The Use of Statistics in Cognitive Linguistics

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Cognitive linguistics:
Some basic facts

**Minimal Assumption:** language can be accounted for in terms of general cognitive strategies
- no autonomous language faculty
- no strict division between grammar and lexicon
- no a priori universals

**Usage-Based:** generalizations emerge from language data
- no strict division between langue and parole
- no underlying forms

**Meaning is Central:** holds for all language phenomena
- no semantically empty forms
- differences in behavior are motivated (but not specifically predicted) by differences in meaning
- metaphor and metonymy play a major role in grammar
What is Cognitive Linguistics?

• Explanation of linguistic phenomena via general cognitive mechanisms
• Meaning is the motive for language and is embodied in physical experience
• Radial categories based on prototypes with extensions via metaphor & metonymy
• Lexicon & grammar are a continuum, observe same patterns
• Empirical (statistical) analysis of authentic language data
• A survey of use of statistics in articles in *Cognitive Linguistics*, 1990-2012

• Concrete examples of how researchers have applied statistical models in linguistics
The Quantitative Turn: 2008

Facilitated by theoretical and historical factors

- CL is usage-based, data-friendly – quantitative studies have always been part of CL
- Advent of digital corpora and statistical software
- Progress in computational linguistics

What this means for the future

- All linguists will need at least passive statistical literacy
- We need to develop best practices for use of statistics in linguistics
- Public archiving of data and code will contribute to advancement of the field
Statistical Methods and How We are Using Them

These are the methods most common in Cognitive Linguistics:

- Chi-square
- Fisher Test
- T-test and ANOVA
- Correlation
- Regression
- CART
- Mixed Effects
- Cluster Analysis
- Correspondence Analysis

These are just some examples of how statistics are being used in cognitive linguistics. There is plenty of room for experimentation.

I will give some examples of how these methods have been applied in Cognitive Linguistics.
Chi-square test

When to use the chi-square test:

You have a matrix with two types of categories and a count for each cell in the matrix. You want to know whether there is a relationship between the two types of categories.

Example: Is there a relationship between the choice of с- (слапить) vs. -ну (чихнуть) and verb classes in Russian?
Verb classes that prefer -ну

-аў

non-prod

1. conj

-״Ђ

(зевать >) Зевнул

(лизать >) Лизнула

(свистеть >) Свистнула
Verb classes that prefer с-

-ова
  (малодушествовать >)
  С малодушествовал

-и
  (грубить >)
  С грубил!

-Ьй
  (робеть >)
  С робела?
Chi-square:
Finding out whether there is a significant difference between distributions
Illustration: Is there a relationship between semelfactive markers and verb classes in Russian?
Result: chi-squared = 269.2249, df = 5, p-value < 2.2e-16
Cramer’s V = 0.83

CAVEATS: chi-square 1) assumes independence of observations; 2) requires at least 5 expected observations in each cell
Semantic Profiles: “Empty” prefixes in Russian

Olga Lyashevskaia

Big Questions:

What is the relationship between form and meaning?  
- ...between prefixes and meanings of verbs?

Are there any “empty” forms?  
- Are prefixes empty as claimed?

<table>
<thead>
<tr>
<th>Imperfective base</th>
<th>Prefixed perfective</th>
</tr>
</thead>
<tbody>
<tr>
<td>советовать ‘advise’</td>
<td>посоветовать ‘advise’</td>
</tr>
<tr>
<td>варить ‘cook’</td>
<td>сварить ‘cook’</td>
</tr>
<tr>
<td>писать ‘write’</td>
<td>написать ‘write’</td>
</tr>
<tr>
<td>твердеть ‘harden’</td>
<td>затвердеть ‘harden’</td>
</tr>
<tr>
<td>греметь ‘thunder’</td>
<td>проГреметь ‘thunder’</td>
</tr>
</tbody>
</table>
Semantic Profiles: “Empty” prefixes in Russian

Operationalization:

Semantic profiling: relationship between meanings (semantic tags) and forms
   ➔ Distribution of Russian verb prefixes vs. semantic tags

Data:
   382 verbs with “empty” prefixes from the Exploring Emptiness database (http://emptyprefixes.uit.no/index.php), semantic tags independently assigned in the Russian National Corpus (http://ruscorpora.ru/)

Statistics:
   Chi-square, Cramer’s V effect size, Fisher Test
Distribution of prefixes/semantic classes

<table>
<thead>
<tr>
<th></th>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
<th>SOUND&amp; SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td>po-</td>
<td>11</td>
<td>62</td>
<td>11</td>
<td>37</td>
</tr>
<tr>
<td>s-</td>
<td>23</td>
<td>11</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>na-</td>
<td>31</td>
<td>3</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>51</td>
</tr>
</tbody>
</table>

Raw Values

• Chi-squared = 248.0058, df = 12, p-value < 2.2e-16, Cramer's V = 0.465
chi-square = 248, df = 12, $p = 2.2\times10^{-16}$; Cramer’s V effect-size = 0.46
Grammatical Profiles: TAM in Russian


Questions:
1) Do perfective verbs behave differently than imperfective verbs?
2) Do paired verbs behave differently depending upon whether they mark aspect with prefixes or suffixes?
# Grammatical Profiles of Russian Verbs

<table>
<thead>
<tr>
<th></th>
<th>Nonpast</th>
<th>Past</th>
<th>Infinitive</th>
<th>Imperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imperfective</td>
<td>1,330,016</td>
<td>915,374</td>
<td>482,860</td>
<td>75,717</td>
</tr>
<tr>
<td>Perfective</td>
<td>375,170</td>
<td>1,972,287</td>
<td>688,317</td>
<td>111,509</td>
</tr>
</tbody>
</table>

Chi-squared = 947756  
\( df = 3 \)  
P-value < 2.2e-16  
Effect size (Cramer’s V) = 0.399  
(medium-large)
Disaggregated data for Russian verbs

