

Annotating the Countability of English Nouns on a large Scale

Tobias Stadtfeld

Overview

- **Introduction**
 - What do we want?
- **Some theoretical assumptions**
 - Point of view on countability
 - Potential problems during annotation
- **Three tests to determine the countability of nouns**
 - Determining syntactic and semantic properties of nouns in restricted context
- **Manual annotation of several thousand English nouns**
 - Setup
 - Inter-annotator-agreement
 - Observed problems and possible improvements
- **Outlook**

Introduction

- Resources on the lexical countability of English and German nouns are scarce.
- Only a few nouns are frequently cited as examples in the literature.
 - **countable:** *car*
 - **uncountable/substance-mass:** *sand*
 - **aggregated/object-mass:** *furniture*
 - **dual-life/dual use:** *cake*
 - **plural only:** *expenses*

Goal: Create a lexicon with the *lexical* countability of a large number of nouns

- **German:** A small scale annotation task of 1.100 German nouns was part of my PhD-thesis (Stadtfeld, forthcoming)
- **English:** Applied method for annotation of German nouns to 7000 English nouns.
 - Part of the project “*Accounting for the Foundations of Mass*” under Jeff Pelletier and Tibor Kiss (funded by the Alexander von Humboldt Foundation)

Some theoretical assumptions

- The “countability interpretation” of a noun is primarily determined by a combination of several *lexical features*
 - *Contextual influence* can alter the countability reading of a noun, which must therefore be excluded/minimized during annotation.
- Lexical countability expresses itself through a mixture of syntactic **and** semantic features:
 - Syntactic features:
 - Noun can appear in singular and/or plural?
 - Noun is compatible with the indefinite article?
 - Noun can appear with certain quantifiers (*some, more*)?
 - ...
 - Semantic features:
 - Conceptualization as homogenous/continuous stuff or as separable countable entity?
- Simply annotating a noun as “countable” or “uncountable” is insufficient.
 - Noun can be syntactically uncountable, while being semantically countable (aggregated/object-mass nouns, e.g. *furniture*)

Some theoretical assumptions – Contextual influence

- There are certain ways to alter the default lexical countability of a noun from
 - mass to count:
 - universal-sorter (Bunt, 1985)
 - a) The waiter recommended **two** different **wines**.
'The waiter recommended two different sorts of wine.'
 - b) They produced **a steel** of extraordinary quality.
'They produced a type of steel with the property'
 - universal-packager (Jackendoff, 1991)
 - c) They ordered **two beers**.
'They ordered two containers filled with beer.'
 - **ATTENTION:** We do not count what we reference to with the mass noun but we count a (hidden) classifier. (sorts/types/containers)
 - count to mass:
 - universal-grinder (Pelletier, 1975)
 - d) There is **dog** all over the street.
(after the (countable) dog has been run over by a car.)

Occurrences with the indefinite article and/or in plural could be mistaken as evidence for a fully countable interpretation of the noun in question.

Given the right context (almost) every noun can be subjected to the universal-grinder.

Some theoretical assumptions – Semantic properties

- Real world knowledge does not help to determine the countability of a noun.
- English speakers conceptualize *hair* in a different manner than German speakers, while still referring to the same real world entity.
 - In English, *hair* only allows a mass reference
 - a) She has more hair than him. ⇒ More volume or mass
 - In German, *hair* (Haare) allows for two ways of conceptualization
 - b) Sie hat mehr Haar[Sg] als er. ⇒ More volume or mass
 - c) Sie hat mehr Haare[Pl] als er. ⇒ More strings of hair
- We need to determine the properties of a **concept**, not of a real world object.
- Semantic properties of a concept should become apparent in certain test sentences.
 - Usage of a noun tells us how it is conceptualized.

Some theoretical assumptions – Substance- vs. object-mass

- An experiment by Barner and Snedeker (2004) shows differences in the applied mode of measurement when comparing substance-mass and object-mass nouns



(Barner and Snedeker, 2004)

- Comparison of object-mass nouns (*silverware*) is based on number
 - These *semantically countable* nouns make use of the natural numbers \mathbb{N}_0
- Comparison of substance-mass nouns (*toothpaste*) is not based on number
 - These *semantically uncountable* nouns are measured on the continuous scale \mathbb{R}^+
 - No atomicity exists in \mathbb{R}^+ (always a smaller number available)

Three tests to determine the countability of English nouns

- We need *minimalistic, standardized tests* to help annotators to
 - use the indefinite article only in a very specific manner
 - detect a hidden type/container-reading (universal-sorter and -packager)
 - detect and ignore an universal-grinder
 - identify and separate object-mass (aggregated nouns) from substance-mass nouns
- Three tests were constructed to determine syntactic and semantic properties of nouns
 - Test I: Mode of measurement in singular?
 - Test II: Type- or container-reading-equivalence?
 - Test III: Compatible with and/or without indefinite article?
- All tests limit the allowed context to a absolute minimum.
 - **Widening the context is strictly forbidden!**
- **When the context is minimal, we should only determine *lexicalized properties* of a noun!**

Test I – Determining the mode of measurement

A has more NOUN[sg] than B

- Wildcards (A, B) and the verb may be replaced in an appropriate way
 - **but no further extension of the context is permitted!**
- Test contains two steps:
 - **Step 1:** Is the noun grammatical in this context?
 - Test is based on the assumption that fully countable nouns will be ungrammatical in scope of *more* while in singular
 - **Step 2:** If noun is grammatical in context, determine the general mode of measurement to distinguish between substance- and object-mass nouns

Test I – Determining the mode of measurement

- Step 1: Is the noun in general valid in the given context?
 - a) The rat ate more cheese than the mouse.
 - b) Paris had more fear than Achilles.
 - c) Nicole owns more silverware than Lisa.
 - d) *John owns more car than Bill.
- The main purpose of the test is to avoid/detect the usage of the universal grinder in d) or of an “ad writer reading” in e) and f) during annotation.
 - e) **Wieviel Haus kann ich mir leisten?**
'How much house can I afford?'
(Advertisement slogan by the Deutsche Bank, 2010)
 - f) **?John got more car for less money than Bill did.** (context violation!)

Test I – Determining the mode of measurement

- Step 2: Given the noun is valid in this type of context, determine the mode of measurement:
 - Is the comparison based on the **number** of pieces ($\mathbb{N}_0 \Rightarrow$ object-mass)
 - a) **Nicole owns more silverware than Lisa.**
Spoons + knives + forks owned by Nicole and Lisa are relevant
 - or is the comparison **not** based on the **number** of pieces ($\mathbb{R}^+ \Rightarrow$ substance-mass)
 - b) **The rat ate more cheese than the mouse.**
Volume or mass is relevant (the exact mode of measurement, however, is irrelevant)
 - c) **Paris had more fear than Achilles.**
Relevant scale is some sort of intensity of fear
- Possible outcomes of test I.1/I.2:
 - **not applicable/not applicable** ('people')
 - **no/not applicable** ('skyscraper')
 - **yes/number** ('jewelry')
 - **yes/ \neg number** ('wine')

Test II – Type or container-reading-equivalence?

A has more NOUN[pl] than B

- Besides the usage of the noun in plural, the defined context of the second test is identical to the pattern of the first:
- Test also contains two steps:
 - **Step 1:** Is the noun valid/grammatical in the given context?
 - a) She owns more cars than him.
 - b) He tasted more wines than her.
 - c) Paris had more fears than Achilles.
 - d) *Thailand produces more rices than China.
 - **Step 2:** If valid in step 1, does the noun imply a hidden type/container-reading?

Test II – Type or container-reading-equivalence?

- **Step 2:** If the noun is grammatical in the test sentence, a second sentence is constructed with a change of number plus adding a classifier

A has more TYPE/CONTAINER (of) NOUN[sg] than B

- Question: Are the propositions of both sentences equivalent?
 - a) A has more wines than B. (step 1)
 - b) A has more types/sorts/containers of wine than B. (step 2)
- **Idea:** If the statement of sentence a) equals the statement of sentence b), we can assume that a) implies a classifier.
- **In this case:** Plural marking of *wine* does imply a type/container-reading!

Test II – Type or container-reading-equivalence?

- However, if a prototypical countable noun is inserted into this test context, we get two different statements:
 - a) A has more cars than B.
 - b) *A has more sorts/brands of car than B.
- Even when the target noun remains in plural, the statements of a) and c) are not necessarily identical
 - c) A has more sorts/brands of cars than B.
- **In this case:** Plural marking of *car* does not imply a type/container-reading!
- Possible outcomes of test II.1/II.2:
 - **not applicable/ not applicable** ('rice')
 - **no/not applicable** ('clutches', 'lighting conditions')
 - **yes/not applicable** ('expenses')
 - **yes/not equivalent** ('car')
 - **yes/equivalent** ('wine')

Test III – Compatible with and/or without indefinite article?

- The purpose of the third test is to determine if the target noun is in need of an indefinite article in a minimalistic context or if the indefinite article can be omitted.
- Again, the test is split in two:

Test III.1: Indefinite article + NOUN[sg] + *is* + valid property of noun

- Even prototypical uncountable nouns can combine with an indefinite article in an *unrestricted* context. (*a steel of extraordinary quality*)
- However, if we restrict the permitted context, only nouns with a countable interpretation should pass test III.1.
- In addition, a second similar test sentence is constructed, but with the indefinite article omitted:

Test III.2: NOUN[sg] + *is* + valid property of noun

Test III – Compatible with and/or without indefinite article?

- Examples:
 - a) A car is a vehicle.
 - b) *Car is a vehicle.
 - c) *A steel is an alloy.
 - d) Steel is an alloy.
- Some nouns pass both tests
 - e) A fish is an animal.
 - f) Fish is eatable and delicious.
- and some nouns none
 - Unique entities
 - g) *A/*Ø/The south is a region of the United States lying to the south of the Mason-Dixon line.
 - All plural only nouns are *not applicable*, as they lack the necessary singular form
 - h) *expenses/people is ...

Test III – Compatible with and/or without indefinite article?

- The test supports the detection of a hidden universal sorter/packager
- Using a classifier in the description section of this test is (by definition) not allowed
 - a) #A beer is a CONTAINER filled with beer. (not a valid test context!)
 - b) Beer is drinkable and usually contains alcohol.
 - *Beer* is quiet frequently used with an indefinite article, but by applying the test, the annotator should become aware that the test only works if an classifier is inserted.
- Possible outcomes of test III.1 and III.2, respectively:
 - **not applicable** ('ethics', 'scissors')
 - **no** (not grammatical)
 - **yes** (grammatical)

The annotation process

- Four native speakers of English annotated several thousand English nouns
 - At least two opinions per noun sense
- Nouns for annotation were taken from OANC
 - Minimum occurrence in corpus > 10
 - Noun must be contained in *WordNet*
 - Annotations were carried out in a spreadsheet with simple drop-down lists

| noun | wordnet senseindex number | wordnet discription | Test I.1: A has more X[sg] than | Test I.2: A has more X[sg] than | Test II.1: A has more X[p] than | Test II.2: A has more kinds/com | Test III.1: Indef. Ar | Test III |
|-------------|---------------------------|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|-----------------------|------------|
| fruitcake | 1 | a whimsically eccentric person | no | not applicable | yes | not equivalent | yes | no |
| fruitcake | 2 | a rich cake containing dried fruit and nuts and citrus peel and so on | yes | not number | yes | not equivalent | yes | yes |
| foam | 1 | a mass of small bubbles formed in or on a liquid; "the beer had a thick head of foam" | yes | not number | not applicable | not applicable | no | yes |
| foam | 2 | a lightweight material in cellular form; made by introducing gas bubbles during manufacture | yes | not number | yes | equivalent | no | yes |
| dehydration | 1 | dryness resulting from the removal of water | not applicable | not number | not applicable | not applicable | no | yes |
| dehydration | 2 | depletion of bodily fluids | no | not number | not applicable | not applicable | no | yes |
| dehydration | 3 | the process of extracting moisture | yes | not number | not applicable | not applicable | no | yes |
| spur | 1 | a verbalization that encourages you to attempt something; "the ceaseless prodding got on his nerves" | don't know | don't know | don't know | don't know | don't know | don't know |

The annotation process

- For training purposes 1225 senses were annotated in group (majority vote wins).
 - Different point of views on the tests and possible resulting ambiguities were discussed in length and solved.
- 7000 lexical items have been annotated by the annotators on their own.
 - These items exhibit 13804 senses
 - Every sense of a noun has been annotated by at least two annotators.
- Annotators were free to comment on problematic nouns and/or mark problematic tests as “don’t know”.
- In addition to the annotation of the tests, annotators were told to mark nominalizations as such.

Preliminary annotation results – Inter-annotator-agreement

- Calculated *Krippendorff's alpha* (Artstein & Poesio, 2008) for every test
 - Values range from 0 (no agreement) to 1 (full agreement).
 - Values above 0.67 are considered good.
 - Values above 0.8 are considered excellent.
- “Don't know” annotations are handled as missing values (no influence on the agreement)
- Values are not a percentage agreement.
 - Krippendorff's alpha considers agreement by chance.
- So far only the annotations of two annotators are considered for IAA calculation
 - Still missing some data from the other annotators.

Preliminary annotation results – IAA test I

- **Agreement test I.1:** (*A has more NOUN[sg] than B – grammatical?*)

| | # tuples | Krippendorff's alpha |
|---|----------|----------------------|
| all valid tuples | 5755 | 0.751 |
| nominalizations excluded | 3289 | 0.785 |
| nominalizations excluded & commented nouns excluded | 2525 | 0.819 |

- **Agreement test I.2:** (*mode of measurement?*)

| | # tuples | Krippendorff's alpha |
|---|----------|----------------------|
| all valid tuples | 5732 | 0.731 |
| nominalizations excluded | 3282 | 0.764 |
| nominalizations excluded & commented nouns excluded | 2523 | 0.799 |

Possible explanations of disagreement in test I:

- Two relevant senses concerning the animal *cod* in *WordNet*.
 - cod#2: lean white flesh of important North Atlantic food fish; usually baked or poached
 - cod#3: major food fish of Arctic and cold-temperate waters
- Annotator A and B agree that cod#2 is substance-mass reading.
 - a) He ate more cod than him.
- For cod#3, Annotator A assumes a fully countable interpretation (*more cod than* is ungrammatical)
- Annotator B agrees BUT also assumes a second/additional interpretation:
 - b) Ocean A holds more cod than ocean B.
 - ⇒ number of cods as mode of measurement ⇒ object-mass reading
 - cod#3 is classified as dual life by annotator B, but is only countable according to annotator A.

