

# Computational approaches to semantic change detection

## Day 1, Part II: Annotation schemas and datasets

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- 1 Manual annotation
- 2 Synthetic datasets
- 3 Regularities in semantic change

# Manual annotation

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## Popular English corpora for diachronic research

Corpus	Size, words	Reference
Helsinki Corpus	$10^6$	[Rissanen et al., 1993]
New-York Times Annotated Corpus	$\approx 2 \times 10^9$	[Sandhaus, 2008]
Google Books Ngrams	$\approx 100 \times 10^9$	[Michel et al., 2011]
English Gigaword	$\approx 4 \times 10^9$	[Parker et al., 2011]
Corpus of Historical American English (COHA)	$400 \times 10^6$	[Davies, 2012]
Amazon Movie Reviews	$\approx 9 \times 10^8$	[McAuley and Leskovec, 2013]
Twitter (also in other languages)	$\approx 14 \times 10^9$	[Banda et al., 2023]

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*How to obtain such annotation?*

# Word-level annotations

[Gulordava and Baroni, 2011]

- ▶ 100 words annotated by 5 participants for semantic change between the 1960s and 1990s
- ▶ Four point annotation scale from *0: no change* to *3: significant change*, average score used as gold standard (GS)
- ▶ Inter-rater agreement = 0.51

Rank	Word	Rank	Word
1	program	100	sleep
2	domain	99	baseball
3	virtual	98	orange
4	address	97	street
5	disk	96	doubt

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## [Del Tredici et al., 2019]

- ▶ 100 words from the *r/LiverpoolFC* subreddit posts from 2011-2013 and 2017
- ▶ Annotated by forum participants, binary decision
- ▶ 26 participants, 8.8 annotations per word
- ▶ Participants saw few randomly chosen examples for each word
- ▶ Inter-rater agreement = 0.58

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	A	B	C
1	<b>target sentence 1</b>	...	<b>target sentence 2</b>
303	Bemerkungen. Ein <b>Donnerwetter</b> in Paris ist mit so vielen Verdrieslichkeiten verknüpft, daß ichs hier anführen muß. Wir hatten heute Abends eins von 6. Uhr bis halb 11. Uhr des Nachts.		Der andre observirte schärfer mit dem Ausruf: „ <b>Donnerwetter</b> , sollte ich mich irren! Sie changirt nicht Farbe, und doch zuckte sie zusammen, als die Lupinus ihr was ins Ohr sagte.“

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—positive vs. negative values indicate innovative vs. reductive meaning change.

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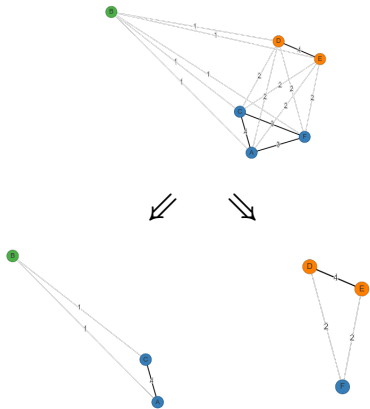
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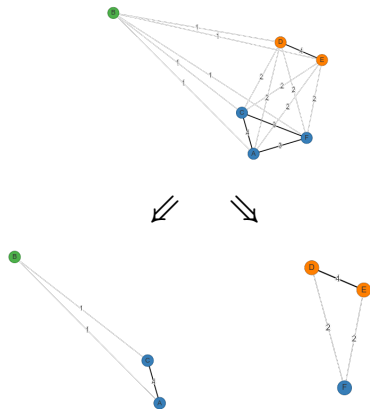
*Let's try it!*

<https://durel.ims.uni-stuttgart.de/>

# Diachronic Word Usage Graphs



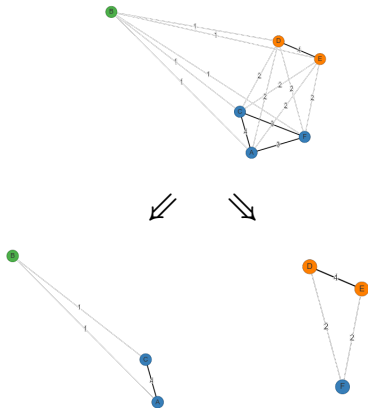
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[Schlechtweg et al., 2021]