<table>
<thead>
<tr>
<th></th>
<th>Ipfv_NonPast</th>
<th>Ipfv_Past</th>
<th>Ipfv_Inf</th>
<th>Ipfv_Imper</th>
<th>Pfvy_NonPast</th>
<th>Pfvy_Past</th>
<th>Pfvy_Inf</th>
<th>Pfvy_Imper</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-partners</td>
<td>475,893</td>
<td>397,409</td>
<td>195,926</td>
<td>36,427</td>
<td>72,439</td>
<td>317,570</td>
<td>114,460</td>
<td>24,280</td>
</tr>
<tr>
<td>s-partners</td>
<td>854,123</td>
<td>517,965</td>
<td>286,934</td>
<td>39,290</td>
<td>302,731</td>
<td>1,654,717</td>
<td>573,857</td>
<td>87,229</td>
</tr>
<tr>
<td></td>
<td>43%</td>
<td>35.9%</td>
<td>17.7%</td>
<td>3.3%</td>
<td>13.7%</td>
<td>60.1%</td>
<td>21.6%</td>
<td>4.6%</td>
</tr>
<tr>
<td></td>
<td>50.3%</td>
<td>30.5%</td>
<td>16.9%</td>
<td>2.3%</td>
<td>11.6%</td>
<td>63.2%</td>
<td>21.9%</td>
<td>3.3%</td>
</tr>
</tbody>
</table>
Prefixation (dark) vs. suffixation (light): Statistically significant, BUT effect sizes too small (0.076 & 0.037)
More examples for chi-square:
The English Ditransitive

English Ditransitive

(1)  a. John told a story to Mary. (prepositional dative construction)
 b. John told Mary a story. (ditransitive construction)

Alternating verbs take both constructions:

\textit{tell, give, show, send, sell, bring, read, lend...}

Non-alternating verbs take only prepositional dative construction:

\textit{explain, whisper, transfer, return, entrust, deliver, present, repeat...}

Question: How do children learn that the non-alternating verbs do not use the ditransitive construction, since there is no negative evidence?
Chi-square: Stefanowitsch 2011

Research question:
English ditransitive: does the ungrammatical ditransitive get preempted when the child gets as input the prepositional data in contexts that should prefer the ditransitive?

Data:
British Component, International Corpus of English (ICE-GB) sentences with prepositional dative construction, 50 sentences per verb

Factors:
verb class (alternating vs. non-alternating)
vs.
givenness (referential distance); syntactic weight (# words); animacy

Result: not significant; no support for preemption
Chi-square: Goldberg 2011

Research question:
Same as Stefanowitsch 2011, plus: are the alternative constructions really in competition?

Data:
Corpus of Contemporary American English
15000+ exx alternating verbs, 400+ exx non-alternating verbs

Factors:
verb class (alternating vs. non-alternating)
vs.
construction (prepositional dative vs. ditransitive)

Result: p<0.0001; 0.04 probability of prepositional dative for alternating verbs vs. 0.83 for non-alternating verbs; sufficient evidence for preemption
Chi-square: Falck and Gibbs 2012

**Research question:**
Do bodily experience of paths vs. roads motivate metaphorical meanings?

**Data:**
Experiment + British National Corpus

**Factors:**
*path* vs. *road*

vs.

description of courses of action/ways of living vs. purposeful activity/political/
financial matters

**Result:** p<0.001; evidence that people’s understanding of their physical experiences with paths and roads also informs their metaphorical choices, making *path* more appropriate for descriptions of personal struggles, and *road* more appropriate for straightforward progress toward a goal
Table 1. Proportion of responses to mental image questions in Study 1

<table>
<thead>
<tr>
<th>Question</th>
<th>Path</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which is more likely to have obstacles along the way?</td>
<td>.58</td>
<td>.42</td>
</tr>
<tr>
<td>Which is more likely to be straight?</td>
<td>.16</td>
<td>.84</td>
</tr>
<tr>
<td>Which is more likely to go up and down?</td>
<td>.71</td>
<td>.29</td>
</tr>
<tr>
<td>Which is more likely to be wide?</td>
<td>.04</td>
<td>.96</td>
</tr>
<tr>
<td>Which is more likely to be paved?</td>
<td>.04</td>
<td>.96</td>
</tr>
<tr>
<td>Which is more likely to go through problematic terrain?</td>
<td>.87</td>
<td>.13</td>
</tr>
<tr>
<td>Which is more likely to take you to a specific destination?</td>
<td>.21</td>
<td>.79</td>
</tr>
<tr>
<td>Which is more likely to make you move fast?</td>
<td>.13</td>
<td>.87</td>
</tr>
<tr>
<td>Which is more likely to move you along in an aimless way?</td>
<td>.79</td>
<td>.21</td>
</tr>
<tr>
<td>Which is more likely for you to enjoy traveling?</td>
<td>.83</td>
<td>.17</td>
</tr>
<tr>
<td>Which is more likely for you to stop every now and then?</td>
<td>.83</td>
<td>.17</td>
</tr>
<tr>
<td>Which is more likely for you to be driving on?</td>
<td>.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Which is more likely for you to be biking on?</td>
<td>.54</td>
<td>.46</td>
</tr>
<tr>
<td>Which is more likely for you to be moving along on foot?</td>
<td>1.00</td>
<td>.00</td>
</tr>
</tbody>
</table>

Table 3. Results of corpus Study 2

<table>
<thead>
<tr>
<th>Target domain</th>
<th>Path</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course of Action/Way of living</td>
<td>.58</td>
<td>.12</td>
</tr>
<tr>
<td>Purposeful activity</td>
<td>.18</td>
<td>.36</td>
</tr>
<tr>
<td>Development</td>
<td>.07</td>
<td>.00</td>
</tr>
<tr>
<td>Political/Financial</td>
<td>.06</td>
<td>.52</td>
</tr>
<tr>
<td>Computer/Mathematics</td>
<td>.08</td>
<td>.00</td>
</tr>
<tr>
<td>Other</td>
<td>.03</td>
<td>.00</td>
</tr>
</tbody>
</table>
Fisher test

When to use the Fisher test:

You have a matrix with two types of categories and a count for each cell in the matrix. You want to know whether a specific cell in the matrix deviates significantly from the overall distribution.

Example: We know there is a relationship between semantic class of the verb and choice of prefix in Russian, but precisely which combinations are significant?
chi-square = 248, df = 12, p = 2.2e-16; Cramer’s V effect-size = 0.4

9% 35% 53% 66%
15% 51% 17% 5%
8% 31% 14% 31%
78%

po  s  pro
9% 8% 17%
31% 35% 14%
14% 5% 14%
66% 31% 15%
1% 1% 6%
0%

через- + sound and speech, as in прогреметь
Fisher test:
Finding out whether a value deviates significantly from the overall distribution

**Illustration:** There are 51 Natural Perfective verbs prefixed in *pro-* in the Russian National Corpus that have the semantic tag “sound & speech”. This exceeds the expected value, but is there a relationship between the prefix and the semantic class?