Possible explanations of disagreement in test I:

- Annotators agree that noun is grammatical in test I (step 1), but do not agree upon mode of measurement in second step:
 - dynamite#1: an explosive containing nitrate sensitized with nitroglycerin absorbed on wood pulp

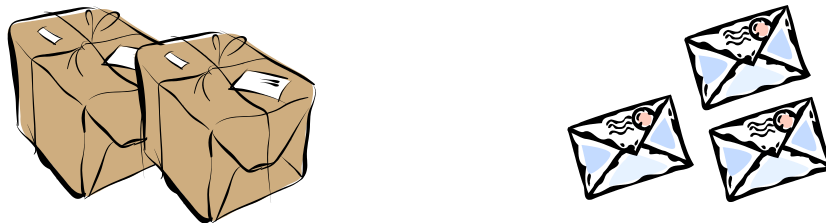
- Relevant mode of measurement: Mass/volume of dynamite or number of sticks of dynamite?



- World knowledge of usual packaging (sticks) of dynamite might be responsible here.

- correspondence#1: communication by the exchange of letters

- Mass/volume of letters/packages vs. number of items exchanged



Preliminary annotation results – IAA test II

- **Agreement test II.2:** (*A has more NOUN[pl] than B* – grammatical (step 1) and kind/container-reading equivalent (step 2)?)

| | # tuples | Krippendorff's alpha |
|---|----------|----------------------|
| all valid tuples | 5726 | 0.695 |
| nominalizations excluded | 3268 | 0.724 |
| nominalizations excluded & commented nouns excluded | 2524 | 0.752 |

- Surprisingly, annotators disagreed more often on the question of whether or not a noun can take a plural than on the legitimacy of a noun in test I.

Explanations of problems in test II: Legitimacy of plural form

- According to one annotator some nouns can never appear in plural, while another annotator says they can – But then they express a hidden type/container-reading!
 - **Examples:** *chloride(s)*, *pleasure(s)*, *standardization(s)*, *etiquette(s)*, *pain(s)*, *asphalt(s)*, *opium(s)*, *sulfate(s)*, *harassment(s)*, *asthma(s)* and many more.
- Sometimes there is no right or wrong annotation:
 - Annotator A needs to establish an explicit classifier to express different kinds
 - a) Student A knows more different types of chloride than student B.
 - while annotator B can achieve this also through plural usage.
 - b) Student A knows more chlorides than student B.
- These cases were also one of the major sources of disagreement during the group annotation and mostly seem to be dependent on the speaker's preferences.

Preliminary annotation results – IAA test III

- **Agreement test III.1:** (grammatical with indefinite article)

| | # tuples | Krippendorff's alpha |
|---|----------|----------------------|
| all valid tuples | 5738 | 0.773 |
| nominalizations excluded | 3275 | 0.815 |
| nominalizations excluded & commented nouns excluded | 2522 | 0.843 |

- **Agreement test III.2:** (grammatical without indefinite article)

| | # tuples | Krippendorff's alpha |
|---|----------|----------------------|
| all valid tuples | 5747 | 0.760 |
| nominalizations excluded | 3282 | 0.788 |
| nominalizations excluded & commented nouns excluded | 2522 | 0.847 |

Remaining Problems – Nominalizations

- In *WordNet*, a clear differentiation between all possible readings of a nominalization is not always given.
 - *event reading, object reading and result reading* are summed up in one sense.
- reflection#1: **a calm, lengthy, intent consideration**
 - 50/50 split among annotators across all tests
 - Test II.1: ?A did/had more reflections than B. (countable acts of reflection)
 - Test III.1: ?A reflection is the RESULT of...
 - Test III.2: ?Reflection is the ACT of...
- tracking#1: **the pursuit (of a person or animal) by following tracks or marks they left behind**
 - Test I: He does more tracking than him. (four annotators; 100% agreement)
 - Test II: ?He did more trackings than him. (multiple events of tracking; 50/50 split)
- Clarification on what kind of reading should be annotated could significantly reduce disagreement among annotators.
- Source of error here is *WordNet* (to an extent), as it quite often only lists a fuzzy description.

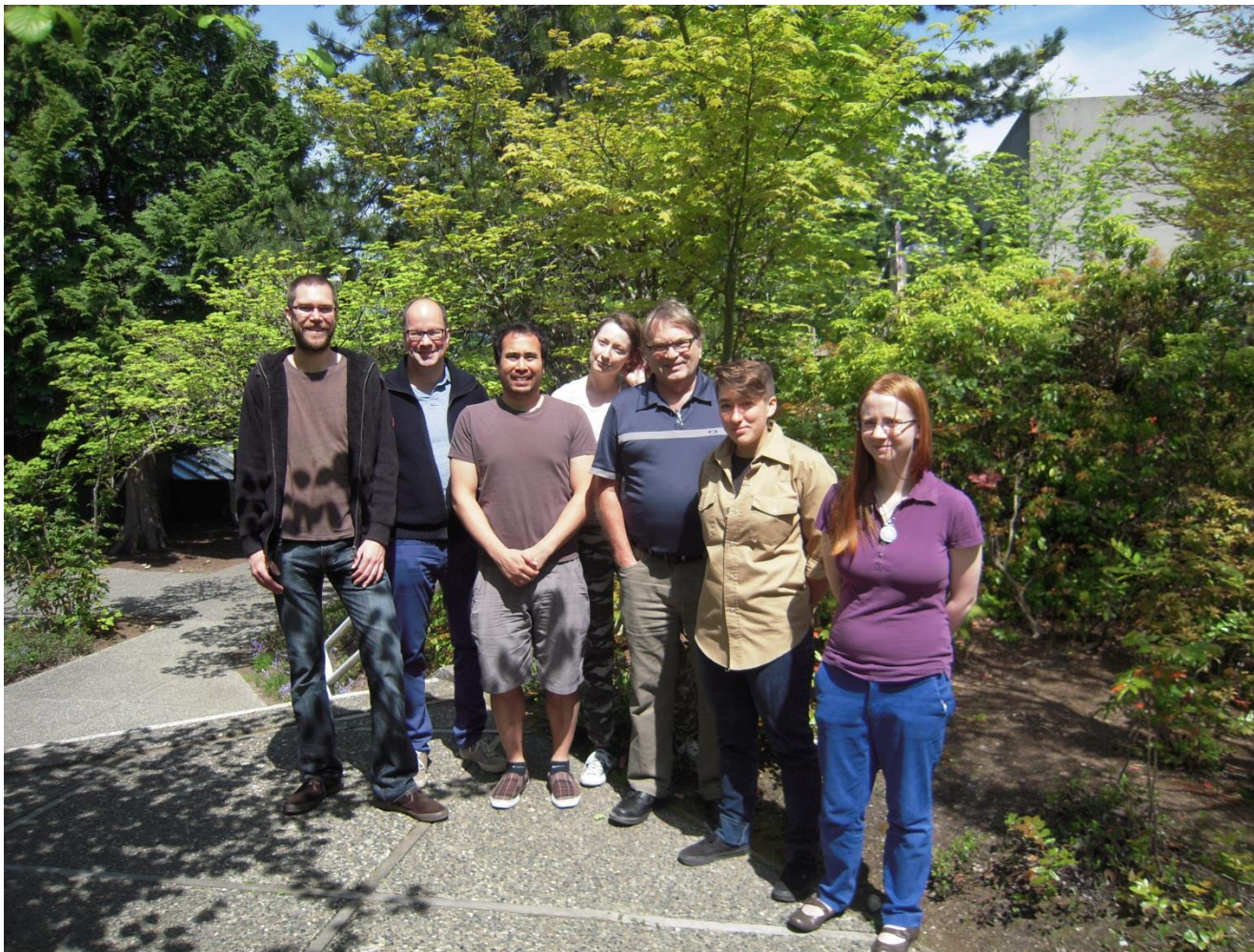
Inconsistencies in *WordNet*: Dual life vs. two separate senses

- *WordNet* has it flaws:
 - Multiple senses cover different countability readings in some cases
 - emerald#1: a green transparent form of beryl; highly valued as a gemstone
⇒ substance-mass noun, no plural, not compatible with indefinite article
 - emerald#2: a transparent piece of emerald that has been cut and polished and is valued as a precious gem
⇒ fully countable, can appear in plural, compatible with indefinite article
 - while in other cases the substance-reading and countable sense are one
 - rock#1: a lump or mass of hard consolidated mineral matter; "he threw a rock at me"
⇒ Dual-life noun: substance-mass and fully countable
- Annotators were told to stay as close to the given sense description as possible.
- Annotators sometimes needed to read all sense descriptions of a noun to correctly interpret the one under investigation.

Outlook

- Question of how to handle dual life nouns in the lexicon remains open for debate:
 - Should dual life nouns be split into two separate sense entries?
 - *rock#1 (dual life) ⇒ rock#1 (countable) & rock#2 (substance-mass)*
 - ...or should there be one entry with two different interpretations/senses mentioned?
 - *emerald#1 (substance-mass) & emerald#2 (countable) ⇒ emerald#1 (dual life)*
- Handling of different interpretations of nominalizations:
 - Requires re-editing and/or adding of sense descriptions to *the lexicon*
 - *and/or more detailed instructions on how to handle different readings in the test settings.*
- Distinction between *abstract* and *concrete* nouns is underway
 - (Roughly based on Aristotle's categories) Annotators annotate if a noun
 - is a primary substance
 - is a secondary substance
 - is a proper noun
 - describes kinds of something
 - describes a quality
- Having a large(r) lexicon with the lexical countability of nouns at hand, a fully automated supervised classification attempt is one of the next logical steps.

Thank you!



Tobias Stadtfeld, Tibor Kiss, Mathieu Dovan, Lisa Shorten, Jeff Pelletier, Meghan Jeffrey & Fiona Wilson (from left to right)

References

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Countability classes of German nouns

| Class | Group | Example | Test I Mode of measurement in singular? | Test II Type- or Container- reading- equivalence? | Test III.1 With indefinite article? | Test III.2 Without indefinite article? |
|-------|-------|--|--|---|---|--|
| VI | 1 | <i>Fegefeuer</i> (purgatory) | not applicable | not applicable | no | no |
| | 2 | <i>Lichtverhältnisse</i> (lighting conditions) | not applicable | not applicable | no | not applicable |
| | 3 | <i>Biochemie</i> (biochemistry) | not applicable | not applicable | yes | yes |
| V | 1 | <i>Reis</i> (rice) | ¬number | not valid | no | yes |
| | 2 | <i>Schmuck</i> (jewelry) | number | not valid | no | yes |
| IV | 1 | <i>Wasser</i> (water) | ¬number | no | no | yes |
| | 2 | <i>Besteck</i> (silverware) | number | yes | no | yes |
| III | 1 | <i>Kuchen</i> (cake) | ¬number | no | no | yes |
| | 2 | <i>Spielzeug</i> (toy) | number | no | no | yes |
| II | 1 | <i>Hosen</i> (trousers) | not applicable | not applicable | no | not applicable |
| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | no | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

Six countability classes

syntactically
and/or
semantically
“more”
countable

Countability classes of German nouns

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|-------|-------|--|---|---|---|--|-----|-----|
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| | 2 | <i>Lichtverhältnisse</i> (lighting conditions) | not applicable | not applicable | not applicable | not applicable | | |
| | 3 | <i>Biochemie</i> (biochemistry) |  <p>Unique entities – (real) Singulariatantum also proper nouns (<i>Mississippi</i>)</p> | | | | yes | |
| V | 1 | <i>Reis</i> (rice) | | | | | | yes |
| | 2 | <i>Schmuck</i> (jew) | | | | | | yes |
| IV | 1 | <i>Wein</i> (wine) | ¬number | yes | no | yes | | |
| | 2 | <i>Besteck</i> (silverware) | number | yes | no | yes | | |
| III | 1 | <i>Kuchen</i> (cake) | ¬number | no | yes | yes | | |
| | 2 | <i>Spielzeug</i> (toy) | number | no | yes | yes | | |
| II | 1 | <i>Hosen</i> (trousers) | not applicable | not applicable/no | not applicable/no | not applicable | | |
| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable | | |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable | | |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no | | |

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| | 2 | <i>Lichtverhältnisse</i> (lighting conditions) | not applicable | not applicable | not applicable | not applicable |
| | 3 | <i>Biochemie</i> (biochemistry) | not applicable | not applicable | no | yes |
| V | 1 | <i>Reis</i> (rice) | number | no | no | yes |
| | 2 | <i>Schmuck</i> (jewelry) | number | no | no | yes |
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| | 2 | <i>Besteck</i> (silverware) | number | no | no | yes |
| III | 1 | <i>Kuchen</i> (cake) | ¬number | no | yes | yes |
| | 2 | <i>Spielzeug</i> (toy) | number | no | yes | yes |
| II | 1 | <i>Hosen</i> (trousers) | not applicable | not applicable/no | not applicable/no | not applicable |
| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

(real) Pluraliatantum



Countability classes of German nouns

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| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

field categories,
also proper nouns (Great Britain)

Countability classes of German nouns

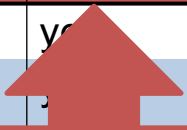
| Class | Group | Example | Test I Mode of measurement in singular? | Test II Type- or Container- reading- equivalence? | Test III.1 With indefinite article? | Test III.2 Without indefinite article? |
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| VI | 1 | <i>Fegefeuer</i> (purgatory) | not applicable | not applicable | no | no |
| | 2 | <i>Lichtverhältnisse</i> (lighting conditions) | not applicable | not applicable | not applicable | not applicable |
| | 3 | <i>Biochemie</i> (biochemistry) | not applicable | not applicable | no | yes |
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| II | 1 | <i>Hosen</i> (trousers) | not applicable | not applicable/no | not applicable/no | not applicable |
| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

