Instances of genericity: A distributional semantic approach to generic and specific masculines' semantics in German

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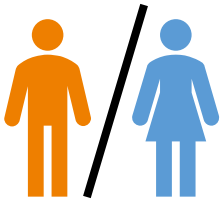
Role nouns in German

Professor
'professor'

Professor
'professor'



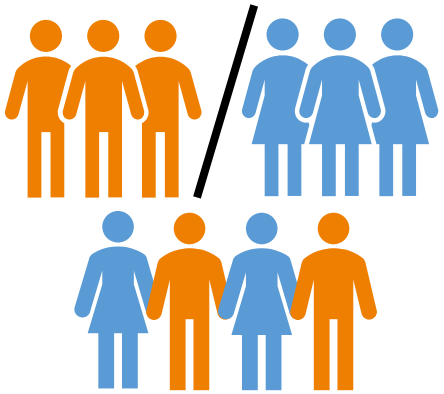
Professorin
'professor'

SINGULAR

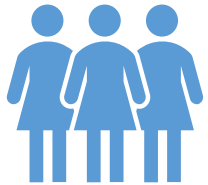
PLURAL

Professoren
'professors'

Professoren
'professors'



Professorinnen
'professors'



Generic masculines

- generic masculines are
  - orthographically and phonologically **identical** to explicit masculines
  - used to describe individuals of **all genders** in singular and plural contexts
  - traditionally assumed to "abstract away" notions of gender,

    i.e. to be **gender-neutral** (cf. Doleschal 2002)
- however, previous research has cast doubt on the gender-neutral use of generic masculines
- most (if not all) behavioural studies on the subject find one overall result

  → generic masculines are not gender-neutral but show a clear bias towards the explicit masculine reading (e.g. Demarmels 2017; Garnham et al. 2012; Gygax et al. 2008; Irmen & Kurovskaja 2010; Irmen & Linner 2005; Koch 2021; Misersky et al. 2019; Stahlberg & Sczesny, 2001)
- gender-neutral intention, but gender-specific comprehension

Generic masculines

- recently, computational methods entered this field of research (Schmitz 2023; Schmitz et al. 2023; Schmitz 2024)
- Schmitz (2023) and Schmitz et al. (2023) used **semantic vectors** to investigate the semantics of generic masculines, specific masculines, and specific feminines
- **semantic vectors** are mathematical representations of a word's semantics
- however, Schmitz (2023) and Schmitz et al. (2023)'s implementations come with two issues
- today's aim: solve these issues by implementing alternative methods

Previous implementation

- semantic vectors were computed for words and inflectional functions based on a corpus with **Naive Discriminative Learning** (NDL; e.g. Baayen & Ramscar, 2015)
- **NDL** follows the Rescorla-Wagner rules (Rescorla & Wagner, 1972)
  - **outcomes** (word forms) are predicted by **cues** (words/inflection)
  - the **associative strength** between an outcome and a cue is represented by a single number
- they used each sentence to predict each individual word/function within the sentence by the other words/functions in that sentence

Previous implementation

- for content words, semantic vectors were the sum of the vectors of their parts, e.g. $\overrightarrow{apples} = \overrightarrow{apple} + \overrightarrow{plural}$
- thus, e.g., the semantics of the target word paradigm *Lehrer* 'teacher' consisted of

target	base		number		gender		genericity
Lehrer	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{singular}}$	+	$\overrightarrow{\text{masculine}}$	+	$\overrightarrow{\text{generic}}$
Lehrer	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{singular}}$	+	$\overrightarrow{\text{masculine}}$	+	$\overrightarrow{\text{explicit}}$
Lehrerin	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{singular}}$	+	$\overrightarrow{\text{feminine}}$	+	$\overrightarrow{\text{explicit}}$
Lehrer	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{plural}}$	+	$\overrightarrow{\text{masculine}}$	+	$\overrightarrow{\text{generic}}$
Lehrer	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{plural}}$	+	$\overrightarrow{\text{masculine}}$	+	$\overrightarrow{\text{explicit}}$
Lehrerinnen	$\overrightarrow{Lehrer}$	+	$\overrightarrow{\text{plural}}$	+	$\overrightarrow{\text{feminine}}$	+	$\overrightarrow{\text{explicit}}$

