Fourth Globalex Workshop on Lexicography and Neology, Mannheim, Euralex 2022

Diachronic Semantic Evolution Automatic Tracking : a pilot study in Modern and Contemporary French combining Dependency Analysis and Contextual Embeddings

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Contents

Lexical semantic change (LSC) : omnipresent, multidimensional

- Evidence of lexical change
  - variation of meaning across linguistic communities : location (diatopy : char), sociolinguistic parameters (diastraty : covidiot), pragmatic parameter (communication settings)
  - variation through time : voiture, téléphone…
  - Metaphorical / metonymical use : Mannheim is a (whatever except a town!)
- Formal, phrasal and semantic neologisms
- Stability of meaning remains the base : we manage to communicate!
- Of paramount importance for lexicography : languages are dynamic systems

- **Research questions**
  - how to model LSC and its parameters? What hints can we use to detect semantic shifts?
  - how to track LSC in the numerical era, with the availability of more and more corpora and language use data?

Context

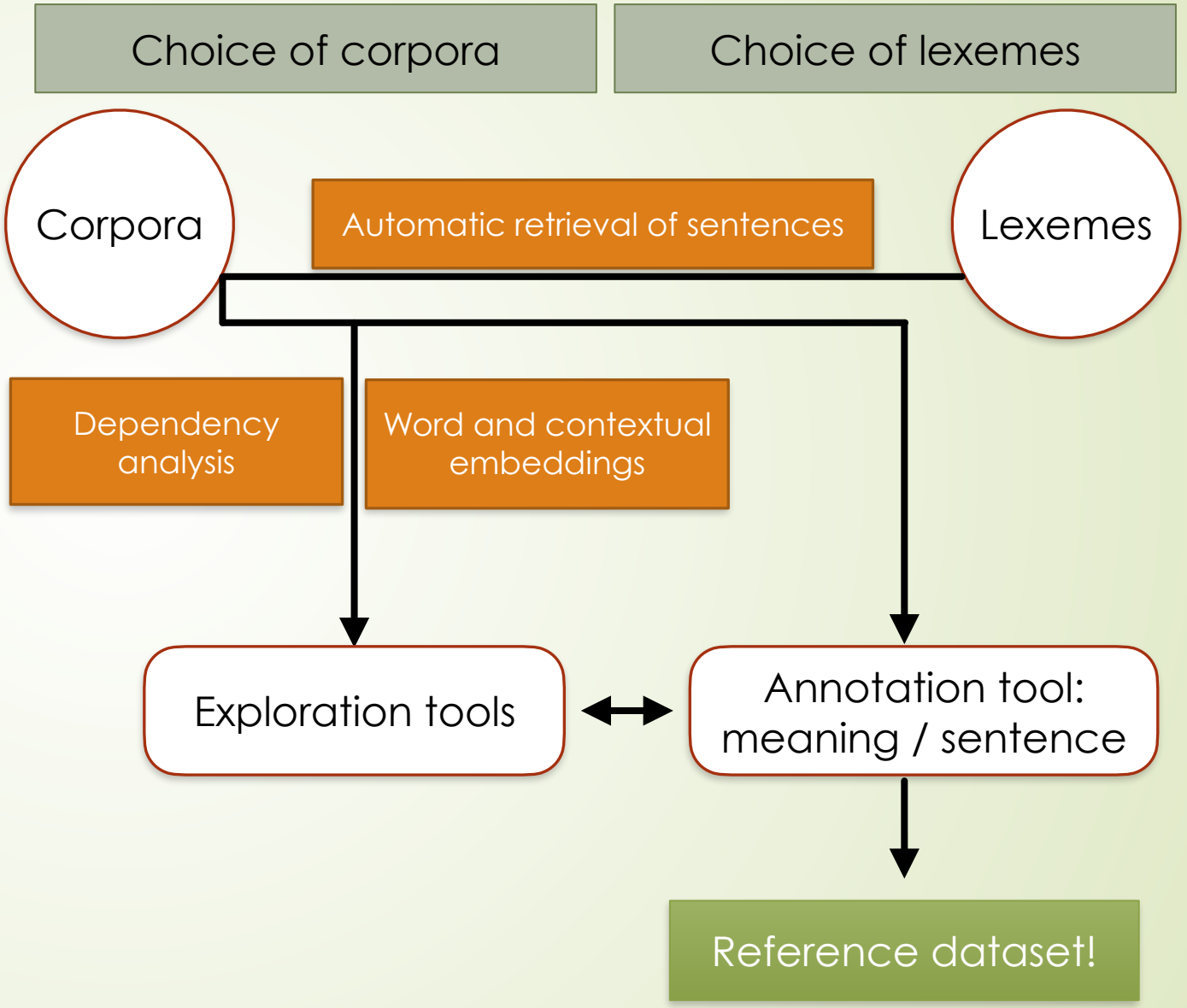
- Current project (funded by Labex Empirical Foundations of Linguistics, Paris) - EvolSem
  - **Setup a reference dataset of semantic lexical change in Modern and Contemporary French (for Linguistic, Computational Linguistics research … and the general public)**
  - **Setup a web exploration platform to get CL state-of-the-art approaches to semantic meaning and semantic change detection**
  - Setup a web platform to retrieve and edit potentially evolving lexical units
  - Prototype a automatic system to detect and track lexical semantic change
- Here I present the first steps of this project