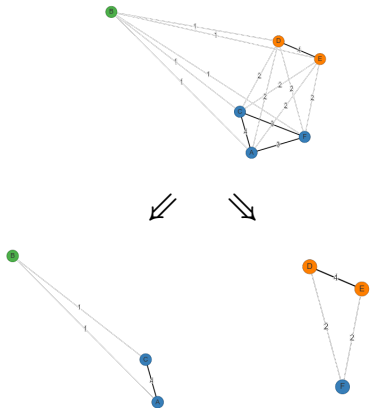
1. Randomly sample pairs of sentences for annotation
2. Annotate on the 1-4 scale
3. Cluster the graph
4. Sample additional edges to connect smaller cluster to bigger
5. Repeat 2-4 until the point each cluster has been compared to each other cluster
6. Degree of change:
  - ▶ Binary: appearing/disappearing cluster
  - ▶ Graded: difference between cluster distributions

# Diachronic Word Usage Graphs



- ▶ This procedure was used in the SemEval 2020 Task 1 Shared Task, which standardized and established benchmarks for semantic change detection [Schlechtweg et al., 2020]
- ▶ Later used in annotation for other datasets [Zamora-Reina et al., 2022, Kutuzov et al., 2022]

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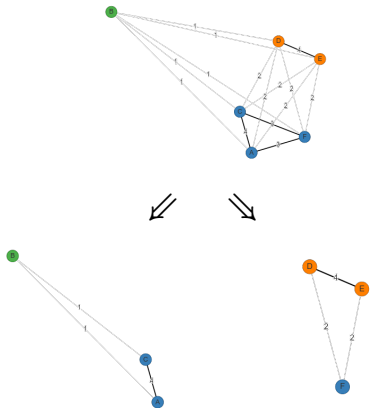


## But

- ▶ Requires additional efforts in annotating pairs from the same time period
- ▶ Sampling and clustering hyperparameters may affect the results
- ▶ Many datasets only use annotations of pairs from different time periods (*COMPARE* score) to reduce annotation efforts



# Diachronic Word Usage Graphs



## But2

- ▶ In some cases it is hard for annotators to judge whether a word used in the same sense in a pair of sentences
- ▶ Connection between sentence clusters and word **senses** is not straightforward
- ▶ Instead of using sentence pairs, some datasets annotated by explicitly linking sentences to senses from dictionaries [Schlechtweg et al., 2020] (for Latin), [Basile et al., 2020]

# (Almost) all existing datasets

## Data

	EN	DE	LA	SW	IT	NO-1	NO-2	RU-1	RU-2	RU-3	ES	SI
<b>Period 1</b>	1810-1860	1800-1899	-200-0	1790-1830	1945-1970	1929-1965	1980-1990	1700-1916	1918-1990	1700-1916	1810-1906	1997
<b>Period 2</b>	1960-2010	1946-1990	0-2000	1895-1903	1990-2014	1970-2013	2012-2019	1918-1990	1992-2016	1992-2016	1994-2020	2018
<b>Tokens (mln)</b>	7+7	70+72	2+9	71+110	52+197	57+175	43+649	93+122	122+107	93+107	13+22	70+80
<b>Targets</b>	37	48	40	32	18	80	80	99	99	99	80	104
<b>Graded</b>	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓
<b>Binary</b>	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✗
<b>Reference</b>	[Schlechtweg et al., 2020]				[Basile et al., 2020]	[Kutuzov et al., 2022]		[Kutuzov and Pivovarova, 2021]			[Zamora-Reina et al., 2022]	[Martinc et al., 2022]

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- ▶ A variety of datasets to develop **generalizable** methods for semantic change detection
- ▶ BUT:
  - ▶ Only Indo-European languages from three language families
  - ▶ "Only" few dozen words for each language, not all phenomena presented
  - ▶ Large variety among corpora that eclipses variety among languages
  - ▶ Only two time periods for most languages

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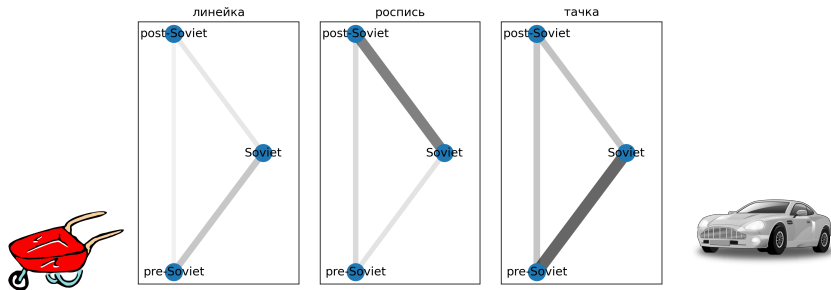
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# Diachronic trajectory types in RuShiftEval

1. **changes in every period pair**, all relatedness scores are low: линейка ('carriage/ruler/series of goods')
2. **change in the Soviet period VS the pre-Soviet period**: роспись ('list/painting')
3. **change in the post-Soviet period VS the Soviet period**: тачка ('wheelbarrow/car')
4. (trivial) **no changes**: all three relatedness scores are high.
5. (not found) **change in the Soviet period then coming back to the original meaning**



Time relatedness graphs. **Nodes**: time periods; **edge width**: relatedness scores.

