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Creating and exploiting a lexical database of deverbal nouns in French

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Introduction

Introduction

- Interest in the semantics of derivational processes has increased in recent years[1]
- Common topics of investigation include
  - the **polysemy** of derivational processes[2]
  - semantic differences between **competing** processes[3]
  - the semantic **transparency** of derived words[4]
  - the **transfer** of cross-categorial semantic properties between bases and derivatives[5]

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1 Rainer et al. (2014); Bauer et al. (2015); Lieber (2016); Kotowski and Plag (2023); a.o.

2 Melloni (2011); Schulte (2015); Plag et al. (2018); a.o.

3 Naccarato (2019); Huyghe and Wauquier (2021); Nagano (2023); a.o.

4 Schäfer (2018); Günther and Marelli (2019); Libben et al. (2020); a.o.

5 Haas et al. (2008); Fábregas and Marín (2012); a.o.

Introduction

- Providing reliable answers to research questions on the semantics of derivation requires detailed semantic information about large amounts of data
- The data used to analyze the semantic aspects of derivation are often limited in the number of derivatives or processes considered
- The semantic analysis conducted rarely allows broad comparisons or quantitative generalizations
- The semantic information that can be obtained automatically is often too coarse or imprecise to address key research questions

Outline

- In this talk, we focus on the case of verb-to-noun derivation and present a large-scale manually annotated database of French deverbal nouns
- We first provide details on the creation of the database (sample selection, annotation scheme, annotation quality)
- We then present descriptive results with respect to 3 research topics
  - Affix polyfunctionality and lexical ambiguity
  - The preservation of lexical aspect in nominalizations
  - The variety of semantic types across derivational families

Database

Sampling

- We assemble a sample of deverbal nouns from the French web corpus FRCOW[6] (10.8 billion tokens)
- Nouns formally related to a verb in the corpus are automatically extracted, considering
  - 42 suffixes (e.g., *-age*, *-ment*, *-eur*) and 4 forms of conversion (e.g., past participles, nominalized infinitives)
  - regular allomorphy (e.g., *certifier* 'certify'/*certification* 'certification')
- In total, 59,353 V-N candidate pairs are automatically extracted

[6] Schäfer (2015); Schäfer and Bildhauer (2012)

Sampling

- The candidate pairs are controlled to select only those with a relation between at least one sense of the verb and one sense of the noun
- The sampling of V-N pairs is conducted in **3 steps**

  S1 Exhaustive manual filtering of lists of candidates for the 36 weakly productive processes (e.g., *-ade*, *-ail*, *-ard*, *-is*, *-ette*)

  S2 Selection of nouns for the 10 highly productive morphological processes to complete the morphological families initiated in S1

  S3 Random selection of additional V-N pairs from the highly productive processes and completion of morphological families

- The final sample includes 5,274 nouns and 1,710 verbs

Semantic annotation

- V-N pairs are manually annotated for
  - **semantic type** of N
  - **lexical aspect** of V and N
  - semantic roles of the **arguments** of V and N
- To account for lexical ambiguity, the different senses of V and N are kept separated in the annotation
- The annotators rely on the instructions and definitions from annotation guidelines

Semantic annotation

- The annotation guidelines are available on GitHub

Semantic types

- Semantic types are defined as
  - Ontological types, depending on the nature of the referent denoted by the noun (e.g., event, animate, artefact)
  - Relational types (e.g., transposition, agent, result), depending on the relation with the base verb
  - **Combined types**, i.e., ontological + relational types

Ontological types

- 14 simple ontological types are distinguished based on linguistic tests[7]

Type	Example	Type	Example
Artefact	*bouilloire* 'kettle'	Cognitive	*corrélat* 'correlate'
Domain	*jardinage* 'gardening'	Financial	*redevance* 'license-fee'
Animate	*collaboratrice* 'colleague'	Natural	*nageoire* 'fin'
State	*agacement* 'irritation'	Phenomenon	*senteur* 'scent'
Event	*accouchement* 'labor'	Property	*persévérance* 'perseverance'
Institution	*association* 'society'	Quantity	*lichette* 'lick'
Disease	*pelade* 'autoimmune alopecia'	Time	*échéance* 'due date'
NA	*échappatoire* 'way out'		

