

Measuring the meaning of words

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Information Access Group

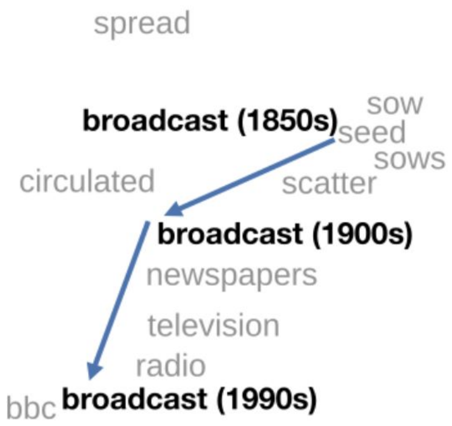

SAY DIGITAL HUMANITIES
ONE MORE TIME

TEXT MINING !

COMPUTATIONAL TEXT ANALYSIS !

NATURAL LANGUAGE PROCESSING !

Word meaning over time



This linguistic evolution is traceable in a large text corpus

Words occurring in similar (linguistic) contexts tend to be semantically similar (distributional hypothesis, Firth)

e.g. *broadcast* was once found in similar linguistic contexts as *sow* and *seed*

Distributional hypothesis:
John R. Firth. 1957. A synopsis of linguistic theory 1930–55. In *Studies in Linguistic Analysis (special volume of the Philological Society)*, pages 1–32, Oxford. The Philological Society.

Figure:
William L. Hamilton, Jure Leskovec, and Dan Jurafsky. ACL 2016. Diachronic Word Embeddings Reveal Statistical Laws of Semantic Change.

Cosine similarity (distance) reflects semantic similarity (distance)

	get	see	use	hear	eat	kill
knife	0.027	-0.024	0.206	-0.022	-0.044	-0.042
cat	0.031	0.143	-0.243	-0.015	-0.009	0.131
dog	-0.026	0.021	-0.212	0.064	0.013	0.014
boat	-0.022	0.009	-0.044	-0.040	-0.074	-0.042
cup	-0.014	-0.173	-0.249	-0.099	-0.119	-0.042
pig	-0.069	0.094	-0.158	0.000	0.094	0.265
banana	0.047	-0.139	-0.104	-0.022	0.267	-0.042

Term = word, lemma, phrase, morpheme, . . .

