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Bridging NLP and LLOD: Humanities Approaches to Semantic Change. Part 1

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Summary

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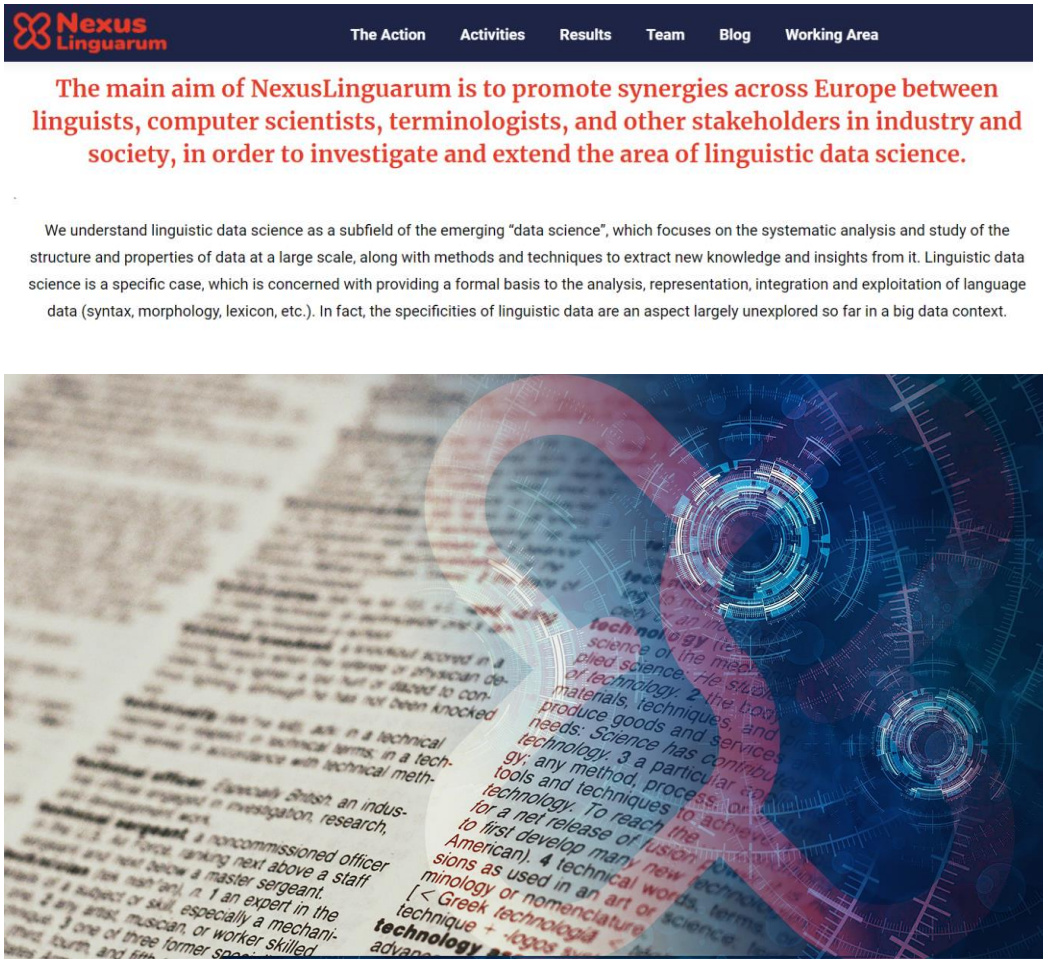
Part 1