Previous works

- **Research on lexical semantics and lexical semantic change**
  - etymology : reconstructing the origin of words and meanings
  - Traditional linguistics: extension/restriction, metaphor, metonymy, denotation/connotation, polysemy (Bréal, 1897)
  - Cognitive linguistics / semantics : metaphor and analogy at the root of human categorization / prototypes and peripheral uses, entrenchment as the process of use emergence, diffusion and adoption (Langacker, 1989; Schmid, 2020)
  - Corpus linguistics / distributional linguistics / distributional semantics (Baroni and Lenci, 2010):
    - First-order principle : « you shall know a word by the company it keeps, » (Firth, 1957)
    - Second-order principle : « if we consider words or morpheme A and B to be more different in meaning than A and C, then we will often find that the distributions of A and B are more different than the distributions of A and C. In other words, difference of meaning correlates with difference of distribution » (Harris, 1954)
  - Sociolinguistics : dia- parameters of variation (eg Coseriu, 1955)
  - Pragmatics : discourse and communication events maintain and modify the evolving system
- **Two tracks of research are studied here, each derived from the distributional hypothesis**
  - Patterns of usage / meaning and their change (collocations, collostructions, behavioral profile (Gries, 2012)
  - Word and Contextual embeddings as an approximation of the distributional hypothesis

Methodology : EvolSem project

- Diachronic corpora
- Choice of evolving lexemes
- Automatic tools : dependency analysis of sentences and exploration of patterns of usage
- Automatic tools : word embeddings and contextual embeddings
- Annotation of sentences / meaning or similarity



Methodology : diachronic corpora

- **Project Focus**
  - Timeframe : modern and contemporary French : 1800 - now
  - Genre : general language > general press

- **Diachronic corpora in French : rare and quantitatively small (or noisy!)**
  - Google Books NGrams (Michel et al., 2010)
  - Frantext : 1 152 documents (1800-1900), essentially from literature
  - Gallica (Bibliothèque Nationale de France): the most significant and complete resource even if not focusing on corpus linguistics, availability through an API, complex queries, free-of-charge (up to 1950 due to copyright constraints) - low OCR quality for old documents (up to 1850)

- **Contemporary corpora : a variety of choices!**
  - Néoveille corpora : (https://tal.lipn.univ-paris13.fr/neoveille/html/evolsem2/html/index.search.evolsem.php), European media Monitor (https://emm.newsbrief.eu/)
  - JSI Timestamped corpora (Trampus et al., 2012) : monitor corpora from RSS feeds (2014-), available through SketchEngine API, retrieve sentences and pos-tagging analysis

- **Outcome**
  - Two periods : Gallica (1800-1850) and JSI (2014-2020)
  - Quantity : at least 200 sentences per period for each evolving lexeme (up to 5000)

