From graded ratings to binary decisions: 
A case study on argument alternations in German

Markus Bader & Jana Häussler

Universities of Konstanz and Potsdam

Berlin, 30.03.2011
Starting point

People are able to give gradient judgments on grammaticality. (see Fanselow et al., 2006, for an overview of experimental research)
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Questions

How do graded grammaticality ratings relate to . . .

► language comprehension?
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Questions

How do graded grammaticality ratings relate to . . .

► language comprehension?
► language production?
► binary grammaticality judgments?
The Decathlon Model
(Featherston, 2005)

Structure(s)

Constraint evaluation (cumulative) → gradient judgments

Output selection (competitive)

frequency patterns → binary judgments
An Alternative
An Alternative

Structure(s) → Constraint evaluation
          ↓
Grammaticality value(s) → Gradient-to-binary mapping
          ↓
gradient judgments → binary judgments

Parser
An Alternative

Sentence Formulator → Structure(s) ← Constraint evaluation

Selection

Grammaraticality value(s) → Gradient-to-binary mapping

- frequency patterns
- gradient judgments
- binary judgments

Parser
Outline

Empirical domain

Experiments 1 and 2: Grammaticality judgments

Corpus Analysis

From grammaticality to language use

Experiment 3: Production preferences

Conclusions
Ditransitive verbs in German

(1) ... dass er dem Mann ein Buch schickte.

‘... that he sent a book to the man.’
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.’

Ditransitive verbs are suitable because ...

argument alternations are subject to verb-specific restrictions in a gradual way:

▷ Optionality of the dative object

▷ Compatibility with the so-called *bekommen* passive
Ditransitive verbs in German

Dropping the dative object:

(2) ... dass er dem Mann ein Buch schickte.

‘...that he sent a book.’
Ditransitive verbs in German

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.’
Ditransitive verbs in German

*Bekommen* passive:

(4) ... dass der Mann das Buch geschickt *bekam*.

that the.NOM man the.ACC book sent got

‘...that the man was sent the book.’
Ditransitive verbs in German

*Bekommen* passive:

(4) ... dass der Mann das Buch geschickt bekam.

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Regular passive

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<tr>
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Auxiliary: *werden*

Bekommen passive

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Auxiliary: *bekommen*
Ditransitive verbs in German

*Bekommen* passive:

(5) ... dass der Mann das Buch geschickt *bekam*.

‘... that the man was sent the book.’
Ditransitive verbs in German

*Bekommen* passive:

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

(6) ?... dass der Mann das Buch gestohlen bekam.
that the.NOM man the.ACC book stolen got
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(7) ... dass dem Mann das Buch geschickt wurde.
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(7) ... dass dem Mann das Buch geschickt *wurde.*

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(8) ... dass dem Mann das Buch gestohlen *wurde.*

that the.DAT man the.NOM book stolen was
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Experiments 1 & 2

(9)  
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.’
Experiments 1 & 2

(9) **Active**

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(11) **Bekommen passive**
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that the son last year by the landlord the house left got  
‘the son was left the house last year (by the landlord).’
(9) **Active**
that the landlord last year the son the house left
‘that the landlord left the house (to the son) last year.’

(10) **Regular passive**
that the house was left to the son last year (by the landlord)

(11) **Bekommen passive**
that the son was left the house last year (by the landlord).

- 240 sentences (120 verbs)
- 3×2 design (Structure × Number of Arguments)
Experiments 1 & 2

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- 240 sentences (120 verbs)
- 3×2 design (Structure × Number of Arguments)
- 36 participants in each experiment
Experiments 1 & 2

Experiment 1: Magnitude Estimation
Experiments 1 & 2

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.
Experiments 1 & 2

Experiment 1: Magnitude Estimation

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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 & 2

#### Mean ME scores in Experiment 1 (log ratios).

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#### Mean percentages of judgments ‘grammatical’ in Experiment 2.

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Verb-specific variability

Rank-ordered distribution of mean ME scores for the 120 verbs.
Verb-specific variability

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

Do gradient grammaticality scores predict binary judgments?
From gradient to binary judgments

Do gradient grammaticality scores predict binary judgments?