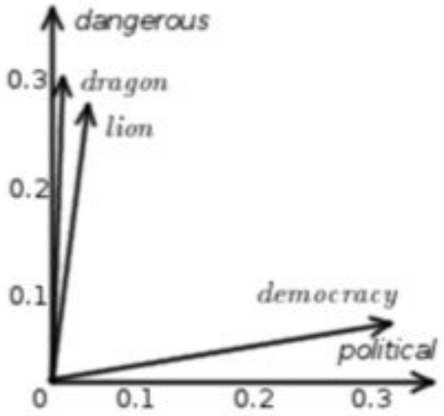
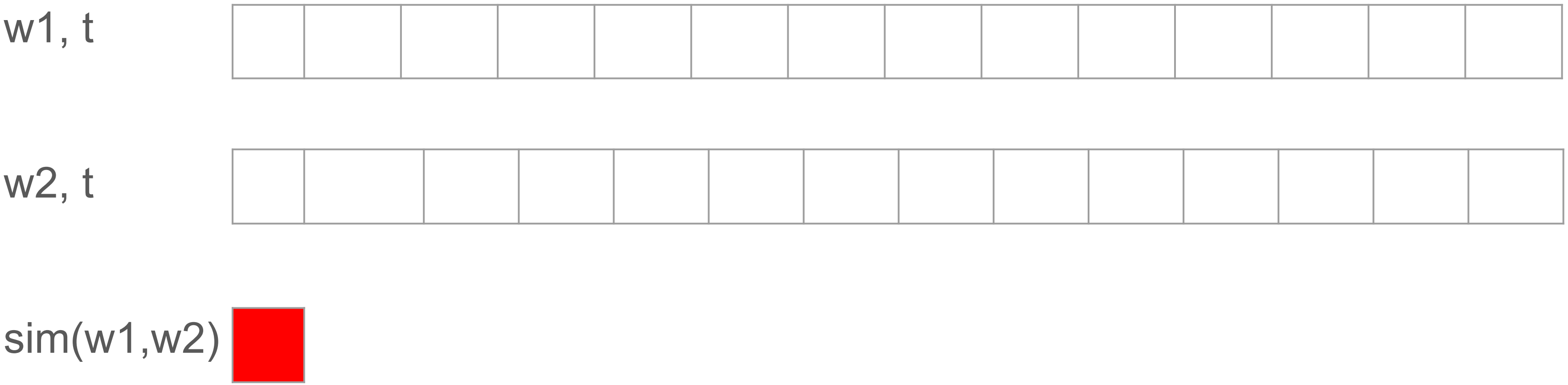
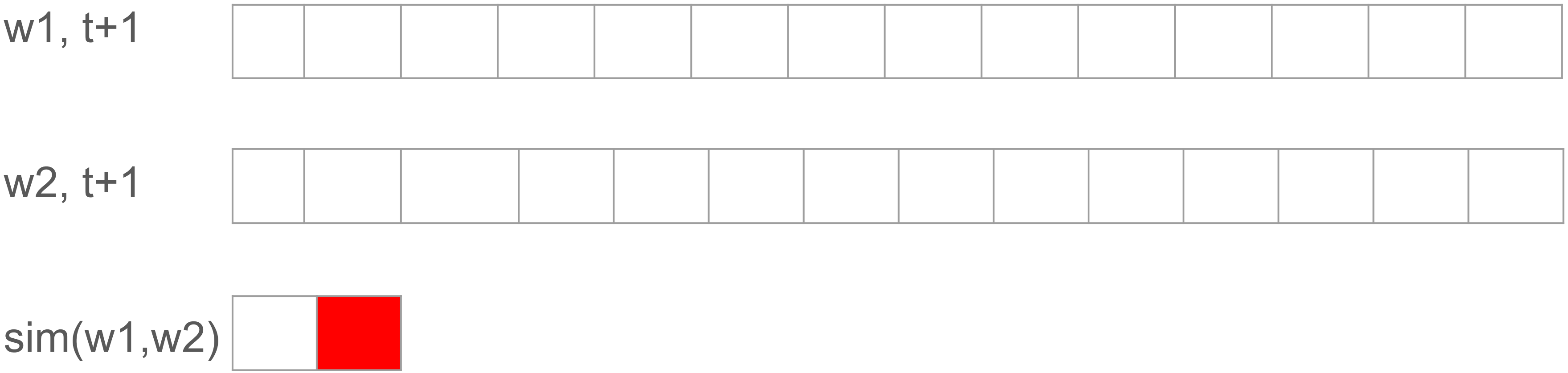


Figure left: Stefan Evert. Distributional Semantic Models
Tutorial at NAACL-HLT 2010, Los Angeles, CA.

Figure right: http://aurelieherbelot.net/research/distributional-semantics-intro/


w1, t
w2, t
sim(w1,w2)


w1, t+1
w2, t+1
sim(w1,w2)


t
t + 1
sim(w1,w2)

time series of mutual cosine similarities shows positive correlation with time

Word	Moving towards	Moving away	Shift start
gay	homosexual, lesbian	happy, showy	ca 1950
fatal	illness, lethal	fate, inevitable	<1800
awful	disgusting, mess	impressive, majestic	<1800
nice	pleasant, lovely	refined, dainty	ca 1890
broadcast	transmit, radio	scatter, seed	ca 1920
monitor	display, screen	—	ca 1930
record	tape, album	—	ca 1920
guy	fellow, man	—	ca 1850
call	phone, message	—	ca 1890

Method	Corpus	% Correct	%Sig.
PPMI	ENGALL	77.1	51.9
	COHA	85.7	52.4
SVD	ENGALL	92.6	81.5
	COHA	95.8	62.5
SGNS	ENGALL	100.0	88.9
	COHA	87.5	50.0

Table 2: Set of attested historical shifts used to evaluate the methods. The examples are taken from previous works on semantic change and from the Oxford English Dictionary (OED), e.g. using 'obsolete' tags. The shift start points were estimated using attestation dates in the OED. The first six examples are words that shifted dramatically in meaning while the remaining four are words that acquired new meanings (while potentially also keeping their old ones).