Methodology : choice of lexemes

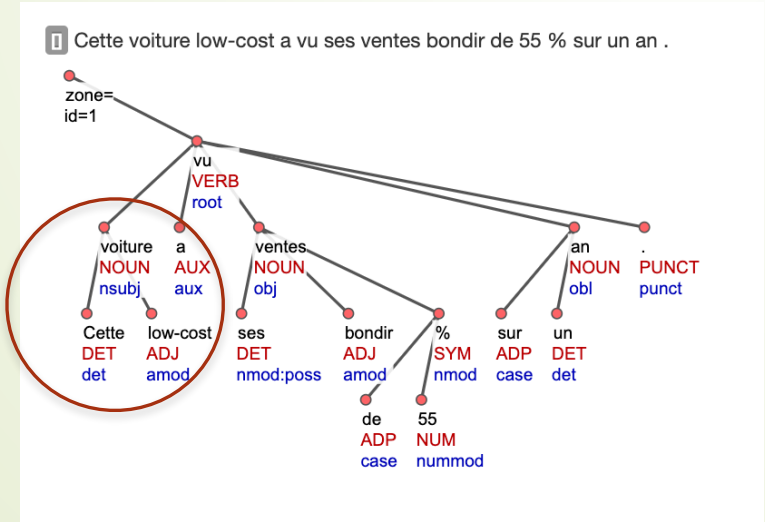
- **(Research) Question : how to find words that have undergone a semantic evolution, systematically?**
  - Absence of (systematic) lexicographic work focusing on LSC => setup from scratch or from etymological dictionaries?

- **Available methods**
  - Lexemes with frequency shifts through time : from Google Ngrams (noisy)
  - Start from the assumption : polysemy as the result of semantic changes (e.g. Bybee, 2015) - requires an available (and freely accessible) database of words
  - X-WIC (Raganato et al., 2021) reference dataset : retrieve from wiktionary all words with several meanings, with the definition and illustrative contexts => automatic approach enables to create a « big » reference dataset (but binary similarity judgements between meanings)

- **Method used in the project**
  - French Wiktionary as a valuable resource (moderation, mostly inspired by reputed dictionaries with a continuous update of meanings / words) - not perfect, but a good base
  - Retrieve set of nouns and verbs having at least two senses and having an "obsolete" mark, for at least one of the senses : 21,837 nouns and 7,997 verbs
  - Filter : at least 200 phrasal contexts in the Gallica press corpus and in the JSI corpus : 13,502 nouns and 5,187 verbs.
  - From these candidate lexemes, sample of 100 verbs and 100 nouns

Methodology : dependency analysis

- **Goal : from a sample of sentences**
  - extract lexico-syntactic patterns of use
  - explore the link between patterns and meaning
- **Procedure**
  - UDPipe analysis (Straka, 2018, https://ufal.mff.cuni.cz/udpipe/2)
  - Aggregation of patterns according to syntactic valid patterns (eg for Nouns : N + ADJ, N de N, V + N (as object), N (as object) + V)



Aggregation

nmod (635) - nominal modifier

Group	count(id_sent)
accident de (42)	42
attentat à DET (33)	33
volant de DET (31)	31
conducteur de DET (20)	20
contrôle de DET (14)	14
coffre de DET (14)	14
bord de DET (14)	14
explosion de DET (9)	9
capot de DET (7)	7
occupant de DET (7)	7
achat de DET (7)	7
prix de DET (7)	7
propriétaire de DET (6)	6
vol de (5)	5
passage de DET (5)	5

Methodology : word and contextual embeddings

- **Goal**
  - Check change of meaning with change of similar words
- **Procedures**
  - **Word embeddings** : Word2vec (Mikolov et al., 2013), FastText (Bojanovski et al., 2016) pretrained language models for French : retrieve most similar words of a given word (no polysemy handling). Word2vec model trained with Gallica news press corpora.
  - **Contextual embeddings** : French version of BERT, CamemBERT (Martin et al., 2019), pretrained => retrieve most probable words in sentences with masked language prediction task, and aggregate results. No available model for first period.

