Paradigmatic vs. Syntagmatic

...

The refugee is a person.
The refugee fled her home.
The migrant cannot return safely.

A migrant is a person.
The displaced person fled his home.
The displaced person cannot return.

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Evaluating Language Change Detection

Detecting Different Forms of Semantic Shift in Word Embeddings via Paradigmatic and Syntagmatic Association Changes

Anna Wegmann, Florian Lemmerich, Markus Strohmaier
RWTH Aachen University & Utrecht University

November 2020, **International Semantic Web Conference 2020**

Word Embeddings change

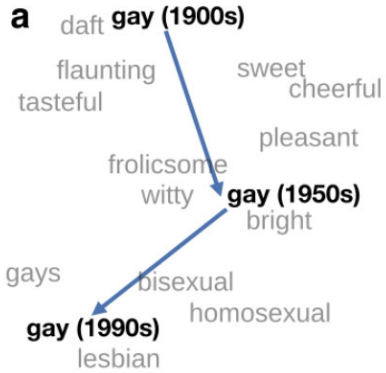
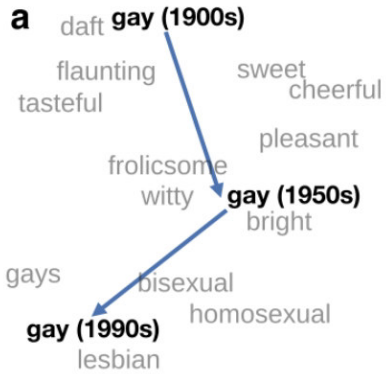


Figure from [W.L. Hamilton et al., Diachronic Word Embeddings Reveal Statistical Laws of Semantic Change, 2016]

Word Embeddings change



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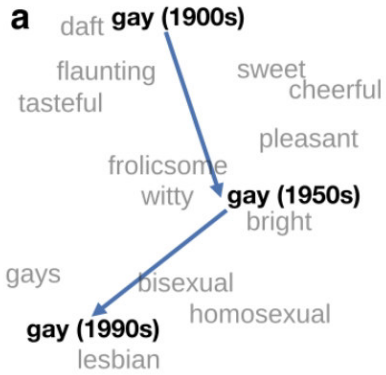
Semantic Shift Problem:

Given word w and texts $T_1,...,T_k$ in time-sensitive order

$\Rightarrow$ (How) did w shift "in meaning" over time?

Semantic Shift Problem



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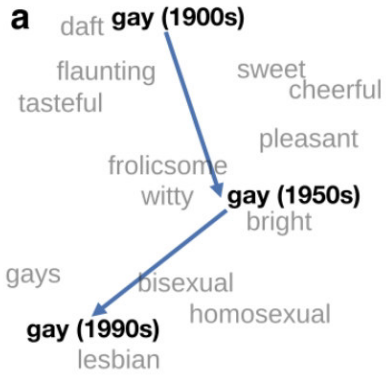
Why is this interesting?

- linguistic/societal analysis

Semantic Shift Problem



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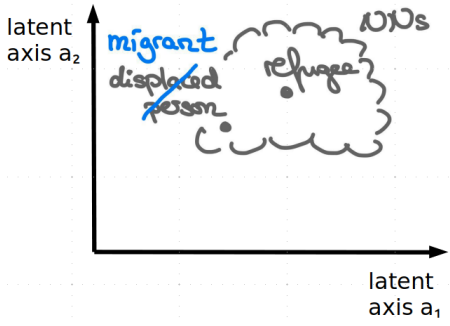
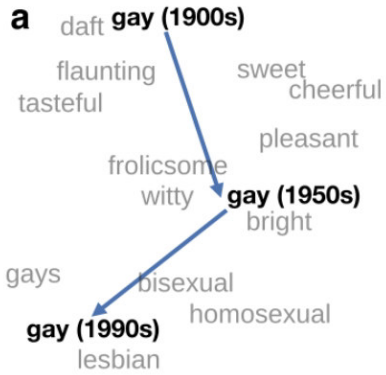


Semantic Shift Problem



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Why is this interesting?