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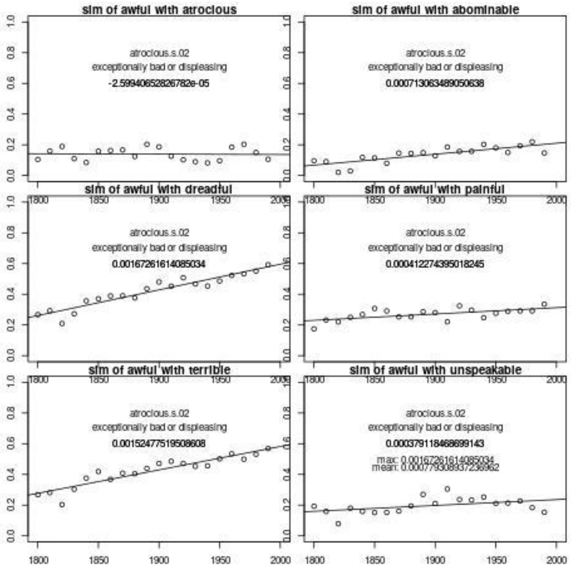
			50.0

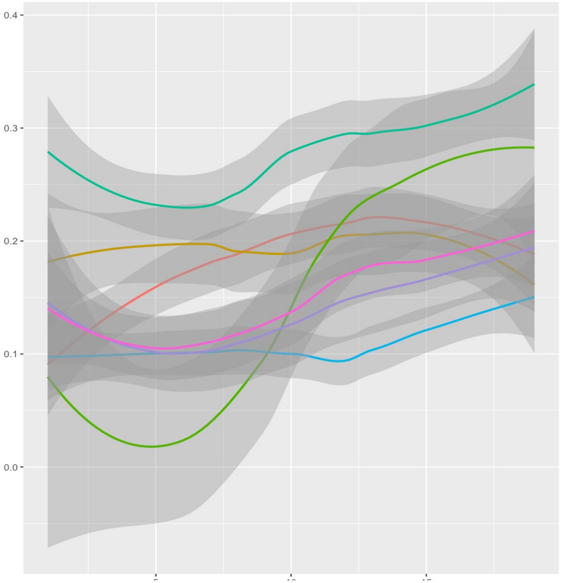
100 per cent accuracy
N=28
manually selected contrast terms

William L. Hamilt ... tical Laws of Semantic Change.

THE HISTORICAL THESAURUS OF ENGLISH

- New, larger dataset
- More contrast terms, automatically selected
- Aggregated findings per dictionary sense





Word-Shift-Eval	**eng-all**			
	HT+	wsct+	HW+	HW
setting 1				
correct(%)	51	79	80	100
sig(%)	42	55	62	89
N	1718	14	49	28
setting 2				
correct(%)	58	69	80	100
sig(%)	39	67	60	89
N	1459	13	44	27

THE HISTORICAL THESAURUS OF ENGLISH

SenseShift-Eval	**eng-all**		
	HT+	wsct+	HW+
setting 1			
average vec.	50	100	73
argmax(corr)	54	100	92
argmax(freq)	52	80	85
majority vote	44	100	77
argmin(p(corr))	54	100	92
AVG	51	96	84
N	504	5	13
setting 2			
average vec.	56	100	78
argmax(corr)	61	100	85
argmax(freq)	57	80	85
majority vote	51	100	77
argmin(p(corr))	62	100	85
AVG	57	96	82
N	449	5	13

Word-Shift-Eval	eng-all			
	HT+	wsct+	HW+	HW
setting 1				
correct(%)	51	79	80	100
sig(%)	42	55	62	89
N	1718	14	49	28
setting 2				
correct(%)	58	69	80	100
sig(%)	39	67	60	89
N	1459	13	44	27

