Crowdsourcing Ground Truth for Medical Relation Extraction

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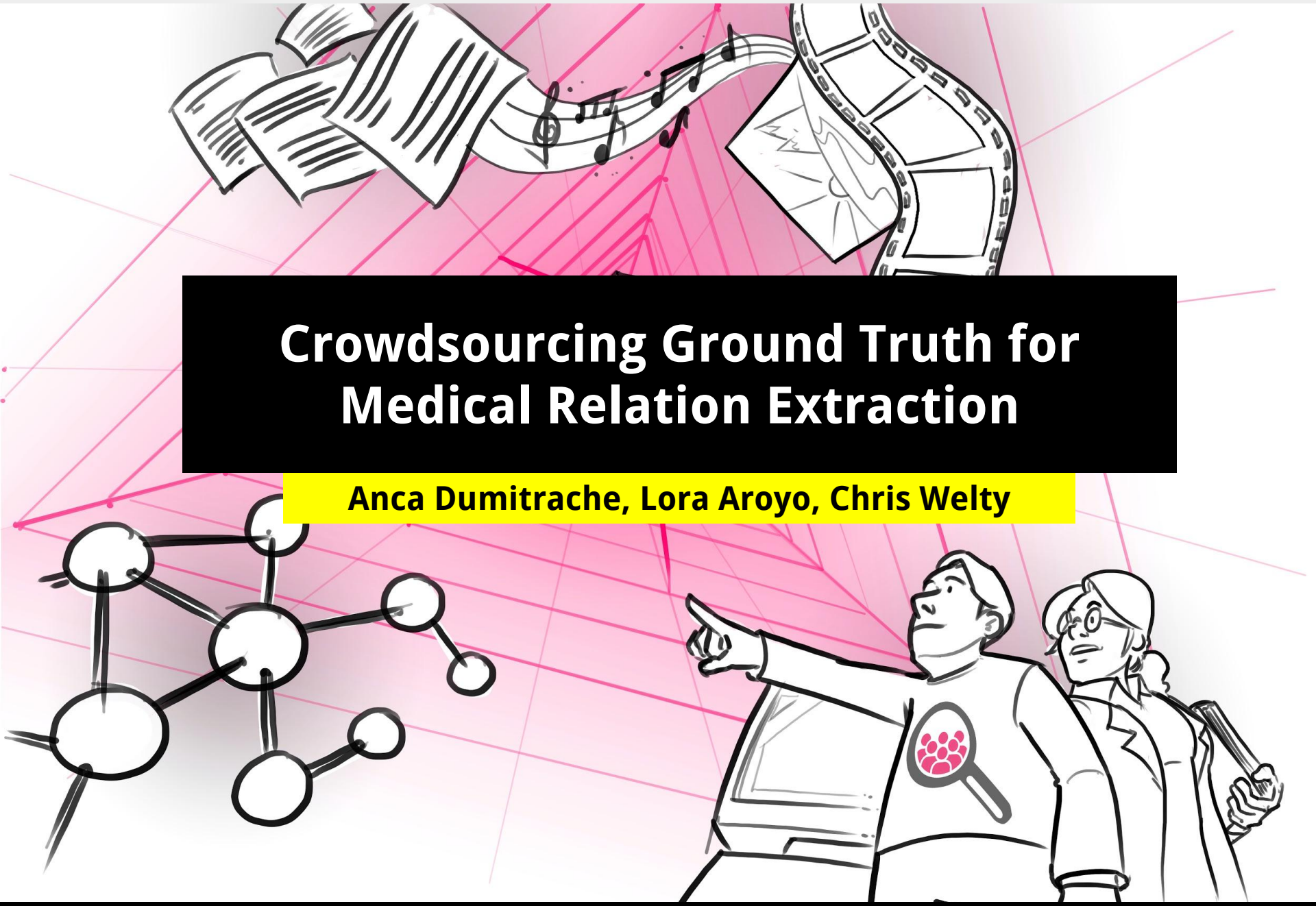