<table>
<thead>
<tr>
<th>a = value in the given cell</th>
<th>b = row total - value in the given cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 51</td>
<td>= 106 - 51</td>
</tr>
<tr>
<td></td>
<td>= 55</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c = column total - value in the given cell</th>
<th>d = table total - value in the given cell - b - c</th>
</tr>
</thead>
<tbody>
<tr>
<td>= 65 - 51</td>
<td>= 382 - 51 - 55 - 14</td>
</tr>
<tr>
<td>= 14</td>
<td>= 262</td>
</tr>
</tbody>
</table>

**NOTE:** You need to know the relationship between the observed and the expected value before you can do the Fisher test. If the observed value is greater than the expected value, you need to choose alternative=”greater” to test the significance of finding a value this high or higher. If the observed value is less than the expected value, you need to choose alternative=”less” to test the significance of finding a value this low or lower.

**CAVEAT:** Fisher test does not work well on large numbers and differences!!!
How can we use the Fisher Test to measure the relationship of each number to the rest of the matrix?

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
<th>SOUND&amp; SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>po-</td>
<td>11</td>
<td>62</td>
<td>11</td>
</tr>
<tr>
<td>s-</td>
<td>23</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>na-</td>
<td>31</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Let’s look at pro- with sound & speech
First find the expected values!

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
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</tr>
</thead>
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<tr>
<td></td>
<td><strong>Raw Values</strong></td>
<td></td>
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<td>po-</td>
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<td>11</td>
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<td>3</td>
<td>17</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Expected value = 
(row sum x column sum) / total sum
In R:

\[ \text{ExpProSS} = \frac{(10 + 4 + 0 + 51)(37 + 9 + 8 + 1 + 51)}{382} \]

The observed value (51) is GREATER than the expected value (18).
How to do this in R

Let's take the same example of pro- with verbs of sound & speech (“pross”):

```r
> pross = matrix(c(51, 55, 14, 262), ncol=2, byrow=TRUE)
> pross
 [,1] [,2]
[1,]  51  55
[2,]  14 262
> fisher.test(pross, alternative="greater")

Fisher's Exact Test for Count Data

data: pross
p-value < 2.2e-16
alternative hypothesis: true odds ratio is greater than 1
95 percent confidence interval:
  9.531013      Inf
sample estimates:
odds ratio
 17.16661
```

This is the probability that you would get 51 examples or more if the actual distribution in the population was random.
Now for a more interesting example:

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CHANGE</th>
<th>BEHAV</th>
<th>SOUND &amp; SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Values</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>11</td>
<td>62</td>
<td>11</td>
</tr>
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<td>s-</td>
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<td>11</td>
<td>23</td>
</tr>
<tr>
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<td>3</td>
<td>17</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Does 11 = 11 = 11 here?
Chi-square = 248, df = 12, p = 2.2e-16; Cramer’s V effect-size = 0.4

- **po- + impact**, as in покрыть
- **s- + behav**, as in полениться
- **c- + changest**, as in сгнить
Find the expected values!

<table>
<thead>
<tr>
<th></th>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Raw Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>po-</td>
<td>11</td>
<td>62</td>
<td>11</td>
<td>37</td>
</tr>
<tr>
<td>s-</td>
<td>25</td>
<td>11</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>na-</td>
<td>31</td>
<td>3</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>51</td>
</tr>
</tbody>
</table>

Expected value = \[
\frac{(\text{row sum} \times \text{column sum})}{\text{total sum}}\]
**Expected value = (row sum x column sum) / total sum**

<table>
<thead>
<tr>
<th></th>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
<th>SOUND &amp; SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expected Values (rounded to the nearest integer)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>po-</td>
<td>39</td>
<td>32</td>
<td>16</td>
<td>34</td>
</tr>
<tr>
<td>s-</td>
<td>21</td>
<td>18</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>na-</td>
<td>19</td>
<td>16</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>za-</td>
<td>22</td>
<td>19</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>pro-</td>
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<td>17</td>
<td>9</td>
<td>18</td>
</tr>
</tbody>
</table>
What is the difference between the observed values and the expected values?

<table>
<thead>
<tr>
<th></th>
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<th>SOUN &amp; SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observed - Expected Values</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>po-</td>
<td>-28</td>
<td>30</td>
<td>-5</td>
<td>3</td>
</tr>
<tr>
<td>s-</td>
<td>2</td>
<td>-7</td>
<td>14</td>
<td>-9</td>
</tr>
<tr>
<td>na-</td>
<td>12</td>
<td>-15</td>
<td>9</td>
<td>-8</td>
</tr>
<tr>
<td>za-</td>
<td>24</td>
<td>3</td>
<td>-9</td>
<td>-19</td>
</tr>
<tr>
<td>pro-</td>
<td>-11</td>
<td>-13</td>
<td>-9</td>
<td>33</td>
</tr>
</tbody>
</table>
Now prepare the four values you need for the Fisher Test:

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CHANGEST</th>
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<td>11</td>
</tr>
<tr>
<td>s-</td>
<td>23</td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>na-</td>
<td>31</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>za-</td>
<td>47</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>pro-</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

\[
a = \text{value in the given cell} = 11
\]

\[
b = \text{row total - value in the given cell}
\]

\[
c = \text{column total - value in the given cell}
\]

\[
d = \text{table total - value in the given cell} - b - c
\]
Here are the input values for the whole table:

<table>
<thead>
<tr>
<th></th>
<th>a = 11, b = 111</th>
<th>a = 62, b = 40</th>
<th>a = 11, b = 41</th>
<th>a = 37, b = 69</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>c = 110, d = 150</td>
<td>c = 59, d = 221</td>
<td>c = 110, d = 220</td>
<td>c = 84, d = 192</td>
</tr>
<tr>
<td></td>
<td>prob a &lt;= 11</td>
<td>prob a &gt;= 62</td>
<td>prob a &lt;= 11</td>
<td>prob a &gt;= 37</td>
</tr>
<tr>
<td>s-</td>
<td>a = 23, b = 99</td>
<td>a = 11, b = 91</td>
<td>a = 23, b = 29</td>
<td>a = 9, b = 97</td>
</tr>
<tr>
<td></td>
<td>c = 43, d = 217</td>
<td>c = 55, d = 225</td>
<td>c = 43, d = 287</td>
<td>c = 57, d = 219</td>
</tr>
<tr>
<td></td>
<td>prob a &gt;= 23</td>
<td>prob a &lt;= 11</td>
<td>prob a &gt;= 23</td>
<td>prob a &lt;= 9</td>
</tr>
<tr>
<td>na-</td>
<td>a = 31, b = 91</td>
<td>a = 17, b = 99</td>
<td>a = 8, b = 98</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c = 28, d = 232</td>
<td>c = 56, d = 224</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>prob a &gt;= 31</td>
<td>prob a &lt;= 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>za-</td>
<td>a = 47, b = 75</td>
<td>a = 22, b = 80</td>
<td>a = 1, b = 51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c = 24, d = 236</td>
<td>c = 49, d = 231</td>
<td>a = 1, b = 105</td>
<td></td>
</tr>
<tr>
<td></td>
<td>prob a &gt;= 47</td>
<td>prob a &gt;= 22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pro-</td>
<td>a = 10, b = 112</td>
<td>a = 4, b = 98</td>
<td>a = 0, b = 52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c = 55, d = 205</td>
<td>c = 61, d = 219</td>
<td>a = 51, b = 55</td>
<td></td>
</tr>
<tr>
<td></td>
<td>prob a &lt;= 10</td>
<td>prob a &lt;= 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>c = 14, d = 262</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>prob a &lt;= 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fisher Test input values
Here are the p-values from the Fisher Test

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CHANGEST</th>
<th>BEHAV</th>
<th>SOUND&amp;SPEECH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisher Test p-value (probability that Observed - Expected could be greater)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>po-</strong></td>
<td>[-] 4e-12</td>
<td>[+</td>
<td>6.3e-13</td>
</tr>
<tr>
<td><strong>s-</strong></td>
<td>[+</td>
<td>0.33</td>
<td>[-</td>
</tr>
<tr>
<td><strong>na-</strong></td>
<td>[+</td>
<td>0.0003</td>
<td>[-</td>
</tr>
<tr>
<td><strong>za-</strong></td>
<td>[+</td>
<td>3.7e-11</td>
<td>[+</td>
</tr>
<tr>
<td><strong>pro-</strong></td>
<td>[-</td>
<td>0.0009</td>
<td>[-</td>
</tr>
</tbody>
</table>

Strongest attractions:  
- po- / sound&speech  
- po- / changest  
- za- / impact  
- s- / behav  

Strongest repulsions:  
- po- / impact  
- na- / changest  
- za- / sound&speech  
- pro- / changest  
- pro- / behav  

Other repulsions:  
- s- / changest  
- s- / sound&speech  
- pro- / impact  
- na- / sound&speech  
- za- / behav  

Other attractions:  
- na- / impact  
- na- / behav  

Neutral:  
- s- / impact  
- za- / changest  
- po- / sound&speech  
- po- / behav
chi-square = 248, df = 12, p = 2.2e-16; Cramer’s V effect-size = 0.4

strong repulsion
neutral
repetition
Collostructional analysis...

• “starts with a particular construction and investigates which lexemes are strongly attracted or repelled by a particular slot in the construction”; takes into account the overall frequency of both lexemes and constructions

• **Collexeme**: a word that is attracted to or repelled by a construction

  – This article looks at collostructions in the following constructions:

    • **NP waiting to happen**
    • *cause NP*
    • **NP think nothing of Vgerund**
    • *Sagent V Opatient/agent into Vgerund*
    • **ditransitive**
    • progressive
    • imperative
    • past tense

    **We will look only at NP waiting to happen and ditransitive**
How the authors did the Fisher Test

• Authors use the following four data points:
  – frequency of the collexeme in the construction
  – frequency of all other lexemes in the construction
  – frequency of the collexeme in all other constructions
  – frequency of all other lexemes in all other constructions

Only boldfaced data comes directly from corpus; all other data supplied via subtraction from totals

Italicized data depends on calculation of frequency of all constructions in BNC = total # of verb tags (not an exact measure, on the order of 10M)
Interpreting the data: The p-values tell you how likely it is that one could get this distribution in a sample of this size from a potentially infinite distribution in which there was NO attraction/repulsion.

- **accident** $p=2.12E-34$, which is: $0.0000000000000000000000000000000212$ (33 0s after .)
- **event** $p=6.92E-02$, which is: $0.0692$ (not significant)
Ditransitive

• An entirely schematic construction
• Prototype and extensions according to Goldberg:
  – prototype: actual transfer *(give, pass, hand)*
  – A. Satisfaction of conditions *(guarantee, promise)*
  – B. Enabling *(permit, allow)*
  – C. Negation *(refuse, deny)*
  – D. Future *(leave, bequeath)*
  – E. Intention *(bake, make, build)*
  – F. Communication as transfer *(tell, teach, fax)*
  – G. Perceiving as receiving *(show)*
  – H. Directed action as transfer *(blow (a kiss))*
• Exceptions: *cost, charge, envy, forgive*
Ditransitive, cont’d.

- *give* is by far most attracted to the construction
- strong polysemy of the construction – extended uses are strongly represented in top 15 collexemes:
  - A: *offer, owe, promise*; B: *allow*; C: *deny*; D: *grant*; E: *earn*; F: *tell, teach*; G: *show*; H: (none);
  Exceptions: *cost*
What Stefanowitsch and Gries conclude:

• Advantages of collostructional analysis
  – Improved description (lexicography, pedagogy)
  – Support for construction grammar
    • “If syntactic structures served as meaningless templates waiting for the insertion of lexical material, no significant associations between these templates and specific verbs would be expected”
  – Implications for psycholinguistics, acquisition
    • collostructional analysis identifies the most prototypical collostructions
So what’s wrong here?

• Fisher Test was designed for small numbers, all on approximately the same order of magnitude
• The “d” cell is not an exact measure (and note that the “c” value is dependent on “d”) and it is many orders of magnitude greater than the “a” and “b” values
• The p-value for a Fisher Test is not technically a measure
• For many collexemes, there is only one example
• Criticism from Baayen, Bybee, and Schmid & Küchenhoff
ANOVA = “analysis of variance”

When to use ANOVA:

You have two (or more) sets of numerical scores obtained under different conditions. You want to know whether there is a difference between the sets of scores, whether the different conditions make a difference.

