SFB 991

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Project C08

The semantics of derivational morphology: A frame-based approach

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The problem

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- Affixes (or morphological processes) are frequently semantically underspecified
- Polysemy and meaning extensions of various sorts (Bauer, Lieber & Plag 2013)

Table 1: Readings of English nominalizations (Kawaletz and Plag, 2015)

Semantic category	paraphrase	examples
Result	'the outcome of V-ing'	*acceptance, alteration*
Product	'the thing that is created by V-ing'	*pavement, growth*
Instrument	'the thing that V-s'	*seasoning, advertisement*
Location	'the place of V-ing'	*dump, residence*
Agent	'people or person who V-s'	*administration, cook*
Measure	'how much is V-ed'	*pinch, deceleration*
Path	'the direction of V-ing'	*decline, direction*
Patient	'the thing affected or moved by V-ing'	*catch, acquisition*
State	'the state of V-ing or being V-ed'	*alienation, disappointment*
Instance	'an instance of V-ing'	*belch, cuddle*

- *-er* nominalizations:
  fryer *Agent, Instrument, Patient* (Anderson & Andreou 2018)

Research questions

- Which kinds of readings or meaning extensions are possible and which ones should be impossible for a given derivative?
- What is the role of the bases?
- What is the role of encyclopaedic knowledge?
- How can the semantics of derivational morphology be formally modelled?

State of the art

Lieber's theory of word-formation semantics (2004)

- Highly restricted set of semantic features ('skeleton')
- Conceptual knowledge representations ('body')

Problems

- Not clear how polysemy of affixes (or derivatives) comes about

Derivation as unification

$$\mathbf{e}\begin{bmatrix} \textit{bounded-event} & \\ \text{NOUN-DIM} & \boxed{3} \\ \text{VERB-DIM} & \boxed{3} \\ \text{M-DIM} & \boxed{3}\begin{bmatrix} \textit{scale} & \\ \text{MIN} & \boxed{1} \\ \text{THRESHOLD} & \boxed{2} \end{bmatrix} \\ \text{INIT} & \begin{bmatrix} \textit{stage} & \\ \text{DEG} & \boxed{1} \end{bmatrix} \\ \text{FIN} & \begin{bmatrix} \textit{stage} & \\ \text{DEG} & \boxed{4} \end{bmatrix} \end{bmatrix}$$

$$\boxed{2} \leq \boxed{4}$$

Na-

$$\mathbf{e}\begin{bmatrix} \textit{change-of-state} & \\ \text{MANNER} & \begin{bmatrix} \textit{heat} \end{bmatrix} \\ \text{ACTOR} & \boxed{1} \\ \text{THEME} & \boxed{2} \\ \text{VERB-DIM} & \boxed{3}\begin{bmatrix} \textit{temperature} \end{bmatrix} \\ \text{M-DIM} & \boxed{3} \end{bmatrix}$$

Gret‘ ‘to heat’

(Zinova 2016, 232-3)

Derivation as unification

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$$\mathbf{e}\begin{bmatrix} \textit{bounded-event} \wedge \textit{change-of-state} & \\ \text{MANNER} & \begin{bmatrix}\textit{heat}\end{bmatrix} \\ \text{ACTOR} & \boxed{1} \\ \text{THEME} & \boxed{2} \\ \text{NOUN-DIM} & \boxed{3} \\ \text{VERB-DIM} & \boxed{3} \\ \text{M-DIM} & \boxed{3}\begin{bmatrix} \textit{scale} \wedge \textit{temperature} & \\ \text{MIN} & \boxed{4} \\ \text{THRESHOLD} & \boxed{5} \end{bmatrix} \\ \text{INIT} & \begin{bmatrix} \textit{stage} & \\ \text{DEG} & \boxed{4} \end{bmatrix} \\ \text{FIN} & \begin{bmatrix} \textit{stage} & \\ \text{DEG} & \boxed{6} \end{bmatrix} \end{bmatrix}$$

$$\boxed{5} \leq \boxed{6}$$

Nagret‘ ‘to warm up’

(Zinova 2016, 234)

Lexical rules

- Model the interaction of the semantics of the morphological process and the semantics of the base.
- Reduce redundancy
- Capture generalizations in the lexicon
  (see among others, Bresnan 1982; Pollard and Sag 1994; Briscoe and Copestake 1999; Sag 2012; Bonami and Crysmann 2016).