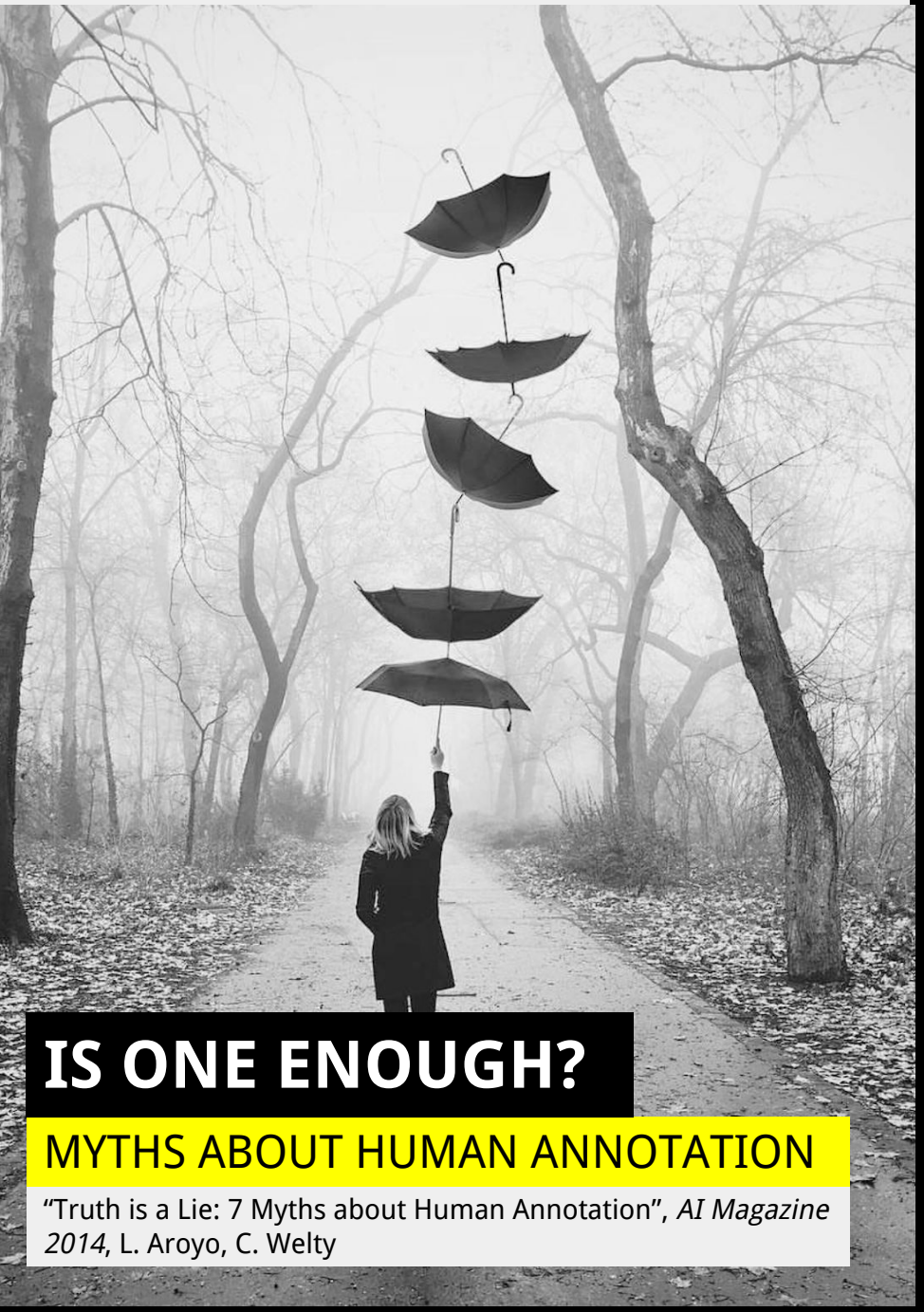

IS ONE ENOUGH?

MYTHS ABOUT HUMAN ANNOTATION

"Truth is a Lie: 7 Myths about Human Annotation", *AI Magazine 2014*, L. Aroyo, C. Welty

One truth: knowledge acquisition for the semantic web assumes one correct interpretation for every example

All examples are created equal: triples are triples, one is not more important than another, they are all either true or false

Disagreement bad: when people disagree, they don't understand the problem

Experts rule: knowledge is captured from domain experts

One is enough: knowledge by a single expert is sufficient

DOES THIS SENTENCE EXPRESS TREATS RELATION?

Treats: Chloroquine, Malaria

Rheumatoid arthritis and **MALARIA** have been treated with **CHLOROQUINE** for decades.

For prevention of malaria, use only in individuals traveling to malarious areas where **CHLOROQUINE** resistant P. falciparum **MALARIA** has not been reported.

Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

WHAT DO EXPERTS SAY?

Treats: Chloroquine, Malaria

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WHAT DOES THE CROWD SAY?

Treats: Chloroquine, Malaria

Rheumatoid arthritis and **MALARIA** have been treated with **CHLOROQUINE** for decades.

95%

For prevention of malaria, use only in individuals traveling to malarious areas where **CHLOROQUINE** resistant P. falciparum **MALARIA** has not been reported.

75%

Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

50%

Intuition: This is better

WHAT DOES THE CROWD SAY?

Treats: Chloroquine, Malaria

Rheumatoid arthritis and **MALARIA** have been treated with **CHLOROQUINE** for decades.

95%

BETTER

There's a difference between these two

For prevention of malaria, use only in individuals traveling to malarious areas where **CHLOROQUINE** resistant P. falciparum **MALARIA** has not been reported.