Issues

Issue 1: vector correlations

- $\overrightarrow{specific}$ and $\overrightarrow{generic}$ are computed across all their attestations, i.e. we end up with one general vector for specific and one for generic semantics
- $\overrightarrow{generic}$ only ever occurs with masculine forms
- $\overrightarrow{specific}$ occurs with masculine and feminine forms

➡ $\overrightarrow{generic}$ is strongly correlated with $\overrightarrow{masculine}$

➡ $\overrightarrow{generic}$ is biased towards the masculine and masculine referents

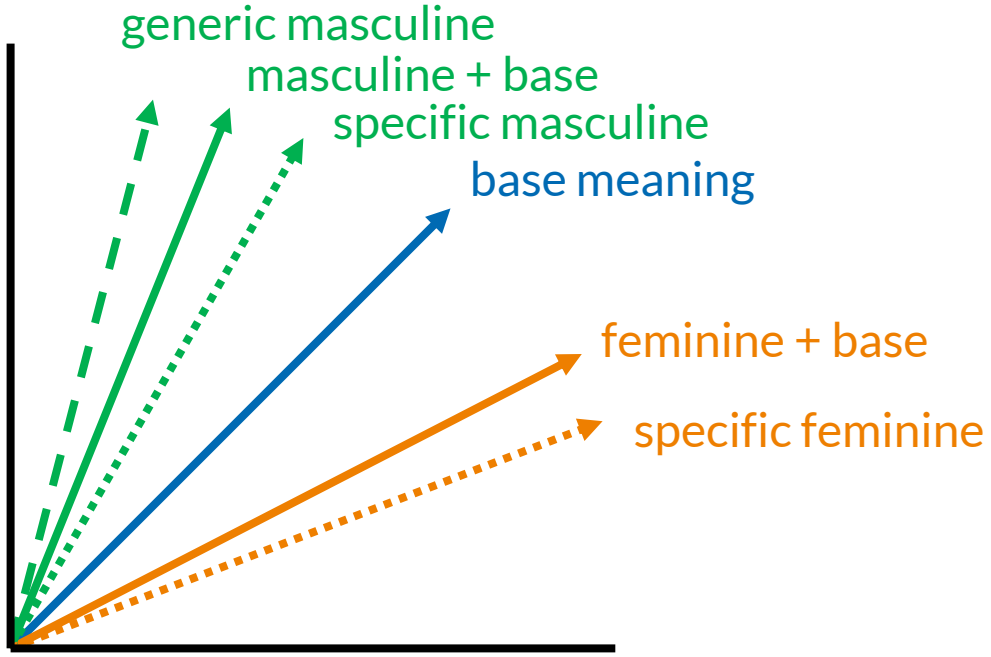
Issues

Issue 2: genericity ≠ inflection

- role noun semantics were constructed as sum of their parts, e.g.

$$\overrightarrow{Lehrer_{generic}} = \overrightarrow{Lehrer_{base\ meaning}} + \overrightarrow{singular} + \overrightarrow{masculine} + \overrightarrow{generic}$$

- addition of a vector = shift of direction in a multidimensional space



Alternative computational approach

- solution: use instance vectors instead
- **instance vectors** (Lapesa et al., 2018)
  - instance vectors are vectors computed for each instance, i.e. attestation, of a given target word within a given corpus
  - each instance vector is the average of n context words preceding and following the target word in a pertinent attestation
- the computation of instance vectors requires three prerequisites
  1. target word attestations
  2. semantic vectors of context words
  3. a decision on the size of n

Instance vectors

1. target word attestations

- 75 of the 113 target word paradigms from the NDL/LDL study were adapted
  - 9 were dropped because of fewer than 10 attestations overall
  - 28 were dropped because of fewer than 10 attestations for one type
- for the remaining 75 paradigms, an even number across types was retained, e.g.
  - *Arbeiter* 'worker': 375 generic masculine, 113 specific masculine, 12 specific feminine attestations
  - sampling of further specific feminine attestations lead to the inclusion of 40 random attestations per type

Instance vectors

1. target word attestations

- in the NDL/LDL study's corpus,
  - words were automatically annotated for inflectional functions
  - words were represented by their base forms (= masculine nominative)
  - target words were manually annotated for genericity (specific vs. generic)
- for the present implementation, the non-annotated sentences were used, i.e. sentences were used in their original form
- overall, 3,020 target word attestations were used

