
broken	0.59	0.009	0.39	good
bround	0.61	0.03	0.35	bad
sound	0.33	0.01	0.64	good

Naive Discriminative Learner

- NDL does well.
- Model overestimates sound plurals, and is uncertain about bround plurals.

All models

- The performance of the models seems to correlate with the performance of the native speakers (NDL) and the proportions found in the lexicon.
- Especially NDL suggests that phonotactics play an important role in predicting which singular gets what plural.
- It is still difficult to pin down what it is exactly that speakers use as base for the analogies they produce.

Conclusion

- There is structure in the data.
- Native speakers are able to inflect novel nouns, as sound, broken or bround.
- Several models with very different architectures can learn the plural system relatively successfully.
- NDL learns based on bigrams: dare I say prosodic structure.
- If true, then phonotactics of the singular does indeed determine the plural form.
- There really is no reason to despair.
- (And, as always: much work still needs to be done.)

grazzi ħafna!

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