“traditional” uncountable nouns.
syntactically and semantically uncountable

substance-mass nouns

Countability classes of German nouns

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| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |



 syntactically uncountable
 but semantically countable nouns.
 object-mass nouns

Countability classes of German nouns

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| | 2 | <i>Spielzeug</i> (toy) | | | | yes |
| II | 1 | <i>Hosen</i> (trousers) | | | able/no | not applicable |
| | 2 | <i>Kosten</i> (cost/expense) | | | able | not applicable |
| | 3 | <i>Leute</i> (people) | | | able | not applicable |
| I | - | <i>Auto</i> (car) | | | | no |

“traditional” uncountable nouns.
 syntactically and semantically uncountable.
BUT can establish hidden classifier!
 substance-mass nouns

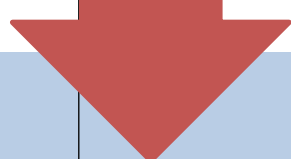
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|-------|-------|--|---|---|---|--|----------------|
| VI | 1 | <i>Fegefeuer</i> (purgatory) | not applicable | not applicable | no | no | |
| | 2 | <i>Lichtverhältnis</i> (lighting conditions) | <p style="text-align: center;">syntactically uncountable and semantically countable. <i>BUT can establish hidden classifier!</i></p> <p style="text-align: center;">object-mass nouns</p>  | | | | not applicable |
| | 3 | <i>Biochemie</i> (biochemistry) | | | | | yes |
| V | 1 | <i>Reis</i> (rice) | ¬number | no | no | yes | |
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Countability classes of German nouns

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| | 2 | <i>Lichtverhältnis</i> (lighting conditions) | <p style="text-align: center;"> Ambiguous in singular! Can show substance-mass reading. Always syntactically and semantically countable in plural. </p> | not applicable | no | not applicable |
| | 3 | <i>Biochemie</i> (biochemistry) | | not applicable | no | yes |
| V | 1 | <i>Reis</i> (rice) | | number | no | no |
| | 2 | <i>Schmuck</i> (jewelry) | number | no | no | yes |
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dual-life nouns

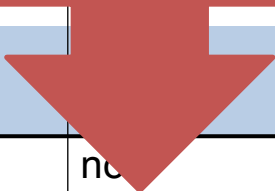


Countability classes of German nouns

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| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

Ambiguous in singular!
Can show object-mass reading.
Always syntactically and semantically
countable in plural.

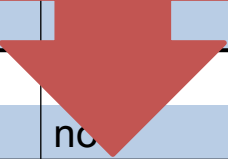
dual-life nouns



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| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

Bipartite nouns.
 Almost extinct in German.
 Due to obligatory classifier *pair* and
 ongoing change of countability class some
 tests are hard to judge



Countability classes of German nouns

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| | 3 | <i>Biochemie</i> (biochemistry) | not applicable | not applicable | no | yes | |
| V | 1 | <i>Reis</i> (rice) | <div style="background-color: #c00000; color: black; padding: 10px; text-align: center;"> <p>Plural only nouns. Fourth test required to distinguish II.2/3 Group 2 (“mass-plural”) incompatible with numerals, Group 3 (“count-plural”) compatible.</p> </div> | | | | yes |
| | 2 | <i>Schmuck</i> (jewelry) | | | | | yes |
| IV | 1 | <i>Wein</i> (wine) | | | | | yes |
| | 2 | <i>Besteck</i> (silverware) | | | | | yes |
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| II | 1 | <i>Hosen</i> (trousers) | | | no/yes | not applicable |
| | 2 | <i>Kosten</i> (cost/expenses) | not applicable | no | not applicable | not applicable |
| | 3 | <i>Leute</i> (people) | not applicable | no | not applicable | not applicable |
| I | - | <i>Auto</i> (car) | not applicable | no | yes | no |

Fully countable nouns



Experiment I: *Question 1*

- „Zwei Ihnen unbekannte Personen besuchen einen Weinhändler. Person A kauft einmal das Produkt A. Person B kauft einmal das Produkt B.

Welche der beiden Personen hat Ihrer Meinung nach mehr Wein gekauft?“

‘Two to you unfamiliar persons visit a wine merchant. Person A buys product A. Person B buys product B. Which of the two persons has bought more wine?’



properties product A:
name: *Rotwein*
manufacturer: *Aldi Süd*
price: *1.39 Euro*
alcoholic level: *10 % vol.*
rating from critics: *weak*
contents: *1.5 liter*



properties product B:
name: *Mouton Rothschild 1945*
manufacturer: *Château Mouton-Rothschild*
price: *22650 Euro*
alcoholic level: *12 % vol.*
rating from critics: *extraordinary*
contents: *0.75 Liter*

Experiment I: *Question 1 – Possible answers*

- Test subjects were asked to choose one of the following options:
 - Person A
 - Person B
 - None of both persons have bought more wine.
 - I can't decide
 - The question is meaningless
 - (optional), because: ...(free text)

Experiment I: *Question 1 – Possible answers*

- If a participant did choose a person, he or she was asked to check the properties relevant to her decision.
 - *„Ich habe mich für die eine Person entschieden, weil die folgenden Merkmale des von ihr erworbenen Produktes besser/größer sind als bei dem anderem Produkt: (Mehrfachnennungen möglich)“*

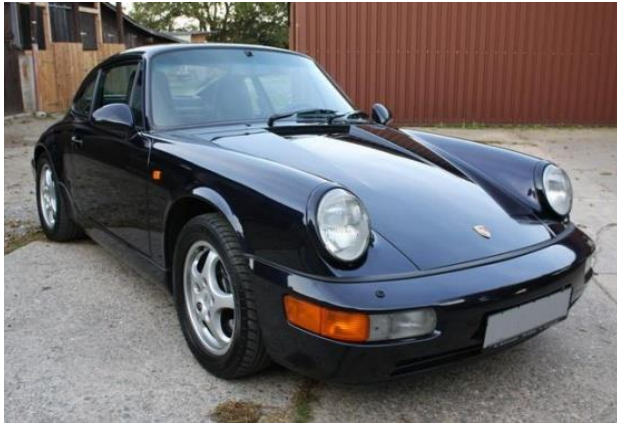
'I chose the checked person, because the following properties of the bought product of this person are better/bigger compared to the other product.
(multiple choices possible)'

- manufacturer
- price
- alcoholic level
- rating of critics
- contents
- overall impression of quality
- price-performance-ratio
- miscellaneous: ... (*free text*)
- no clue

Experiment I: *Question 2*

- *'Two to you unfamiliar persons visit a car merchant. Person A buys product A. Person B buys product B.'*

Which of the two persons has bought more car?'



properties product A:

name: Porsche C 964 C2
manufacturer: Porsche
price: 32980 Euro
mileage: 99814 km
registration date: 03/1993
engine output: 184 kW (250 PS)
weight: 1375 kg



properties product B:

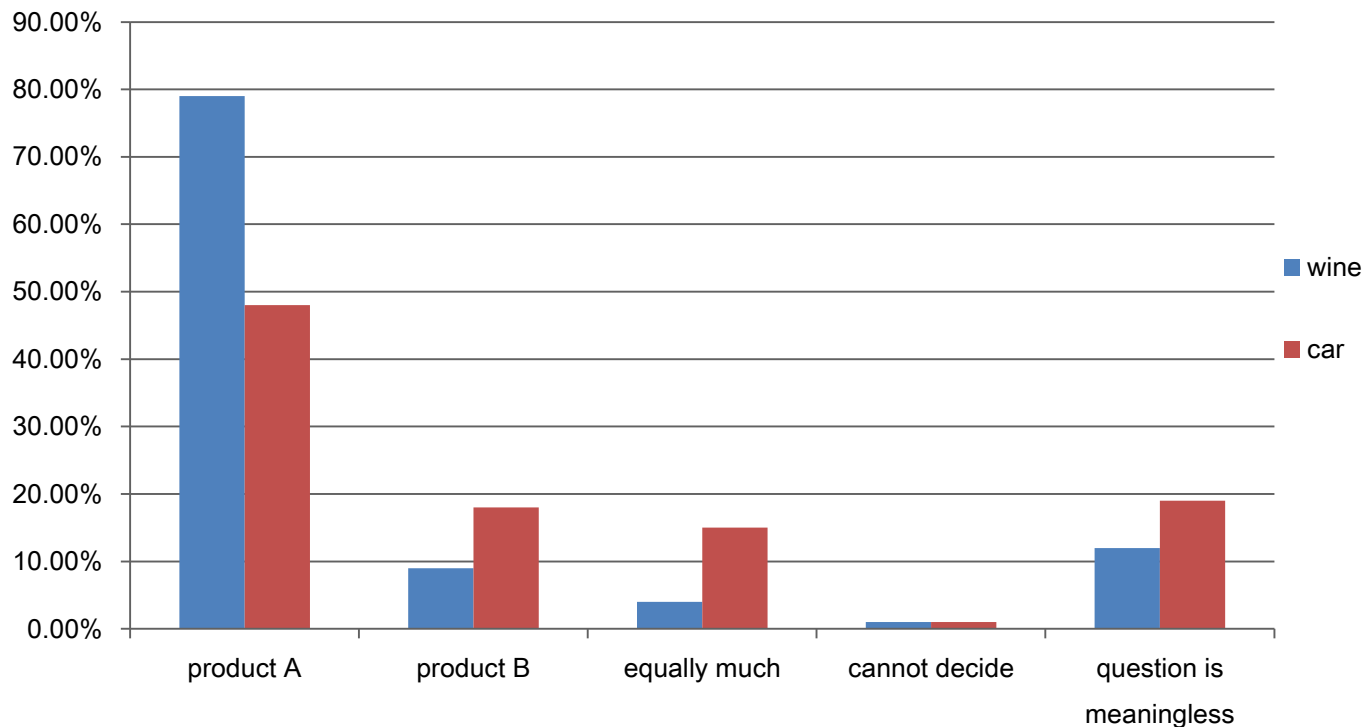
name : Volkswagen Transporter T4
manufacturer: Volkswagen
price: 2700 Euro
mileage: 245000 km
registration date: 04/1992
engine output: 57 kW (77 PS)
weight: 1700 kg

Experiment I: *Question 2 – Possible answers*

- Again, test subjects were asked to choose one of the following options:
 - Person A
 - Person B
 - None of both persons have bought more car.
 - I can't decide
 - The question is meaningless
 - (optional), because: ...(free text)
- *'I chose the checked person, because the following properties of the bought product of this person are better/bigger compared to the other product. (multiple choices possible)'*
 - manufacturer
 - price
 - mileage
 - engine output
 - weight
 - size
 - overall impression of quality
 - price-performance-ratio
 - miscellaneous: ... (*free text*)
 - no clue

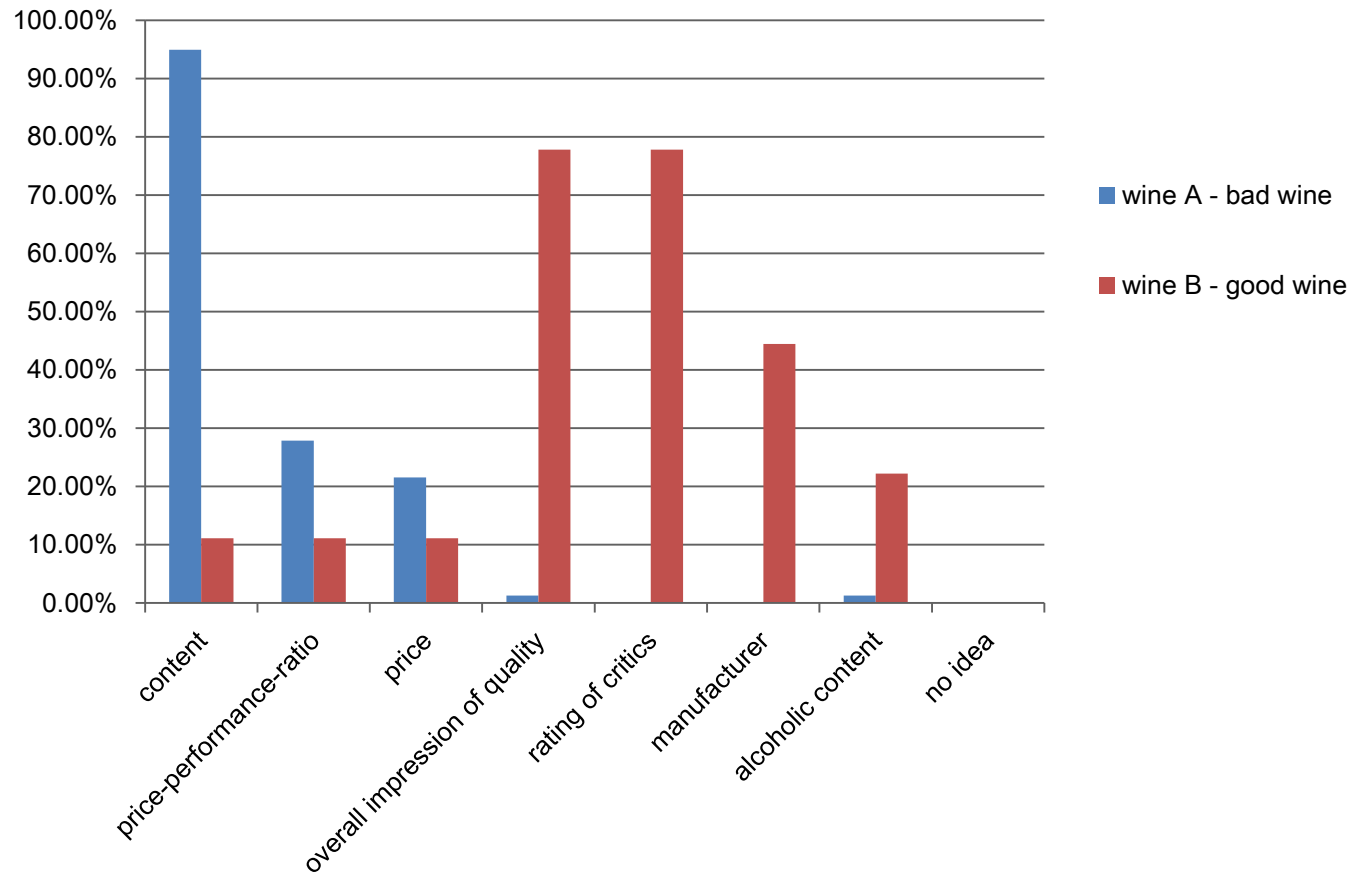
Experiment I: *Results (in short)*

- In case of *wine*:
 - The majority chose product A (bad wine), which is better in sense of *quantity*
- In case of *car*:
 - The majority chose product A (Porsche), which is better in sense of *quality*