Lexical rule for *-ment* (Plag et al. 2018)

$$\begin{bmatrix} \textit{lexeme} & \\ \text{PHON} & \boxed{x}\text{-}\textit{ment} \\ \text{M-BASE} & \begin{bmatrix} \text{PHON} & \boxed{x} \\ \text{SEM} & \end{bmatrix} \end{bmatrix}$$

(cf. Pollard and Sag 1994; Sag 2012; Bonami and Crysmann 2016)

Lexical rule for *-ment* (Plag et al. 2018)

$$
\begin{bmatrix}
\textit{lexeme} & \\
\text{PHON} & \boxed{x}\text{-}\textit{ment} \\
\text{M-BASE} & \begin{bmatrix}
\text{PHON} & \boxed{x} \\
\text{SEM} & \boxed{0} \begin{bmatrix}
\textit{causation event} & \\
\text{ACTOR} & \boxed{1} \\
\text{UNDERGOER} & \boxed{2} \\
\text{INSTRUMENT} & \boxed{3} \\
\text{CAUSE} & \boxed{4} \begin{bmatrix} \textit{activity} & \\ \text{ACTOR} & \boxed{1} \\ \text{UNDERGOER} & \boxed{2} \\ \text{INSTRUMENT} & \boxed{3} \end{bmatrix} \\
\text{EFFECT} & \boxed{5} \begin{bmatrix} \textit{change-of-state} & \\ \text{INITIAL STATE} & \boxed{6} \begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \\ \text{RESULT STATE} & \boxed{7} \begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

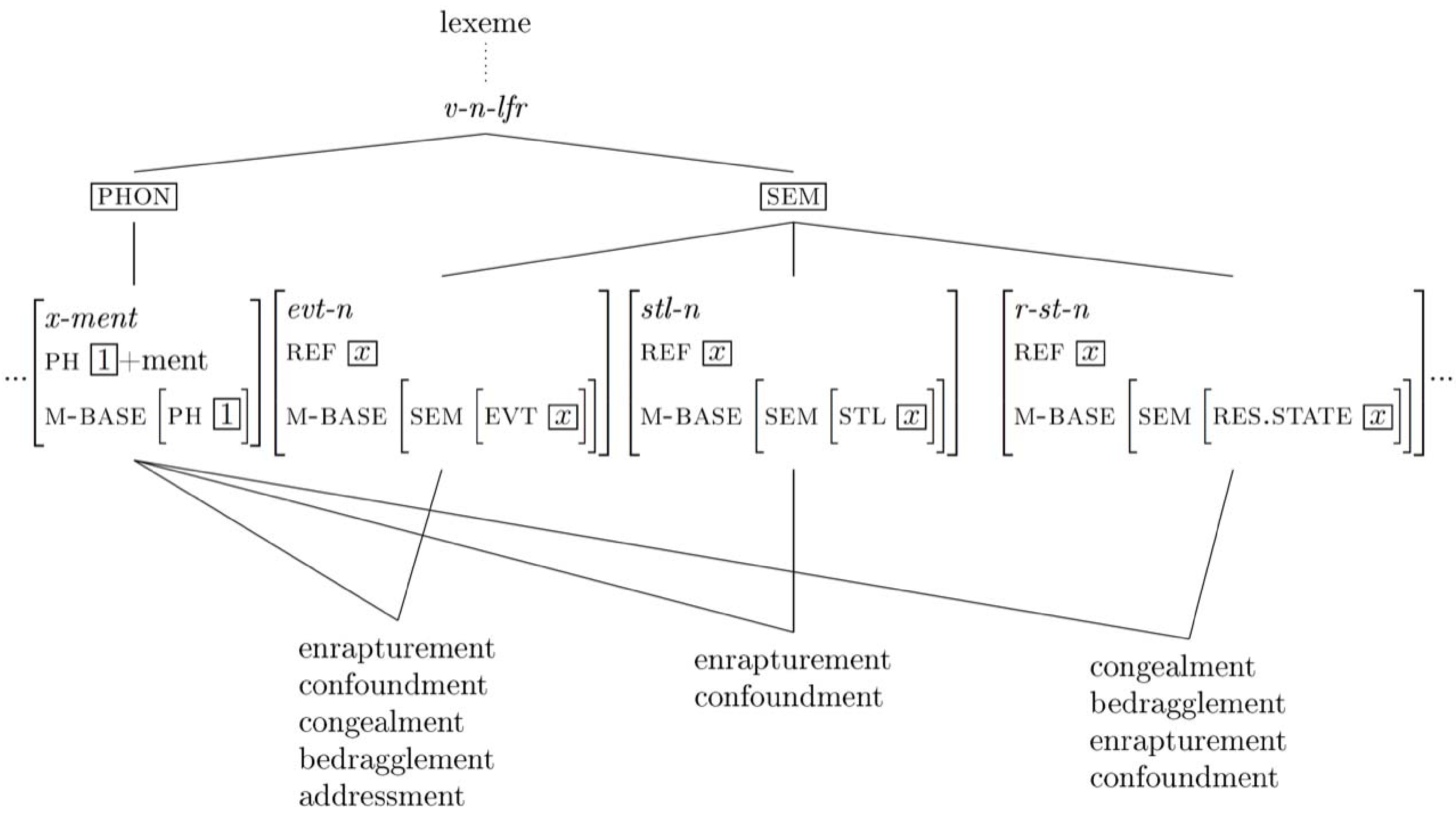
(cf. Pollard and Sag 1994; Sag 2012; Bonami and Crysmann 2016)