Token Embeddings (camembert-base)

Sentence
Depuis plus de vingt ans désormais, il défend son pari de la voiture électrique.
Depuis plus de vingt ans désormais, il défend son pari de la mobilité électrique.
Depuis plus de vingt ans désormais, il défend son pari de la motorisation électrique.
Depuis plus de vingt ans désormais, il défend son pari de la propulsion électrique.
Depuis plus de vingt ans désormais, il défend son pari de la trottinette électrique.

English : for more than twenty years now, he has been defending its commitment to the electric car

Aggregration →

Group	count(lexe... ↓
voiture (1421)	1421
maison (106)	106
moto (85)	85
véhicule (44)	44
chambre (40)	40
machine (28)	28
personne (24)	24
voitures (23)	23
ville (21)	21
femme (20)	20
route (18)	18
bus (17)	17

Current Results

- Editing web platform for annotating words / meaning / sentences : https://tal.lipn.univ-paris13.fr/neoveille/html/evolsem2/html/index.php#
- Exploration platform
  - dependency analysis
  - Word embeddings and contextual embeddings
- Case-studies : réaliser / téléphone / glaner

Results : dependency analysis (réaliser)

- **Make sthg become real (achieve sthg)** : *they made a green building (a green building was realized) / Ils ont réalisé un bâtiment écologique*
- **Happen / become true** : if somebody's fear are realized… / l'impossible s'est réalisé
- **Become aware of sthg** : *I realize my error, I realize that …) : je réalise mon erreur I realize that… /*

Gallica data (3390 sentences)

argumentative_structure (3384) - Any core arguments structure

Group	count(id_se...		
réaliser NOUN (1195)	1195	1...	1...
réaliser (421)	421	4...	4...
réaliser ADP DET NOUN (264)	264	2...	2...
PRON réaliser (240)	240	2...	2...
PRON réaliser NOUN (120)	120	1...	1...
réaliser NOUN ADP DET NOUN (65)	65	6...	6...
réaliser ADP DET NOUN NOUN (55)	55	5...	5...
réaliser VERB (50)	50	5...	5...
PRON réaliser ADP DET NOUN (44)	44	4...	4...
NOUN PRON réaliser (41)	41	4...	4...
réaliser PRON (39)	39	3...	3...
réaliser ADP NOUN (38)	38	3...	3...
PRON PRON réaliser (38)	38	3...	3...
NOUN réaliser NOUN (38)	38	3...	3...
NOUN réaliser (20)	20	2...	2...

1 to 15 of 335 Page 1 of 23

JSI data (2383 sentences)

argumentative_structure (2382) - Any core arguments structure

Group	count(id_se...			
réaliser NOUN (1005)	1005	1...	1...	1...
réaliser ADP DET NOUN (315)	315	3...	3...	3...
réaliser (155)	155	1...	1...	1...
réaliser NOUN ADP DET NO... (111)	111	1...	1...	1...
PRON réaliser (64)	64	6...	6...	6...
PRON réaliser NOUN (63)	63	6...	6...	6...
réaliser SCONJ (46)	46	4...	4...	4...
réaliser que (45)	45	4...	4...	4...
	Mon accident de travail - et l' arrêt forcé de travailler - m' a fait réaliser que ce métier n' était probablement pas ce que je voulais faire de	r...	r...	r...

1 to 15 of 265 Page 1 of 18

- Common : **Make sthg become real (achieve sthg)** : X (agent) *réaliser NOUN (any tangible object or that can have a concrete form [dream]) : réaliser des économies, une réforme, un édifice etc.*
- *Common* : **Happen / become true** : NOUN se réaliser
- JSI : **Become aware of sthg** : *X réaliser que / X réaliser NOUN (evaluation/judgement on a fact/ situation)*

Results : embeddings (réaliser)

- **Make sthg become real (achieve sthg)** : *they made a green building (a green building was realized) / Ils ont réalisé un bâtiment écologique*
- **Happen / become true** : if somebody's fear are realized… / l'impossible s'est réalisé
- **Become aware of sthg** : *I realize my error, I realize that …) : je réalise mon erreur I realize that… /*