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## Pseudo-words

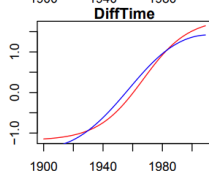
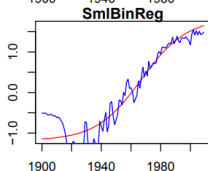
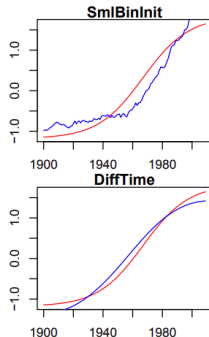
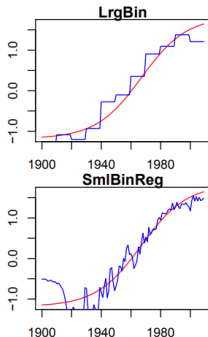
- ▶ [Rosenfeld and Erk, 2018]: Mentions of *word1* and *word2* are replaced with synthetic word *word1* ◦ *word2*
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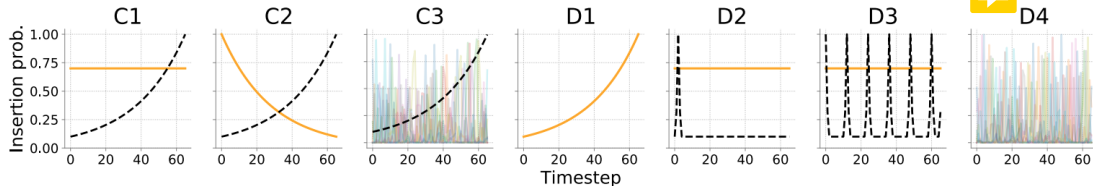
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## Sense-annotated corpus

- ▶ Instead of merging unrelated words, it is possible to use sense-annotated corpus for under/oversampling of certain senses *for the same word*
- ▶ This approach has been used in monolingual [Schlechtweg and Im Walde, 2020] and multilingual [Montariol and Allauzen, 2021] setting.

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    - ▶ In the era of LLMs and huge datasets this may be unfeasible
  - ▶ Resources necessary for more subtle strategies, i.e. sense-annotated dictionaries or WordNets, exist only for major languages

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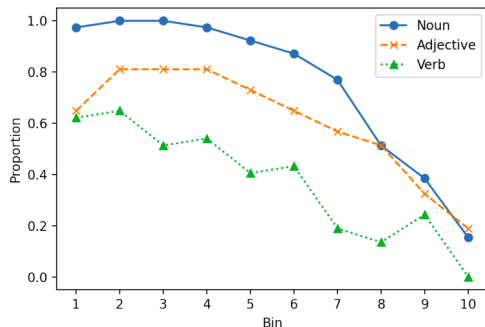


# Regularities in semantic change

- ▶ It is possible to exploit existing linguistic knowledge: historical dictionaries, known cases of semantic shift, established regularities
- ▶ Cognate studies [Uban et al., 2021, Kawasaki et al., 2022]
  - ▶ Cognates are *by definition* words that originated from the same ancestor
  - ▶ Cognates could be either *translations* of each other or *false friends*, in which case at least one of them undergone semantic change

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  - ▶ This can be used as a sanity check




[Kawasaki et al., 2022]: A proportion of translations among different bins of automatically determined semantic similarity among Spanish-French cognates (1 - most semantically similar, 10 - most dissimilar)

# What's next


- ▶ During the next three lectures we will go through various methods for semantic change detection
- ▶ This will include **hands on** exercises in a form of **Jupyter Notebooks**
- ▶ To participate in hand-on sessions you should:
  1. clone our repository [https://github.com/lmphcs/semshift\\_esslli2023](https://github.com/lmphcs/semshift_esslli2023)
  2. install all required packages and make sure you can run Python notebooks
- ▶ It's ok to skip exercises and listen for the lecture part only
- ▶ In any case, we won't have time to setup the environment in the class

# References I

 Banda, J. M., Tekumalla, R., Wang, G., Yu, J., Liu, T., Ding, Y., Artemova, K., Tutubalina, E., and Chowell, G. (2023).

A large-scale COVID-19 Twitter chatter dataset for open scientific research - an international collaboration.

This dataset will be updated bi-weekly at least with additional tweets, look at the github repo for these updates. Release: We have standardized the name of the resource to match our pre-print manuscript and to not have to update it every week.

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