Corpus Linguistics: Inter-Annotator Agreements

Karën Fort

December 15, 2011
Sources

Most of this course is largely inspired by:

- **THE reference article**: *Inter-Coder Agreement for Computational Linguistics* [Artstein and Poesio, 2008]
- Massimo Poesio’s presentation at LREC on the same subject
- Gemma Boleda and Stefan Evert’s course on the same subject (ESSLLI 2009) [http://esslli2009.labri.fr/course.php?id=103]
- Cyril Grouin’s course on the measures used in evaluation protocols [http://perso.limsi.fr/grouin/inalco/1011/]
Crucial issue: **Are the annotations correct?**

- ML learns to make same mistakes as human annotator (noise ≠ patterns in errors [Reidsma and Carletta, 2008])
- Misleading evaluation
- Inconclusive and misleading results from linguistic analysis and hand-crafted systems
We are interested in the **validity** of the manual annotation

- i.e. whether the annotated categories are correct

But there is no “ground truth”

- Linguistic categories are determined by human judgment
- Consequence: we cannot measure correctness directly

Instead measure **reliability** of annotation

- i.e. whether human annotators consistently make same decisions
  - they have internalized the scheme
- Assumption: high reliability implies validity

How can reliability be determined?
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Validity vs. Reliability [Artstein and Poesio, 2008]

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Achieving Reliability (consistency)

- each item is annotated by a single annotator, with random checks ($\approx$ second annotation)
- some of the items are annotated by two or more annotators
- each item is annotated by two or more annotators - followed by reconciliation
- each item is annotated by two or more annotators - followed by final decision by superannotator (expert)

In all cases, measure of reliability: **coefficients of agreement**
In some (rare and often artificial) cases, there exists a “reference”: the corpus was annotated, at least partly, and this annotation is considered “perfect”, a reference [Fort and Sagot, 2010].

In those cases, another, complementary measure, can be used:

Which one?
Particular Case: Gold-standard

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F-measure
Precision/Recall: back to basics

- Recall:

- Silence:

- Precision:

- Noise:
Recall: measures the quantity of found annotations

\[
\text{Recall} = \frac{\text{Nb of correct found annotations}}{\text{Nb of correct expected annotations}}
\]

Silence:

Precision:

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- **Noise**: complement of precision (incorrect annotations found)
Harmonic mean of precision and recall or balanced F-score

\[ F = 2 \times \frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}} \]

... aka the F1 measure, because recall and precision are evenly weighted.

It is a special case of the general F_\beta measure:

\[ F_\beta = (1 + \beta^2) \times \frac{\text{precision} \times \text{recall}}{\beta^2 \times \text{precision} + \text{recall}} \]

The value of \( \beta \) allows to favor:

- recall (\( \beta = 2 \))
- precision (\( \beta = 0.5 \))
A little more from biology and medicine

True and false, positive and negative:

<table>
<thead>
<tr>
<th></th>
<th>Disease is present</th>
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<tbody>
<tr>
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Karén Fort (karen.fort@inist.fr)
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Inter-Annnotator Agreements

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A little more from biology and medicine

- **sensitivity**: corresponds to recall
  
  \[ SE = \frac{\text{true positives}}{\text{true positives} + \text{false negatives}} \]

- **specificity**: rate of true negatives
  
  \[ SP = \frac{\text{true negatives}}{\text{true negatives} + \text{false positives}} \]

- **selectivity**: corresponds to precision
  
  \[ SEL = \frac{\text{true positives}}{\text{true positives} + \text{false positives}} \]

- **accuracy**: nb of correct predictions over the total nb of predictions
  
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Does a “Gold-standard” exist?

- reference rarely pre-exists
- can it be “perfect”? [Fort and Sagot, 2010]
  → can we use F-measure in other cases? Reading for next class!
  ⇒ Back to coefficients of agreement.
Easy and Hard Tasks


Objective tasks

- Decision rules, linguistic tests
- Annotation guidelines with discussion of boundary cases
- POS tagging, syntactic annotation, segmentation, phonetic transcription, . . .

