The primacy of graded grammaticality

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Introduction: Aims and Questions

General aim:
Developing a model of linguistic judgments in order to . . .
  . . . establish a firm basis for linguistic theory
  . . . contribute to the ongoing debate about grammar and language use

Specific questions:
  How do gradient ratings of grammaticality relate to binary grammaticality judgments?
  How does grammaticality relate to frequency of usage?
Experimental Material: Ditransitive verbs

Empirical domain of our investigations: Ditransitive verbs in German

(1) ... dass er dem Mann ein Buch schickte.
    that he.NOM the.DAT man a.ACC book sent
    ‘...that he sent a book to the man.’

Advantage of ditransitive verbs: Argument alternations that are subject to verb-specific restrictions in a gradual way

- Optionality of the dative object
- Compatibility with the so-called *bekommen* passive
Experimental Material: Optionality of dative object

Dropping the dative object:

(2) ... dass er dem Mann ein Buch schickte.
   that he.NOM the.DAT man a.ACC book sent
   ‘...that he sent a book.’

(3) ?... dass er dem Mann ein Buch anvertraute.
   that he.NOM the.DAT man a.ACC book entrusted
   ‘...that he entrusted a book.’

- Experimental results and corpus counts (Bader & Häussler, submitted):
  The option of omitting the dative object is a gradient, verb-specific property
Experimental Material: *Bekommen* passive

*Bekommen* passive: the dative object becomes the subject of *bekommen* (‘to get’)

(4) ... dass der **Mann** das **Buch** geschickt *bekam*.  
    that the.NOM man the.ACC book sent got  
    ‘...that the man was sent the book.’

(5) ?... dass der **Mann** das **Buch** gestohlen *bekam*.  
    that the.NOM man the.ACC book stolen got  
    ‘...that the man was stolen the book.’

- Linguistic literature:  
  *bekommen* passive sentences with verbs like *stehlen* are often presented as fully grammatical (without a ‘?’ or a ‘*’).

- Experimental results and corpus counts (Bader & Häussler, submitted):  
  verbs like *stehlen* are not fully acceptable in the *bekommen* passive.
Regular passive: unrestricted with regard to ditransitive verbs as considered here

(6) ... dass dem Mann das Buch geschickt wurde.
    that the.DAT man the.NOM book sent was
    ‘...that the book was sent to the man.’

(7) ... dass dem Mann das Buch gestohlen wurde.
    that the.DAT man the.NOM book stolen was
    ‘...that the book was stolen from the man.’
120 verbs each in two sentences, for a total of 240 sentences

3×2 design: - Structure (active / regular passive / bekommen passive)
  - Nr. of Arguments (3 vs. 2)

(8) Active
dass der Vermieter letztes Jahr (dem Sohn) das Haus vererbte.
that the landlord last year the son the house left
‘that the landlord left the house to the son last year.’

(9) Regular passive
dass dem Sohn letztes Jahr (von dem Vermieter) das Haus vererbt wurde.
that the son last year by the landlord the house left was
‘that the house was left to the son last year (by the landlord).’

(10) Bekommen passive
dass der Sohn letztes Jahr (von dem Vermieter) das Haus vererbt bekam.
that the son last year by the landlord the house left got
‘the son was left the house last year (by the landlord).’
Experiment 1 and 2: Procedure

Experiment 1: Magnitude Estimation

- First, a reference item is presented to which the participant assigns an arbitrary numeric value ($> 0$).
- All further items are judged in proportion to the reference item on a continuous numerical scale.
- Each individual data point is divided by the reference value and the resulting ratio is log-transformed.

Experiment 2: Speeded Grammaticality Judgments

- Word-by-word presentation in the middle of the screen
- Presentation time for each word: ca. 300–400 ms
- End-of-sentence judgments with a deadline of 2000 ms
# Experiment 1 and 2: Results

**Table**: Mean percentages of judgments ‘grammatical’ (Standard errors by subjects).

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Regular passive</th>
<th><em>Bekommen</em> passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Args.</td>
<td>88 (2.3)</td>
<td>92 (1.5)</td>
<td>81 (2.9)</td>
</tr>
<tr>
<td>2 Args.</td>
<td>77 (2.8)</td>
<td>94 (1.1)</td>
<td>76 (3.2)</td>
</tr>
</tbody>
</table>

**Table**: Mean ME scores (Standard errors by subjects).

<table>
<thead>
<tr>
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<th>Regular passive</th>
<th><em>Bekommen</em> passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Args.</td>
<td>.28 (.038)</td>
<td>.26 (.035)</td>
<td>.23 (.034)</td>
</tr>
<tr>
<td>2 Args.</td>
<td>.24 (.042)</td>
<td>.31 (.041)</td>
<td>.18 (.042)</td>
</tr>
</tbody>
</table>
Experiment 2: Verb-specific variability in grammaticality

Figure: Rank-ordered distribution of mean percentages of grammatical judgments for the 120 verbs used in Experiment 2.
From gradient to binary judgments: Correlations

All 720 data points (120 verbs in 6 conditions; Kendall’s $\tau = 0.42$)

120 data points (verbs) per condition (Kendall’s $\tau$ from 0.19 to 0.55)

Figure: SGJ results plotted against ME results
Do gradient grammaticality scores predict binary judgments?