- linguistic/societal analysis
- practical algorithmic questions: E.g., when should we update embeddings?
  $\rightarrow$ e.g., RDF2Vec[1]

[1] [Cochez et al., Global RDF vector space embeddings, 2017]

Related Work: Paradig. & Syntagmatic Associations

1. Only types of relations
between words are paradigmatic
& syntagmatic[1]

[1], e.g., in [F. de Saussure, Cours de linguistique generale, 1916];

Related Work: Paradig. & Syntagmatic Associations

1. Only types of relations between words are paradigmatic & syntagmatic[1]

2. Paradigmatic & syntagmatic relations capture different semantic properties[2]

[1], e.g., in [F. de Saussure, Cours de linguistique generale, 1916]; [2] in [M. Sahlgren, The word-space model: using distributional analysis to represent syntagmatic and paradigmatic relations between words in high-dimensional vector spaces, 2006] and [Sun et al., Learning word representations by jointly modeling syntagmatic and paradigmatic relations, 2015]

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[3] in [P. Shoemark et al., Room to Glo: A Systematic Comparison of Semantic Change Detection Approaches with Word Embeddings, 2019],[V. Kulkarni et al., Statistically Significant Detection of Linguistic Change, 2015], [A. Rosenfeld et al., Deep Neural Models of Semantic Shift, 2018]

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4. Different measures for semantic shift are different[4]

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Research Question

How can we evaluate the sensitivity of measures to paradigmatic & syntagmatic shift?

Experimental Setup

Quick Concept: Word Embeddings

Input

...

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Text Corpus

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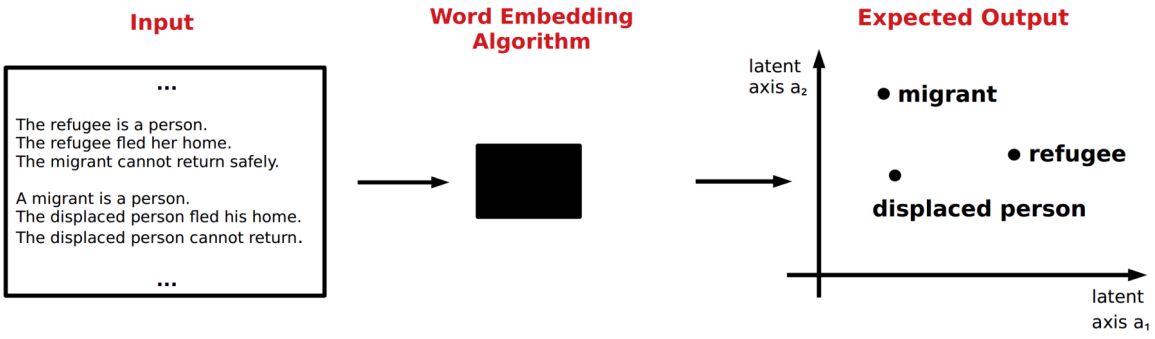
Text Corpus

Word Embedding Algorithm

E.g.: Word2Vec

Quick Concept: Word Embeddings



Datasets

1) **Amazon** reviews: 2005 - 2014 with $\approx$ six billion words

2) **Reddit**: 2012 - 2018 with $\approx$ 170 billion words.

3) **Wikipedia**: 2014 - 2018 with $\approx$ 13 billion words

made available by 1) [J. McAuley et al., Image-based Recommendations on Styles and Substitutes, 2015] on `jmcauley.ucsd.edu/data/amazon/`, 2) J. Baumgartner on `https://files.pushshift.io/reddit/` and 3) Wikimedia on archive.org

Synthetic Attacks

NNs - nearest neighbors or closest words to "refugee"

Corpus Change

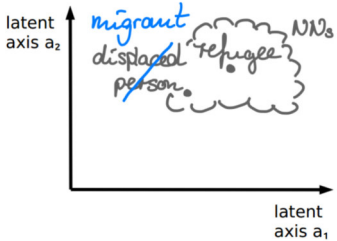
The refugee is a person.
The refugee fled her home.
The refugee cannot return safely.

migrant

A displaced person is a person.
The displaced person fled his home.
The displaced person cannot return.