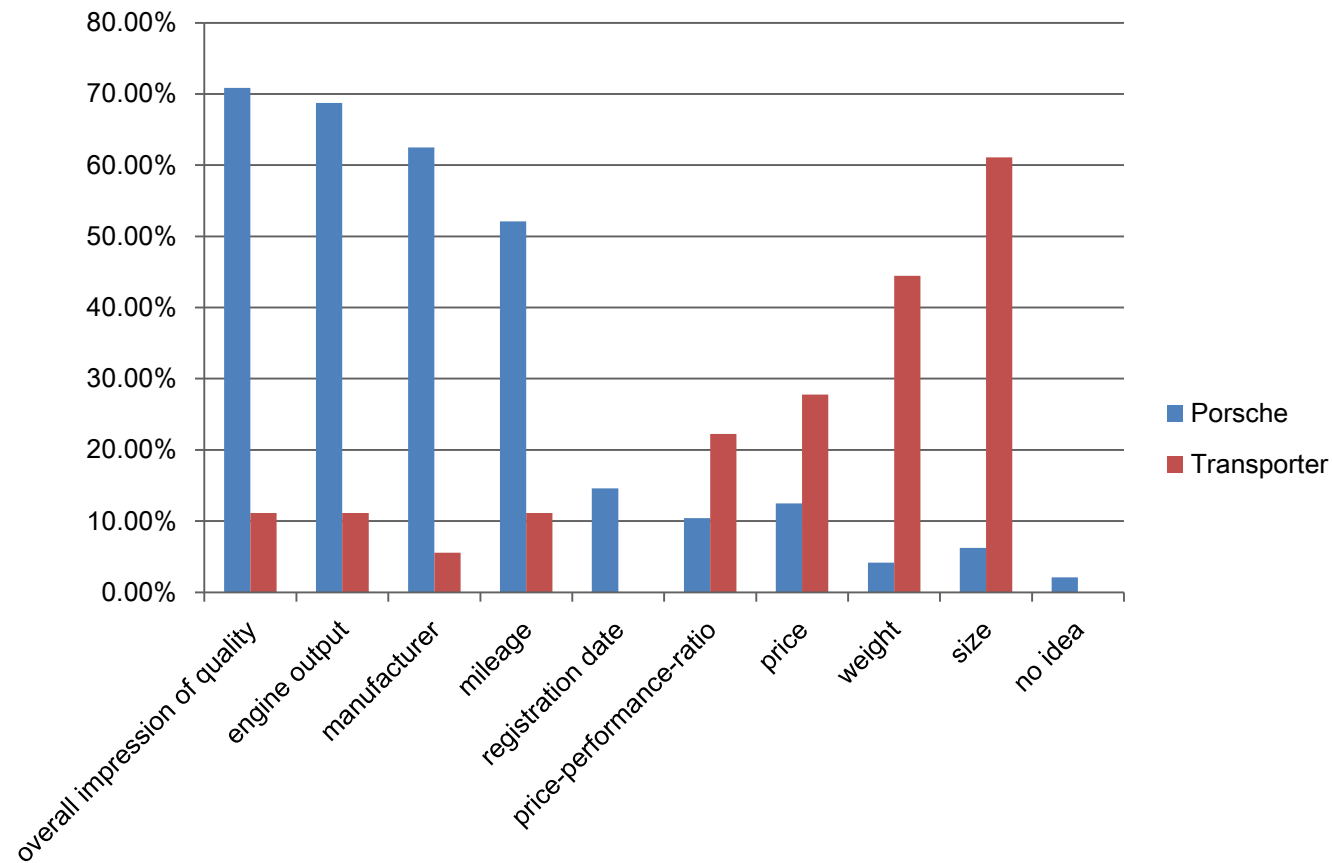
Experiment I: *Results (in short)*

- Detailed view on chosen properties in case of *wine*
 - chosen properties match with chosen product (properties are indeed better; no surprises here)



Experiment I: *Results (in short)*

- Detailed view on chosen properties in case of *car*
 - *price* is considered as a positive, but also as negative property sometimes (don't use it in future experiments!)



Experiment I: *Some remarks from participants*

- Some participants had quite a difficult time to judge question no. 2 (cars)
 - Did manual plural marking of *car* on questionnaire (“Spelling error correction”)
 - Interesting comments: (literally translated)
 - “car is car”;
 - “both have one functioning car”
 - “both have equal number of cars”
 - “you can’t buy more car, only more cars”
 - “for me a car is a car. There are no cars that are more car than other cars.”
 - ...many more similar statement
- Despite making these comments, most test subjects still chose the Porsche.

Midway conclusions

- Results contradict contextual-view
 - **Same context should establish same foundation for comparison, which is clearly not the case!**
- If a semantically countable noun is in uncountable syntax, two options exist
 - I. **no universal-grinder-context is established** (as seen in experiment I)
 - This means, there is no grinding machine implied/made up by recipient
 - comparison using *more* is based on quality, not quantity
 - I call it: *Ad writer-reading*
 - *Mehr Handy, weniger Gewicht* (advertisement slogan *O²*, 2011)
'More mobile phone, less weight'
 - We don't want bigger mobile phones! We want better mobile phones!
 - II. **universal-grinder-context is established** (the car is smashed by a giant machine)
 - noun is conceptualized as a mass-noun
 - comparison is based on mass or volume (as it is usually the case with mass-nouns)
 - However, not every countable noun is compatible with the universal-grinder
 - **see next experiment!**

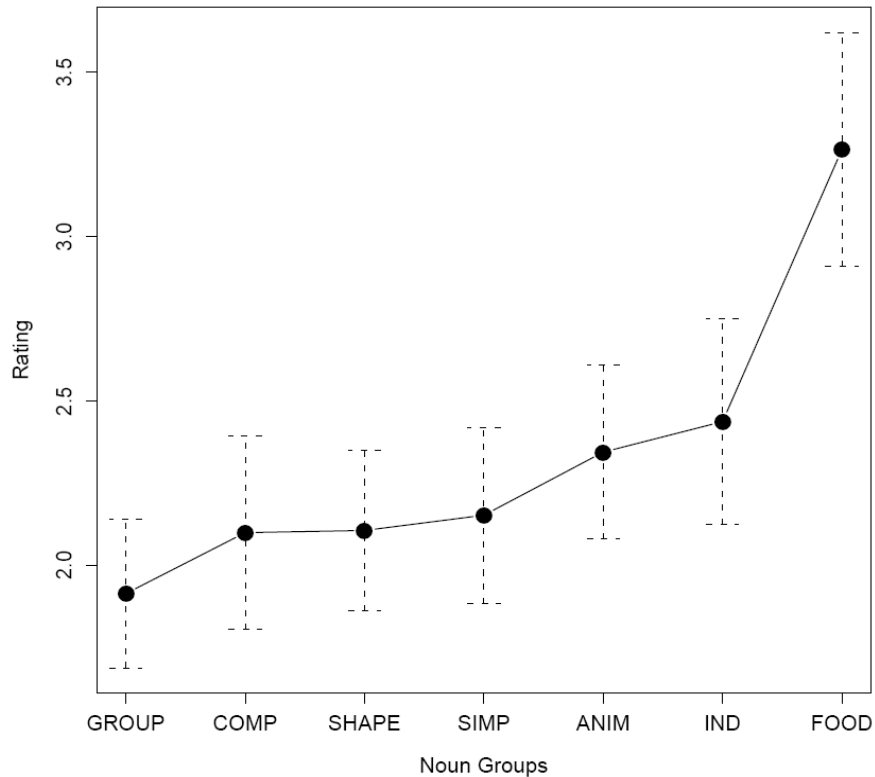
Experiment II: *The universal-grinder is not universal*

- The universal-grinder establishes a context in which an individuated entity gets transformed in some way to become mass:
 - *“Aliens arrive from outer space and lift up a pyramid with a tractor beam. Using their giant disruptor, they disintegrate the pyramid and disperse it all over the desert.”*
 - ⇒ *There is pyramid all over the desert!*
- Given the right context, many count-nouns can derive a mass-reading.
- However, without a proper background story some sentences get quite odd
 - *?Astrid has more shoe than Antje.*
 - **Björn has more symptom than Gregor.*
- If the noun does not get ground, we do not know the mode of measurement
 - maybe some quality of the shoe/symptom, but which one?

Experiment II: *The universal-grinder is not universal*

- Nouns describing food are most acceptable in grinder-context
 - but still get lower ratings than filler sentences (mean 5,67 (SD 1,84))

Plot of Means



“There is *deer* all over the highway”

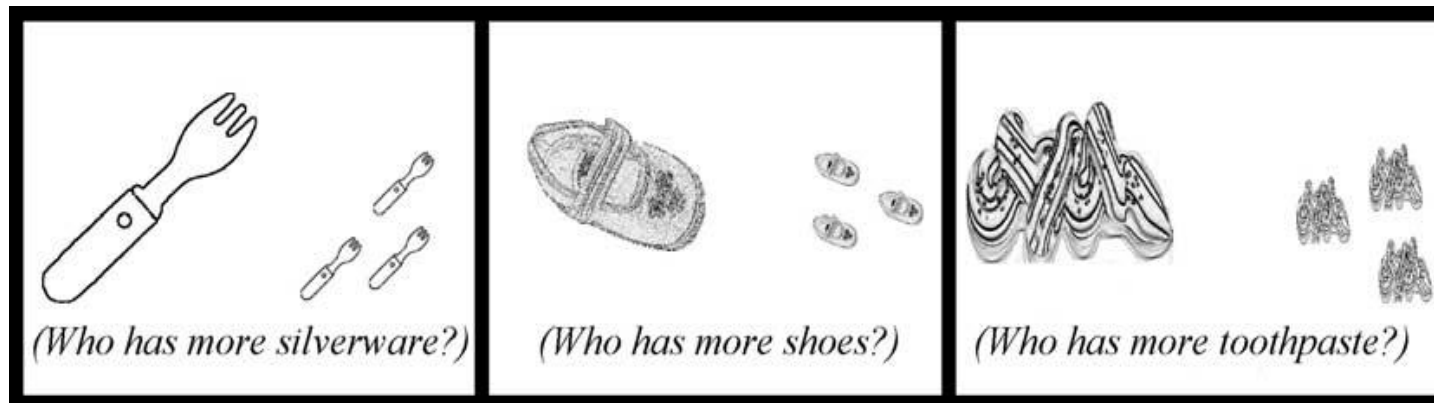
vs.

“There is *toaster* all over the kitchen”

(Grimm et al., 2010)

Experiment III: *Substance- and object-mass*

- Experiment by Barner and Snedeker (2004) show differences in mode of measurement of substance-mass and object-mass nouns (aggregated nouns)
- Both types can appear in uncountable syntax
- But huge difference in semantics
 - object-mass-nouns (*silverware*)
 - comparison is based on number
 - substance-mass-nouns (*wine, fear*)
 - comparison is **not** based on number



(Barner and Snedeker, 2004)