Logistic regression with mixed-effect modeling:
- results of Experiment 2 (SGJ2) as predicted variable
- results of Experiment 1 (ME) as predictor variable
- participants and items as random effects

Results of logistic regression:
- ME scores are a highly significant predictor of SGJ results
- Somers C = 0.82 (n = 8640)
From gradient to binary judgments: Model fit

Figure: Observed and fitted SGJ results plotted against observed ME results ($R^2 = 0.94$)
Grammaticality and frequency: corpus details

Can the experimental results be reduced to corpus-derived frequency measures?

The deWaC corpus described in Baroni et al. (2009) was analyzed:

- The deWaC corpus is a huge corpus of German built by web crawling.
- It contains 1,278,177,539 tokens of text tagged for part of speech

Various verb-specific frequency measures were derived from the deWaC corpus, including:

- \( p(\text{Dative object}) \): the probability of a ditransitive verb to occur with an overt dative object
- bigram ratio: bigram frequency for a verb (participle + auxiliary) divided by the verb’s lemma frequency
Grammaticality and frequency: correlations

Table: Rank correlations (Kendall’s tau) between experimental grammaticality scores (SGJ) and different frequency measures.

<table>
<thead>
<tr>
<th></th>
<th>Active 3 Args</th>
<th>Active 2 Args</th>
<th>Regular passive 3 Args</th>
<th>Regular passive 2 Args</th>
<th>Bekommen passive 3 Args</th>
<th>Bekommen passive 2 Args</th>
</tr>
</thead>
<tbody>
<tr>
<td>p(dative object)</td>
<td>.09</td>
<td>-.32**</td>
<td>.07</td>
<td>.03</td>
<td>-.03</td>
<td>.10</td>
</tr>
<tr>
<td>Bigram ratios</td>
<td>-.17**</td>
<td>-.08</td>
<td>-.02</td>
<td>.10</td>
<td>.23**</td>
<td>.36**</td>
</tr>
</tbody>
</table>

Summary:
- The grammaticality-frequency correlations are far from perfect:
  - ‘High grammaticality despite low frequency’ occurs often
  - ‘High frequency despite low grammaticality’ occurs rarely

Conclusion:
- Frequency cannot predict grammaticality
From grammaticality to language use

Hypothesis:
Grammaticality determines language use, not the other way round.

The probability of a sentence $s_n$ can be modeled as follows:

\[
p(s_n) = f(\text{grammaticality}[s_n], \\
\text{real world context}[s_n], \\
\text{linguistic context}[s_n], \\
\text{performance}[s_n])
\]

Here, we consider only two factors:
- grammaticality: estimated from our experiment
- real world-context: approximated by overall verb frequency

The remaining two factors are left out:
- performance: not relevant for our sentences
- linguistic context: relevant, but not yet coded
The relationship between grammaticality and frequency

From grammaticality to language use

Figure: Bigram frequency plotted against verb frequency (upper row) and against experimental grammaticality scores (lower row).
**From grammaticality to language use**

**Table:** Results of Poisson regression with bigram frequency as predicted variable and either grammaticality alone, verb frequency alone or grammaticality and verb frequency together.

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Regular passive</th>
<th>Bekommen Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null deviance</td>
<td>5701182</td>
<td>959280</td>
<td>19741</td>
</tr>
<tr>
<td>Reduction R²</td>
<td>2505 .00</td>
<td>8016 .00</td>
<td>5907 .19</td>
</tr>
<tr>
<td>Grammaticality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>5492666 .95</td>
<td>734056 .57</td>
<td>3567 .12</td>
</tr>
<tr>
<td>Grammaticality &amp; Frequency</td>
<td>5493190 .95</td>
<td>734365 .56</td>
<td>10508 .47</td>
</tr>
</tbody>
</table>
Conclusion

- Binary grammaticality judgments can be derived directly from gradient judgments.
- Grammaticality is not determined by frequency but is rather among the factors determining frequency.