Research background

1. About the project. *NexusLinguarum. Humanities use case. Overview*



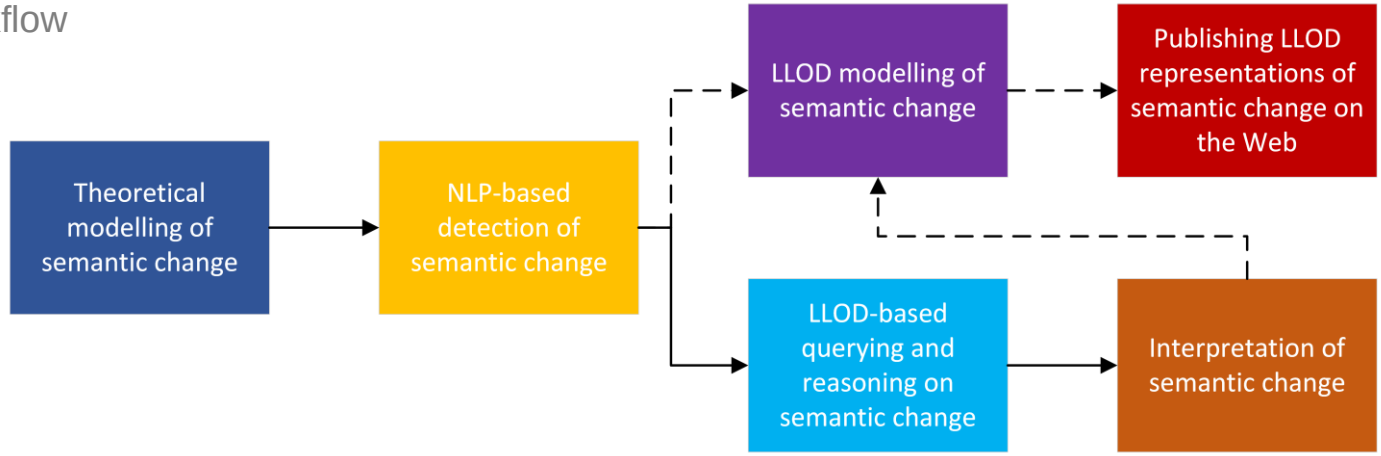
- *Nexus Linguarum* - European network for Web-centred linguistic data science (https://nexuslinguarum.eu/)
  - COST Action, CA18209 (2019-2024)
- Use case in the Humanities (UC4.2.1, working group 04) objectives
  - trace the evolution of (parallel) concepts in a collection of multilingual, diachronic corpora;
  - combine natural language processing (NLP) and linguistic linked open data (LLOD) to detect and model semantic change;
  - publish a sample of diachronic ontologies in the LLOD cloud.

1. About the project. *NexusLinguarum. Humanities use case. Research questions and workflow*

- Semantic change
  - change in meaning, either of a lexical unit (word or expression) or
  - of a concept (a complex knowledge structure that can encompass one or more lexical units as well as relations among them and with other concepts).

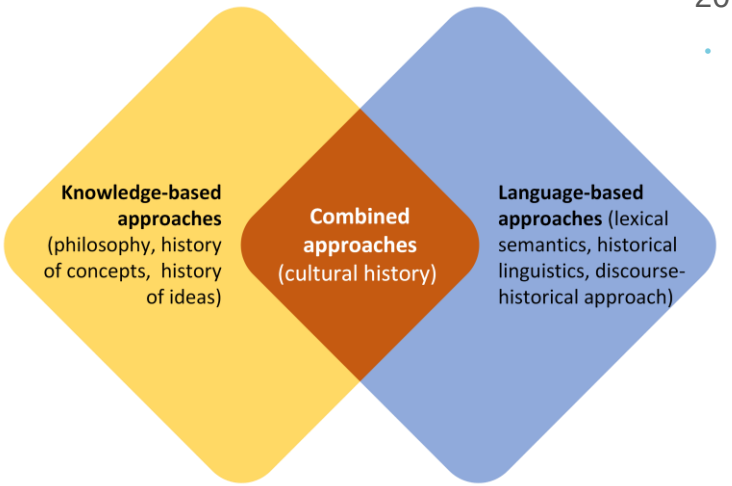
- Research questions
  - What are the mechanisms that determine linguistic innovation?
  - How are these mechanisms related to the reality?
  - Are these mechanisms language- and culture-specific or do they encompass universal aspects, applying to all languages?
  - Is it possible to detect, represent and reason about semantic change through NLP methods and linked data formalisms such as LLOD? What types of resources are needed to attain this goal?