Subjective tasks

- Based on speaker intuitions
- Short annotation instructions
- Lexical semantics (subjective interpretation!), discourse annotation & pragmatics, subjectivity analysis, . . .
Easy and Hard Tasks


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→ IAA ≈ 98.5% (POS tagging)
IAA ≈ 93.0% (syntax)

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- Based on speaker intuitions
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→ IAA = 68.6% (HW)
   IAA ≈ 70% (word senses)
## Example

<table>
<thead>
<tr>
<th>Sentence</th>
<th>A</th>
<th>B</th>
<th>Agree?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put <strong>tea</strong> in a <strong>heat-resistant jug</strong> and add the boiling water.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Where are the <strong>batteries</strong> kept in a <strong>phone</strong>?</td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Vinegar’s <strong>usefulness</strong> doesn’t stop inside the <strong>house</strong>.</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>How do I recognize a <strong>room</strong> that contains <strong>radioactive materials</strong>?</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>A letterbox is a plastic, screw-top <strong>bottle</strong> that contains a small <strong>notebook</strong> and a unique rubber stamp.</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
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→ Agreement?
### Contingency Table and Observed Agreement

<table>
<thead>
<tr>
<th></th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td></td>
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<tr>
<td>Yes</td>
<td>4</td>
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<tr>
<td>No</td>
<td>2</td>
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<tr>
<td>Total</td>
<td>6</td>
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**Observed Agreement ($A_o$)**

Proportion of items on which 2 annotators agree.

Here:
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<td>B</td>
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<tr>
<td>Total</td>
<td>6</td>
<td>4</td>
<td>10</td>
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**Observed Agreement (A₀)**

proportion of items on which 2 annotators agree.

Here: \( A₀ = \frac{4+2}{10} = 0.6 \)
Some agreement is expected by chance alone: 

*In our case, what proportion of agreement is expected by chance?*
Chance Agreement

Some agreement is expected by chance alone:

- Two annotators randomly assigning “Yes” and “No” labels will agree half of the time (0.5 can be obtained purely by chance: what does it mean for our result?).
- The amount expected by chance varies depending on the annotation scheme and on the annotated data.

Meaningful agreement is the agreement above chance.
→ Similar to the concept of “baseline” for system evaluation.
Taking Chance into Account

Expected Agreement ($A_e$)

- Expected value of observed agreement.

Amount of agreement above chance: $A_o - A_e$

Maximum possible agreement above chance: $1 - A_e$

Proportion of agreement above chance attained: $\frac{A_o - A_e}{1 - A_e}$

Perfect agreement: $\frac{1 - A_e}{1 - A_e}$

Perfect disagreement: $\frac{-A_e}{1 - A_e}$
How to compute the amount of agreement expected by chance ($A_e$)?
S Coefficient

S [Bennett et al., 1954]

Same chance for all annotators and categories.

Number of category labels: \( q \)
Probability of one annotator picking a particular category \( q_a: \frac{1}{q} \)
Probability of both annotators picking a particular category \( q_a: \left( \frac{1}{q} \right)^2 \)

Probability of both annotators picking the same category:

\[
A_e^S = q \cdot \left( \frac{1}{q} \right)^2 = \frac{1}{q}
\]
All the categories are equally likely: consequences

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A_o = \frac{20 + 20}{50} = 0.8
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A_e = \frac{1}{2} = 0.5
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\[
S = \frac{0.8 - 0.5}{1 - 0.5} = 0.6
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A_e = \frac{1}{4} = 0.25 \\
S = \frac{0.8 - 0.25}{1 - 0.25} = 0.73
\]
Different chance for different categories.