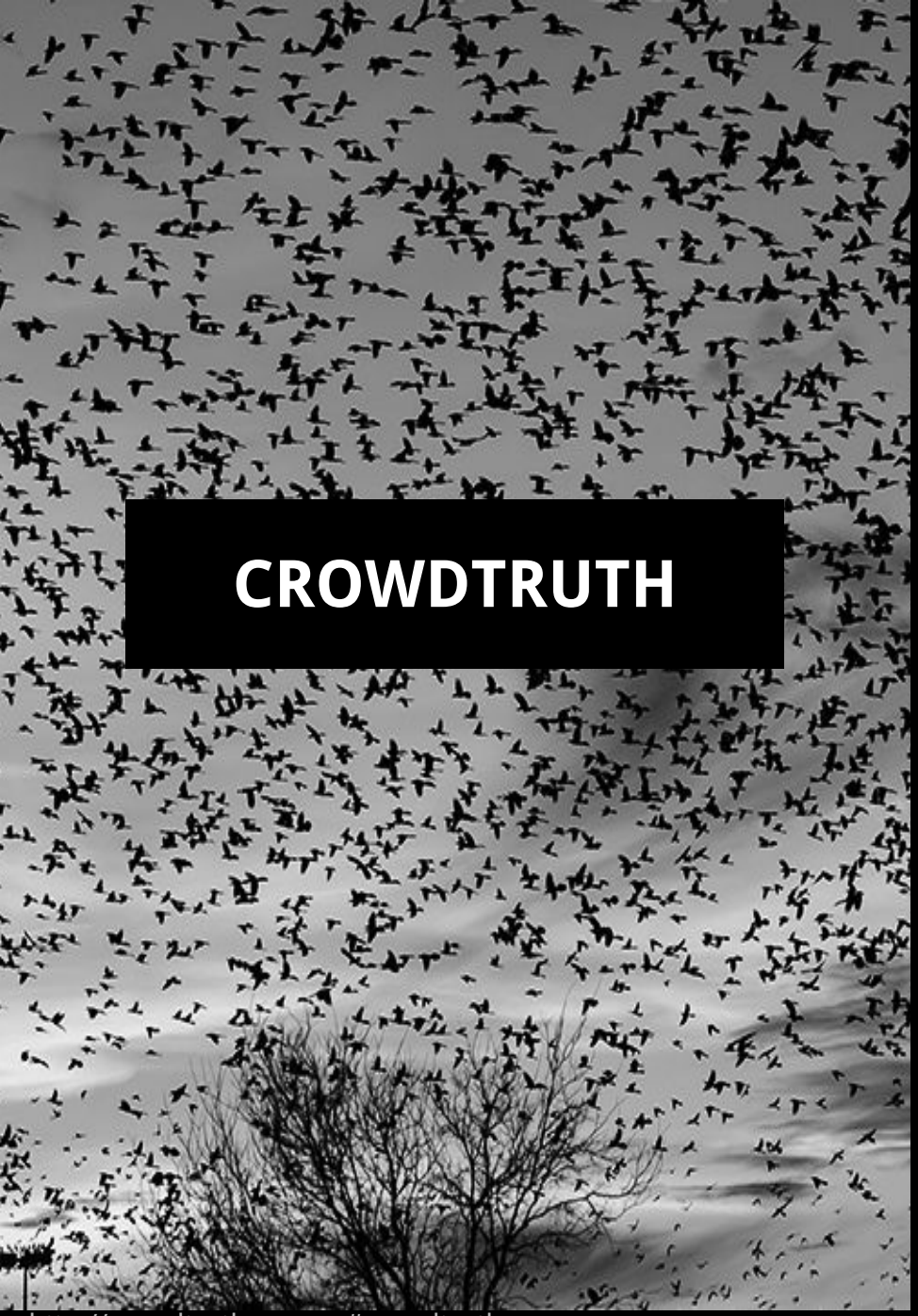
75%

WORSE

Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

50%

This one isn't utterly wrong

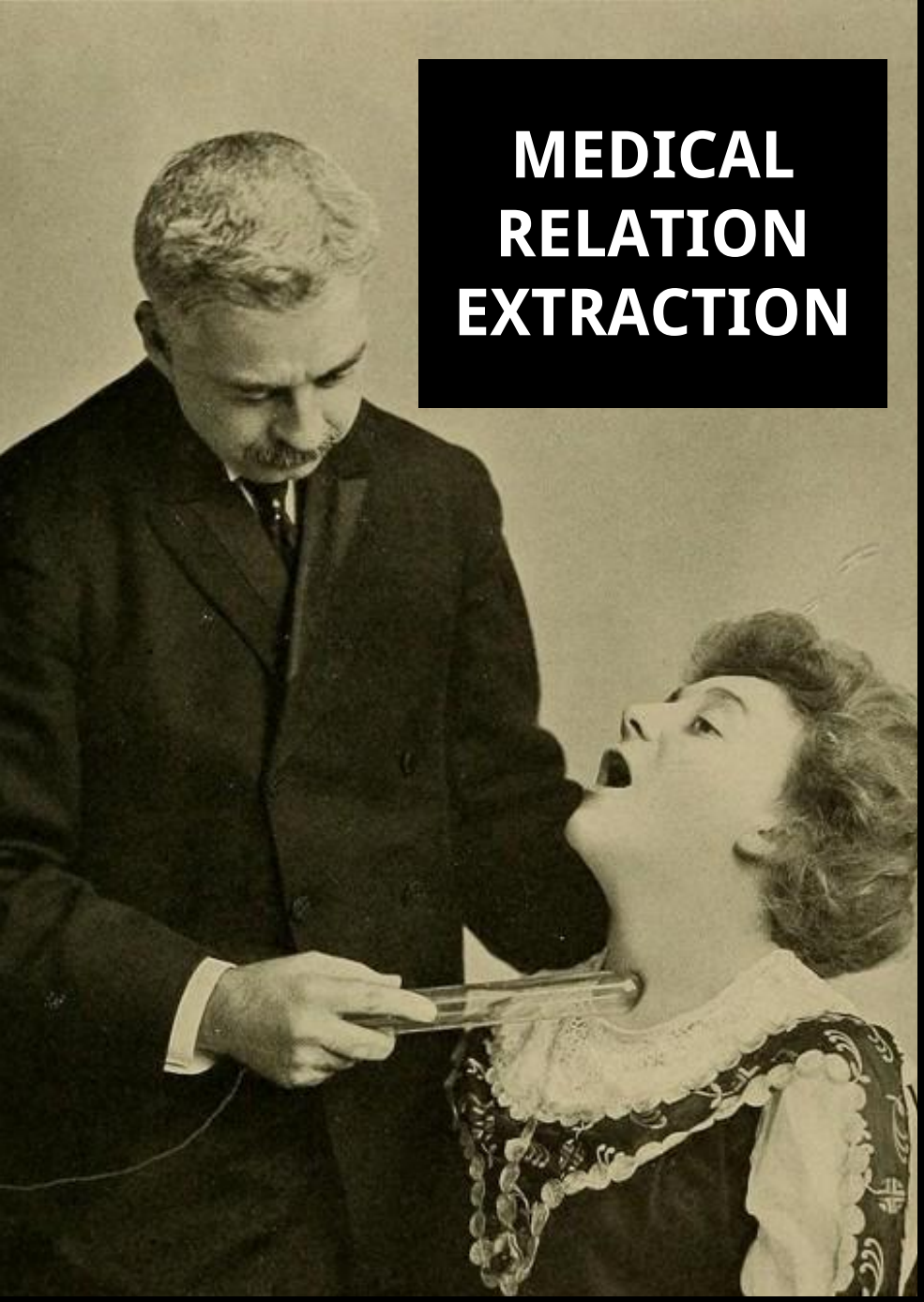


CROWDTRUTH

Annotator disagreement is **signal, not noise**

It is indicative of the **variation of human semantic interpretation**

It can indicate **ambiguity, vagueness, similarity, over-generality,** and most importantly **quality**



MEDICAL RELATION EXTRACTION

Goals:

- crowdsource a gold standard for *treat* & *cause* medical relation extraction
- improve performance of manifold model sentence-level classifier

Approach:

- compare crowd & medical expert on 900 sentences
- compare crowd & distant supervision on 3,900 sentences

CROWD TASK

Medical Relation Extraction

powered by CrowdTruth

1 **In the following sentence:**

Sentence:

Among 56 subjects reporting to a clinic with symptoms of **malaria**, 53 (95%) had ordinarily effective levels of **chloroquine** in blood.

2 **Is chloroquine related to malaria? Choose all that apply.**

- Treats
- Diagnosed By
- Causes
- Location
- ✓ Manifestation
- Contraindicates
- ✓ Associated With
- Is A
- Part Of
- ✓ Symptom
- ✓ Other
- None

SYMPTOM: Deviation from normal function indicating the presence of disease or abnormality, e.g. pain is a symptom of a broken arm.