⇒

Expected Embedding Change



Paradigmatic Attack

similar to [Kulkarni et al., **Statistically significant detection of linguistic change**, 2015]

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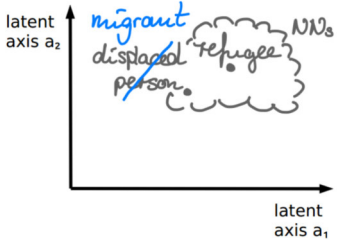


Paradigmatic Attack

Corpus Change

Syrian

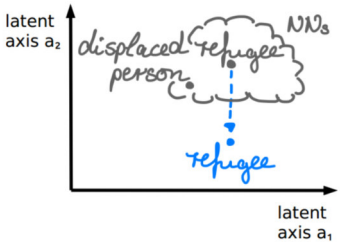
The refugee is a person.
The refugee fled her home.
The refugee cannot return safely.

the war to Syria

A displaced person is a person.
The displaced person fled his home.
The displaced person cannot return.

⇒

Expected Embedding Change



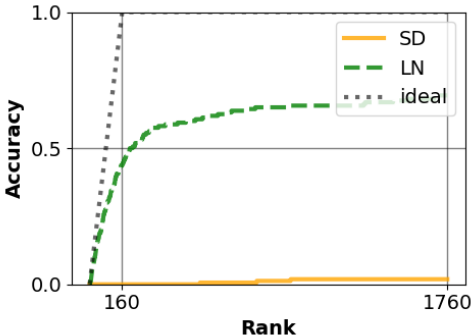
Paradigmatic & Syntagmatic Attack

Experimental Results

Results

Measures of Semantic Shift:
- Local Neighborhood (LN)[1]
- Global Semantic Displacement (SD)[2]

Paradigmatic Attack



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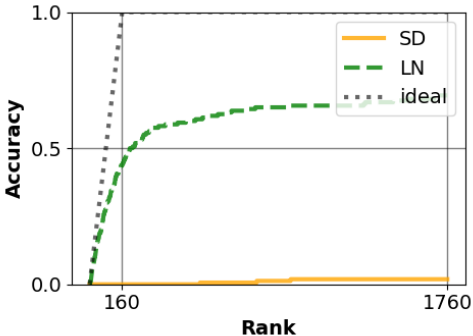
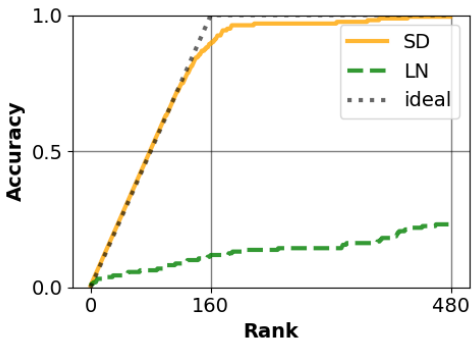
Paradigmatic Attack



Para. & Syntagmatic



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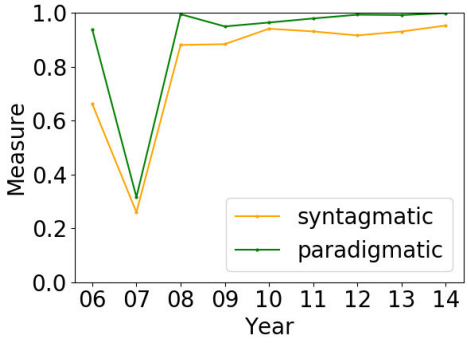
Empirical Results

with the best paradigmatic
and syntagmatic measure

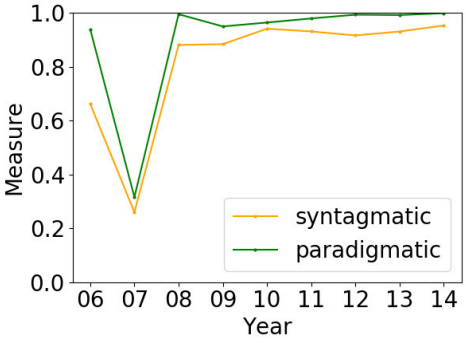
Synchronous Paradigmatic and Syntagmatic Shift