Lexical rule for *-ment* (Plag et al. 2018)

$$
\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{lexeme}} \\
\text{PHON} & \boxed{x}\text{-}\textit{ment} \\
\text{M-BASE} & \left[\begin{array}{ll}
\text{PHON} & \boxed{x} \\
\text{SEM} & \boxed{0}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{causation event}} \\
\text{ACTOR} & \boxed{1} \\
\text{UNDERGOER} & \boxed{2} \\
\text{INSTRUMENT} & \boxed{3} \\
\text{CAUSE} & \boxed{4}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{activity}} \\
\text{ACTOR} & \boxed{1} \\
\text{UNDERGOER} & \boxed{2} \\
\text{INSTRUMENT} & \boxed{3}
\end{array}\right] \\
\text{EFFECT} & \boxed{5}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{change-of-state}} \\
\text{INITIAL STATE} & \boxed{6}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{state}} \\
\text{PATIENT} & \boxed{2}
\end{array}\right] \\
\text{RESULT STATE} & \boxed{7}\left[\begin{array}{ll}
\multicolumn{2}{l}{\textit{state}} \\
\text{PATIENT} & \boxed{2}
\end{array}\right]
\end{array}\right]
\end{array}\right]
\end{array}\right]
\end{array}\right] \\
\multicolumn{2}{l}{\text{REF} = \left\{\boxed{0}, \boxed{3}, \boxed{4}, \boxed{5}, \boxed{7}, \boxed{2}\text{-}\boxed{7}\right\}}
\end{array}\right]
$$

(cf. Pollard and Sag 1994; Sag 2012; Bonami and Crysmann 2016)

Inheritance hierarchy



(cf. Riehemann 1998; Koenig 1999; Desmets & Villoing 2009; Booij 2010; Tribout 2010; Bonami & Crysmann 2016)

This talk: Overview of our work

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- Introduction

Mechanisms

- Shift of reference through derivation:
  Polysemy of *-ment*
- Manipulating attribute values through derivation:
  Stereotype negation

Computational implementaion

- Implementing derivational polysemy:
  XMG
- Distributional semantic approach to disambiguation

Polysemy in derivation: *-ment*

- Affix polysemy in deverbal nominalization with *–ment*
- Input semantics → Output semantics
- Neologisms taken from corpora
- Four input classes based on Levin 1993/VerbNet
  - Change of state verbs
  - Psych verbs
  - Putting verbs
  - Force verbs

The data

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- PATIENT
  - I set down the scrap of doll's dress, a **bedragglement** of loose lace hem (COCA FIC Bk:MournersBench 1999)
- PRODUCT
  - There is an obvious **embrittlement** and cracking on the nonwoven fabric (Figure 6.5b). (GoogleBooks ACAD Cellulose Based Composites 2014)
- EVENTUALITY
  - Hydrides then form and can limit the fuel lifetime due to their **embrittlement** of the cladding. (Google WEB imperial.ac.uk 2014)