WORKER VECTOR FOR A SENTENCE

Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

MANY WORKERS FOR THE SAME SENTENCE

Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

ALL WORKER VECTORS AGGREGATED IN A SENTENCE VECTOR

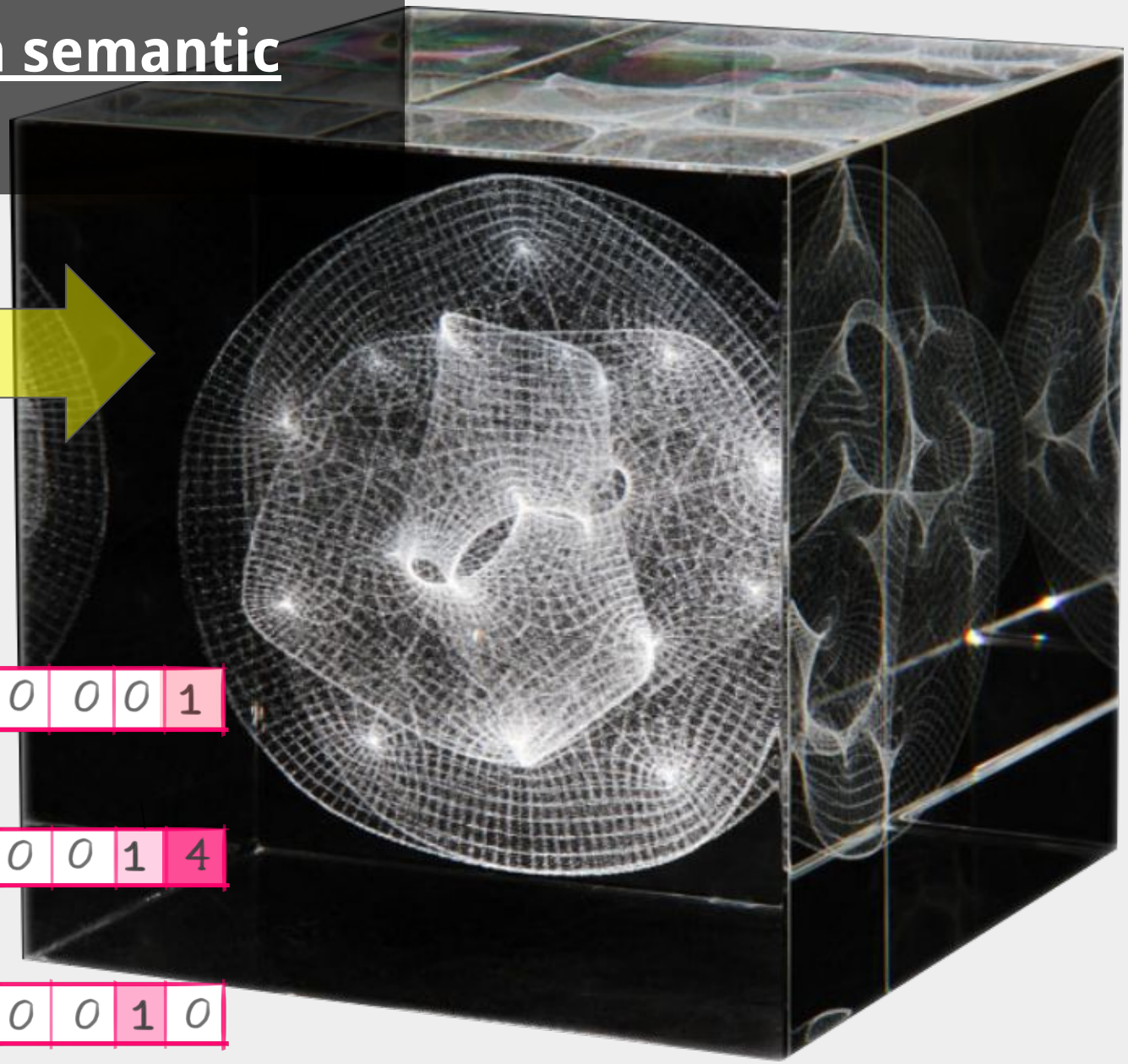
Among 56 subjects reporting to a clinic with symptoms of **MALARIA** 53 (95%) had ordinarily effective levels of **CHLOROQUINE** in blood.

0	0	0	1	1	1	0	0	0	0	0	0
0	0	0	1	0	1	0	1	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0

manifestation	symptom	side effect	treats	associated	_with	none	other
1	0	0	6	1	2	0	3	0	0	1	0