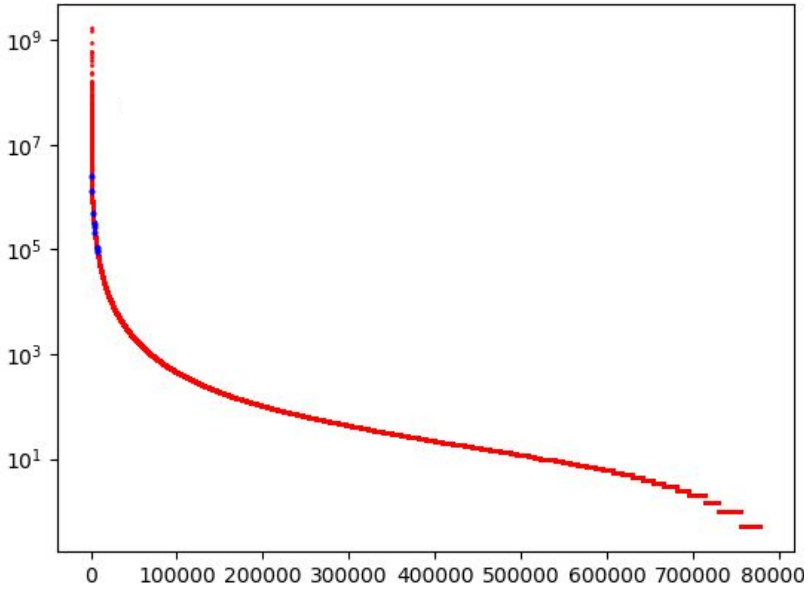
Note the differences in results between

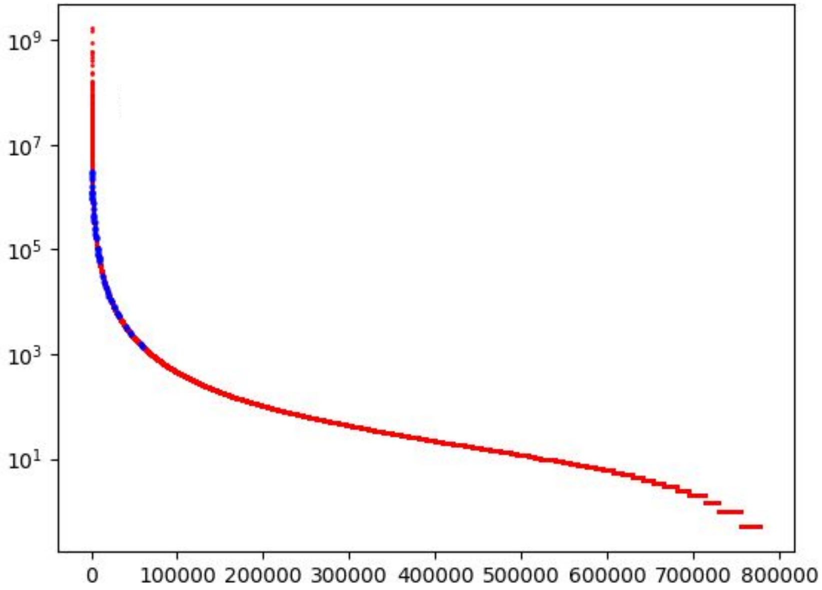
- *evaluation sets*
- *setting 1 and 2 (computational artefact)*