Total number of judgments: \( N \)

Probability of one annotator picking a particular category \( q_a \): \( \frac{n_{qa}}{N} \)

Probability of both annotators picking a particular category \( q_a \): \( \left( \frac{n_{qa}}{N} \right)^2 \)

Probability of both annotators picking the same category:

\[
A^\pi_e = \sum_q \left( \frac{n_q}{N} \right)^2 = \frac{1}{N^2} \sum_q n_q^2
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## Comparing $S$ and $\pi$

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$A_o = 0.8$

$S = 0.6$

$A_o = 0.8$

$S = 0.73$
### Comparing $S$ and $\pi$

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- $A_o = 0.8$
- $S = 0.6$

\[
A_e^\pi = \frac{((\frac{25+25}{2})^2 + (\frac{25+25}{2})^2)}{50^2} = 0.5
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\[
\pi = \frac{0.8-0.5}{1-0.5} = 0.6
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- $A_o = 0.8$
- $S = 0.73$
## Comparing $S$ and $\pi$

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\[
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S = 0.6
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A_\pi = \frac{\left(\frac{25+25}{2}\right)^2 + \left(\frac{25+25}{2}\right)^2}{50^2} = 0.5
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\[
\pi = \frac{0.8-0.5}{1-0.5} = 0.6
\]

Karëen Fort (karen.fort@inist.fr)
Different annotators have different interpretations of the instructions (bias/prejudice). $\kappa$ takes individual bias into account.

Total number of items: $i$

Probability of one annotator $A_x$ picking a particular category $q_a$: $\frac{n_{A_x q_a}}{i}$

Probability of both annotators picking a particular category $q_a$: $\frac{n_{A_1 q_a}}{i} \cdot \frac{n_{A_2 q_a}}{i}$

Probability of both annotators picking the same category:

$$A_e^\kappa = \sum_q \frac{n_{A_1 q}}{i} \cdot \frac{n_{A_2 q}}{i} = \frac{1}{i^2} \sum_q n_{A_1 q} n_{A_2 q}$$
Comparing $\pi$ and $\kappa$

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$A_\circ = 0.8$

$A_{\pi}^e = \frac{((\frac{25+25}{2})^2 + (\frac{25+25}{2})^2)}{50^2} = 0.5$

$\pi = \frac{0.8-0.5}{1-0.5} = 0.6$
## Comparing $\pi$ and $\kappa$

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\[
A_\circ = 0.8 \\
A_{e\pi}^\pi = \frac{\left(\frac{25+25}{2}\right)^2 + \left(\frac{25+25}{2}\right)^2}{50^2} = 0.5 \\
\pi = \frac{0.8 - 0.5}{1 - 0.5} = 0.6 \\
A_{e\kappa}^\kappa = \frac{\frac{25 \times 25}{50} + \frac{25 \times 25}{50}}{50} = 0.5 \\
\kappa = \frac{0.8 - 0.5}{1 - 0.5} = 0.6
\]
### Comparing $\pi$ and $\kappa$

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\[
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A_e^\pi = \frac{\left(\frac{25+25}{2}\right)^2 + \left(\frac{25+25}{2}\right)^2}{50^2} = 0.5 \\
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A_e^\kappa = \frac{\left(\frac{25\times25}{50}\right)+\left(\frac{25\times25}{50}\right)}{50} = 0.5 \\
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Comparing $\pi$ and $\kappa$

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$A_o = 0.8$

$A_e^\pi = \frac{\left(\frac{25+25}{2}\right)^2 + \left(\frac{25+25}{2}\right)^2}{50^2} = 0.5$

$\pi = \frac{0.8 - 0.5}{1 - 0.5} = 0.6$

$A_o = 0.68$

$A_e^\pi = \frac{\left(\frac{38+32}{2}\right)^2 + \left(\frac{32+38}{2}\right)^2}{70^2} = 0.5$

$\pi = \frac{0.68 - 0.5}{1 - 0.5} = 0.36$
Comparing $\pi$ and $\kappa$

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$$A_o = 0.8$$

$$A_{\pi e} = \frac{\left(\frac{25+25}{2}\right)^2 + \left(\frac{25+25}{2}\right)^2}{50^2} = 0.5$$

$$\pi = \frac{0.8-0.5}{1-0.5} = 0.6$$

$$A_{\kappa e} = \frac{\left(\frac{25\times25}{50}\right) + \left(\frac{25\times25}{50}\right)}{50} = 0.5$$

$$\kappa = \frac{0.8-0.5}{1-0.5} = 0.6$$

$$A_o = 0.68$$

$$A_{\pi e} = \frac{\left(\frac{38+32}{2}\right)^2 + \left(\frac{32+38}{2}\right)^2}{70^2} = 0.5$$

$$\pi = \frac{0.68-0.5}{1-0.5} = 0.36$$
Comparing $\pi$ and $\kappa$

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$A_\pi = \frac{(\frac{25+25}{2})^2 + (\frac{25+25}{2})^2}{50^2} = 0.5$