SENTENCE VECTORS FOR THE 3 SENTENCES

SEMBEDDINGS
Embeddings with semantic dimensions

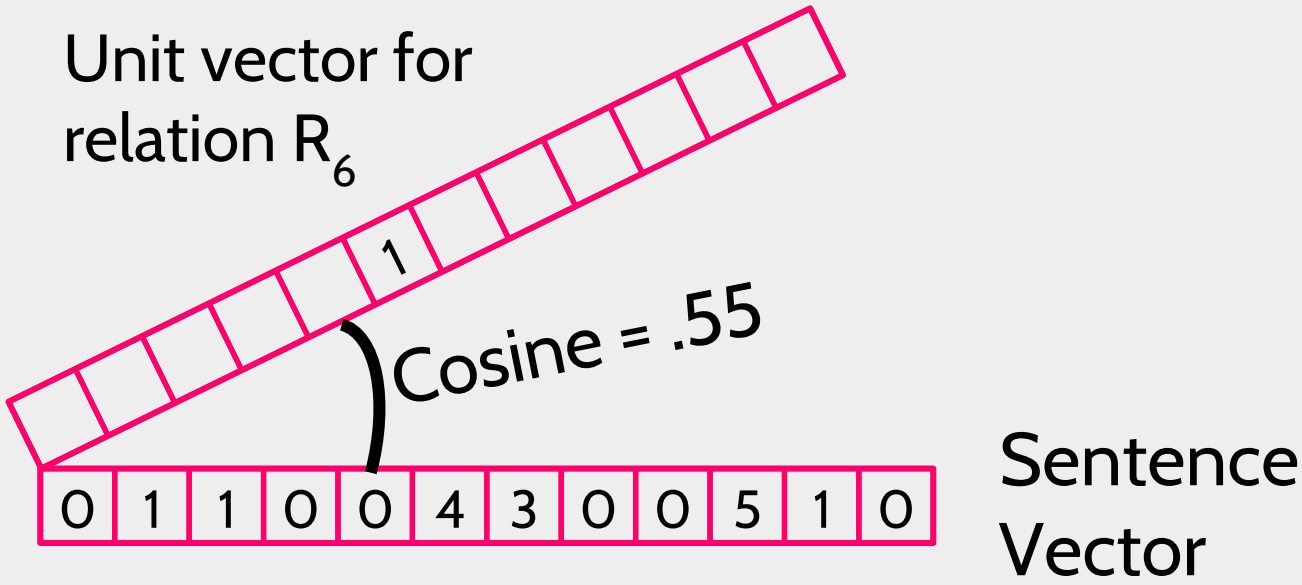


0	0	0	0	0	14	0	0	0	0	0	1

2	0	2	0	0	6	0	1	0	0	1	4

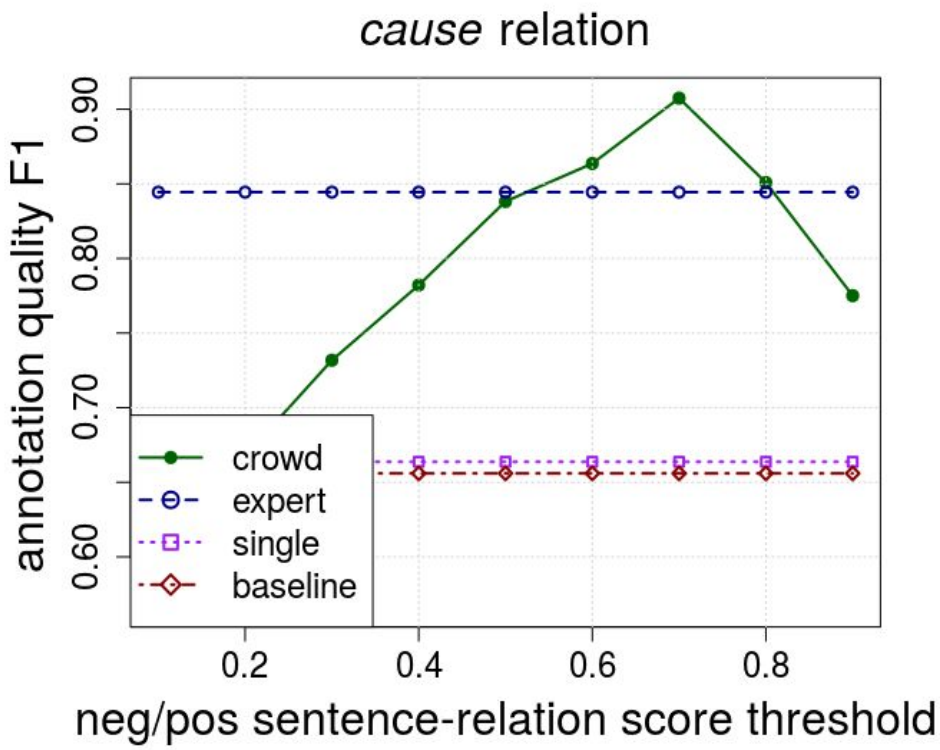
1	0	0	6	1	2	0	3	0	0	1	0

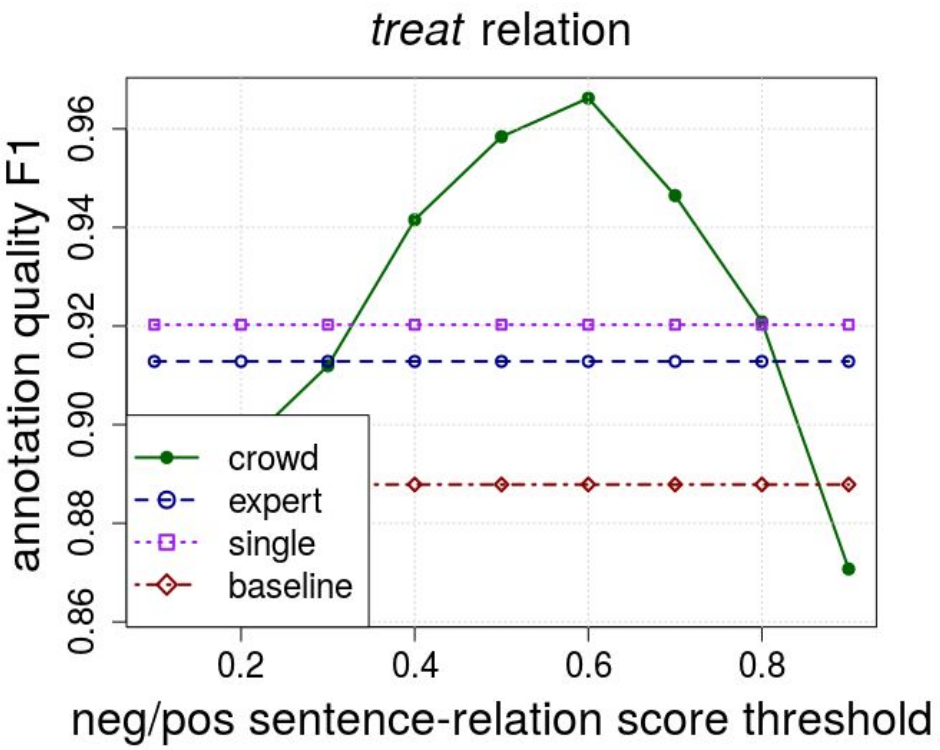
SENTENCE - RELATION SCORE (SRS)