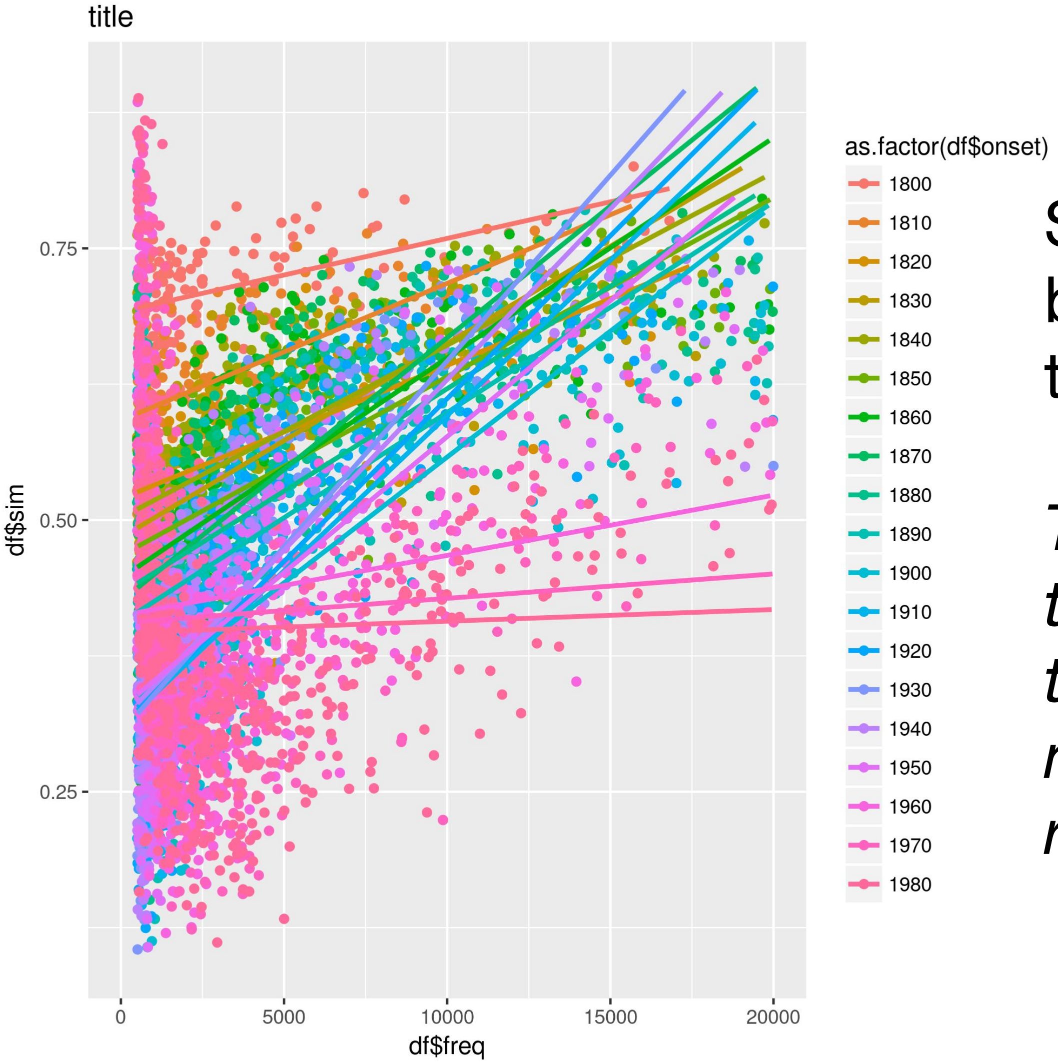
SenseShift-Eval	eng-all		
	HT+	wsct+	HW+
setting 1			
average vec.	50	100	73
argmax(corr)	54	100	92
argmax(freq)	52	80	85
majority vote	44	100	77
argmin(p(corr))	54	100	92
AVG	51	96	84
N	504	5	13
setting 2			
average vec.	56	100	78
argmax(corr)	61	100	85
argmax(freq)	57	80	85
majority vote	51	100	77
argmin(p(corr))	62	100	85
AVG	57	96	82
N	449	5	13