- Workflow



2. Semantic change. *Theoretical frameworks*

- History of concepts (*Begriffs-geschichte*) (Koselleck 1994)
  - Relationship **concepts** – **reality** over a period of time:
    1) concepts and related reality – **stable**;
    2) concepts and reality **change** at the **same time**;
    3) **concept change** without a change in the reality;
    4) **reality changes**, concepts remain the same.
  - Concepts -> multi-layered **temporal structure** -> ties with:
    - past events and experiences;
    - present reality;
    - expectations for the future.
  - **Sources** -> temporal structure:
    - **instant** use (newspapers, letters, speeches);
    - gradual **development** (lexicons, dictionaries, encyclopaedias, handbooks);
    - **unchanging** forms (classical texts, timeless values).



- Lexical semantics (Geeraerts 2010):
  - **Mechanisms** of semantic change:
    1. **semasiological** (meaning-related) -> semasiological innovations endowing existing words with new meanings;
    2. **onomasiological** (naming-related) -> onomasiological innovations coupling "concepts to words in a way that is not yet part of the lexical inventory of the language" (p. 26).

- Cultural history:
  - **Language** (Richter 1994: 125, 126):
    - understood as an "agent and an indicator of structural changes",
    - that "both shaped and registered the process of change".

➢ *How to capture through digital means the dynamic interaction between conceptual and socio-cultural changes?*

- Use of digital sources: **corpora** as a reflection of reality and **dictionaries** as normative resources.

2. Semantic change. *NLP approaches. Word embedding*

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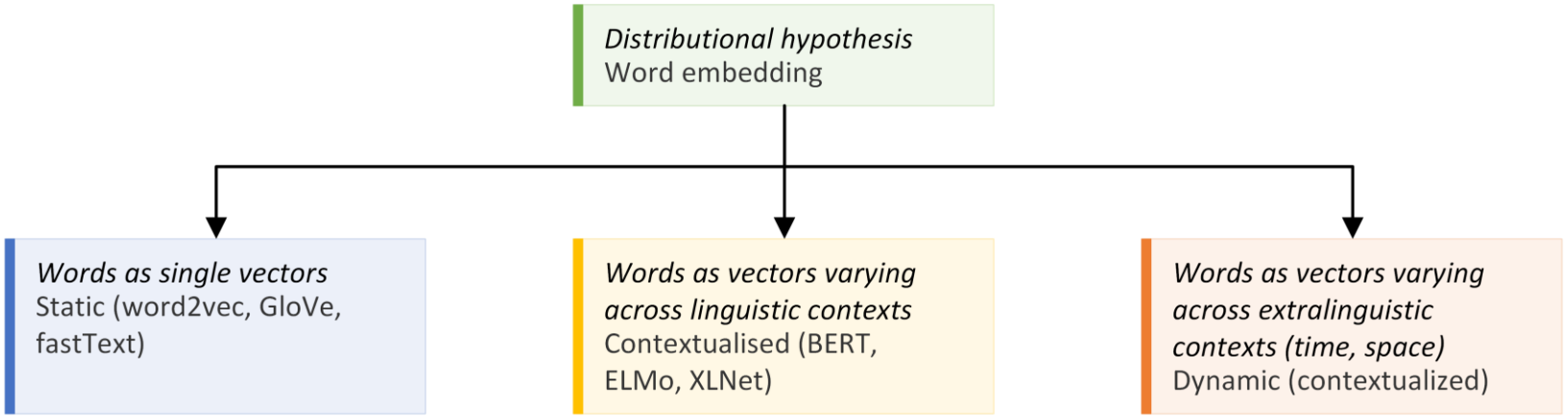
- Distributional hypothesis
  - words such as "*oculist* and *eye-doctor* […] occur in almost the **same environments**." (Harris 1954: 156)
  - **distributional semantics** -> quantifying "semantic similarities between linguistic items according to their distributional properties in large text corpora". (Goldberg, 2017: 118)
  - **word embedding** -> "learning representations of the meaning of words, called embeddings, directly from their distributions in texts". (Jurafsky and Martin, 2021: ch.6: 1)