Example: How do Russians perceive marginal factitive verbs (like осерьёзнить, увкуснить) in comparison with standard verbs and nonce verbs?
**More about variance and ANOVA**

**Variance** is a measure of the shape of a distribution in terms of deviations from the mean.

ANOVA divides the total variation among scores into two groups, the within-groups variation, where the variance is due to chance vs. the between-groups variation, where the variance is due to both chance and the treatment effect (if there is any).

The F ratio has the between-groups variance in the numerator and the within-groups variance in the denominator.

If F is 1 or less, the inherent variance is greater than or equal to the between-groups variance, meaning that there is no treatment effect.

If F is greater than 1, higher values show a greater treatment effect and ANOVA can yield p-values to indicate significance.

ANOVA can also handle multiple variables, for example priming vs. none and male vs. female and show whether each variable has an effect (called a main effect) and whether there is an interaction between the variables (for example if females respond even better to priming).
Experimental design by Anna Endresen

- **STANDARD WORDS**: 10 о + 10 у
- **MARGINAL WORDS**: 10 о + 10 у
- **NONCE WORDS**: 10 о + 10 у

- **STANDARD WORDS**: Words that are standard and conventional, might be stored in memory rather than generated on the fly.
- **NONCE WORDS**: Words that cannot be generated and do not exist (because they do not conform to phonotactical laws and are not based on productive morphological patterns).
- **MARGINAL WORDS**: Words that are generated by some speakers and can be understood/accepted by some speakers.

Examples of words:

- **STANDARD WORDS**: объяснить, ускорить
- **MARGINAL WORDS**: осерьёзнить, увкуснить
- **NONCE WORDS**: осурить, усаглить
Experiment: score-assignment test

The task: Evaluate the marked word using one of the statements.

Давно пора как-то оприличить наше общение более мягкими выражениями.
‘It’s high time we made our interaction respectable by using kinder statements.’

- 5 points - Это совершенно нормальное слово русского языка.
  ‘This is an absolutely normal Russian word’
- 4 points - Это слово нормальное, но его мало используют.
  ‘This word is normal, but it is rarely used’
- 3 points - Это слово звучит странно, но, может быть, его кто-то использует.
  ‘This word sounds strange, but someone might use it’
- 2 points - Это слово звучит странно, и его вряд ли кто-то использует.
  ‘This word sounds strange and it is unlikely that anyone uses it’
- 1 point - Этого слова в русском языке нет.
  ‘This word does not exist in the Russian language.’
ANOVA RESULTS:
F = 546, df = 2, p-value < 2.2e-16

Standard Verbs
MAX = 605
MEAN = 595
MIN = 549
stand dev = 15
variance = 235

Marginal Verbs
MAX = 479
MEAN = 286.4
MIN = 169
stand dev = 67
variance = 4446

Nonce Verbs
MAX = 223
MEAN = 183.4
MIN = 150
stand dev = 19
variance = 360
Research question:
Do speakers perform as well on unprototypical examples of LDDs as on prototypical ones?
(LDD = long-distance dependency)
Prototypical LDD: What do you think the funny old man really hopes?
Unprototypical LDD: What does the funny old man really hope you think?

Data: Experiment

Factors:
construction (declarative vs. question)
prototypical vs. unprototypical
age

Result: Both construction (p = 0.016) and prototypicality (p = 0.021) were found to be main effects, but not age. Significant interaction between construction and age (p = 0.01). Support for usage-based approach, according to which children acquire lexically specific templates and make more abstract generalizations about constructions only later, and in some cases may continue to rely on templates even as adults.
above are attributable entirely to data from the remaining 9 children. The difficulty could be to the delay or the greater complexity of the experimental sentences. It is also possible that imitating a ''disembodied'' computer-produced voice (rather than simply imitating the person sitting next to them) requires greater concentration. It should also be pointed out that many of the errors that the children produced—for instance, omission of the adverb or one of the adjectives—are clearly uninformative with regard to their knowledge about question formation and complementation.

We therefore reanalysed the data using a more focussed scoring method in which the child was given credit for a sentence if the only error(s) involved (a) omission or placement of the adverb, or substitution of a different adverb and/or (b) omission of the determiner or the adjective(s) inside the heavy NP, or substitution of a different adjective. Thus, under the new scoring system, all the responses given in (8) were coded as correct imitations of the target sentence

What does the pretty little girl really expect you said?

(8) (a) What does the pretty little girl expect you said? [omission of adverb]
(b) What does the little girl expect you said? [omission of adverb and adjective]
(c) What does the really pretty girl expect you said? [misplacement of adverb and omission of adjective]
(d) What does the small little girl probably expect you said? [substitution of adverb and substitution of adjective]

The number of correct responses using this scoring method are given in Table 5. An ANOVA on these figures revealed a significant main effect of construction, $F(1,34) = 6.47, p = 0.016$, with the children correctly imitating more question than declaratives, and a significant main effect of prototypicality, $F(1;34) = 5.82, p = 0.021$, with performance better on prototypical than unprototypical sentences, as predicted by the lexically specific template hypothesis. The main effect of age was not significant. However, there was a significant interaction construction/age ($F = 7.51, p = 0.010$).

Table 5. Mean number (standard deviation) of correctly repeated sentences (study 2, focused scoring)

<table>
<thead>
<tr>
<th>Condition</th>
<th>5-year-olds (SD)</th>
<th>6-year-olds (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototypical question</td>
<td>1.35 (1.46)</td>
<td>1.47 (1.22)</td>
</tr>
<tr>
<td>Unprototypical question</td>
<td>1.24 (1.25)</td>
<td>1.00 (0.94)</td>
</tr>
<tr>
<td>Prototypical declarative</td>
<td>0.71 (1.05)</td>
<td>1.53 (1.17)</td>
</tr>
<tr>
<td>Unprototypical declarative</td>
<td>0.47 (0.87)</td>
<td>1.00 (1.20)</td>
</tr>
</tbody>
</table>

Main effect of construction ($F = 6.47, p = 0.016$)
Main effect of prototypicality ($F = 5.82, p = 0.021$)
Interaction construction/age ($F = 7.51, p = 0.010$)
Correlation

When to use correlation:

You have one set of items, and each item has two numerical values associated with it, one for Factor A and one for Factor B. You want to know whether there is a relationship between the two numerical values, i.e., a relationship between Factor A and B.