Second annotation-iteration

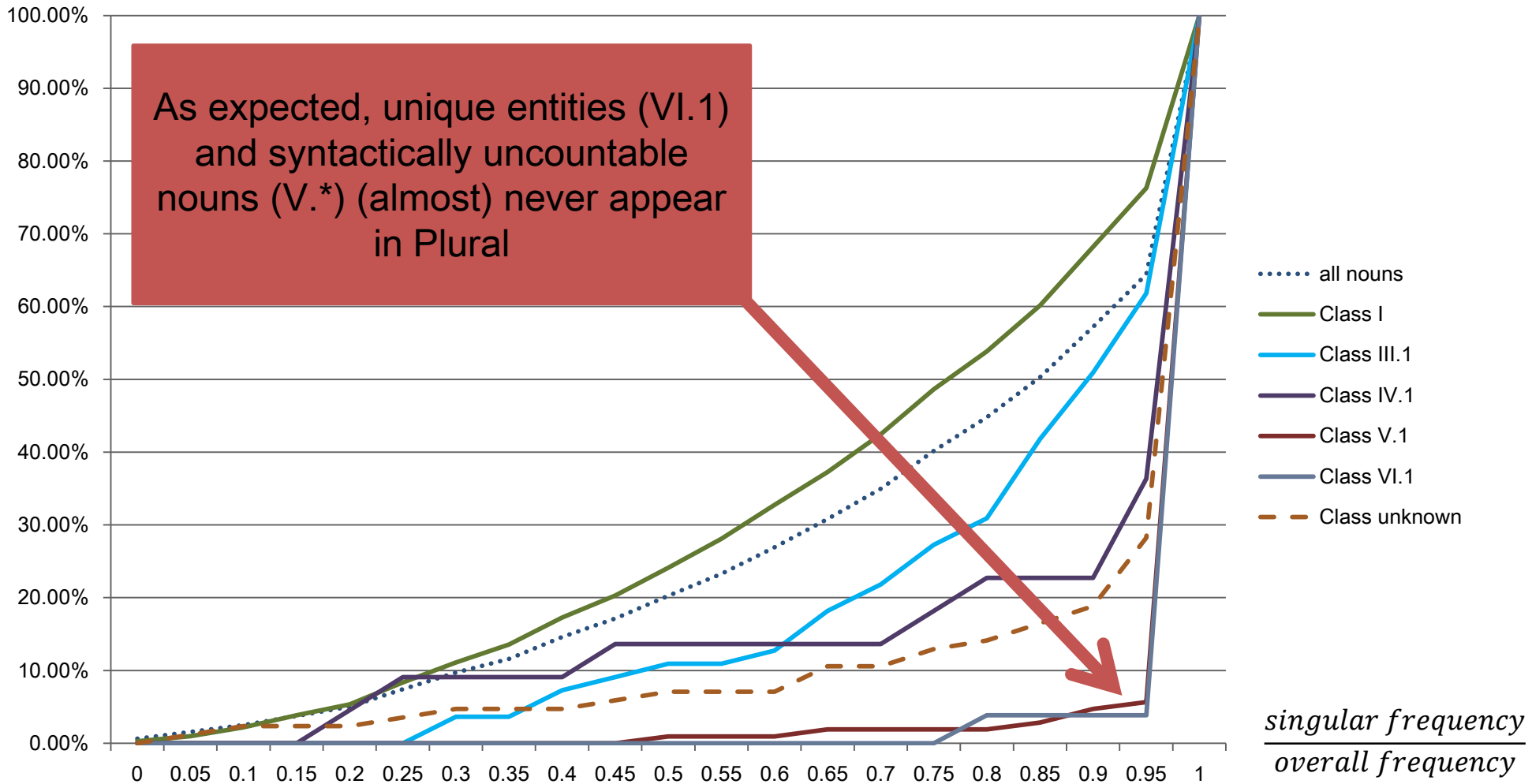
- 1100 German nouns were annotated using the described tests
- After analyzing the annotated data and also considering some countability classes, which were not present in the annotated data (e.g. *bipartite nouns*)
 - **six**
 - At first, proper nouns have been excluded, which was a mistake in my opinion! They should be classified using the tests, like every other noun!
- This results in different test outcomes
- Of 1100 nouns
 - 55 were discarded (FM, NE, only in specific context usable (*auf Pump*), etc.)
 - 960 (91,9%) have been classified
 - 85 (8,1%) did not fit into the categories
 - (more numbers/statistics later on)

Does the annotation make sense? – *Some numbers*

| Second annotation-iteration | | First annotation-iteration | | Difference |
|-----------------------------|-------------|----------------------------|--------------|------------|
| Countability class | Frequency | Countability class | Frequency | |
| I | 732 (76,2%) | countable | 5721 (70,7%) | +5,5% |
| II.2 | 4 (0,4%) | Plural only | 104 (1,3%) | -0,9% |
| III.1 | 55 (5,7%) | Dual-Life | 386 (4,8%) | +1,4% |
| III.2 | 5 (0,5%) | | | |
| IV.1 | 22 (2,3%) | uncountable | 1881 (23,2%) | -6,1% |
| IV.2 | 0 (0%) | | | |
| V.1 | 106 (11,1%) | | | |
| V.2 | 5 (0,5%) | | | |
| VI.1 | 26 (2,7%) | | | |
| VI.2 | 5 (0,5%) | | | |
| Σ | 960 (100%) | | | |

- Observed countability class frequencies could be completely arbitrary
 - (the annotator just could have used a dice)
- But certain statistical forecasts concerning specific classes can be made and tested in a larger corpus
 - Ratio of appearance in singular and plural
 - Frequency of appearance with indefinite article

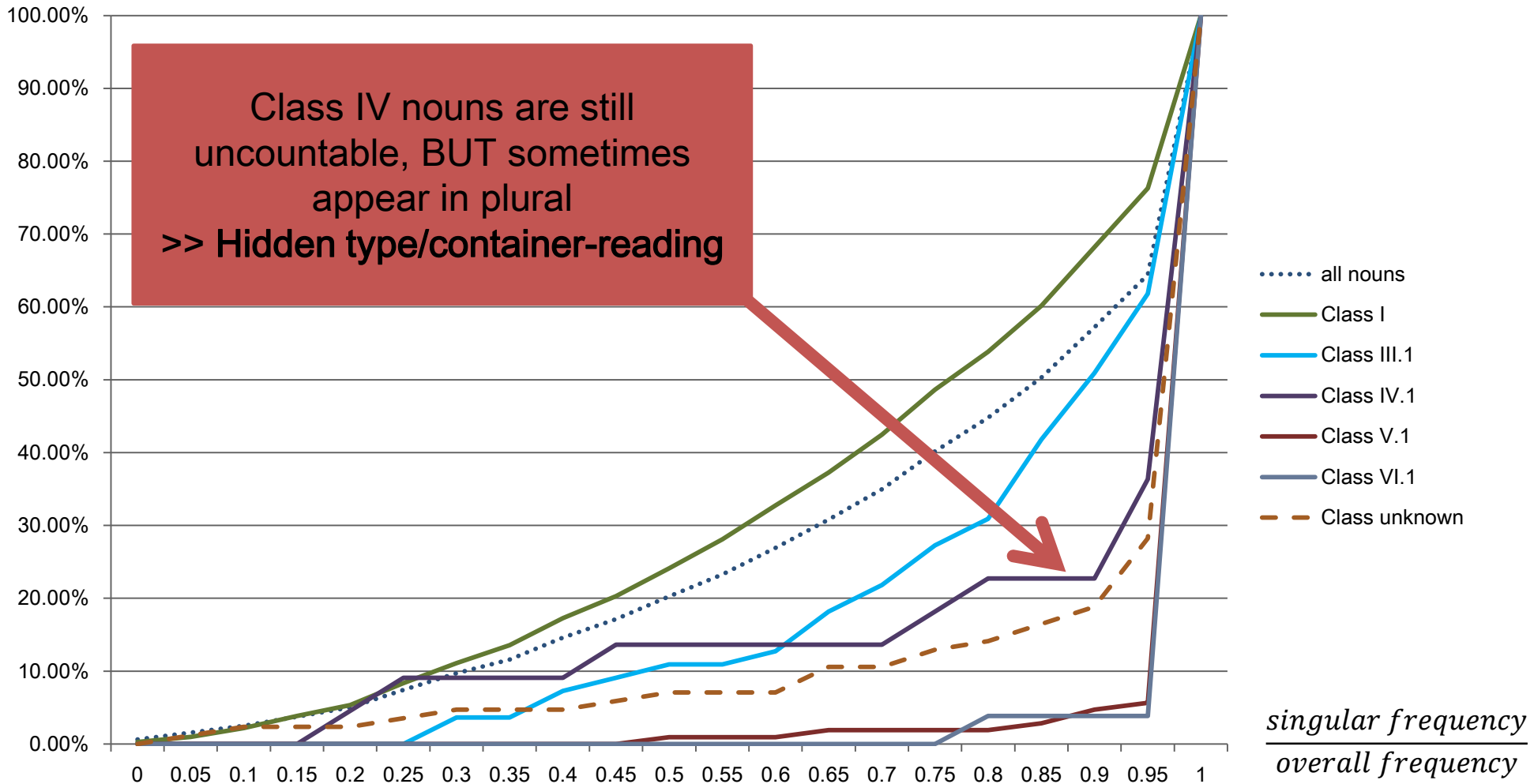
Does the annotation make sense? – Number distribution



Cumulative frequencies of ratio of singular and overall appearances of nouns

Number-tagging done with SMOR (Schmid et al., 2004), Corpus: *Neue Zürcher Zeitung* (230 mio. Token)

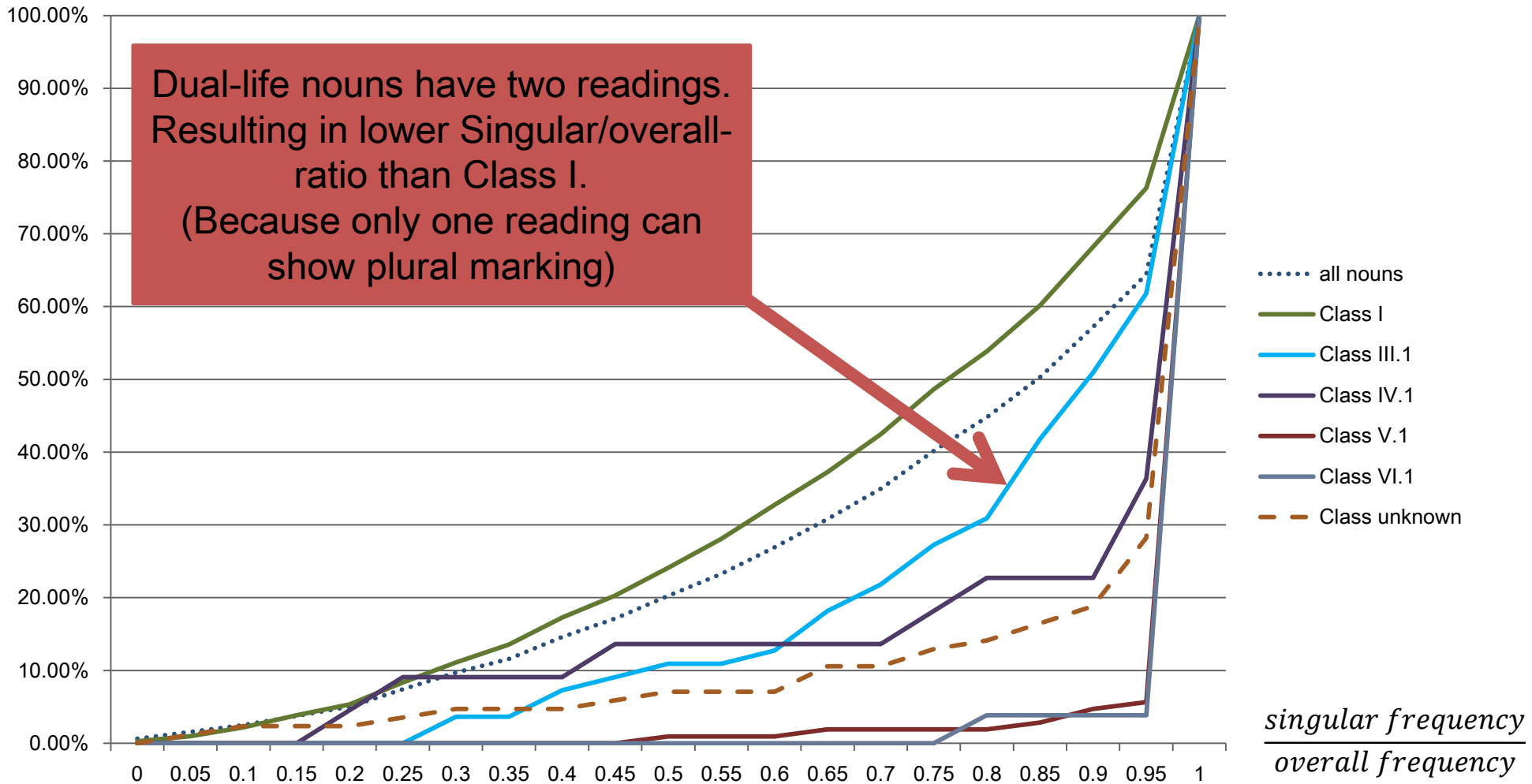
Does the annotation make sense? – Number distribution



Cumulative frequencies of ratio of singular and overall appearances of nouns

Number-tagging done with SMOR (Schmid et al., 2004), Corpus: *Neue Zürcher Zeitung* (230 mio. Token)

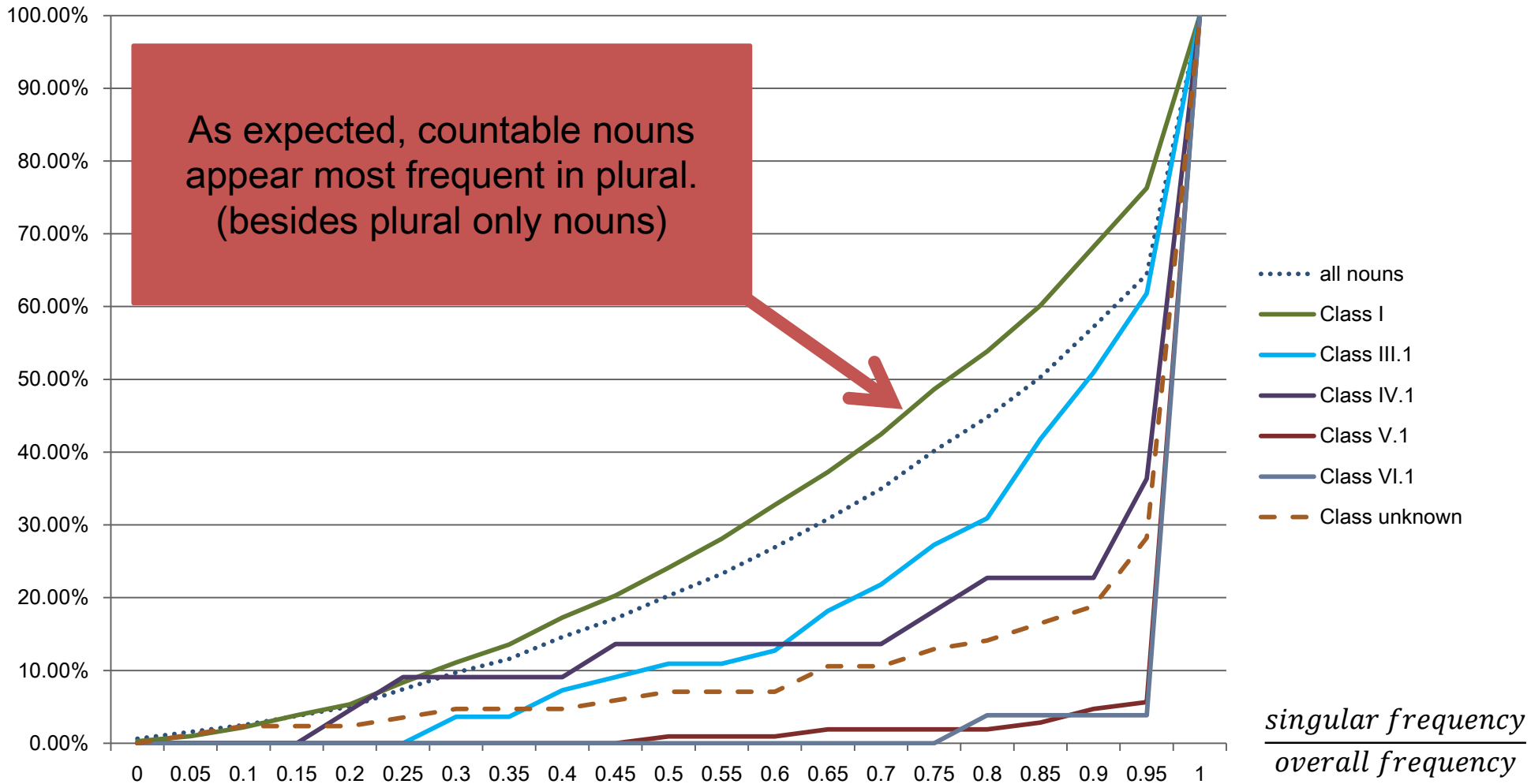
Does the annotation make sense? – Number distribution