Table 1: Simple ontological types

[7] Godard and Jayez (1996); Flaux and Van de Velde (2000); Huyghe (2015)

Ontological types

- 7 complex ontological types are used to describe nouns with a hybrid meaning consisting in the combination of two simple types[8]

(1) *déclarer* 'announce' → *déclaration* 'announcement' [Cognitive*Event]

(2) L'hôpital Legouest de Metz a effectué une **déclaration** selon laquelle il venait d'accueillir deux victimes blessées par balles. (web)

'The Legouest Hospital in Metz made a **statement** according to which they had just received two victims with gunshot wounds'

[8] Cruse (1995); Pustejovsky (1995); Asher (2011); Murphy (2021); a.o.

Ontological types

Complex type	Example
Artefact*Cognitive	*circulaire* ‘memorandum’
Event*Natural	*inflammation* ‘inflammation’
Artefact*Institution	*restaurant* ‘restaurant’
Event*Phenomenon	*crissement* ‘squeaking’
Cognitive*Event	*témoignage* ‘testimony’
Event*State	*disparition* ‘disappearance’
Event*Financial	*paiement* ‘payment’

Table 2: Complex ontological types

Relational types

- 17 relational types adapted from the VerbNet and LIRICS semantic role inventories[9] are distinguished on the basis of definitions provided in the guidelines
- They are semantically equivalent to the roles that derived nouns fulfill with respect to base verb predicates

(3)

a.	*arroser* 'water'	→	*arrosoir* 'watering can'	[INSTRUMENT]
b.	*vendre* 'sell'	→	*vendeur* 'seller'	[AGENT]
c.	*traîner* 'drag'	→	*traîneau* 'sled'	[THEME]
d.	*mourir* 'die'	→	*mourant* 'dying person'	[PATIENT]

[9] Kipper-Schuler (2005); Petukhova and Bunt (2019)

Relational types

- A **TRANSPOSITION** type is added to account for cases where the derivative denotes (more or less) the same eventuality as the base[10]

(4)
a. *atterrir* 'land' → *atterrissage* 'landing' [TRANSPOSITION]
b. *se méfier* 'be suspicious of' → *méfiance* 'suspicion' [TRANSPOSITION]

[10] Ten Hacken (2021); Lieber (2015)

Semantic functions

- Ontological and relational types are concatenated to form combined types
- The same ontological type can be associated with different relational types (5), and vice versa (6)

(5)

a.	*bâtir* 'build'	→	*bâtiment* 'building'	[Artefact-RESULT]
b.	*raser* 'shave'	→	*rasoir* 'razor'	[Artefact-INSTRUMENT]
c.	*garer* 'park'	→	*garage* 'garage'	[Artefact-LOCATION]

(6)

a.	*bâtir* 'build'	→	*bâtiment* 'building'	[Artefact-RESULT]
b.	*énerver* 'irritate'	→	*énervement* 'irritation'	[State-RESULT]
c.	*créer* 'create'	→	*créature* 'creature'	[Animate-RESULT]

Aspectual properties

- Annotated aspectual properties are the following
  - Dynamicity
  - Durativity
  - Telicity
  - Post-phase (i.e. ability to denote a resulting state)[11]
- The annotation of aspectual properties is based on linguistic tests taken from the literature on lexical aspect[12]

[11] Piñón (1997 ; 1999); Apothéloz (2008); Fradin (2011); Haas and Jugnet (2013)

[12] Vendler (1967); Dowty (1979); Rothstein (2004); Haas et al. (2008); Filip (2012); a.o.

Argument structure

- The maximal possible argument structure is annotated for both verbs and nouns
- Each argument is described by the semantic role it is assigned by the base verb or the derived noun
- The list of possible semantic roles for the annotation of arguments is the same as the one used for the annotation of relational types

Lexical ambiguity

- Different meanings are postulated for any change of base verb (7), ontological type (8), or relational type (9)

(7)
a. *balayer*$_1$ 'sweep' → *balayage*$_1$ 'sweeping'
b. *balayer*$_2$ 'scan' → *balayage*$_2$ 'scanning'