Measures how clearly a sentence expresses a relation

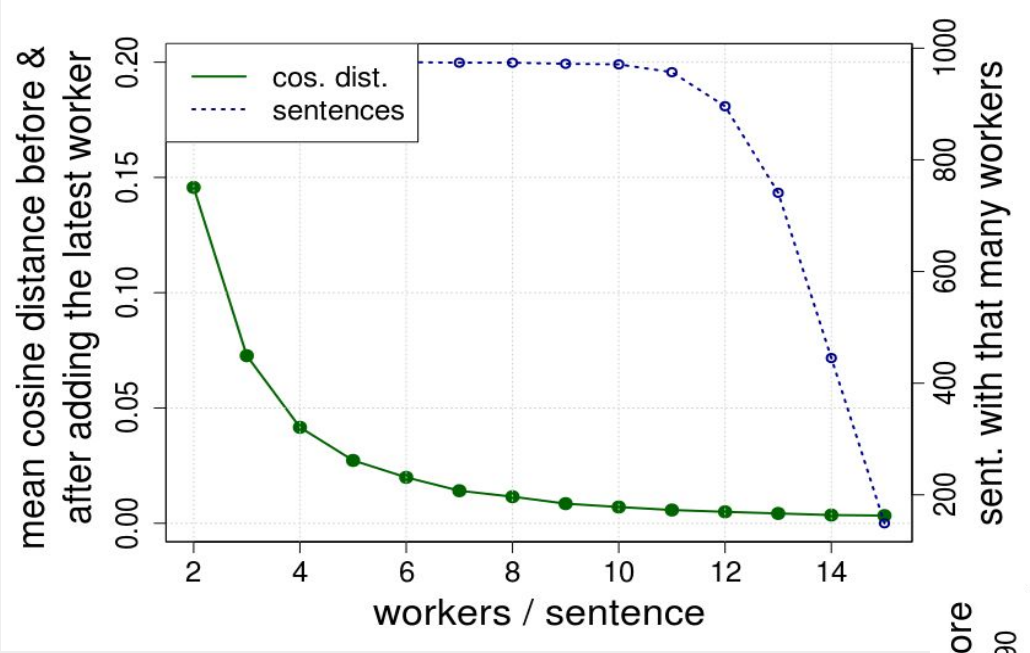
CROWD vs. EXPERT ANNOTATION QUALITY





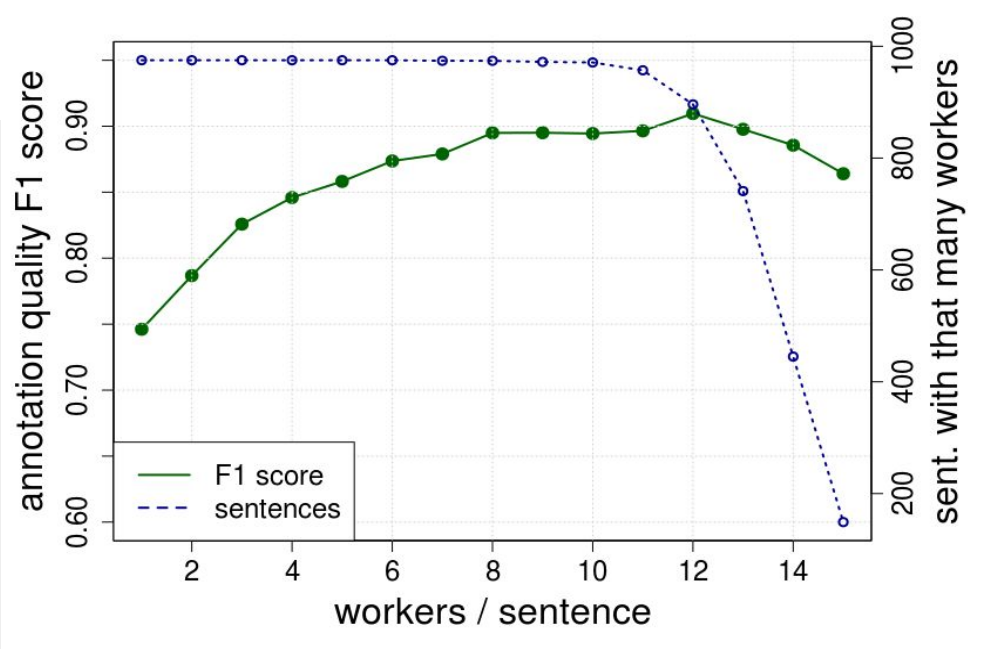
[0.6 - 0.8] crowd significantly out-performs expert

HOW MANY WORKERS / SENTENCE?



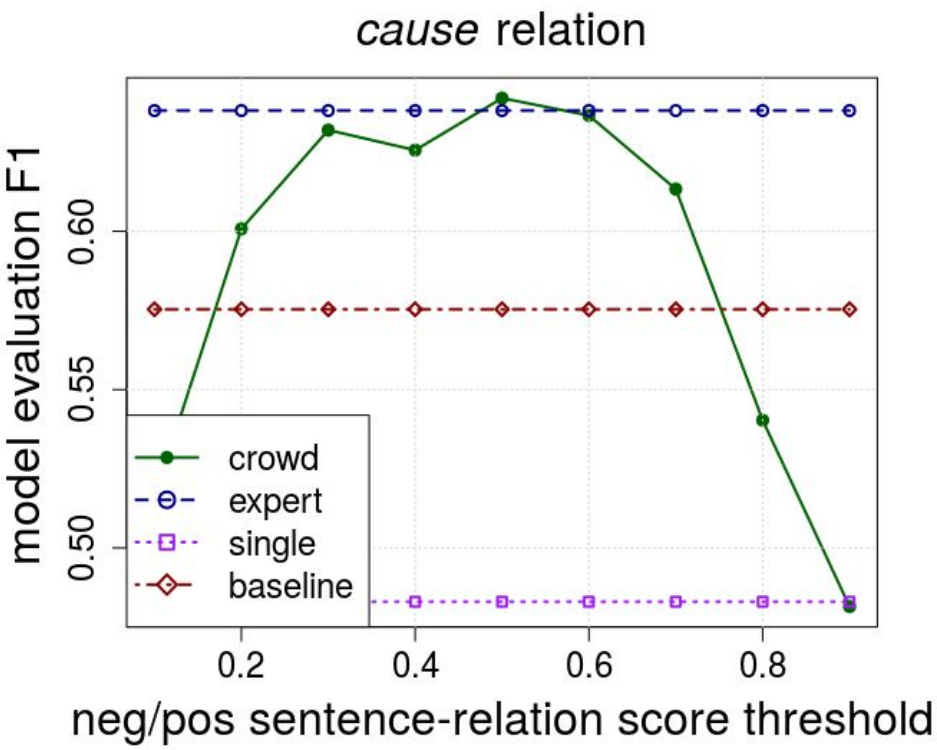
cosine & F1 scores are stable at 15 workers / sentence