Change-of-state verbs as bases
(causative/inchoative)

$$\boxed{0}\begin{bmatrix} \textit{causation-event} & \\ \text{AGENT} & \boxed{1} \\ \text{PATIENT} & \boxed{2} \\ \text{INSTRUMENT} & \boxed{3} \\ \text{CAUSE} & \boxed{4}\begin{bmatrix} \textit{eventuality} & \\ \text{PARTICIPANT}_{\text{X}} & \boxed{x} \\ \ldots & \boxed{\ldots} \end{bmatrix} \\ \text{EFFECT} & \boxed{5}\begin{bmatrix} \textit{change-of-state} & \\ \text{INITIAL STATE} & \boxed{6}\begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \\ \text{RESULT STATE} & \boxed{7}\begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\text{REF} = \left\{\boxed{0}, \boxed{5}\right\}$$

- Underspecified first subevent
- Reference: complex event or change of state
- Constraints

There exists at least one participant P in $\boxed{4}$.
Every P in $\boxed{4}$ may or may not be co-indexed with $\boxed{1}$, $\boxed{2}$, or $\boxed{3}$.

Derived nouns (e.g. *embrittlement*)

$$\boxed{0}\begin{bmatrix} \textit{causation-event} & & \\ \text{AGENT} & \boxed{1} & \\ \text{PATIENT} & \boxed{2} & \\ \text{INSTRUMENT} & \boxed{3} & \\ \text{CAUSE} & \boxed{4} & \begin{bmatrix} \textit{eventuality} & \\ \text{PARTICIPANT}_{x} & \boxed{x} \\ \ldots & \boxed{\ldots} \end{bmatrix} \\ \text{EFFECT} & \boxed{5} & \begin{bmatrix} \textit{change-of-state} & & \\ \text{INITIAL STATE} & \boxed{6} & \begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \\ \text{RESULT STATE} & \boxed{7} & \begin{bmatrix} \textit{state} & \\ \text{PATIENT} & \boxed{2} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\text{REF} = \left\{ \boxed{0}, \boxed{3}, \boxed{4}, \boxed{5}, \boxed{7}, \boxed{2}\text{-}\boxed{7} \right\}$$

- Reference: range of possible readings

There exists at least one participant P in $\boxed{4}$.
Every P in $\boxed{4}$ may or may not be co-indexed with $\boxed{1}$, $\boxed{2}$, or $\boxed{3}$.

Psych verbs as bases
(causative)

$$\boxed{0}\begin{bmatrix} \textit{psych-causation-event} & \\ \text{STIMULUS} & \boxed{1} \\ \text{EXPERIENCER} & \boxed{2} \\ \text{CAUSE} & \boxed{3}\begin{bmatrix}\textit{eventuality} & \\ \text{PARTICIPANT}_{\text{X}} & \boxed{x} \\ \ldots & \boxed{\cdots}\end{bmatrix} \\ \text{EFFECT} & \boxed{4}\begin{bmatrix}\textit{change-of-psych-state} & \\ \text{INITIAL STATE} & \boxed{5}\begin{bmatrix}\textit{psych state} & \\ \text{EXPERIENCER} & \boxed{2}\end{bmatrix} \\ \text{RESULT STATE} & \boxed{6}\begin{bmatrix}\textit{psych state} & \\ \text{EXPERIENCER} & \boxed{2}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

$$\text{REF} = \left\{\boxed{0}\right\}$$

- Event type and participants reflect verb class
- Reference: only complex event

There exists at least one participant P in $\boxed{3}$.
Every P in $\boxed{3}$ may or may not be co-indexed with $\boxed{1}$ or $\boxed{2}$.