(8)
a. *ravitailler*$_1$ 'resupply' → *ravitaillement*$_1$ 'resupplying' [Event]
b. *ravitailler*$_1$ 'resupply' → *ravitaillement*$_2$ 'supplies' [Artefact]

(9)
a. *sécher*$_1$ 'dry' → *séchoir*$_1$ 'clothes horse' [INSTRUMENT]
b. *sécher*$_1$ 'dry' → *séchoir*$_2$ 'drying room' [LOCATION]

- A total of 8,206 senses are finally identified

Inter-annotator agreement

- The annotation of senses relies on lexicographic definitions[13] and the examination of corpus occurrences (FRCOW and web)
- The quality of the annotation and the reliability of the annotation schema is evaluated through measures of inter-annotator agreement
  - The agreement on ambiguity is computed with ICC score for 10 samples of 50 N annotated by two annotators (ICC = 0.54)
  - The agreement for the 17 semantic properties is computed with Kappa score and PABAK[14] for 10 samples of 50 verb-nouns pairs

[13] *Le Trésor de la Langue Française informatisé*; *Le Petit Robert*

[14] Byrt et al. (1993)

Inter-annotator Agreement

	Raw agreement	Kappa	PABAK
V Transitivity	0.93	0.80	0.88
V Dynamicity	0.99	0.90	0.98
V Durativity	0.86	0.53	0.74
V Telicity	0.73	0.55	0.61
V Post-phase	0.83	0.44	0.61
V Subject role	0.75	0.60	0.72
V Object role	0.73	0.66	0.71
V Oblique role	0.84	0.44	0.82
N Ontological type	0.73	0.66	0.71
N Relational type	0.80	0.72	0.78
N Dynamicity	0.99	0.94	0.98
N Durativity	0.91	0.83	0.87
N Telicity	0.87	0.79	0.83
N Post-phase	0.91	0.83	0.87
N Role of 1rst argument	0.67	0.58	0.64
N Role of 2nd argument	0.81	0.64	0.79
N Role of 3rd argument	0.97	0.39	0.95
Mean	0.84	0.67	0.79

Table 3:
Inter-annotator agreement for 10 samples of 50 verb-noun pairs

Descriptive results

Ambiguity and polyfunctionality

- **Lexical ambiguity** (i.e. the number of senses of a word) should be carefully distinguished from **affix polyfunctionality** (i.e. the number of semantic types realized by an affix) when investigating the polysemy of nominalizations
- Not all the derivatives formed with a process instantiate all the semantic types realized by the process
- In our dataset, nominalizing suffixes have an average polyfunctionality of 8.9 (SD = 8.8), whereas derivatives have an average ambiguity of 1.6 (SD = 0.9)
- A moderate correlation can be observed between average lexical ambiguity and affix polyfunctionality (Kendall's τ = 0.35, $p < 0.001$)