Make sthg become real

Sentence
Il réalise son rêve de succès aux élections
Il concrétise son rêve de succès aux élections
Il exprime son rêve de succès aux élections
Il poursuit son rêve de succès aux élections
Il affiche son rêve de succès aux élections

he realizes his dream of success in the elections

Sentence
Il est un édifice écologique de très haute qualité
Il constitue un édifice écologique de très haute qualité
Il construit un édifice écologique de très haute qualité
Il possède un édifice écologique de très haute qualité
Il offre un édifice écologique de très haute qualité

it creates a high quality ecological building

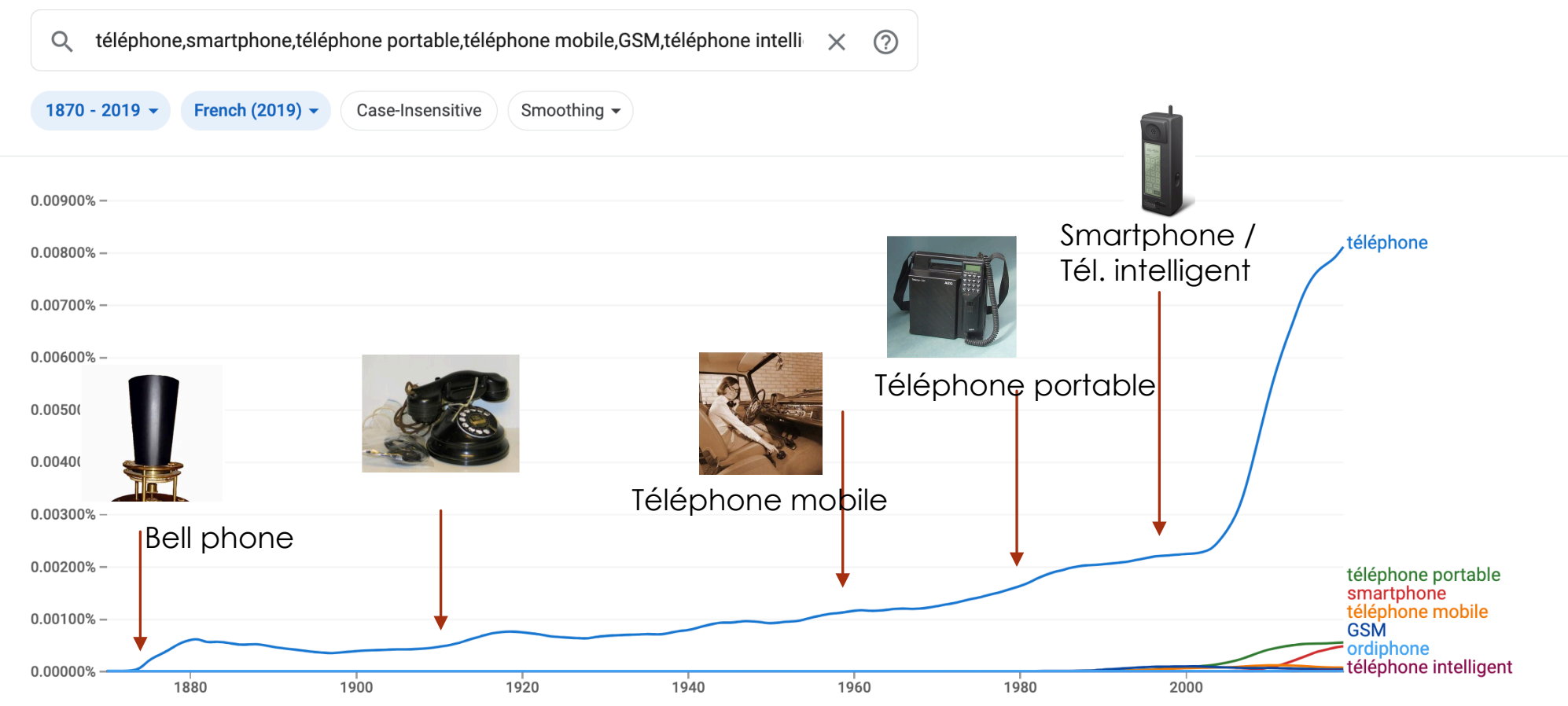
Become aware of

Sentence
Il dit que son projet n'est pas réaliste
Il estime que son projet n'est pas réaliste
Il précise que son projet n'est pas réaliste
Il affirme que son projet n'est pas réaliste
Il déclare que son projet n'est pas réaliste