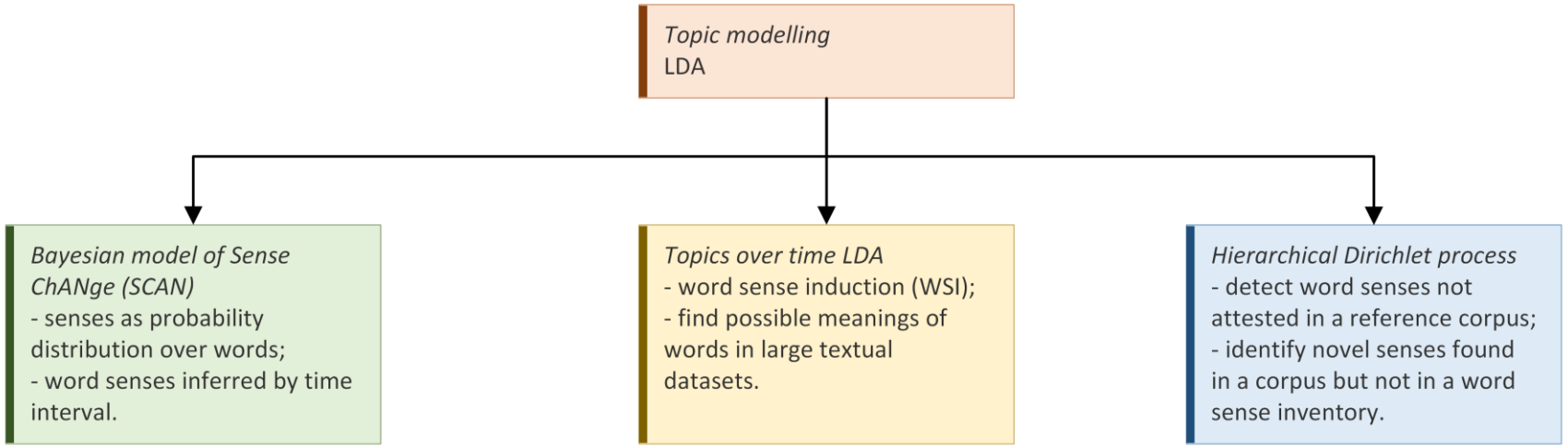
- Word embedding techniques used in "NLP **tasks** involving **semantic variability**" (Hofmann et al. 2021)



2. Semantic change. *NLP approaches. Topic modelling*

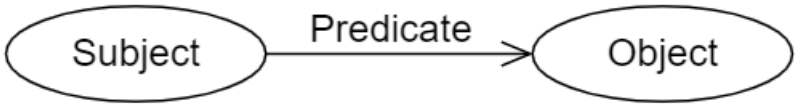
- Latent Dirichlet allocation (LDA) (Blei et al. 2003)
  - probabilistic technique -> representing each document in a corpus as a distribution over topics and each topic as a distribution over words.

- LDA as an element of **comparison** or as a basis for further **extensions** considering the temporal dimension in word meaning evolution (Armaselu et al. 2022a: 1065-1066)