Ambiguity and polyfunctionality

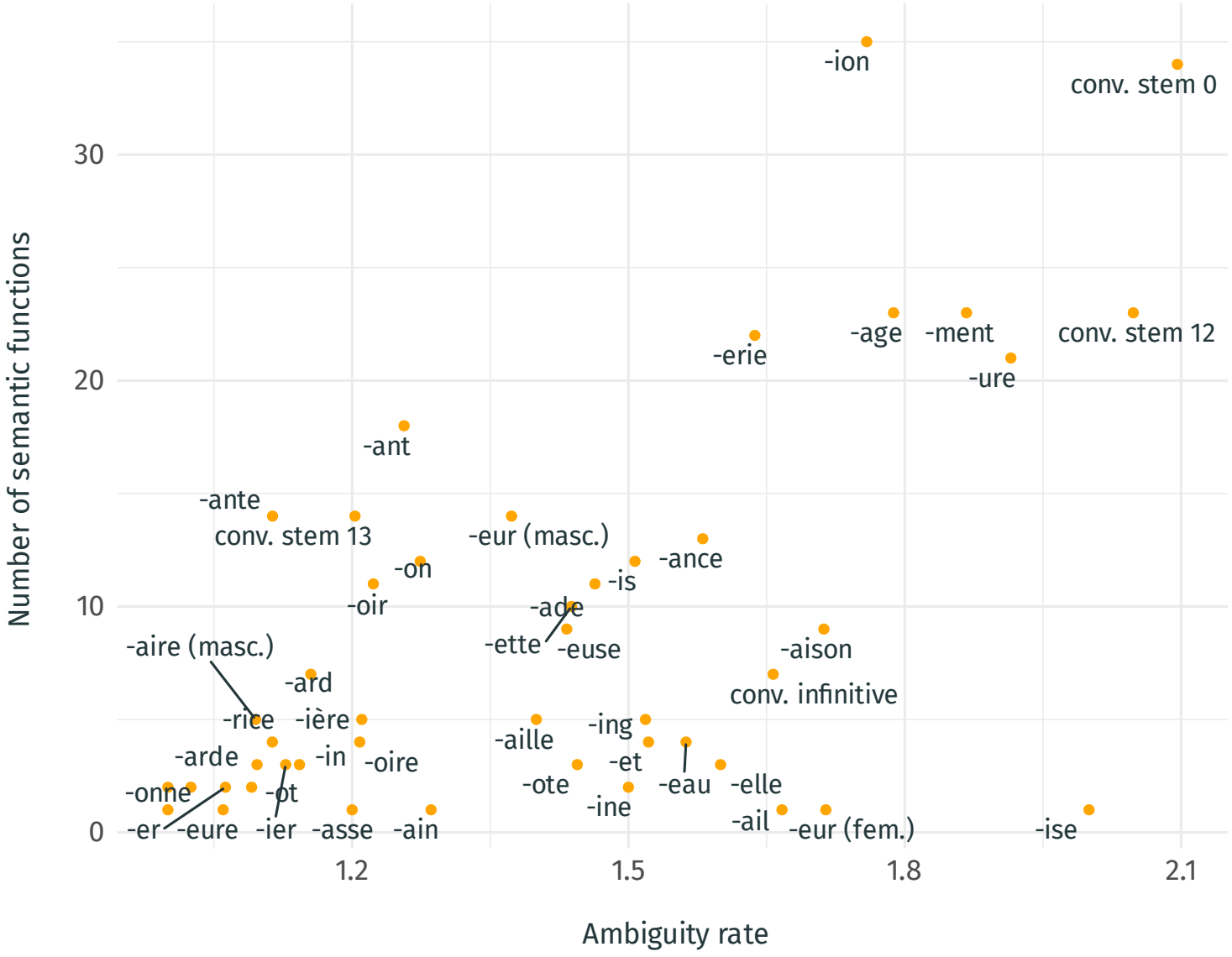

Figure 1: Relationship between lexical ambiguity and polyfunctionality across deverbal processes

Ambiguity and polyfunctionality

- A corollary to the distinction between ambiguity and polyfunctionality is that not all semantic types are equally frequent in the lexical output of a process
- The dataset allows us to compute a measure of semantic diversity (the **Hill-Shannon index**) that is based on
  (i) the **number of functions** served by each morphological process
  (ii) the **evenness** of their distribution
- The Hill-Shannon index can be interpreted as the number of different functions a process would have if these functions were perfectly evenly distributed among the process's derivatives

Ambiguity and polyfunctionality

- Conversions from stems 0, 12 and 13 and suffixes *-erie* and *-ure* are the most diverse processes in the dataset (i.e., diversity is not strongly related to productivity)