He realizes that his project is not realistic

Results : dependency analysis (téléphone)

Dependency analysis as a way to access semantic features



- **Verbal patterns (Noun (subject) Verb)**
  - **common features : sonner, transmettre,**
  - **new features : denoting some semantic features of the new meaning (vibrer, biper, borner, etc.)**

- **Modifier patterns (Noun ADJ)**
  - **new features : téléphone mobile (> mobile), téléphone portable (>portable), téléphone intelligent versus smartphone (> smartphone)**
  - **Current concurrency - *téléphone* versus *portable* versus *smartphone* (Metropolitan France) versus cell phone (Canada) / handy**

Results : embeddings + dependency analysis (glaner)

<u>1800-1850 (by frequency of usage)</u>
1/ semer/récolter [to sow/harvest] (glaner des épis de blé [to glean ears of corn]),
2/lire/apprendre [to read/to learn](glaner après les anciens [to glean from the elderly),
3/trouver/chercher/découvrir [to find/search/discover] (glaner des informations [to glean information])

<u>2014-2020</u>
3/trouver/chercher/découvrir [to find/search/discover] (glaner des informations [to glean information])
4/glaner/gagner [to glean/to win] (glaner des trophées [to win trophies])
2/ has disappeared

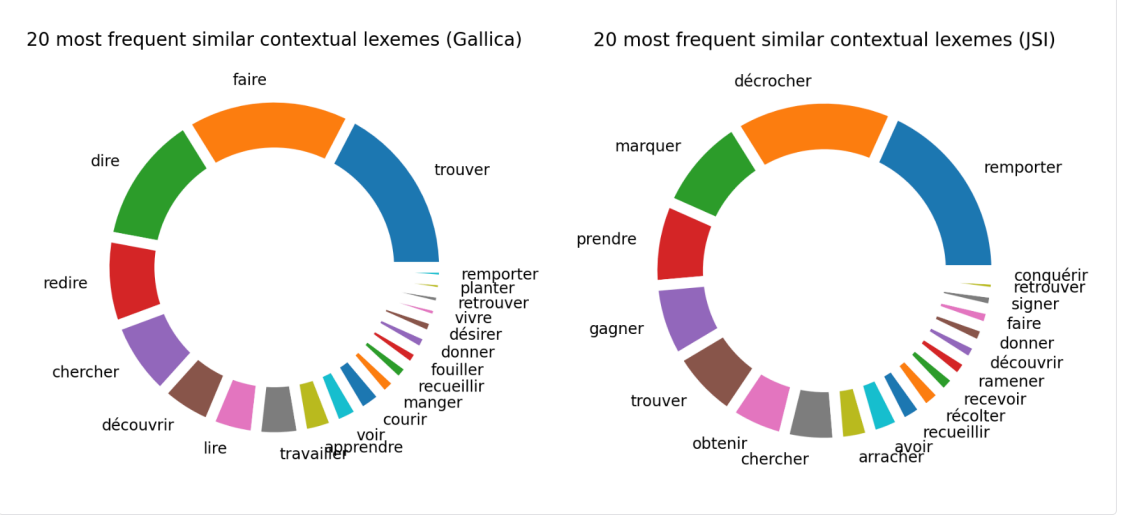
=> fill-mask task allows to discover, by induction, the semantic features that explain the meaning shifts.
The historically primary meaning of glaner denotes the **collection, after the main harvest, of the remains of the ears of wheat or any other crop**.

Two semantic features thus coexist:
- the **<u>remainder</u>**, and at the same time a **<u>remainder of a certain value</u>** (food at first).
The conjunction of these two traits is preserved by metaphor in senses 2 and 3, while only the second trait is used in sense 4, essentially applied to sports.