Example: Is the use of the possessive suffix (NPx), which is being lost in North Saami, better preserved with words of high frequency?
Correlation:
Finding significant relationships among values

Correlation

\[ r = +1 \] for a perfect positive correlation
\[ r = 0 \] for no correlation
\[ r = -1 \] for a perfect negative correlation.

CAVEATS:
1) assumption of linear relationship
2) correlation does not imply causation
SCATTERPLOTS & CORRELATION

Correlation - indicates a relationship (connection) between two sets of data.

- Strong positive correlation
- Weak positive correlation
- Strong negative correlation
- Weak negative correlation
- Moderate negative correlation
- No correlation
Anscombe’s quartet: These four plots yield the SAME correlation values.
An ongoing language change: NPx is being replaced by ReflN

These two examples were found only a few pages apart in Kirsti Paltto’s novel Ája

**NPx** (possessive suffix with HIGH morphological complexity):

(1a) **Son manai latnjasis**.

3S.NOM go.IND.PRET.3S room.ILL.SG.

‘He went into his room and lay down.’

**ReflN** (analytic construction with reflexive genitive pronoun):

(1b) **son... gavccui loktii iežas latnjii...**

3S.NOM climb.IND.PRET.3S upstairs.ILL.SG REFL.GEN.3S room.ILL.SG

‘she... climbed upstairs into her room...’

**Is this language change affected by frequency? Are high frequency words less vulnerable to this change?**
North Saami:
No evidence that high frequency helps to retain NPx
\( r = -0.14, p = 0.0001, 95\% \text{ confidence interval: } -0.2 \quad -0.07 \)
Correlation: Ambridge & Goldberg 2008

Research Question:
Are backgrounded constructions islands; are they hard to extract in LDDs?

Data: Experiment
“difference score” measures to what extent a clause is an island = difference in acceptability between extraction in questions (Who did Pat stammer that she liked) and declarative (Pat stammered that she liked Dominic)
“negation test” measures to what extent clause is assumed background = rating that She didn’t think that he left implies He didn’t leave.

Factors: difference score vs. negation test

Result: Mean negation test score was a highly significant negative predictor of mean difference score; \( r = -0.83, p = 0.001 \)
from 71 participants. A scatterplot of this correlation is shown in Figure 3.

This analysis revealed that the mean negation test score was a highly significant (negative) predictor of mean difference score ($r = -0.83$, $p < 0.001$), accounting for over two thirds of the observed variance ($R^2 = 0.69$).

The correlation of $|.83|$ is strikingly high, as perfect correlations ($\pm 1$) are almost non-existent when distinct measures are used. Separate measures of the same thing, e.g., mean length of utterance (MLU) at 28 months, have been found to correlate in the .75–.80 range (Bates and Goodman 1997).

5.4. Any role for subjacency?

The subjacency account clearly does not predict the pattern of results found in the present study. In particular, subjacency does not predict any distinctions based on the semantic class of the verbs involved without

10. Mean negation test score was also a significant (positive) predictor of mean rating of acceptability for the extraction question ($r = 0.58$, $p < 0.05$), accounting for approximately one third of the observed variance ($R^2 = 0.34$). Thus although, as we have argued, difference scores constitute a more appropriate measure of (un)acceptability than raw scores, our finding of a significant association between backgrounding and the acceptability of WH-extraction questions does not hinge on using difference scores.

Figure 3. Correlation between difference scores (dispreference for question scores) and negation test scores
Regression: Finding significant relationships among values

**Regression builds upon correlation** (the regression line is a correlation line), so it inherits all the caveats of correlation.

**Regression is useful** when you have found (or suspect) a relationship between a dependent variable and an independent variable, but there are other variables that you need to take into account.

Dependent variable = the one you are trying to predict
Independent variables = the ones that you are using to predict the dependent one
The Locative Alternation in Russian: Svetlana Sokolova

**Theme-object construction**

грузить сено на телегу

**Goal-object construction**

грузить телегу сеном

Variables: VERB (prefixes), (passive) PARTICIPLE, REDUCED

- **VERB:** unprefixed грузить or prefixed: нагрузить, загрузить, погрузить
- **PARTICIPLE:**
  - Theme-object: сено гружено на телегу
  - Goal-object: телега гружена сеном
- **REDUCED:**
  - Theme-object: грузить сено
  - Goal-object: грузить телегу
The Locative Alternation in Russian

**RIVAL FORMS:** the two constructions, theme-object vs. goal-object

**DEPENDENT VARIABLE:**

**CONSTRUCTION:**
theme-object vs. goal-object

**INDEPENDENT VARIABLES:**

**VERB:**
zero (for the unprefixed verb грузить) vs. на-
vs. за- vs. по-

**PARTICIPLE:**
yes vs. no

**REDUCED:**
yes vs. no

**DATA:** 1920 sentences from the Russian National Corpus
Logistic regression model
See Handout

Optimal model: CONSTRUCTION~VERB+REDUCED
+PARTICIPLE+VERB*PARTICIPLE

The model estimates how the log of the number of theme constructions divided by the log of the number of goal constructions depends on the predictors. The coefficient of the estimate (Coeff.) is POSITIVE if the combination of factors predicts more theme constructions, but NEGATIVE if they predict more goal constructions.
Optimal model: CONSTRUCTION~VERB+REDUCED+PARTICIPLE+VERB*PARTICIPLE

Model Likelihood Discrimination Rank Discrim.
Ratio Test Indexes Indexes

<table>
<thead>
<tr>
<th>Obs</th>
<th>LR chi2</th>
<th>1738.47</th>
<th>R2</th>
<th>0.796</th>
<th>C</th>
<th>0.964</th>
</tr>
</thead>
<tbody>
<tr>
<td>goal</td>
<td>871</td>
<td>d.f.</td>
<td>8</td>
<td>g</td>
<td>4.643</td>
<td>Dxy</td>
</tr>
<tr>
<td>theme</td>
<td>1049</td>
<td>Pr(&gt; chi2) &lt;0.0001</td>
<td>gr</td>
<td>103.877</td>
<td>gamma</td>
<td>0.945</td>
</tr>
<tr>
<td>max</td>
<td></td>
<td></td>
<td></td>
<td>gp</td>
<td>0.459</td>
<td>tau-a</td>
</tr>
</tbody>
</table>
max | | | | Brier | 0.076 |       |       |