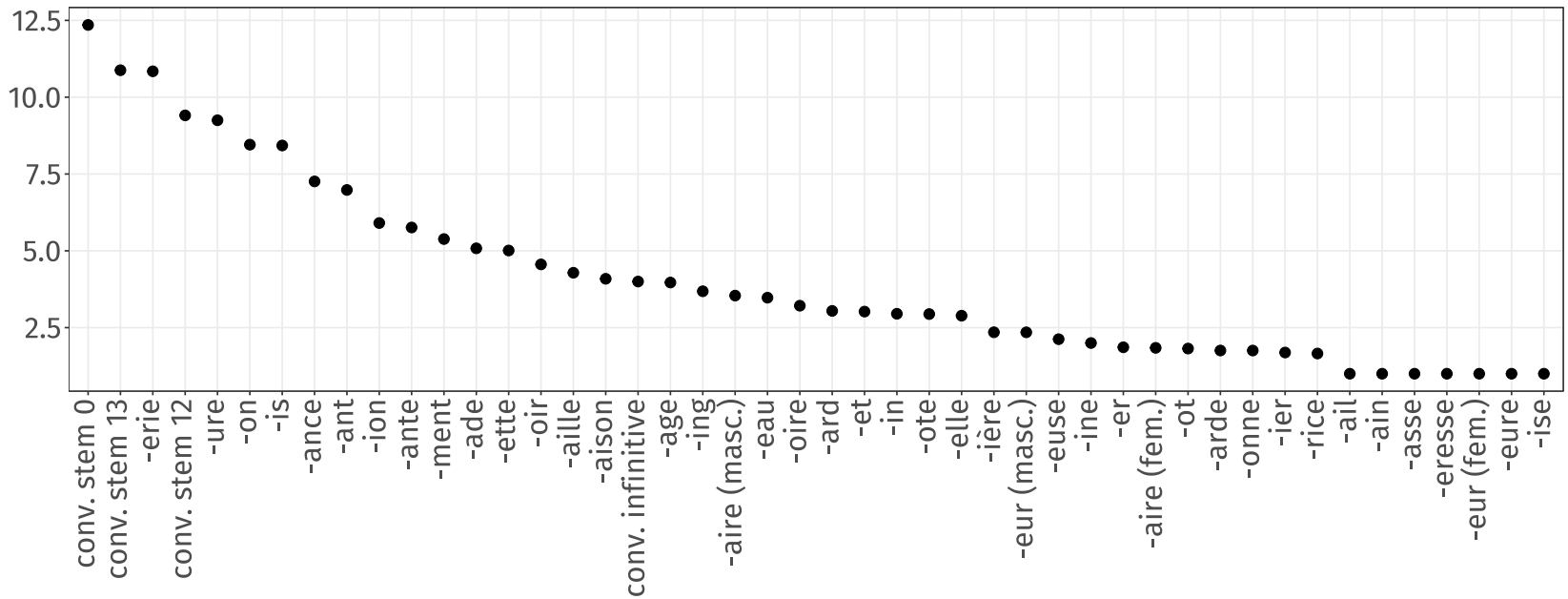

Figure 2: Hill-Shannon diversity score per derivational process

Lexical aspect preservation

- It is often assumed that eventuality-denoting nominalizations inherit the lexical aspect of their bases

  (10) **Aspect Preservation Hypothesis (APH)**
  "The lexical aspect of a verb is preserved under nominalization if the resulting nominal denotes an eventuality"[15]

- To investigate the preservation of lexical aspect in nominalizations, we focus on nouns denoting eventualities

[15] Fábregas et al. (2012)

Lexical aspect preservation

- Eventuality-denoting nominalizations inherit the properties of the base verbs (durativity, dynamicity, telicity, and post-phase) in **most but not all** cases (3,515/4,162 lexemes = 84.5%)
- Differences can be observed between aspectual features

	Dynamicity	Durativity	Telicity	Post-phase
# preserving lexemes	3,920	3,772	3,652	3,800
% preservation	94.2	90.6	87.7	91.3

Table 4: Results per aspectual feature

Lexical aspect preservation

- The aspectual discrepancies observed between bases and derivatives may result from lexicalization
- However, aspectual discrepancies are not independent from processes (χ^2 = 415.3, $p < .001$), which suggest that discrepancies may be influenced by derivational processes
- Additional investigations on neologisms ending in *-age*, *-ment* and *-ion* reveal distinct trends in aspect shifts depending on the suffix[16]

[16] Huyghe et al. (2023)

Derivational families

- The semantic structure of derivational families can be described for the verbal lexemes present in the dataset
- The verbal lexemes are associated on average with
  - 2.4 derivatives (nouns with different forms) (*SD* = 1.6)
  - 2.9 lexemes (nouns with different senses) (*SD* = 2.2)
- The number of semantic types found in the different morphological families is quite variable