Group	count(id_sent)
glaner (686)	686
glaner ADP DET NOUN (558)	558
glaner dans DET champ (91)	91
glaner après DET ancien (10)	10
glaner à DET successeur (7)	7
glaner de DET souvenir (6)	6
glaner pour DET histoire (6)	6
glaner dans DET œuvre (6)	6
glaner dans DET domaine (5)	5
glaner de DET côté (5)	5
glaner dans DET page (5)	5
glaner après DET moisson (5)	5
glaner dans DET ouvrage (5)	5
glaner dans DET livre (5)	5
glaner de DET information (5)	5
glaner dans DET volume (4)	4

Filters
Columns

Group
glaner NOUN (796)
glaner point (169)
glaner titre (68)
glaner victoire (50)
glaner maximum (41)
glaner information (39)
glaner médaille (30)
glaner succès (29)
glaner trophée (18)
glaner conseil (16)
glaner voix (14)
glaner place (10)
glaner temps (10)
glaner laurier (9)
glaner résultat (9)
glaner prix (7)



Conclusion / perspectives

- Pilot study to identify semantic structure and its evolution from three parameters
  - (Cognitive aspects) frequency change,
  - (Linguistic aspects) patterns of usage, distribution similarity,

- About 10 nouns and 10 verbs with meanings and prototypical sentences
- Exploration web platform will be available soon

Conclusion / perspectives

- **Contextual Embeddings**
  - **Advantages**
    - Useful to identify meanings by providing synonyms
    - most of the time, all meanings are present but with a different importance in use (eg : glaner => récupérer dans les champs versus recueillir une information versus gagner qch en sport)
  - **Drawbacks**
    - Very sensitive to sentence structure => **requires simple sentences and even prototypical sentences as meaning anchors**
    - Mix of synonyms, hypernyms and co-hyponyms

Conclusion / perspectives

- **Patterns of usage / dependency analysis**
  - **Advantages**
    - Useful to get prototypical patterns of usage and the paths of lexical innovation - **readable and interpretable**
    - Combination of syntactic patterns ans lexico-syntactic patterns the most promising avenue of research
    - New meanings appear first explicitly (example : téléphone mobile, portable) before being embedded in a short form (>téléphone).
    - Patterns can also retrieve (semi-)frozen multiword expressions
  - **Drawbacks**
    - Very sensitive to sentence structure => requires simple sentences
    - **Association measures to the rescue!**

Conclusion / perspectives

- **Diachronic Lexical Semantic Change Detection still in its infancy**
  - State-of-the-art systems only work on toy reference datasets, mainly in English
  - Current monopoly of Neuronal Approaches, whereas these methods are approximated numerical representation of linguistic features
- **Need for a combination of criteria :**
  - Frequency shift (as the main hint of entrenchment)
  - Usage patterns shift
  - Distributional shifts
  - Sociolinguistical / contextual shifts
- **Next steps :**
  - Manual choice of prototypical sentences as anchor for meaning ans clustering of Embeddings to show evolution and graduality
  - Usage patterns complemented with association measures to get MWE and the most accurate new patterns
  - Annotation campaign of sentences similarity to check the expert annotations

- Do not overtrust corpora but use them!
- Thank you!

Methodology : linguistic annotation

- Two schemes : discrete meanings versus prototypical meanings and peripheral uses

Method / references	Advantages	Drawbacks
a priori sets of meaning - annotators decide on meaning annotation per sentence + inter-annotator agreement	Explicit meanings	Arbitrary set of meanings Low inter-annotator agreement
retrieve sample of sentences with the given word - annotators are presented pairs of sentences and they decide on the similarity of meanings + inter annotator agreements	Higher inter annotator agreement Gradability of meanings and prototypical meanings	Implicit meanings

Methodology : linguistic annotation

- **Linguistic description of meanings with several instructions**
  - Prototypical versus peripheral meanings
  - Describe prototypical pattern uses for every meaning
  - Describe lexical change processes
  - Find prototypical sentences