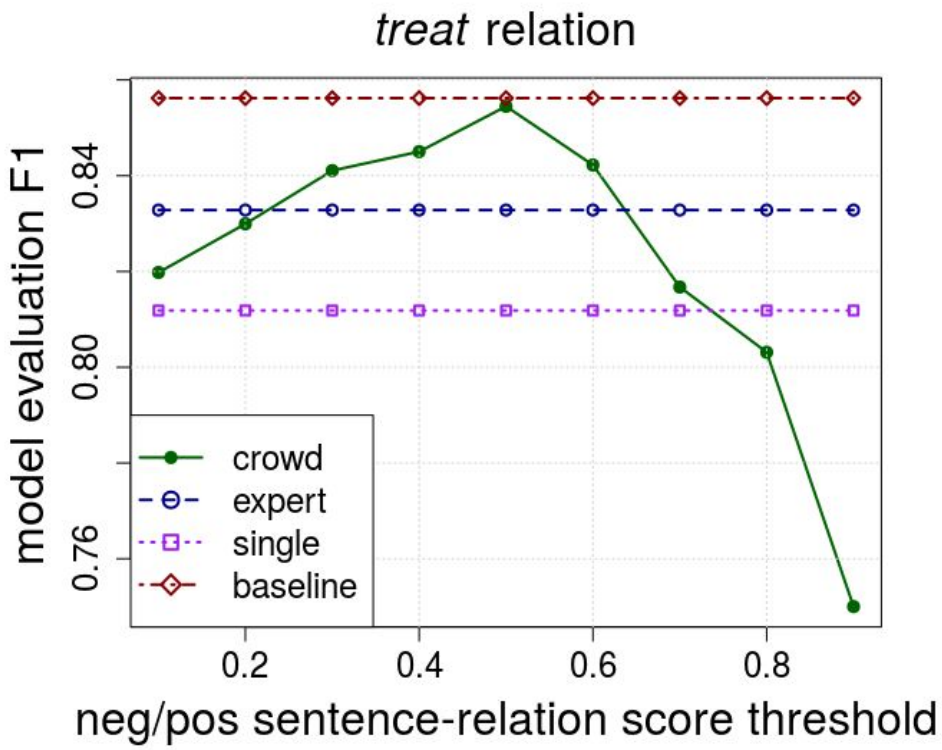
15 workers / sentence still costs less than 1 expert / sentence



CROWD vs. EXPERT MODEL QUALITY

RelEx model: Wang & Fan. *Medical relation extraction with manifold models*. ACL 2014





crowd provides training data that is at least as good, if not better than experts

EVALUATING WITH SRS-WEIGHTED METRICS

Weighted Precision:

$$P' = \frac{\sum_s srs(s) \cdot tp(s)}{\sum_s srs(s) \cdot tp(s) + (1 - srs(s)) \cdot fp(s)}$$

Weighted Recall:

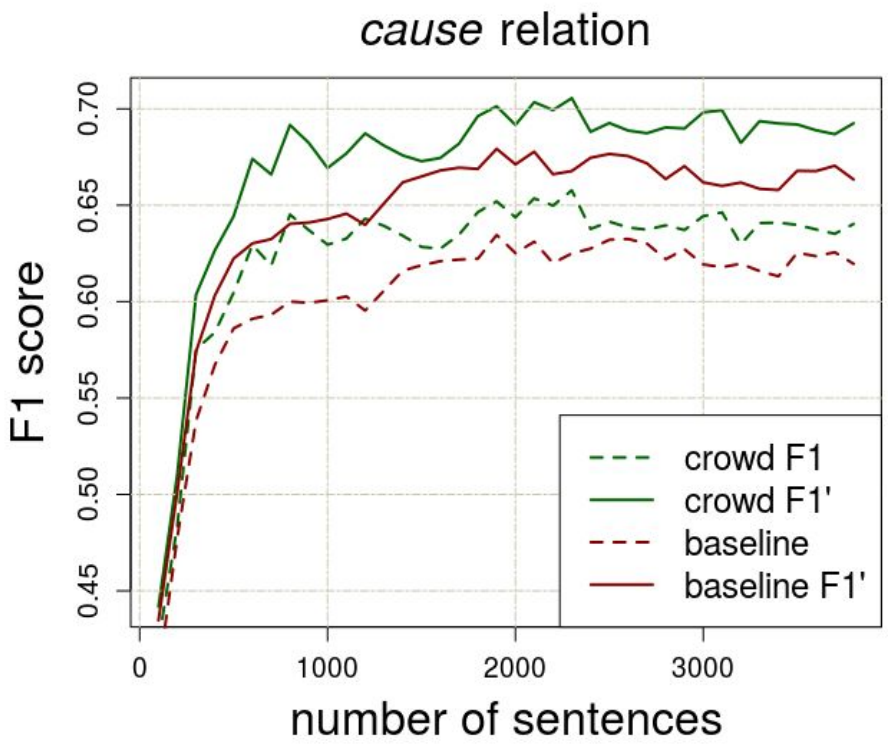
$$R' = \frac{\sum_s srs(s) \cdot tp(s)}{\sum_s srs(s) \cdot tp(s) + srs(s) \cdot fn(s)}$$