Derivational families

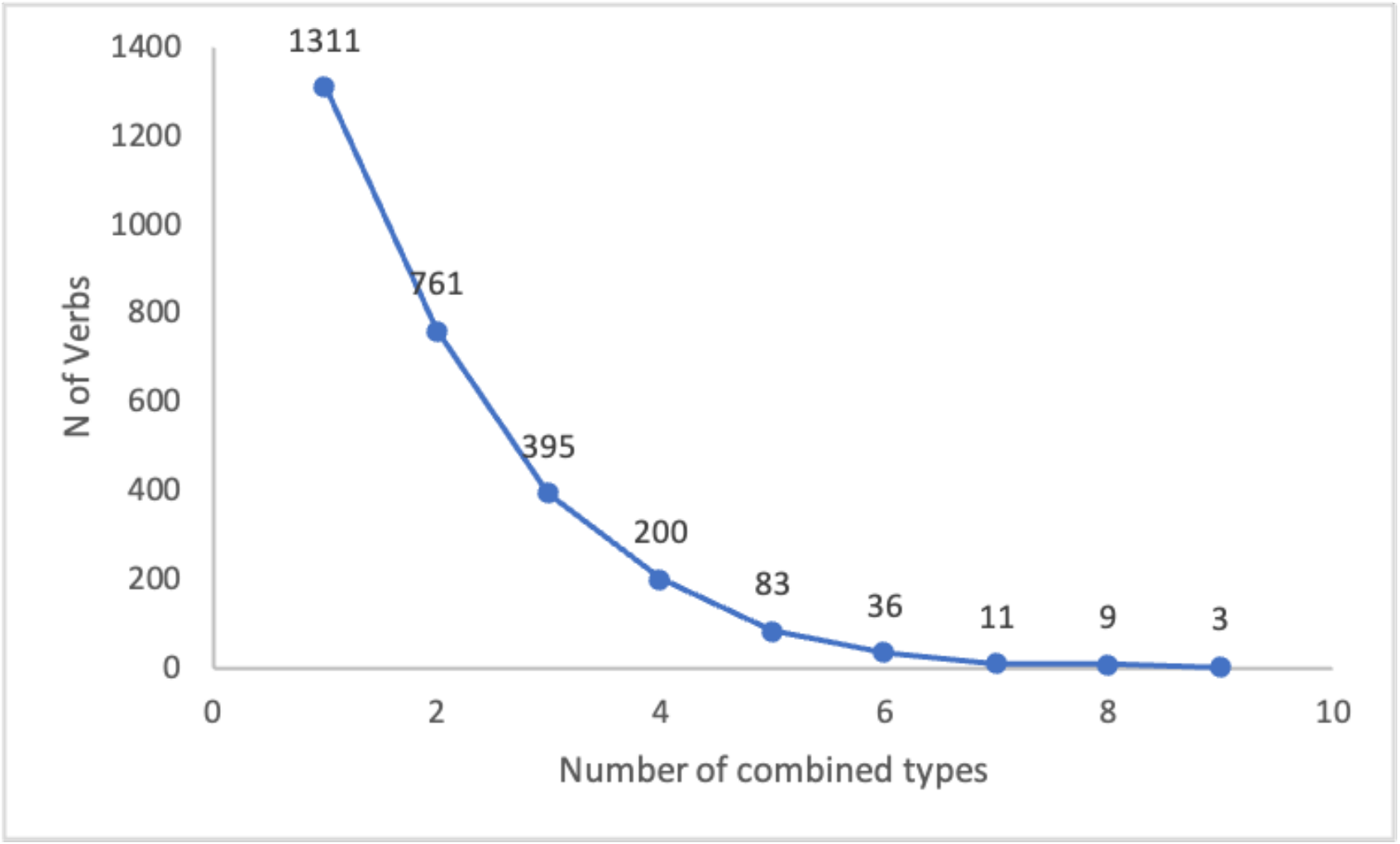

Figure 3: Number of verbs per number of combined types observed in morphological families

Derivational families

- The most frequent semantic structures observed among morphological families generally include a (possibly complex) eventive type

Semantic types	# verbal lexemes	%
Event-TRANSPOSITION	511	18.2
Event*State-TRANSPOSITION	440	15.7
Animate-AGENT, Event-TRANSPOSITION	221	7.9
Animate-AGENT	73	2.6
Cognitive*Event-TRANSPOSITION	66	2.3
Artefact-INSTRUMENT, Event-TRANSPOSITION	49	1.7
Animate-AGENT, Cognitive*Event-TRANSPOSITION	48	1.7
Animate-AGENT, Artefact-INSTRUMENT, Event-TRANSPOSITION	47	1.7
Animate-AGENT, Event*State-TRANSPOSITION	29	1.0