Instance vectors

2. semantic vectors of context words

- semantic vectors of context words were generated with fastText (Bojanowski et al., 2016; Mikolov et al., 2013)
- other algorithms to create semantic vectors with can be used as well, but fastText vectors were easily available

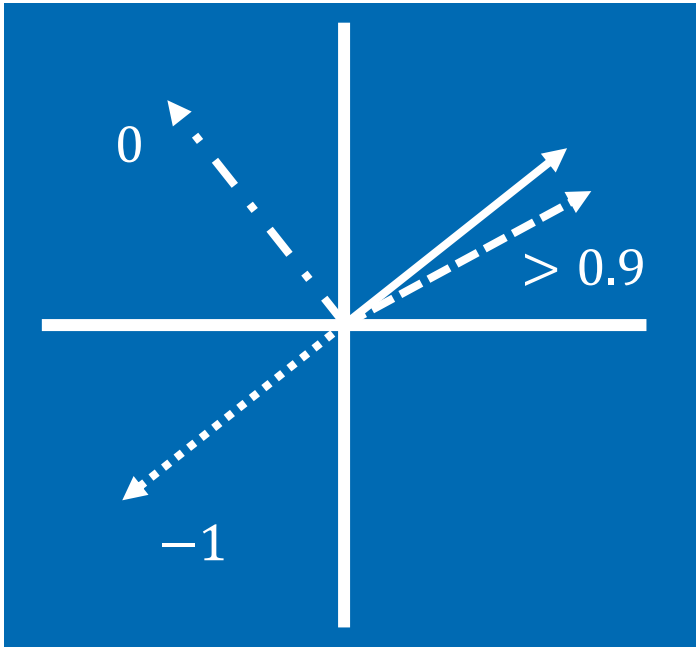
Instance vectors

3. a decision on the size of n

- following Lapesa et al. (2018), the following sizes were used
  - $n = 2$ assumed to reflect true semantic similarity
  - $n = 8$ assumed to reflect topical similarity
- additionally
  - $n = 5$

Analysis

- semantic similarity was analysed via **cosine similarity**
- cosine similarity measures the similarity between two vectors in a multidimensional space by computing the cosine of the angle between them
- cosine similarity values are always in the interval of $[-1,1]$
  - 1 proportional = semantically identical
  - 0 orthogonal = no semantic similarity
  - -1 opposite = antonymy



- within each target word paradigm, each vector of a given type A was compared to each vector of a given type B

Analysis

- **beta regression** was the statistical model of choice to adequately model the interval restrictions of the cosine similarity values
- however, as there were cosine similarity values below 0, a transformation was required
- cosine similarity values were shifted and scaled mapping the interval $(-1,1)$ to the interval $(0,1)$

$$cosim\_trans = \frac{(cosim + 1)}{2}$$

- finally, as beta regression cannot handle true ones, they had to be excluded
  - true ones were contained in the data especially for the $n = 2$ instance vectors because of identical context words across multiple attestations

Data sets

- the final cosine similarity data consists of more than 350,000 cosine similarity values of 75 target word paradigms per context window size n