$\pi = \frac{0.8-0.5}{1-0.5} = 0.6$

$A_\kappa = \frac{(\frac{25\times25}{50}) + (\frac{25\times25}{50})}{50} = 0.5$

$\kappa = \frac{0.8-0.5}{1-0.5} = 0.6$

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$A_o = 0.68$

$A_\pi = \frac{(\frac{38+32}{2})^2 + (\frac{32+38}{2})^2}{70^2} = 0.5$

$\pi = \frac{0.68-0.5}{1-0.5} = 0.36$

$A_\kappa = \frac{(\frac{38\times32}{70}) + (\frac{32\times38}{70})}{70} = 0.49$

$\kappa = \frac{0.68-0.49}{1-0.49} = 0.37$
For any sample:

\[ A_e^\pi \geq A_e^S \quad \pi \leq S \]
\[ A_e^\pi \geq A_e^\kappa \quad \pi \leq \kappa \]

What is a "good" \( \kappa \) (or \( \pi \) or \( S \))?
Scales for the interpretation of Kappa

- **Landis and Koch, 1977**
  - 0.0: slight
  - 0.2: fair
  - 0.4: moderate
  - 0.6: substantial
  - 0.8: perfect

- **Krippendorff, 1980**
  - 0.67: discard
  - 0.8: tentative
  - 1.0: good

- **Green, 1997**
  - 0.0: low
  - 0.4: fair / good
  - 0.75: high

- “if a threshold needs to be set, 0.8 is a good value” [Artstein and Poesio, 2008]
Scales for the interpretation of Kappa

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  [Artstein and Poesio, 2008]
Scales for the interpretation of Kappa

- **Landis and Koch, 1977**
  
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- **Krippendorff, 1980**
  
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- **Green, 1997**
  
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- “if a threshold needs to be set, 0.8 is a good value” [Artstein and Poesio, 2008]
More Annotators?

Differences among coders are diluted when more coders are used.

- With many coders, difference between $\pi$ and $\kappa$ is small
- Another argument for using many coders
More than two annotators

Agreement is the proportion of agreeing pairs

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<td>Engine1</td>
<td>Engine1</td>
<td>Engine1</td>
<td>Engine1</td>
<td>6/6</td>
</tr>
</tbody>
</table>

When 3 of 4 coders agree, only 3 of 6 pairs agree...
\( K \)

**Beware!**

\( K \) is a generalization of \( \pi \) (not \( \kappa \)!) 

**Expected agreement**

The probability of agreement for an arbitrary pair of coders.

Total number of judgments: \( N \)

Probability of arbitrary annotator picking a particular category \( q_a: \frac{n_{qa}}{N} \)

Probability of two annotators picking a particular category \( q_a: \left( \frac{n_{qa}}{N} \right)^2 \)

Probability of two arbitrary annotators picking the same category:

\[
A_{e}^{\pi} = \sum_{q} \left( \frac{n_{q}}{N} \right)^2 = \frac{1}{N^2} \sum_{q} n_{q}^2
\]
Missing Points and Reflexions

I did not introduced the *weighted coefficients*, in particular $\alpha$ [Krippendorff, 2004]. If you are interested, have a look at [Artstein and Poesio, 2008].

There are ongoing reflexions on some issues, like:

- prevalence
- finding the “right“ negative case (we’ll see that in practical course)
• Precision, recall, F-measure
• Accuracy
• Observed agreement
• $S$, $\kappa$, $\pi$
• More than 2 annotators
Read carefully: [Hripcsak and Rothschild, 2005]
(http://ukpmc.ac.uk/articles/PMC1090460)

Apply the grid we saw in the second course to this article.


In *Proc. of the Fourth ACL Linguistic Annotation Workshop, Uppsala, Suède.*


Sense tagging: does it make sense?

In *Corpus Linguistics Conference*, Lancaster, Angleterre.