"kindle" on Amazon

"kindle" - Amazon ebook reader introduced in 2007

Synchronous Paradigmatic and Syntagmatic Shift



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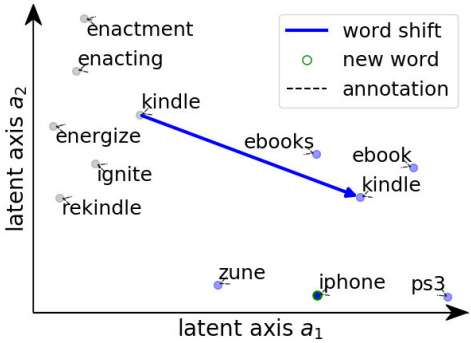
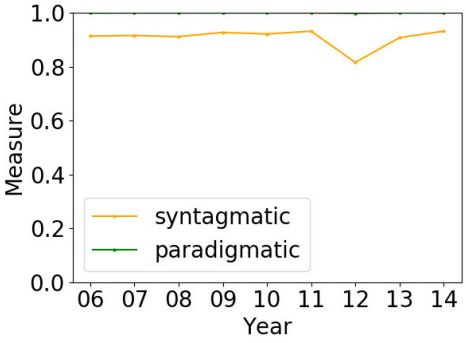


Embedding Shift from 2006 to 2007

"kindle" - Amazon ebook reader introduced in 2007

Syntagmatic without Paradigmatic Shift



"fifty" on Amazon

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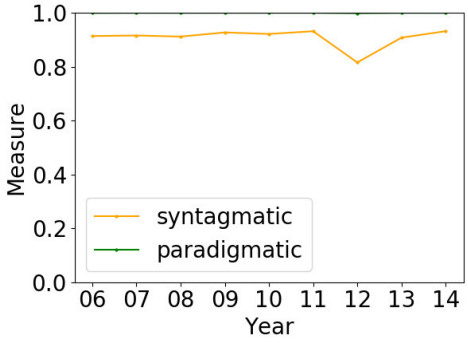

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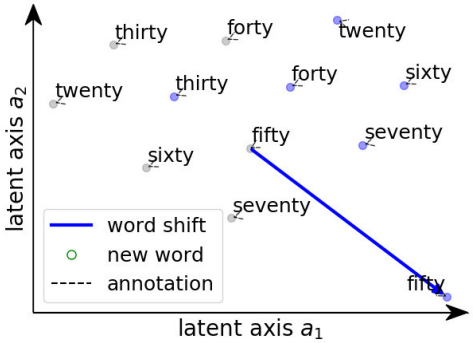
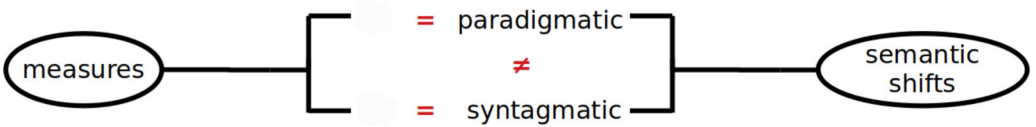


Embedding Shift from 2011 to 2012

In Conclusion

Results and Contributions



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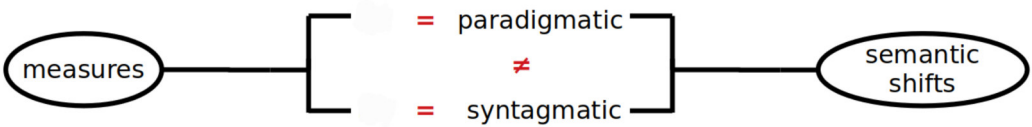

$\Rightarrow$

i. operationalization of paradigmatic and syntagmatic shift

ii. more nuanced understanding of semantic shift

Limitations

- semantic shift $\neq$ paradig.-/syntagmatic shift?

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and Future Work

- thresholding for (RDF) embeddings

Limitations and Future Work

- semantic shift $\neq$ paradig.-/syntagmatic shift?
- measure shift $\Rightarrow$ paradigmatic/syntagmatic shift?

- thresholding for (RDF) embeddings
- inferring the reason for semantic shifts

See you at the *virtual* ISWC 2020 Q&A session

or online under `https://annawegmann.github.io/`

Paper link: https://annawegmann.github.io/pdf/Detecting-Different-Forms-of-Semantic-Shift.pdf