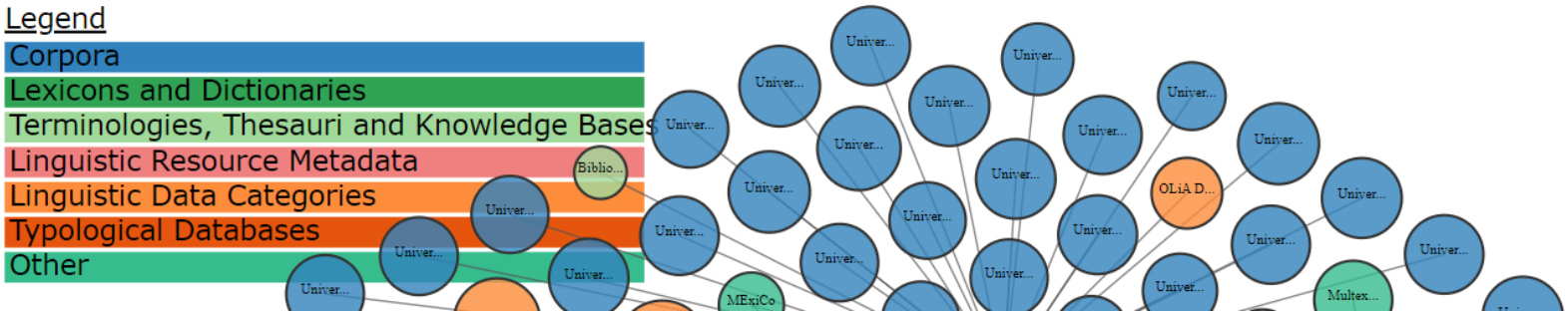


2. Semantic change. *LLOD formalisms (1)*

- Linguistic Linked Open Data (LLOD) (https://linguistic-lod.org/)
  - "movement about **publishing data for linguistics and natural language processing**" using "Web standards such as HTML, RDF or JSON-LD";
  - Resource Description Framework (RDF) -> framework for representing information on the Web as a set of **triples**: *subject, predicate* and *object* called an RDF graph, that can be visualised as a node and directed-arc diagram.



  - Linguistic Linked Open Data **cloud** diagram (Chiarcos et al. 2012)



2. Semantic change. *LLOD formalisms (2)*

- LLOD models
  - OntoLex-Lemon (McCrae 2017) -> model for **publishing lexicons** as linked data:
    - **LexicalEntry**: “head word” of a lexicon entry;
    - **Form**: written/spoken representation (morphological expressions);
    - **LexicalSense**: word sense;
    - **LexicalConcept**: equivalent lexical senses (synonyms).
  - Frequency, Attestation and Corpus Information module (OntoLex-FrAC) (Chiarcos et al. 2022) -> model integrating **lexical resources** and **information derived from corpora**:
    - **Observable**: observed entity (e.g., in a corpus) (e.g., LexicalEntry);
    - **Observation**: information based on or created from a corpus (e.g., *Attestation* – link to a lexicographical or corpus source; *Frequency* – absolute, relative frequency in a corpus; *Embeddings* – vector size, values).
  - Encoding of **etymological** information (Khan. 2018), extension of OntoLex-Lemon
    - **Etymology, Etymon**, **EtymologicalLink** - representing etymological entities and relationships.
- Other models (RDF limitation, not possible to add a temporal parameter to binary properties)
  - OWL-based, ***perdurantist*** approach - modelling entities as having temporal parts (Welty 2006).
  - OWL-Time - allowing to encode **temporal aspects** in RDF (Hobbs and Pan 2006).

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Part 2

Nexus Linguarum humanities use case. Ongoing experiments

(currently unavailable, considered for publication)

5. Conclusion and future work

- Combine **NLP** and **LLOD corpus-** and **dictionary-based resources** to enable reasoning in the task of semantic change detection and representation within a multi-lingual context
  - integrate **attestation** from **dictionaries** (dates, citations) with **corpus information** (context examples, frequency, neighbours, embeddings, similarity or other types of measures);
  - capture the **interconnections** between **language** (attested by dictionaries) and **reality** change (as expressed in corpora);
  - enable **intra-** and **cross-lingual** inferences through **etymology** and **translation** relations;
  - record new **lexical forms/meanings**, when corpus evidence is identified;
  - detect **emerging concepts** (clusters of meaning), if possible, **before** having been **lexicalised**;
  - include persistent links to **digital facsimiles** (when available).

- Starting points
  - Combine diachronic word embedding results with LLOD formalisms, such as OntoLex-FrAC (Chiarcos et al. 2022).
  - Consider as an initial dictionary framework DBnary (Sérasset, 2015) – a periodically updated version of Wiktionary in linked data format.

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