Cumulative frequencies of ratio of singular and overall appearances of nouns

Number-tagging done with SMOR (Schmid et al., 2004), Corpus: *Neue Zürcher Zeitung* (230 mio. Token)

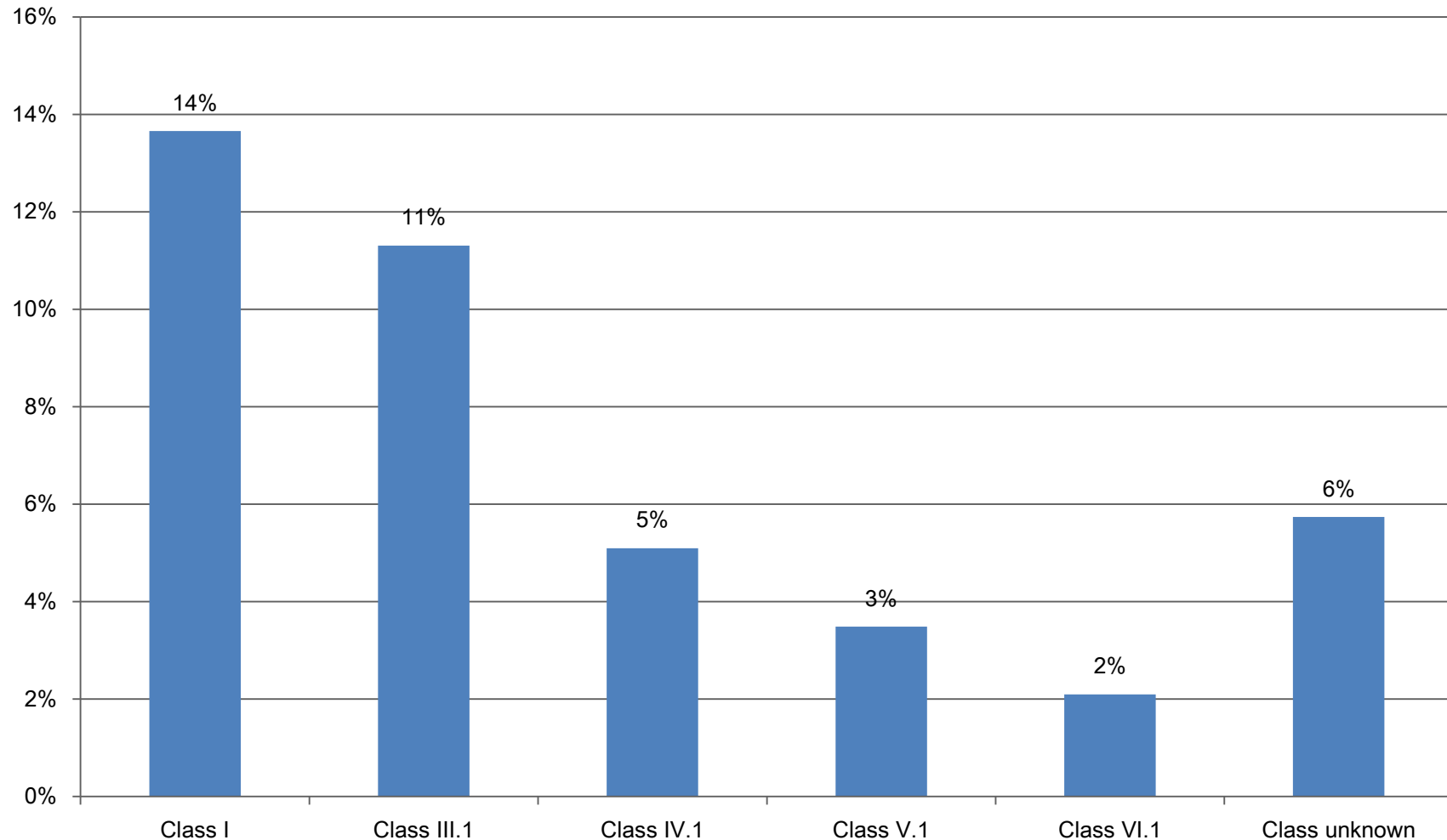
Does the annotation make sense? – *Number distribution*



Cumulative frequencies of ratio of singular and overall appearances of nouns

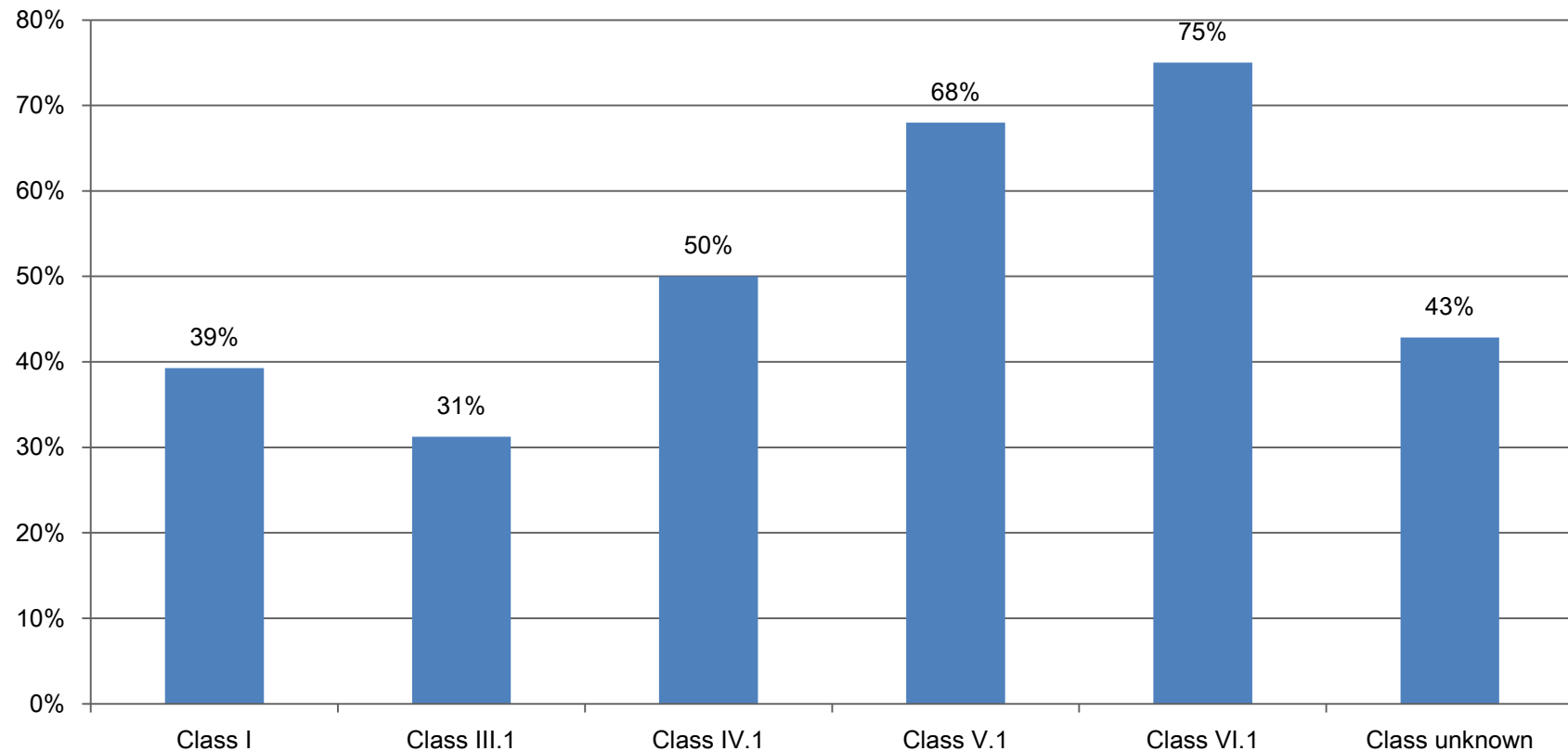
Number-tagging done with SMOR (Schmid et al., 2004), Corpus: *Neue Zürcher Zeitung* (230 mio. Token)

Does the annotation make sense? – *Indefinite article distribution*



Occurrence of a noun with an indefinite article when in singular (median)

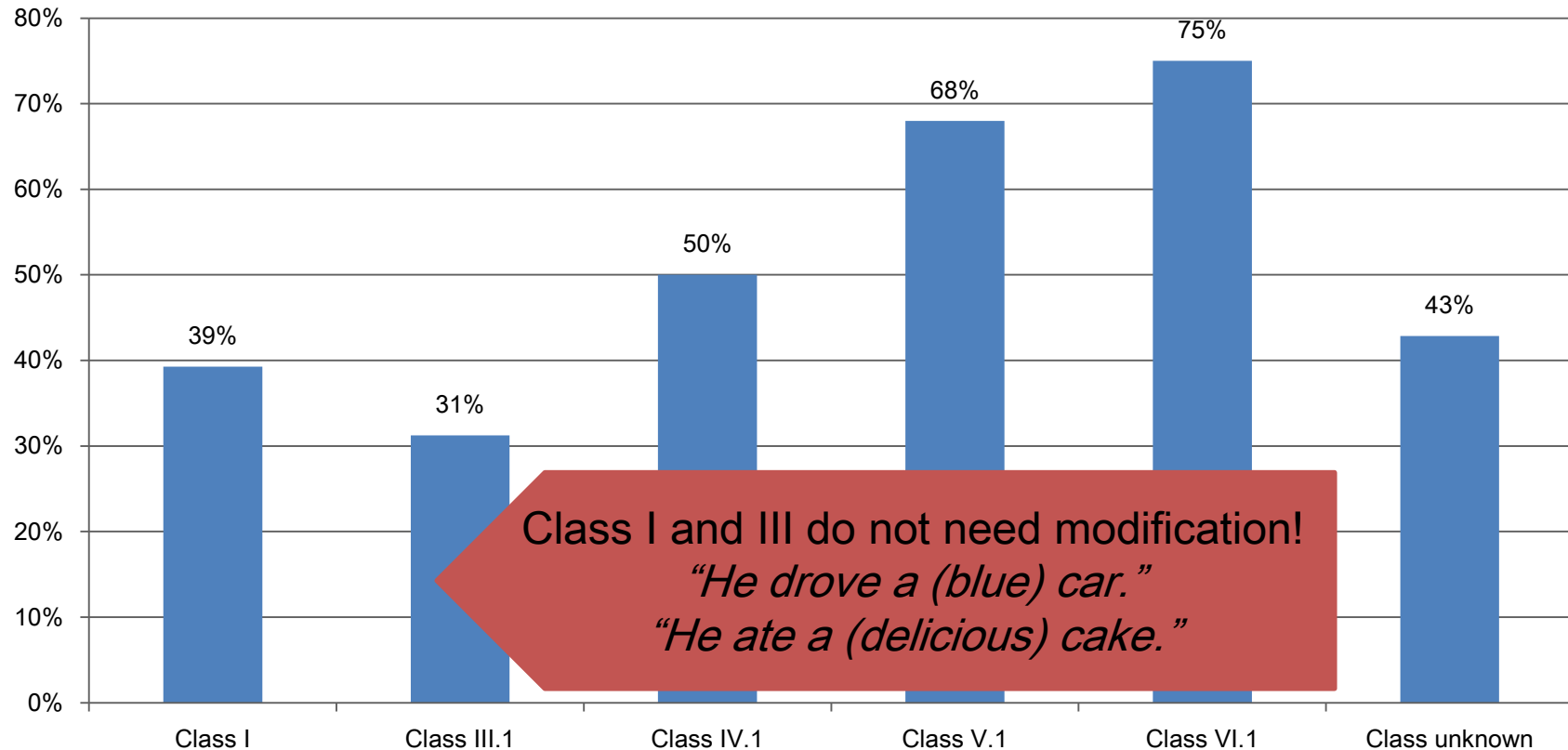
Does the annotation make sense? – *Indefinite article & ADJA*



Occurrence of an attributive adjective, if noun occurs with an indefinite article

- Attributive adjectives are not the only way to modify a noun.
 - But modification through relative clauses and PPs are not that simple to identify!