Table 5: Most frequent semantic structures observed among morphological families

Conclusion

Conclusion

- Large-scale morphological resources that include fine systematic semantic description are necessary to address central research questions about the semantics of derivation
- Manually annotated datasets can be further associated with computational methods
  - to tackle specific issues (e.g. semantic granularity in derivation)
  - as a gold-standard for training classifiers or machine annotators
- An intrinsic limitation of large hand datasets is that they are extremely time-consuming and typically restricted to one or a few languages

Thank you!

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Relational types

- Annotation of relational types ≠ annotation of semantic roles
- Relational types are not context-dependent
- For example, the relational type of *inspecteur* 'inspector' is AGENT, independently of the semantic role of the noun in context

(10) Contextual Agent

L'**inspecteur** a interrogé les témoins.
'The **inspector** interviewed the witnesses'

(11) Contextual Patient

Le détenu a frappé l'**inspecteur**.
'The prisoner hit the **inspector**'

(12) Contextual Beneficiary

Le commissaire a offert des fleurs à l'**inspecteur**.
'The superintendent offered flowers to the **inspector**'

Aspectual properties

V Dynamicity

X est en train de V (Y)
'X is Ving (Y)'

OR

– Qu'a fait X hier?/Que s'est-il passé hier?
– X a Vé (Y)
'– What did X do yesterday?/What happened yesterday?'
'– V Ved (Y)'

(13) Pierre est en train de **manger** une pomme
'Pierre **is eating** an apple'

(14) – Que s'est-il passé hier? – Le pont **s'est écroulé**
'– What happened yesterday? – The bridge **collapsed**'

Aspectual properties

V Telicity

X a Vé (Y) en x temps
'X Ved (Y) in x time'

(15) J'**ai rénové** mon chalet en trois mois
'I **renovated** my chalet in three months'

Aspectual properties

V Durativity

X a {commencé à/continué de/arrêté de} V (Y)
'X {began to V (Y)/continued V (Y)/stopped Ving (Y)}'

AND

X a Vé (Y) {en/pendant} x temps
'X Ved (Y) {in/for} x time'

(16) Marie a continué de **jouer** du piano
'Marie continued to **play** the piano'

(17) Pierre **a mangé** sa pomme en cinq minutes
'Pierre **ate** his apple in five minutes'

Aspectual properties

- Post-phase relates to the possibility of having a durative result state interpretation[17]

V Post-phase

X a Vé (Y) pendant x temps [Result state reading]
'X Ved (Y) for x time'

(18) Les autorités l'**ont emprisonné** pendant trois ans
'The authorities **imprisoned** him for three years'

[17] Piñón (1997 ; 1999); Haas and Jugnet (2013); a.o.

Aspectual properties

N Dynamicity

{Le/Ce} N {a eu lieu/s'est produit} à tel {moment/endroit}
'{The/This} N {took place/occurred} {at such time/in such place}'

OR

X {a procédé à/a accompli} un N + expansion
'X {undertook/accomplished} a N + expansion'

OR

X a fait du N toute la journée
'X did some N today'

(19) L'explosion s'est produite hier matin
'The explosion occurred yesterday morning'

(20) La mécanicienne a procédé à une réparation d'urgence
'The mechanic performed an emergency repair'

(21) J'ai fait du jardinage toute la journée
'I did some gardening today'

Aspectual properties

N Durativity

Le N a duré x temps
'The N lasted x time'

OR

un N de x temps
'a x-time N'

OR

Le N s'est déroulé à tel endroit
'The N took place in x place'

(22) Le papotage a duré quinze minutes
'The chattering lasted fifteen minutes'

(23) Un accouchement de huit heures
'an eight-hour delivery'

(24) La manifestation s'est déroulée à Paris
'The demonstration took place in Paris'

Aspectual properties

N Telicity

Le N a été interrompu $\not\Rightarrow$ X a Vé (Y)
'The N was interrupted' $\not\Rightarrow$ 'X Ved (Y)'

OR

un N en x temps
'a N in two hours'