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)

SGJ results plotted against ME results
From gradient to binary judgments

Logistic regression with mixed-effect modeling:

- results of Experiment 2 (SGJ) as predicted variable
- results of Experiment 1 (ME) as predictor variable
- participants and items as random effects
From gradient to binary judgments

Logistic regression with mixed-effect modeling:

- results of Experiment 2 (SGJ) as predicted variable
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Results of logistic regression:

- ME scores are a highly significant predictor of SGJ results
- Somers’ C = 0.82 (n = 8640)
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deWaC (cf. Baroni et al., 2009)

- German part of Wacky
- built by web crawling
- 1.7 billion tokens of text
- POS tagged and lemmatised (using TreeTagger)
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For comparison:
Tiger Treebank (Release 2): about 880,000 tokens in ca. 50,000 sentences
For 29 out of the 120 verbs, it does not even contain the past participle form
(http://www.ims.uni-stuttgart.de/projekte/TIGER)
Corpus Analysis

Raw corpus counts:

- verb frequencies: lemma frequencies based on the lemma information contained in DeWac
- bigram frequencies:
  - regular passive: past participle + \textit{werden} (lemma)
  - \textit{bekommen} passive: past participle + \textit{bekommen} (lemma)
  - active: finite or non-finite verbform in clause-final position
    - past participle + \textit{haben} (lemma)
    - infinitive + modal verb (lemma)
# Grammaticality and frequency

Frequency counts for active, regular passive and *bekommen* passive bigrams

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Grammar and frequency

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

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<tr>
<td>Bigram ratios</td>
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<tr>
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<td>.05</td>
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<td>.12</td>
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** indicates significance at the 0.05 level.
Grammaticality and frequency

(12) expected construction frequency for $v_n$
\[ = f(\text{lemma}_n) \times p(\text{construction}) \]
\[ = f(\text{lemma}_n) \times \frac{f(\text{construction}_{\text{total}})}{f(\text{lemma}_{\text{total}})} \]

(13) Probability of a verb to occur in the bekommen passive
\[ = \frac{f(\text{bekommen}_{\text{total}})}{f(\text{lemma}_{\text{total}})} = \frac{10,929}{10,225,623} = 0.00107 \]

(14) observed-to-expected-ratio for $v_n$
\[ = \frac{\text{observed bigram frequency}(v_n)}{\text{expected bigram frequency}(v_n)} \]
Grammaticality and frequency

(15)  
   a. expected bigram frequency for *schicken*  
        = 0.00107 × 78443 = 84  
   b. expected bigram frequency for *stehlen*  
        = 0.00107 × 20463 = 22

(16)  
   a. observed-to-expected ratio for *schicken* = 235/84 = 2.8  
   b. observed-to-expected ratio for *stehlen* = 4/22 = 0.18
Experimental grammaticality scores (SGJ) plotted against observed-to-expected ratios. The 120 data points in each plot represent the 120 verbs investigated in the experiment.
Experimental grammaticality scores (ME) plotted against observed-to-expected ratios. The 120 data points in each plot represent the 120 verbs investigated in the experiment.
Grammaticality and frequency

Summary:

- There are systematic correlations between grammaticality and frequency:
  - Degraded grammaticality implies low frequency
  - High frequency implies high grammaticality

- There are also systematic mismatches:
  - High grammaticality does not imply high frequency.
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Grammaticality and frequency

Summary:

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► ‘High grammaticality and low frequency’ occurs often.
► ‘High frequency and low grammaticality’ occurs rarely.

(for similar results see Arppe & Järvikivi, 2007)
Outline

Empirical domain

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From grammaticality to language use

Hypothesis:

Grammaticality determines language use, not the other way round.
From grammaticality to language use

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The probability of a sentence \( n \) can be modeled as follows:

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(17) \quad p(s_n) = f(\text{grammaticality}[s_n], \text{real world context}[s_n], \text{linguistic context}[s_n], \text{performance}[s_n])
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From grammaticality to language use

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\hspace{1cm}performance$[s_n])$
From grammaticality to language use

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

Results of Poisson regression with bigram frequency as predicted variable and either grammaticality alone, verb frequency alone or grammaticality and verb frequency together. The columns labeled ‘Reduction’ gives the reduction in deviance achieved by the respective model.