| Coef  | S.E. | Wald Z | Pr(>|Z|) |
|-------|------|--------|----------|
| Intercept | -0.9465 | 0.2023 | -4.68 | <0.0001 |
| VERB=po  | 6.7143 | 1.0220 | 6.57   | <0.0001 |
| VERB=za  | 1.0920 | 0.2451 | 4.45   | <0.0001 |
| VERB=_zero | 2.3336 | 0.2446 | 9.54   | <0.0001 |
| REDUCED=yes | -0.8891 | 0.1748 | -5.09 | <0.0001 |
| PARTICIPLE=yes | -4.1862 | 1.0220 | -4.10 | <0.0001 |
| VERB=po * PARTICIPLE=yes | 3.8953 | 1.5978 | 2.44 | 0.0148 |
| VERB=za * PARTICIPLE=yes | 1.4087 | 1.0774 | 1.31 | 0.1910 |
| VERB=_zero * PARTICIPLE=yes | -1.7717 | 1.4415 | -1.23 | 0.2190 |

The model estimates how the log of the number of theme constructions divided by the log of the number of goal constructions depends on the predictors. The coefficient of the estimate (Coeff.) is POSITIVE if the combination of factors predicts more theme constructions, but NEGATIVE if they predict more goal constructions.
CART: Tree & forest

- **Classification and regression tree (CART)** uses recursive partitioning to yield a classification tree showing the best sorting of observations separating the values for the dependent variable
  - optimal algorithm for predicting an outcome given the predictor values
- **Random forest** uses repeated bootstrap samples drawn with replacement from the dataset such that in each repetition some observations are sampled and serve as a training set and other observations are not sampled, so they can serve for validation of the model
  - predictor variables are also randomly removed from repetitions, making it possible to measure variable importance
Tree & forest: CART

Includes intercept of logistic regression model: VERB = na, PARTICIPLE = no
Tree & forest: variable importance
Regression: Diessel 2008

Research question:
Does the linear order of clauses reflect the order of the reported events such that adverbial clauses reporting prior events are more likely to precede the main clause, whereas adverbial clauses reporting posterior events are more likely to follow the main clause? Is a speaker is more likely to produce *After I fed the cat, I washed the dishes* than *I washed the dishes after I fed the cat*?

Data: ICE-GB

Factors:
dependent variable: position of adverbial clause (initial vs. final)
independent variables: conceptual order (iconicity), meaning (conditional, causal), length, and syntactic complexity

Result: All variables except syntactic complexity are significant. Meaning is significant only for the positioning of conditional *once*- and *until*-clauses, and length is significant only for *once*- and *until*-clauses.
only 22.3 percent of the simultaneously occurring
- clauses are pre-
posed. Leaving aside the one posterior
- clause, a 2
/C2 w
2 -analysis
revealed a significant association between linear structure and conceptual
order (w 2 = 14.25, df = 1, p < 0.001), confirming the hypothesis that
clause order is iconic.

Like
- clauses, after
- and
before
- clauses tend to occur at the end of
a complex sentence. As can be seen in Table 3, there are 151 final and
only 33 initial
after
- and
before
- clauses in the data. Of the initial subordi-
nate clauses, 27 are introduced by
after
and only 6 are introduced by
before.

A2/C2 w2 -analysis revealed a significant association between clause
order and iconicity.

Figure 2. Clause order and iconicity

Chi-squared = 14.25, df = 1, p < 0.001,
but more factors need to be considered
Diessel 2008

Regression analysis was used to predict the position of the adverbial clause (i.e., initial or final) from the following set of predictors: conceptual order (i.e., iconicity), meaning, length, and syntactic complexity. Figure 3 shows the research design.

Conceptual order and syntactic complexity were coded as dichotomous variables: adverbial clauses denoting a prior event were distinguished from adverbial clauses denoting a posterior or simultaneously occurring event, and simple adverbial clauses consisting of a single clause were distinguished from complex adverbial clauses containing another subordinate clause. Meaning was coded as a discrete variable with three levels: (i) purely temporal, (ii) temporal with an implicit conditional meaning, and (iii) temporal with an implicit causal or purposive meaning. Finally, length was coded as a continuous variable, measured by dividing the number of words in the adverbial clause by the total number of words in the complex sentence.

For all features, intercoder reliability was at least 95 percent.

2.2.2. Results.

Table 5 shows the raw frequencies of the categorical predictors, i.e., conceptual order, complexity, and meaning, and Figure 4 shows the histograms of the continuous predictor, relative length (i.e., the ratio of adverbial clause/complex sentence), for final and initial temporal clauses.

Figure 3. Research design
Diessel 2008

Table 6. *Results of the logistic regression analysis*

<table>
<thead>
<tr>
<th>Factor</th>
<th>reg. coef.</th>
<th>Wald  ( \chi^2 )</th>
<th>df</th>
<th>p</th>
<th>odds ratio</th>
<th>lower CI</th>
<th>upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual order</td>
<td>1.902</td>
<td>73.69</td>
<td>1</td>
<td>0.001</td>
<td>6.70</td>
<td>4.34</td>
<td>10.35</td>
</tr>
<tr>
<td>Meaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. causal/purpose</td>
<td>−2.775</td>
<td>7.27</td>
<td>1</td>
<td>0.007</td>
<td>0.06</td>
<td>0.01</td>
<td>0.469</td>
</tr>
<tr>
<td>b. conditional</td>
<td>1.364</td>
<td>31.20</td>
<td>1</td>
<td>0.001</td>
<td>3.91</td>
<td>2.42</td>
<td>6.31</td>
</tr>
<tr>
<td>Length</td>
<td>−1.343</td>
<td>7.39</td>
<td>1</td>
<td>0.001</td>
<td>0.19</td>
<td>0.06</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Look at **regression coefficient** (first column): **Positive** values indicate that the predictor variable **increases** the likelihood of the adverbial clause to precede the main clause.

**Negative** values indicate that the predictor variable **decreases** the likelihood of the adverbial clause to precede the main clause.
**Mixed effects**: Adding individual preferences into a regression model

**Mixed effects builds upon regression**: In an ordinary regression model, all effects are fixed effects. A mixed effects model combines fixed effects with random effects.