(25) L'accouchement a été interrompu $\not\Rightarrow$ Elle a accouché
'The delivery was interrupted' $\not\Rightarrow$ 'She gave birth'

(26) Une réparation en deux heures
'a repair in two hours'

Aspectual properties

N Post-phase

Le N (+ expansion) a duré x temps [Result state reading]
'The N (+ expansion) lasted x time'

(27) L'exclusion du joueur a duré quinze minutes
'The player's exclusion lasted fifteen minutes'

Glimpse of the database

SAMPLE	NOUN	NOUN_LEMMA	ERIV_TYP	ENDE	VERB	VERB_LEMMA	TYPE_ONTO	TYPE_REL	EXAMPLE_N	EXAI
S15	cassis_1	cassis	is	m	casser_1	casser	art	res	Nous embarquons dans la	Le plombier
S15	casson_1	casson	on	m	casser_1	casser	art	res	Les cassons de tuiles	Le plombier
S15	cassure_1	cassure	ure	f	casser_1	casser	nat	res	Il s'agit d'une cassure nette	Le plombier
S15	cassure_2	cassure	ure	f	casser_(se)_1	casser	evt	tsp	La cassure a eu lieu au	Pourquoi ne
S15	castrage_1	castrage	age	m	castrer_1	castrer	evt	tsp	En effet le prix est moins	J'ai fait castr
S15	castrat_1	castrat	conv_13	m	castrer_1	castrer	anm	res	Les Turcs font garder leurs	J'ai fait castr
S15	castration_1	castration	ion	f	castrer_1	castrer	evt	tsp	La personnalité des	J'ai fait castr
S15	castration_2	castration	ion	f	castrer_2	castrer	evt*sta	tsp	La peur de la castration par	Et la mère ca
S15	causation_1	causation	ion	f	causer_1	causer	evt	tsp	Dans l'akrasia en effet, une	La propagati
S15	causerie_1	causerie	erie	f	causer_2	causer	cog*evt	tsp	La plus récente causerie de	Le soupirant
S15	causerie_2	causerie	erie	f	causer_2	causer	ppt	cau	D'une beauté qui fascina,	Le soupirant
S15	causette_1	causette	ette	f	causer_2	causer	evt	tsp	Les deux veuves montaient	Le soupirant
S15	causeur_1	causeur	eur.m	m	causer_1	causer	anm	agt	Ces automates servent à la	La propagati
S15	causeur_2	causeur	eur.m	m	causer_2	causer	anm	agt	De là ces années	Le soupirant
S15	causeuse_1	causeuse	euse	f	causer_1	causer	anm	agt	Et après tu dis que tu n'es	La propagati
S15	causeuse_2	causeuse	euse	f	causer_2	causer	anm	agt	Elle a la réputation de ne	Le soupirant
S15	causeuse_3	causeuse	euse	f	causer_2	causer	art	loc	Assise sur une causeuse à	Le soupirant
S15	cavale_1	cavale	conv_1	f	cavaler_1	cavaler	evt	tsp	Il s'est fait pincer après	Les nuages c
S15	cavaleur_1	cavaleur	eur.m	m	cavaler_1	cavaler	anm	agt	Un "cavaleur" était une	Les nuages c
S15	cavaleur_2	cavaleur	eur.m	m	cavaler_2	cavaler	anm	agt	Son bonhomme était un	Les hommes
S15	cavaleuse_1	cavaleuse	euse	f	cavaler_1	cavaler	anm	agt	Nous étions 36 cavaleuses	Les nuages c
S15	cavaleuse_2	cavaleuse	euse	f	cavaler_2	cavaler	anm	agt	Rassurez-vous, elle n'est	Les hommes
S15	ceinturage_1	ceinturage	age	m	ceinturer_1	ceinturer	evt	tsp	L'occupation a commencé à	En 1909, un
S15	ceinturage_2	ceinturage	age	m	ceinturer_1	ceinturer	art	res	Les maçons réalisent enfin	En 1909, un
S15	ceinturage_3	ceinturage	age	m	ceinturer_2	ceinturer	evt	tsp	Et si le nouveau dress code	Ceinturer so
S15	ceinturage_4	ceinturage	age	m	ceinturer_2	ceinturer	art	ins	Elles sont louées avec un	Ceinturer so