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Was gibt es Neues von Robert? (‘What’s new about Robert?’)

□ Robert hat unserem Opa einen Rasenmäher überreicht.
   R. has our.DAT grandpa a lawnmower handed-over
   ‘Robert handed over a lawnmower to our grandpa.’

□ Von Robert hat unser Opa einen Rasenmäher überreicht bekommen.
   By R. has our.NOM grandpa a lawnmower handed-over got
   ‘By Robert, our grandpa was handed over a lawnmower.’
Experiment 3

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▶ forced-choice selection  
  (cf. Rosenbach, 2005; Bresnan, 2007; Arppe & Järvikivi, 2007)

▶ choice btw active sentence and bekommen-passive sentence

▶ order of the two answers was systematically varied

▶ context question establishes a topic (Agent or Recipient)
Experiment 3

Was gibt es Neues von eurem Opa? (‘What’s about your grandpa?’)

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   ‘To our grandpa, Robert handed over a lawnmower.’

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   ‘Our grandpa was handed over a lawnmower by Robert.’

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▷ 24 sentences (24 verbs)

▷ 48 participants
Experiment 3

Topic = Agent
active sentence   SU Vfin IO DO V
*bekommen* passive by-phrase Vfin SU DO V

Topic = Recipient
active sentence   IO Vfin SU DO V
*bekommen* passive SU Vfin by-phrase DO V
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(18) Prominence hierarchies
   a. Syntactic Function Hierarchy: Subject ⊈ Object
   b. Semantic Role Hierarchy: Agent ⊈ Recipient
   c. Thematic (discourse) Hierarchy: Topic ⊈ ¬Topic
Laboratory Experiment 3

Topic = Agent
active sentence \( SU \) Vfin IO DO V
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(18) Prominence hierarchies

a. Syntactic Function Hierarchy: Subject \( \succ \) Object
b. Semantic Role Hierarchy: Agent \( \succ \) Recipient
c. Thematic (discourse) Hierarchy: Topic \( \succ \) \( \neg \)Topic

- The topic may preferentially be realized as the subject:
  - Active voice for agent topics
  - \( Bekommen \) passive for recipient topics
Experiment 3

(19) -grammatical, - frequent
geben, glauben, stehlen, klauen, beschaffen, besorgen, kaufen ersparen

(20) +grammatical, - frequent
hinterlegen, zeigen, absprechen, zubereiten, schildern, erzählen, vorlegen, vorsingen

(21) +grammatical, +frequent
verschreiben, zustecken, zurückbezahlen, zuspielen, bewilligen, spendieren, zusenden, erstatten

- The probability of choosing the *bekommen* passive may depend on the verb's grammaticality score and or the bigram frequency
Experiment 3

Percentages of choice ‘topic=subject’ (preliminary results, n = 40)

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- strong preference for realizing the topic as subject:
  - Agent topics: 96%
  - Recipient topics: 65%

- The probability of choosing the *bekommen* passive depends on the verb’s grammaticality score and its frequency properties
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How do graded grammaticality ratings relate to . . .

1. language comprehension?
2. language production?
3. binary grammaticality judgments?
Conclusions

How do graded grammaticality ratings relate to . . .

1. language comprehension?
2. language production?
3. binary grammaticality judgments?

ad ①

- The grammar is gradient itself, i.e. gradient judgments are not a mere epiphenomenon caused by language comprehension mechanisms. (see also Pater, 2009)
- We observe gradient judgments even when the material is controlled for performance factors

Note. The experimental sentences are closely matched for length, complexity etc.
Conclusions

How do graded grammaticality ratings relate to . . .

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ad ②
Conclusions

How do graded grammaticality ratings relate to . . .

1. language comprehension?
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ad ②

► Grammaticality and frequency do not always go hand in hand.
► Production frequencies do neither predict gradient judgments nor binary judgments.
► Grammaticality is one of the factors determining by frequency.
Conclusions

How do graded grammaticality ratings relate to . . .

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Conclusions

How do graded grammaticality ratings relate to . . .

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ad ③

- Gradient judgments are highly predictive for binary judgments.
- Binary grammaticality judgments can be derived directly from gradient judgments. (cf. Bader & Häussler, 2010)
Thank you