The baseline terms were among the top-10k most frequent words in the corpus

The terms in our datasets weren't

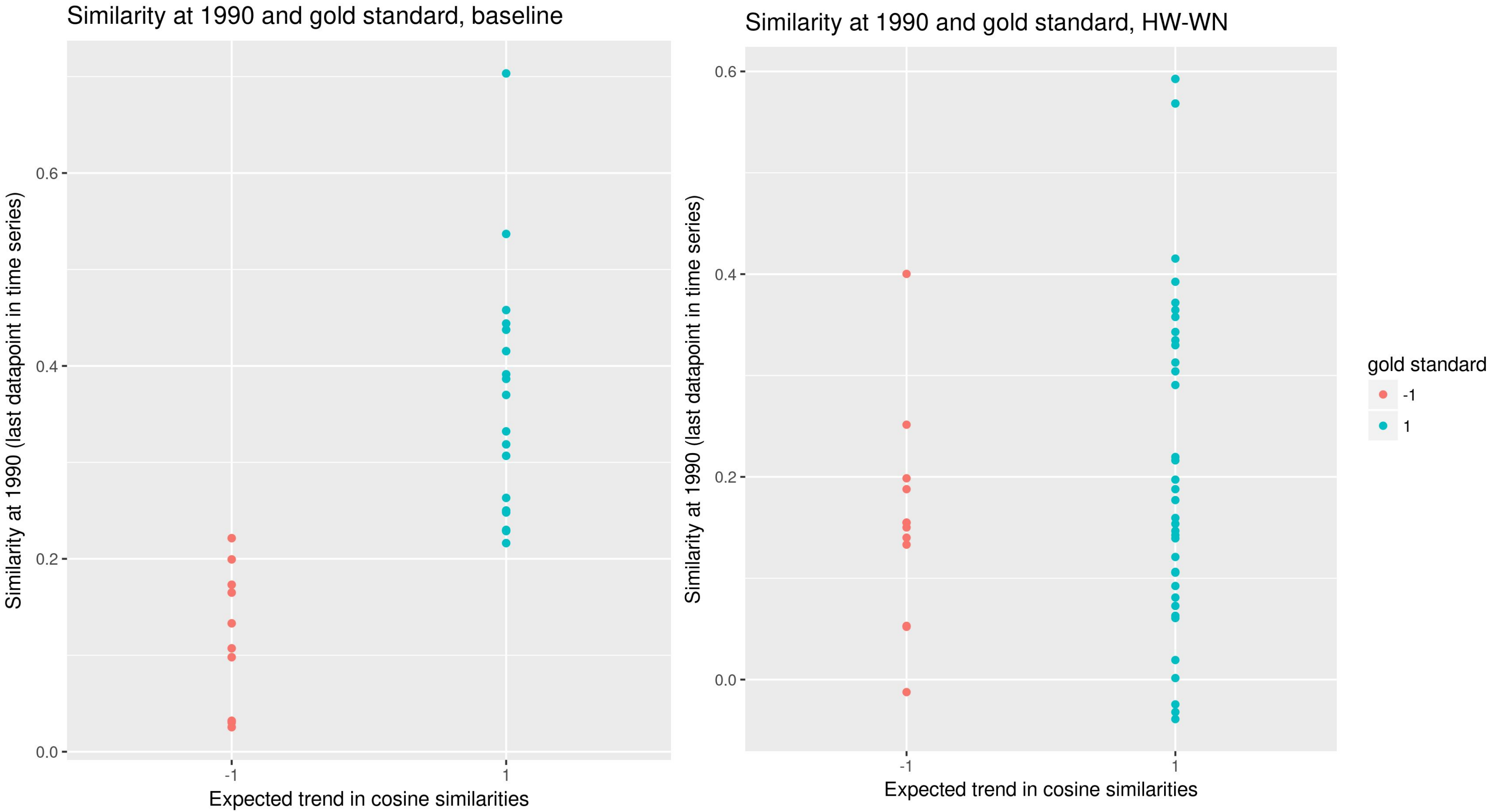






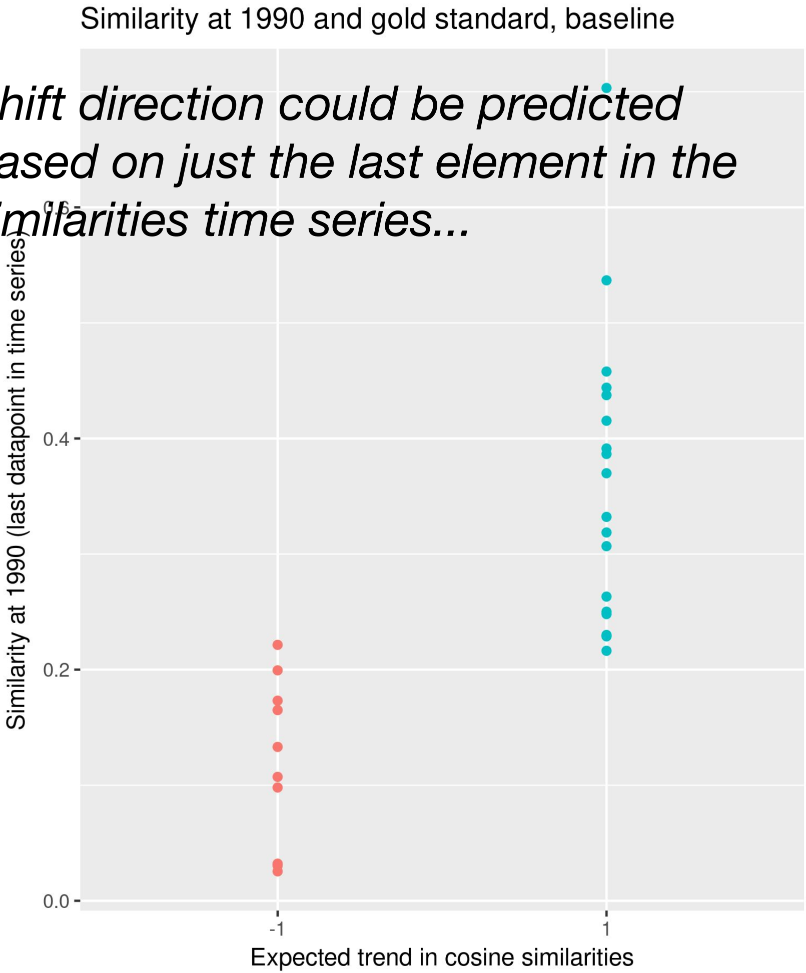
Self-similarity of terms between t and t+1 and term frequency