**Fixed effect**: an independent variable with a fixed set of possible values

**Random effect**: represent preferences of individuals sampled randomly from a potentially infinite population

Mixed effects models combine fixed effects and random effects in a single regression model by measuring the random effects and making adjustments so that the fixed effects can be detected.
When do we need mixed effects models?

**Mixed effects models** are used when individual preferences interfere with obtaining independent observations. Individuals with preferences need to be represented as random variables.

**Some examples of random variables:**

**Subjects** in an experiment will have different individual preferences, and different measures for baseline performance (e.g., reaction time)

**Authors** in a corpus will have different individual preferences for certain words, collocations, and grammatical constructions

**Verbs** in a language can have different individual behaviors with respect to ongoing changes and distribution of inflected forms
Research question:
In Dutch, English loanwords like *backpacker* co-exist with native equivalents like *rugzakker*. What factors contribute to the success/failure of loanwords?

Data: Dutch newspaper corpora

Factors:
dependent variable: success rate of English loanword
independent variables as fixed effects: length, lexical field, era of borrowing, luxury vs. necessary borrowing, concept frequency, data of measurement, register, region
independent variable as random effect: concept expressed

Result:
Two strongest main effects: a negative correlation between concept frequency and the success of an anglicism, and a significantly lower success rate for borrowings from the most recent era (after 1989) than from earlier eras. Interactions: concept frequency is a factor only when the anglicism is also the shortest lexicalization, and the difference between luxury and necessary borrowings is strongest in the 1945-1989 era.
Measuring variation in the success of anglicisms appears that speech economy clearly restricts concept frequency as a factor: if an anglicism is the shortest lexicalization, concept frequency does not have any impeding effect on the success of the anglicism.

For the interaction between era of borrowing and the distinction between luxury and necessary anglicisms, it is again important to remember that reverse estimate is not always the best approach.

Table 1: Interaction model (mixed)
Helmert coding was used for era of borrowing, which means that we first compare the words borrowed up to 1945 with words borrowed between 1945 and 1989, and that next, we take these two groups together and compare them to words borrowed after 1989. Within each age group, we set the behavior of luxury and necessary anglicisms side by side.

Figure 2 shows the first comparison. In the main model presented in the previous section, the difference in success between luxury and necessary loanwords was only borderline significant. Apparently, this is partly due to the interaction with era of borrowing: the difference in success in our present day corpus between luxury and necessary anglicisms is not significant for the oldest group of loanwords, but becomes highly significant for words borrowed between 1945 and 1989. Also, we see that luxury anglicisms follow the structural hypothesis: older loanwords are more successful, as they have had more time to establish themselves in the receptor language. In contrast, necessary anglicisms behave differently: older necessary anglicisms are less successful in our present day corpus than younger necessary anglicisms. Upon closer inspection, this pattern is highly intuitive. Luxury anglicisms are introduced as an alternative for an established lexicalization of a given concept, and hence need time to become a worthy competitor of this established lexeme. The older the luxury anglicism, the more time it has had to establish itself as alternative lexicalization, the more success it will have in our corpus. For necessary anglicisms, the situation is reversed. Given the restrictions to our dataset, all necessary anglicisms studied in this paper have at least one competitor. In these cases, the necessary anglicism is the first and most established lexicalization of the concept, which can gradually lose ground to the upcoming alternative(s). The older the necessary anglicism, the more time

Fig. 2: Interaction era of borrowing and luxury/necessary: age group 1
Cluster analysis:
Finding out which items are grouped together

Cluster analysis is useful when you want to measure the distances between items in a set, given that you have an array of datapoints connected to each item.

In hierarchical cluster analysis, squared Euclidean distances are used to calculate the distances between the arrays of data.

Other methods to achieve similar means include multidimensional scaling and correspondence analysis.
Cluster analysis:  
Janda & Solovyev 2009

Research question:  
Can we measure the distance among near-synonyms?

Data: Russian National Corpus and Biblioteka Moškova

Factors:  
Near-synonyms for ‘happiness’ and ‘sadness’  
(Preposition)+ case constructions

Result: Each noun has a unique constructional profile, and there are stark differences in the constructional profiles of words that are unrelated to each other. For the two sets of synonyms in this study, only six grammatical constructions are regularly attested. The study shows us which nouns behave very similarly as opposed to which are outliers in the sets. The clusters largely confirm the introspective analyses found in synonym dictionaries, giving them a concrete quantitative dimension, but also pinpointing how and why some synonyms are closer than others.
Chi-square = 730.35, df = 30, p < 0.0001, Cramer’s V = 0.305
‘Sadness’
Hierarchical Cluster

печаль  тоска  хандра  меланхолия  грусть  уныние
Correspondence analysis:
Another way to find out which items are grouped together

Correspondence analysis also measures the “distances” between row and column vectors. It constructs a multidimensional space and then represents the two most significant dimensions in a plot.

Example: Use grammatical profiles of Old Church Slavonic verbs as input and ask correspondence analysis to sort them.
Grammatical profiles of OCS verbs: *tvoriti* ‘make’ and *jęti* ‘take’

- To obtain the grammatical profile of a verb:
  - Count up attestations for each subparadigm
  - Calculate distribution across subparadigms in terms of percentages

<table>
<thead>
<tr>
<th></th>
<th>Aorist</th>
<th>Imperative</th>
<th>Imperfect</th>
<th>Infinitive</th>
<th>Past participle</th>
<th>Present</th>
<th>Present participle</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>tvoriti</em></td>
<td>0</td>
<td>14</td>
<td>12</td>
<td>23</td>
<td>0</td>
<td>99</td>
<td>26</td>
</tr>
<tr>
<td>‘make’</td>
<td></td>
<td>8%</td>
<td>7%</td>
<td>13%</td>
<td>0%</td>
<td>57%</td>
<td>15%</td>
</tr>
<tr>
<td><em>jęti</em></td>
<td>25</td>
<td>7</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>‘take’</td>
<td>28%</td>
<td>8%</td>
<td>0%</td>
<td>11%</td>
<td>22%</td>
<td>31%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Correspondence analysis of 129 OCS verbs: 96% equivalent to Dostál’s sorting of verbs

Verbs with - Factor 1 values ≡ imperfactive verbs

Verbs with + Factor 1 values ≡ perfective verbs

Factor 1 is the most important factor. It sorts all verbs into - vs. + values.
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- uses metadata that ensures visibility and retrieval through international services
- is professionally managed by the University Library of Tromsø and an international steering committee.

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