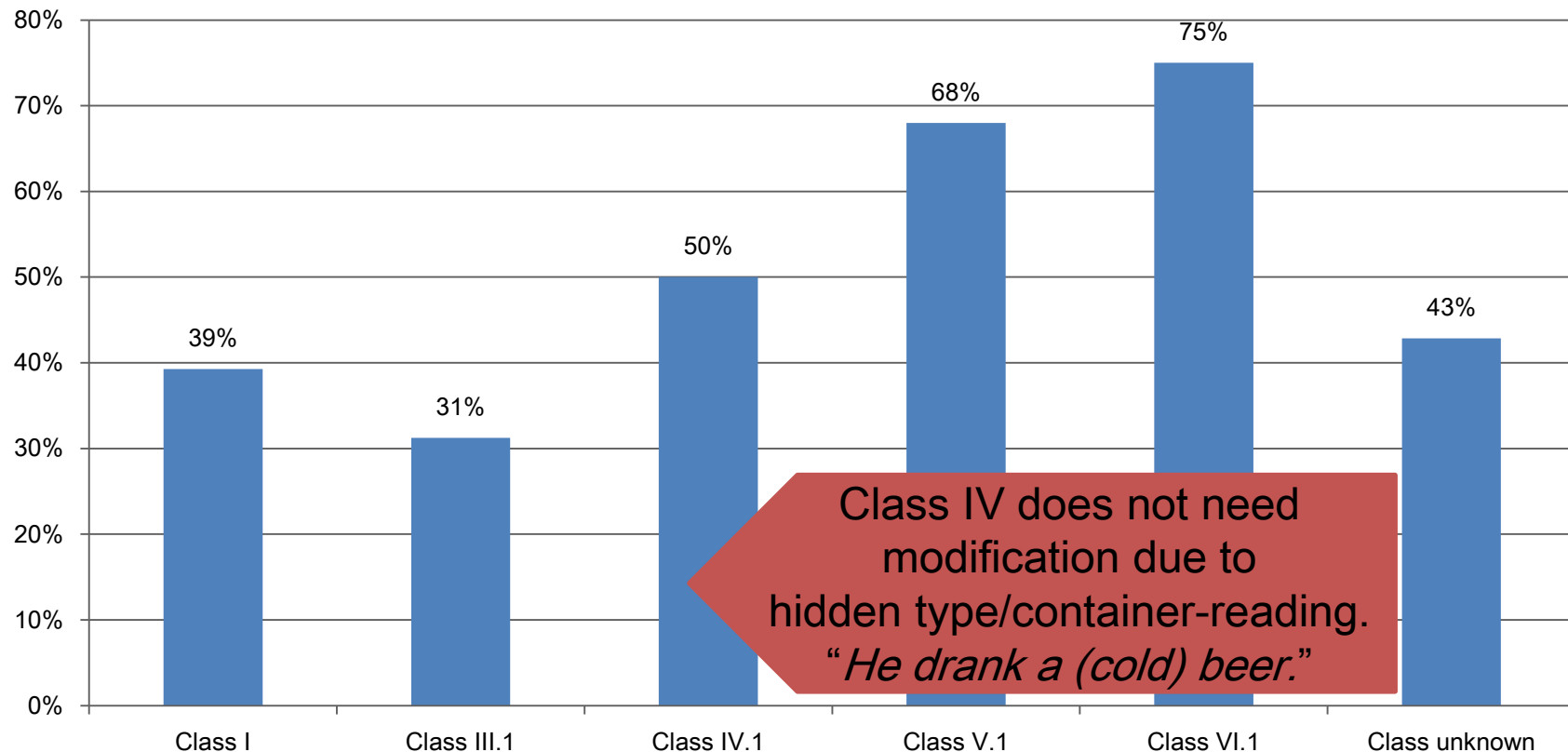
Does the annotation make sense? – *Indefinite article & ADJA*



Occurrences of an attributive adjective, if nouns/classes occur with an indefinite article

- Attributive adjectives are not the only way to modify a noun.
 - But modification through relative clauses and PPs are not that simple to identify!

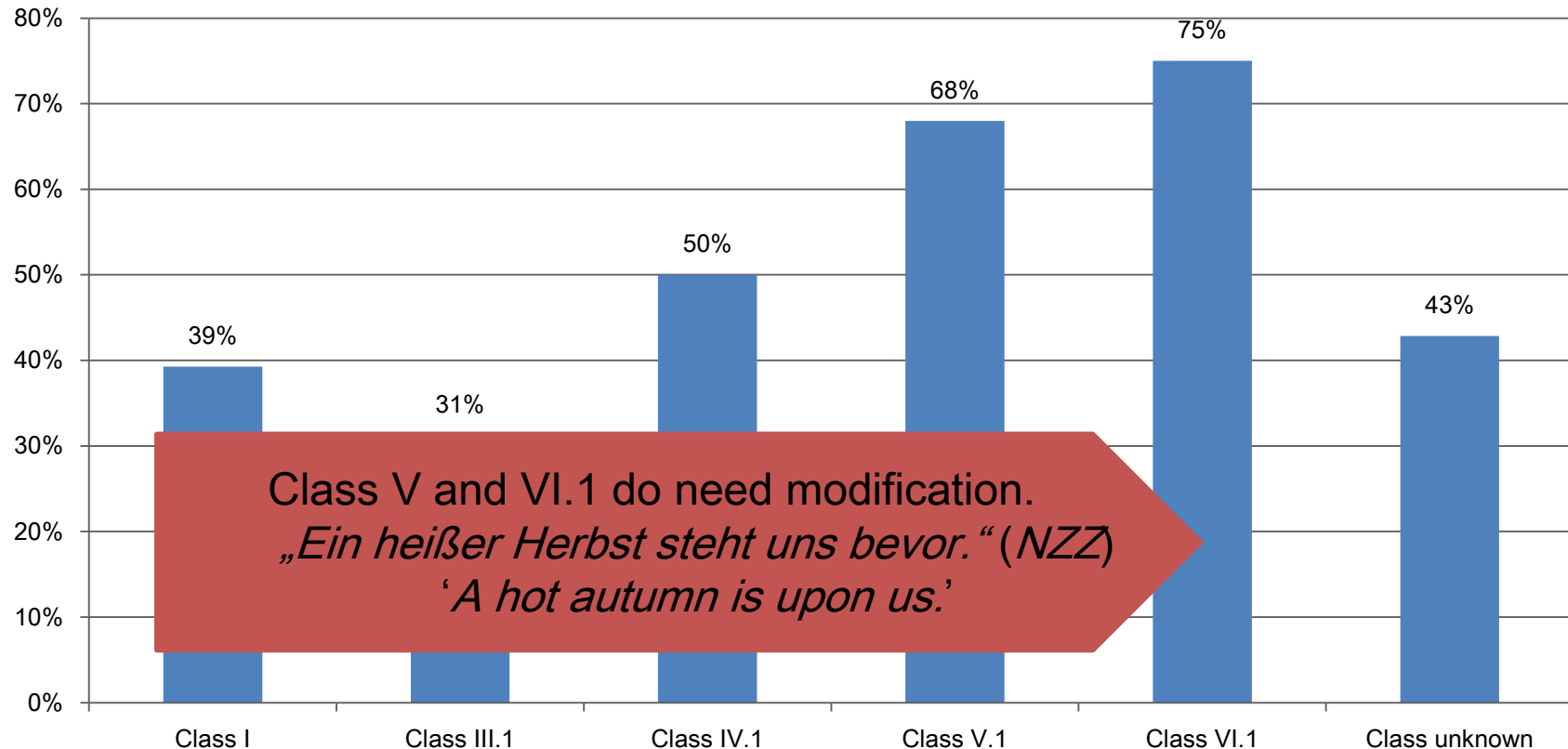
Does the annotation make sense? – *Indefinite article & ADJA*



Occurrences of an attributive adjective, if nouns/classes occur with an indefinite article

- Attributive adjectives are not the only way to modify a noun.
 - But modification through relative clauses and PPs are not that simple to identify!

Does the annotation make sense? – Indefinite article & ADJA



Occurrences of an attributive adjective, if nouns/classes occur with an indefinite article

- Attributive adjectives are not the only way to modify a noun.
 - But modification through relative clauses and PPs are not that simple to identify!

Remaining Problems – *Nominalizations*

- Many of the unclassified nouns are nominalizations
 - especially *-ung, -heit, -keit*
- Some nominalizations allow predicting the countability class.
 - See also Werner (2009)
 - More data is needed to get more conclusive evidence!

| Suffix (Genus) | Sum | Class unknown | Class I | Class III | Class IV | Class V | Class VI |
|----------------|-----|---------------|----------|-----------|----------|---------|----------|
| -ung (fem) | 111 | 17 (15%) | 78 (70%) | 8 (7%) | 0 (0%) | 8 (7%) | 0 (0%) |
| -er (masc) | 57 | 0 (0%) | 53 (93%) | 2 (4%) | 0 (0%) | 2 (4%) | 0 (0%) |
| -tion (fem) | 24 | 3 (13%) | 15 (63%) | 5 (21%) | 0 (0%) | 1 (4%) | 0 (0%) |
| -heit (fem) | 19 | 6 (32%) | 3 (16%) | 3 (16%) | 1 (5%) | 6 (32%) | 0 (0%) |
| -keit (fem) | 14 | 4 (29%) | 1 (7%) | 1 (7%) | 0 (0%) | 8 (57%) | 0 (0%) |
| -er (neut) | 12 | 0 (0%) | 6 (50%) | 0 (0%) | 1 (8%) | 4 (33%) | 1 (8%) |
| -en (neut) | 11 | 2 (18%) | 5 (45%) | 2 (18%) | 0 (0%) | 1 (9%) | 1 (9%) |
| -er (fem) | 10 | 1 (10%) | 9 (90%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| -ismus (masc) | 10 | 1 (10%) | 1 (10%) | 0 (0%) | 4 (40%) | 4 (40%) | 0 (0%) |
| -schaft (fem) | 9 | 3 (33%) | 5 (56%) | 0 (0%) | 0 (0%) | 1 (11%) | 0 (0%) |
| -en (masc) | 8 | 1 (13%) | 5 (63%) | 2 (25%) | 0 (0%) | 0 (0%) | 0 (0%) |

FORM and SUBSTANCE of concepts

| | Heroin (<i>heroin</i>) Class (V) | Bier (<i>beer</i>) (Class IV) | Stein (<i>stone</i>) (Class III) | Auto (<i>car</i>) (Class I) | Kreis (<i>circle</i>) (Class I) |
|--|---|------------------------------------|---|--|--------------------------------------|
| SUBSTANCE: (core properties) | half synthetic opioid, highly addictive (...) | contains alcohol, liquid, (...) | mineral mass, solid state of matter (...) | metal, composites, (...) | ∅ |
| FORM: | | | | | |
| internal instantiating properties | ∅ | ∅ | optional in singular: diameter >= 63mm, no solid contact to surrounding rocks (...) (inspired by DIN 4022 - grain size classification) | prototypical form of auto body, (fit to drive) (...) | circular |
| external implicit classifiers | ∅ | types or containers | ∅ | ∅ | ∅ |

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No plural possible, due to lack of internal form or hidden classifier.
With indefinite article only compatible if additional property is established.
External classifier always possible (valid for all classes):

“*There are numerous kinds of heroin.*”

FORM and SUBSTANCE of concepts

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Plural/indefinite article possible with implicit classifier.
 “There are several Canadian beers I would like to taste.”
 “several types/kinds of beer...”

FORM and SUBSTANCE of concepts

| | Heroin (<i>heroin</i>) Class (V) | Bier (<i>beer</i>) (Class IV) | Stein (<i>stone</i>) (Class III) | Auto (<i>car</i>) (Class I) | Kreis (<i>circle</i>) (Class I) |
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| external implicit classifiers | ∅ | types or containers | ∅ | ∅ | ∅ |

In singular, conceptualizing form is optional.

In plural, no implicit classifier is possible.

Two fishes always means two instances, never two sorts/container of fish.

FORM and SUBSTANCE of concepts

| | Heroin (<i>heroin</i>) Class (V) | Bier (<i>beer</i>) (Class IV) | Stein (<i>stone</i>) (Class III) | Auto (<i>car</i>) (Class I) | Kreis (<i>circle</i>) (Class I) |
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| external implicit classifiers | ∅ | types or containers | ∅ | ∅ | ∅ |

If grinded, FORM is eliminated.

“There is car all over the street.”

-> no longer fit to drive nor is form of auto body conceptualized.

FORM and SUBSTANCE of concepts

| | Heroin (<i>heroin</i>) Class (V) | Bier (<i>beer</i>) (Class IV) | Stein (<i>stone</i>) (Class III) | Auto (<i>car</i>) (Class I) | Kreis (<i>circle</i>) (Class I) |
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Shapes received were bad judgments during experiment II.
No grinding possible, because FORM is only property!

Automatic countability classification with MLR

- *Multinomial logistic regression* (MLR) is used to predict countability class
 - A (countability) class is chosen as frame of reference
 - Class I in our case (fully countable)
 - All other classes are checked whether they are more likely than class I
- Simplifying possible classification outcomes
 - Only six instead of 13 categories
 - Class I (fully countable)
 - Class II* (includes all nouns of classes II.1, II.2, II.3 and VI.2)
 - Class III (dual-life nouns, no subcategorization of substance-mass and object-mass)
 - Class IV (uncountable with hidden classifier, no sub-groups)
 - Class V (uncountable with our hidden classifier, no sub-groups)
 - Class VI.1 (unique entities)
- Many features extracted from corpus for all nouns
 - Def./indef. art (with/without ADJA), numerals, quantifiers, classifier constructions, number-ratio, gender, suffixes and many more...