The more frequent the term,
the more stable (less noisy) its distributional representation

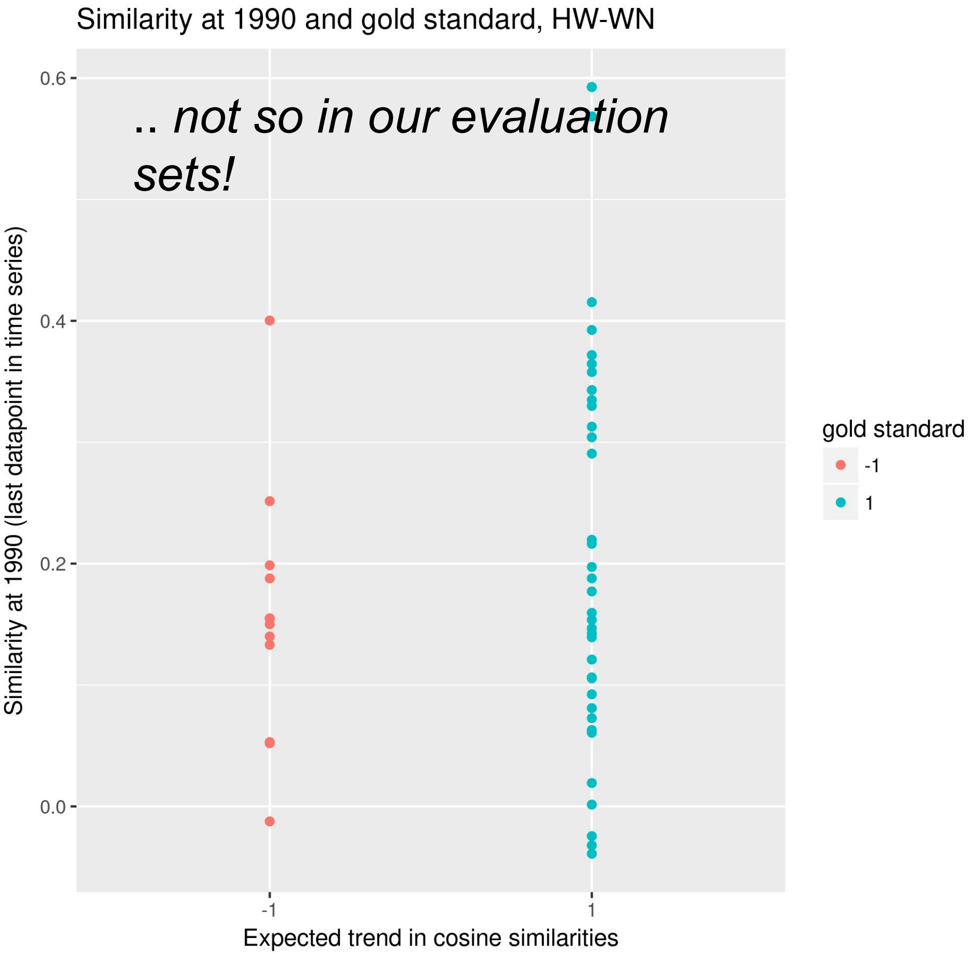


Similarity at 1990 and gold standard, baseline
Similarity at 1990 (last datapoint in time series)
0.0
0.2
0.4
0.6
-1
1
Expected trend in cosine similarities
Similarity at 1990 and gold standard, HW-WN
Similarity at 1990 (last datapoint in time series)
0.0
0.2
0.4
0.6
-1
1
Expected trend in cosine similarities
gold standard
-1
1

Shift direction could be predicted based on just the last element in the similarities time series...



.. not so in our evaluation sets!



Conclusions:

- Existing baseline based on "privileged" examples
- Findings vary very strongly for different datasets and ways of handling missing data
- We really haven't mastered this task yet
- New baseline for (necessary) future work
- Crucial to examine and report characteristics of evaluation set
- Crucial to make implementation "details" explicit

Next project: Implicit bias in portrayal of men and women as experts in the media