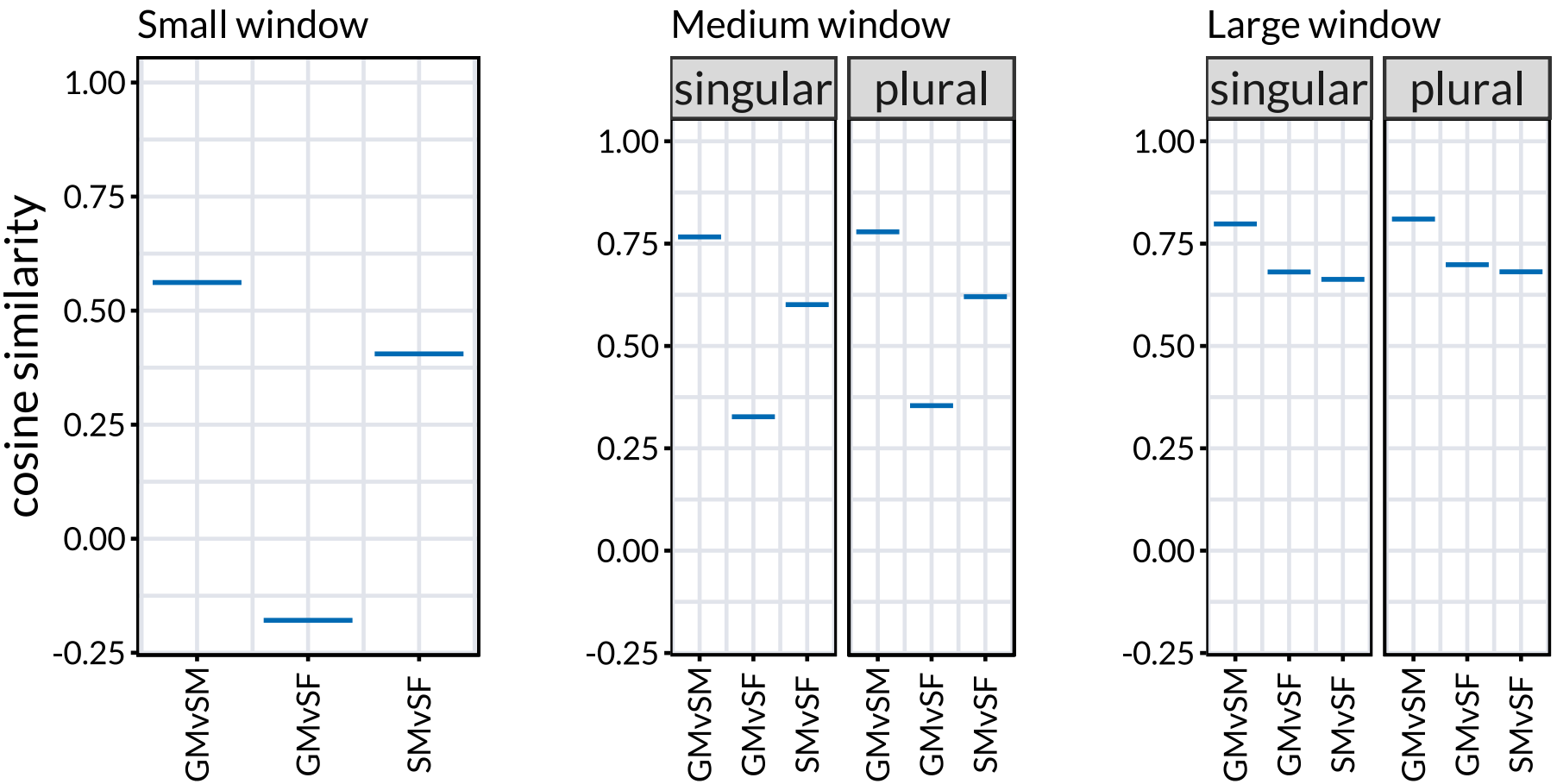
$n = 2$	$n = 5$	$n = 8$
355,625	365,151	372,493

Variables

- **COMPARISON**. Types of the two paradigm member types a given cosine similarity value belongs to.
- **NUMBER**. Number of the two paradigm member types a given cosine similarity value belongs to.
- **STEREOTYPICALITY**. Stereotypicality judgements of the target word paradigm a given cosine similarity value belongs to.
- **FREQUENCIES**. Genericity informed frequencies of the types within a target word paradigm.
- **ATTESTATIONS**. Number of attestations of a given target word paradigm.
- **WORD**. The target word itself (one value per target word paradigm).

Results

- COMPARISON reaches significance in all models; NUMBER in two models



Discussion & conclusion

- the similarity orders of the small and medium context window differ from that of the large context window – why?
  - they are not due to word classes within the context windows; χ2-tests show that the distribution of word classes is not different
  - they are potentially due to syntactic and/or contextual structures
  - for bigger window sizes, it is likely that included material is not directly related to the target word
- generic masculines are semantically most similar to specific masculines
- this is in line with Schmitz (2023), Schmitz et al. (2023) and other previous studies

  (e.g. Demarmels 2017; Garnham et al. 2012; Gygax et al. 2008; Irmen & Kurovskaja 2010; Irmen & Linner 2005; Koch 2021; Misersky et al. 2019; Stahlberg & Sczesny, 2001)

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