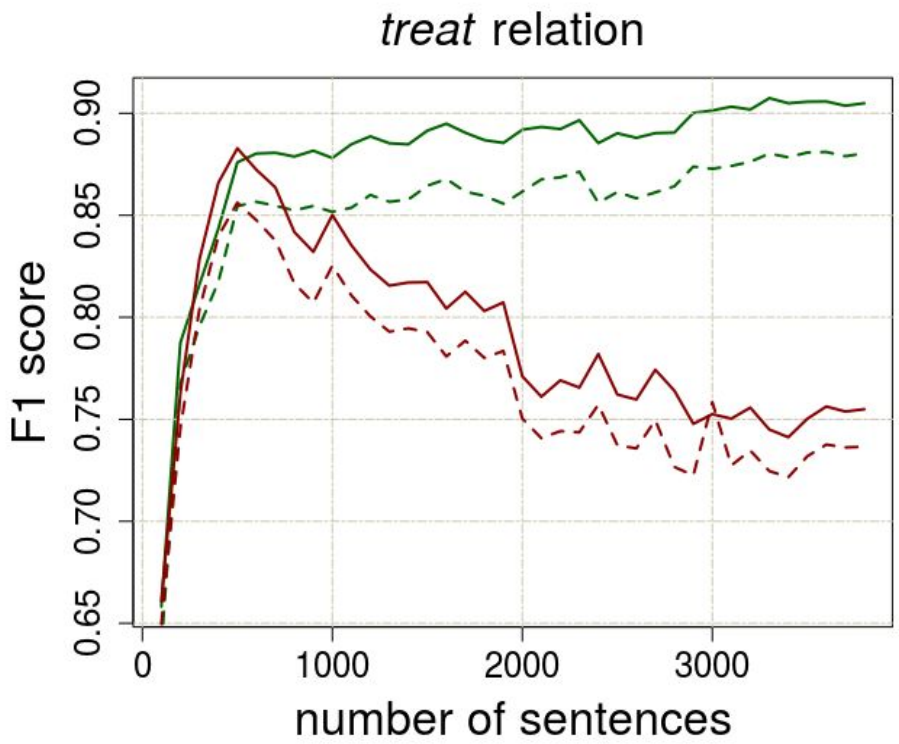
Weighted F1:

$$F1' = \frac{2P'R'}{P' + R'}$$

CROWD vs. DISTANT SUPERVISION MODEL QUALITY

Distant Supervision: Mintz et al. *Distant supervision for relation extraction without labeled data*. ACL 2009





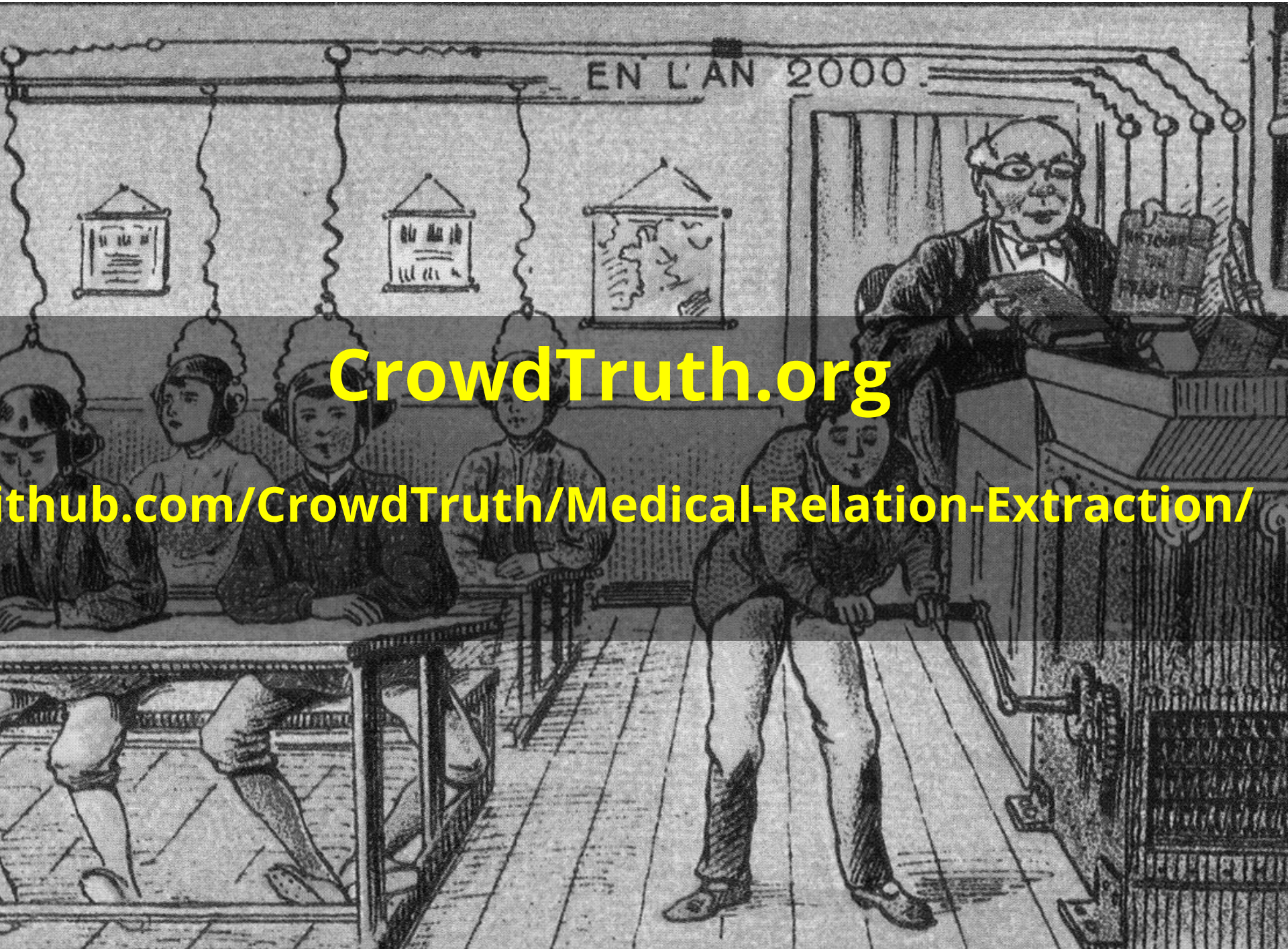
- **crowd is better training data than distant supervision**
- **weighing the eval metrics with SRS results in increase**

RESULTS SUMMARY

CrowdTruth performs **just as well as medical experts** at training a relation extraction classifier, while being **cheaper** and **always available**.

CrowdTruth performs **better than distant supervision** at training the classifier.

Metrics weighted with SRS evaluate **truth on a continuous scale**, as opposed to using binary ground truth labels.



CrowdTruth.org

ithub.com/CrowdTruth/Medical-Relation-Extraction/