Automatic countability classification with MLR

SOME VODOO/TECHNICAL STUFF... 😊

Automatic countability classification with MLR

- Overall MLR performs best
- But fully automatic classification is not an option if one wants to create larger lexicon

| Classifier | Precision | Recall | F-score |
|--|-----------|--------|---------|
| ZeroR _(WEKA) /Baseline | 58,1% | 76,3% | 66,0% |
| NaiveBayes _(WEKA) | 75,5% | 65,7% | 69,3% |
| J48 _(WEKA) | 75,3% | 78,3% | 76,6% |
| RandomForest _(WEKA) | 76,1% | 81,3% | 77,8% |
| SimpleLogistic _(WEKA) | 76,7% | 82,0% | 78,0% |
| Logistic _(WEKA) | 76,1% | 80,7% | 78,0% |
| BayesNet _(WEKA) | 77,5% | 80,9% | 78,9% |
| Multinomial Logistic _(SPSS) | 77,7% | 83,4% | 80,5% |

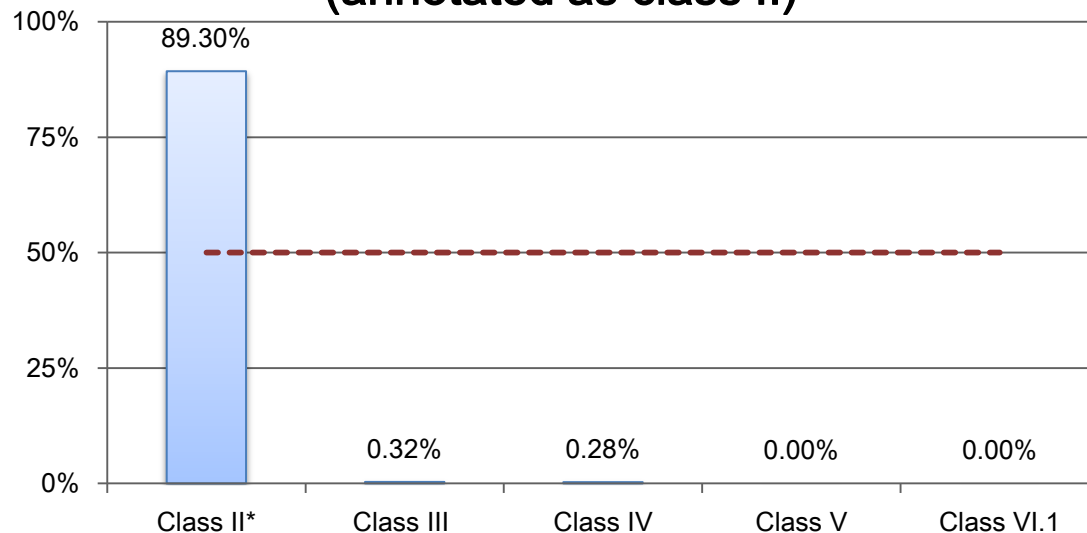
⇒ Combine automatic and manual annotation

- Calculated class probabilities can be helpful for manual annotation

Automatic countability classification with MLR

- Probability that noun is class II (plural only) vs. probability that noun is class I is 90% vs. 10%
 - Probability of noun being class III, IV, V or VI.1 vs. class I is almost zero!
- Nouns only appearing in plural are always classified correctly.
 - Singular/overall-ratio is obviously best predicting feature

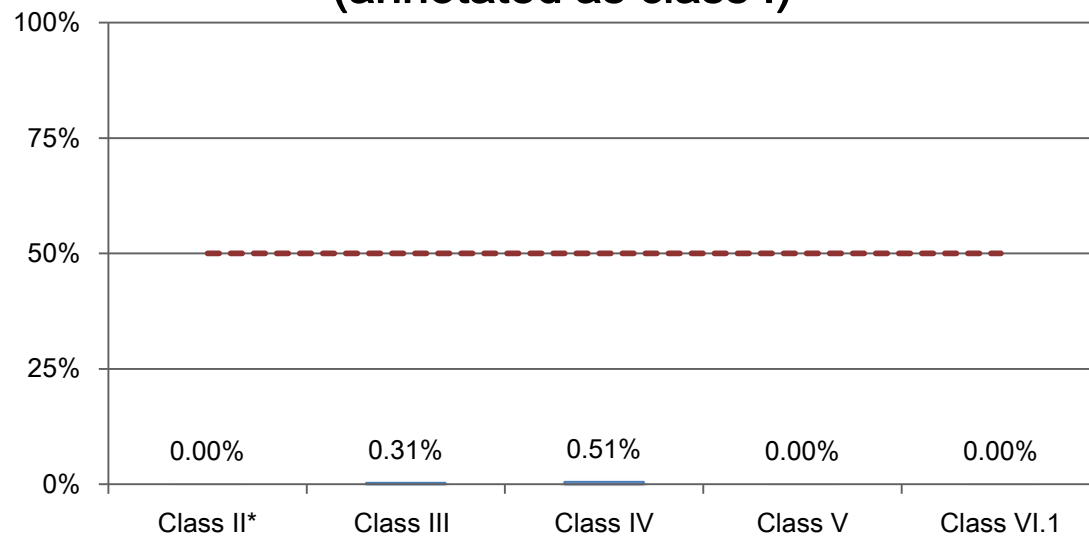
Wechseljahr ('menopause') (annotated as class II)



Automatic countability classification with MLR

- Clear evidence towards class I

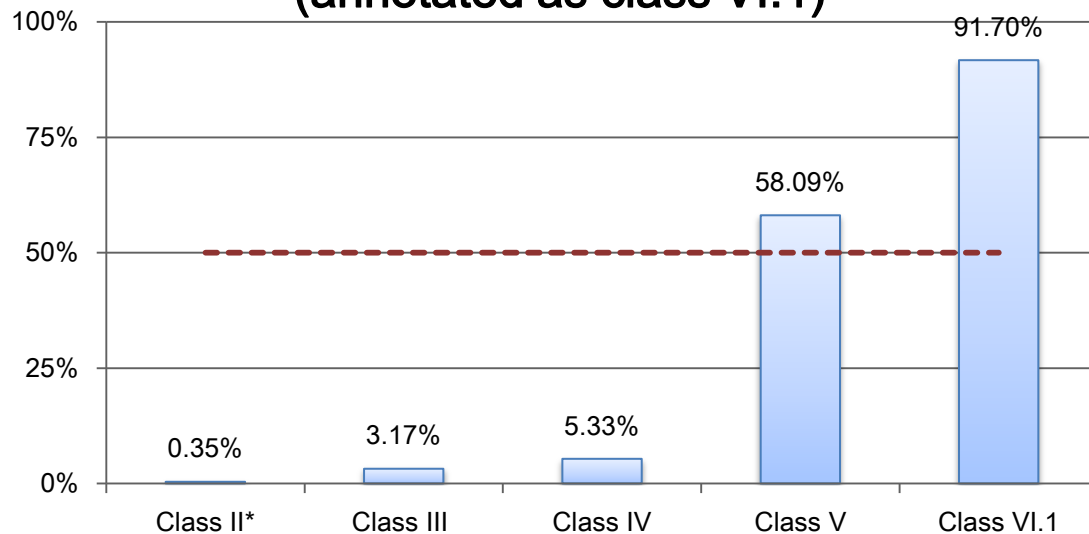
Nachbarstaat ('neighboring state') (annotated as class I)



Automatic countability classification with MLR

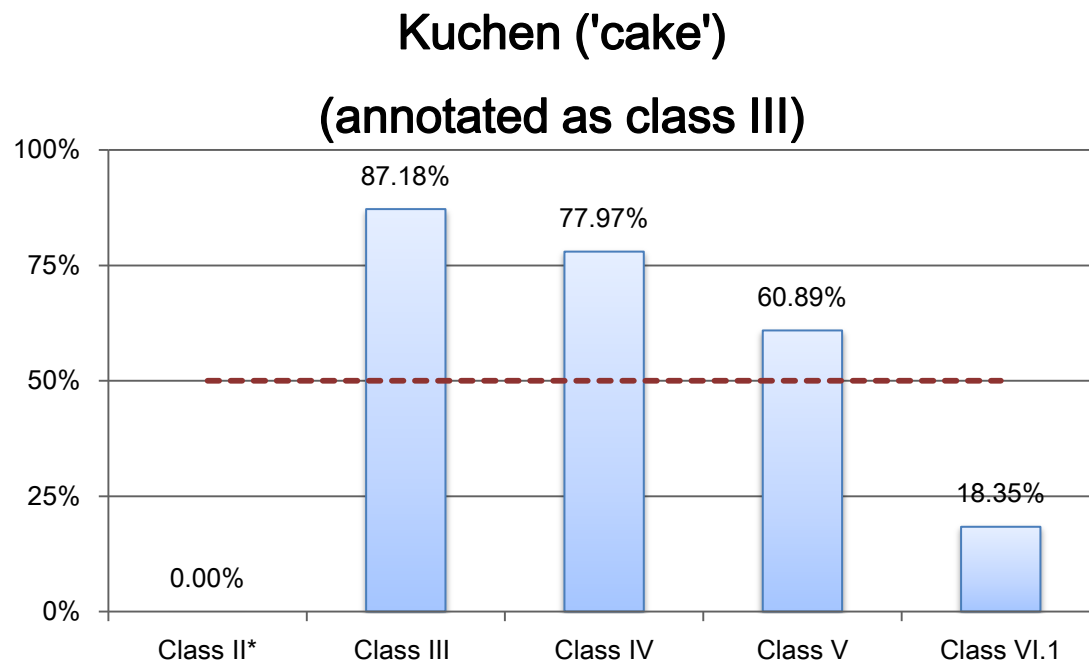
- Again, a quite distinct classification outcome!
- Class VI.1 and V share a great deal of resemblance
 - Usually not with indefinite article, no numerals, etc.

Kriegsrecht ('martial law') (annotated as class VI.1)



Automatic countability classification with MLR

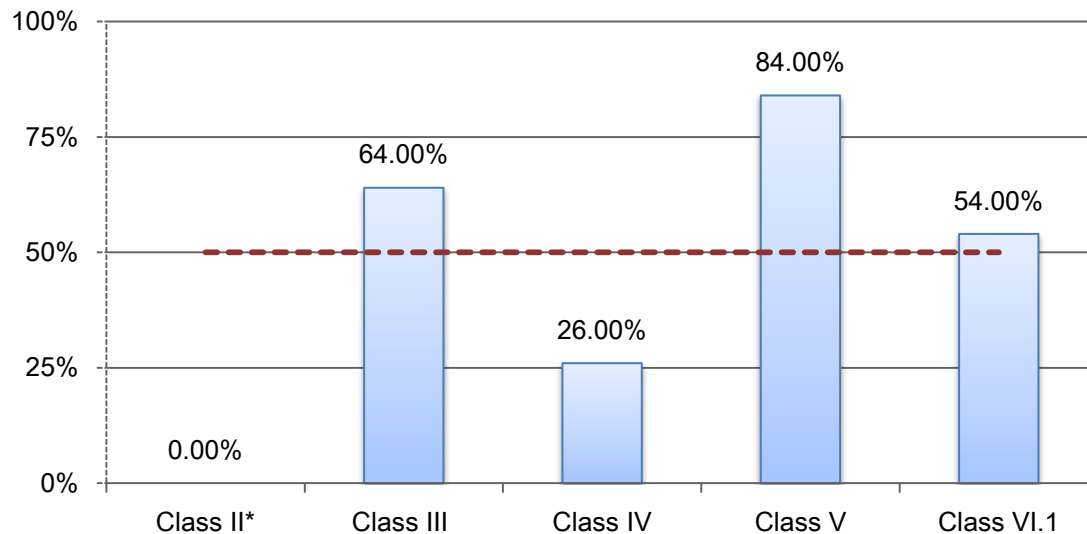
- Not always the picture is as pretty as this one
 - Especially class III nouns share a great resemblance with classes IV and V (due to the optional uncountable concept of class III nouns)
 - In many cases, the probabilities then are very close to each other



Automatic countability classification with MLR

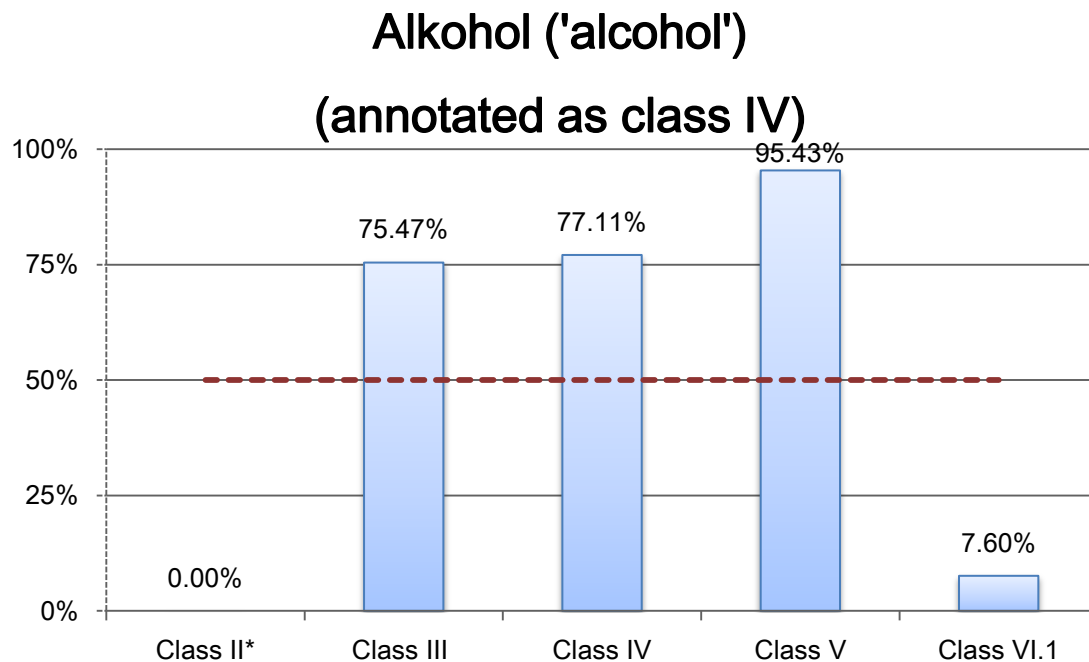
- MLR can disqualify certain classes for afterwards manual annotation
 - Classes I, II and IV are highly unlikely
 - Corpus evidence points towards mass-reading (Class V or III)
 - With more evidence in corpus of countable usage, class III becomes more likely
 - Final decision remains open to annotator

Bedeutungslosigkeit ('meaninglessness') (annotated as class III)



Automatic countability classification with MLR

- There seems to be strong corpus evidence to classify *alcohol* as a noun with at least an uncountable reading.
 - Overall most probable class is class V
 - BUT: Due to usage in plural, classifier also points towards classes III and IV!
 - Further decision is to be made by human annotator



Automatic countability classification with MLR

- If manual and automatic annotation contradict each other
 - Noun may be candidate for re-annotation by second annotator

Substanz ('substance') (annotated as class I)