Derived nouns (e.g. *annoyment*)

$$
\boxed{0}\begin{bmatrix} \textit{psych-causation-event} & \\ \text{STIMULUS} & \boxed{1} \\ \text{EXPERIENCER} & \boxed{2} \\ \text{CAUSE} & \boxed{3}\begin{bmatrix}\textit{eventuality} & \\ \text{PARTICIPANT}_{\text{x}} & \boxed{x} \\ \dots & \boxed{\dots}\end{bmatrix} \\ \text{EFFECT} & \boxed{4}\begin{bmatrix}\textit{change-of-psych-state} & \\ \text{INITIAL STATE} & \boxed{5}\begin{bmatrix}\textit{psych state} & \\ \text{EXPERIENCER} & \boxed{2}\end{bmatrix} \\ \text{RESULT STATE} & \boxed{6}\begin{bmatrix}\textit{psych state} & \\ \text{EXPERIENCER} & \boxed{2}\end{bmatrix}\end{bmatrix}\end{bmatrix}
$$

$$
\text{REF} = \left\{\boxed{0}, \boxed{1}, \boxed{3}, {}^{?}\boxed{4}, \boxed{6}\right\}
$$

- Reference: different range of possible readings
  - No EXPERIENCER-IN-RESULT-STATE
  - No clear CHANGE-OF-STATE

There exists at least one participant P in $\boxed{3}$.

Every P in $\boxed{3}$ may or may not be co-indexed with $\boxed{1}$ or $\boxed{2}$.

Summary

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- Patterns of possible readings can be detected and explained
  - … By differences between base verb classes
    - UNDERGOER: Attested PATIENT vs. unattested EXPERIENCER
    - Differences in CHANGE-OF-STATE attestations (not alternating? No c-o-s subevent in the first place?)
  - … By preferences of –*ment*
    - Animacy constraint (no AGENT, no EXPERIENCER, no animate PATIENT)
  - … By frame-theoretical considerations
    - No INITIAL-STATE readings (bidirectional functionality, see e.g. Löbner 2013)

Mechanisms

- Shift of reference
- Manipulation of attribute values
  - Stereotype negation as a test case

Manipulating attribute values: Stereotype negation

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- *COCA SPOK 1994*: Dawn Upshaw has been called the "**un-diva**" of the opera world, often preferring to perform innovative, relatively obscure works that emphasize words over music in an informal style, often–imagine this–even chatting with an audience at recitals.

- *COCA ACAD 2010*: In my writing workshops I often meet the equivalent writing hobbyists. They are people who are writing what I term "coffee-break books," simpleminded **nonbooks** that they turn out in short order.

Lexical rule for stereotype negation

$$
\begin{bmatrix}
\text{lexeme} & \\
\text{PHON} & /\text{prefix-}\boxed{1}/ \\
\text{CAT} & \textsc{n} \\
\text{SEM} & \begin{bmatrix} \text{IND} & \text{i} \\ \text{S-FRAME} & \boxed{2}\,!\begin{bmatrix} \text{REF} & \text{i} \\ \text{ATTRIBUTE}_j & \neg\alpha \\ \ldots & \end{bmatrix} \end{bmatrix} \\
\text{M-BASE} & \begin{bmatrix} \text{lexeme} & \\ \text{PHON} & \boxed{1} \\ \text{CAT} & \textsc{n} \\ \text{SEM} & \begin{bmatrix} \text{IND} & \text{i} \\ \text{S-FRAME} & \boxed{2}\begin{bmatrix} \text{REF} & \text{i} \\ \text{ATTRIBUTE}_j & \alpha \\ \ldots & \end{bmatrix} \end{bmatrix} \end{bmatrix}
\end{bmatrix}
$$

Lexical rule for *non-*

$$
\begin{bmatrix}
\textit{lexeme} \\
\text{PHON } /\text{nanbʊk}/ \\
\text{CAT } \textsc{n} \\
\text{SEM} \begin{bmatrix}
\text{IND } i \\
\text{S-FRAME} \begin{bmatrix}
\text{REF} & i \\
\text{CONTENT} & \neg\text{complex} \\
\ldots &
\end{bmatrix}
\end{bmatrix} \\
\text{M-BASE} \begin{bmatrix}
\textit{lexeme} \\
\text{PHON } /\text{bʊk}/ \\
\text{CAT } \textsc{n} \\
\text{SEM} \begin{bmatrix}
\text{IND } i \\
\text{S-FRAME} \begin{bmatrix}
\text{REF} & i \\
\text{CONTENT} & \text{complex} \\
\ldots &
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Analysis

- Highlights the importance of structured information of perceptual aspects of meaning (i.e. functional attributes that assign properties to referents and the values these attributes take).
- Shows that the “absence” of a characteristic of the base lexeme can be treated as a change in the value of an attribute of the base lexeme and not as absence of the attribute (i.e. the general characteristic) itself.

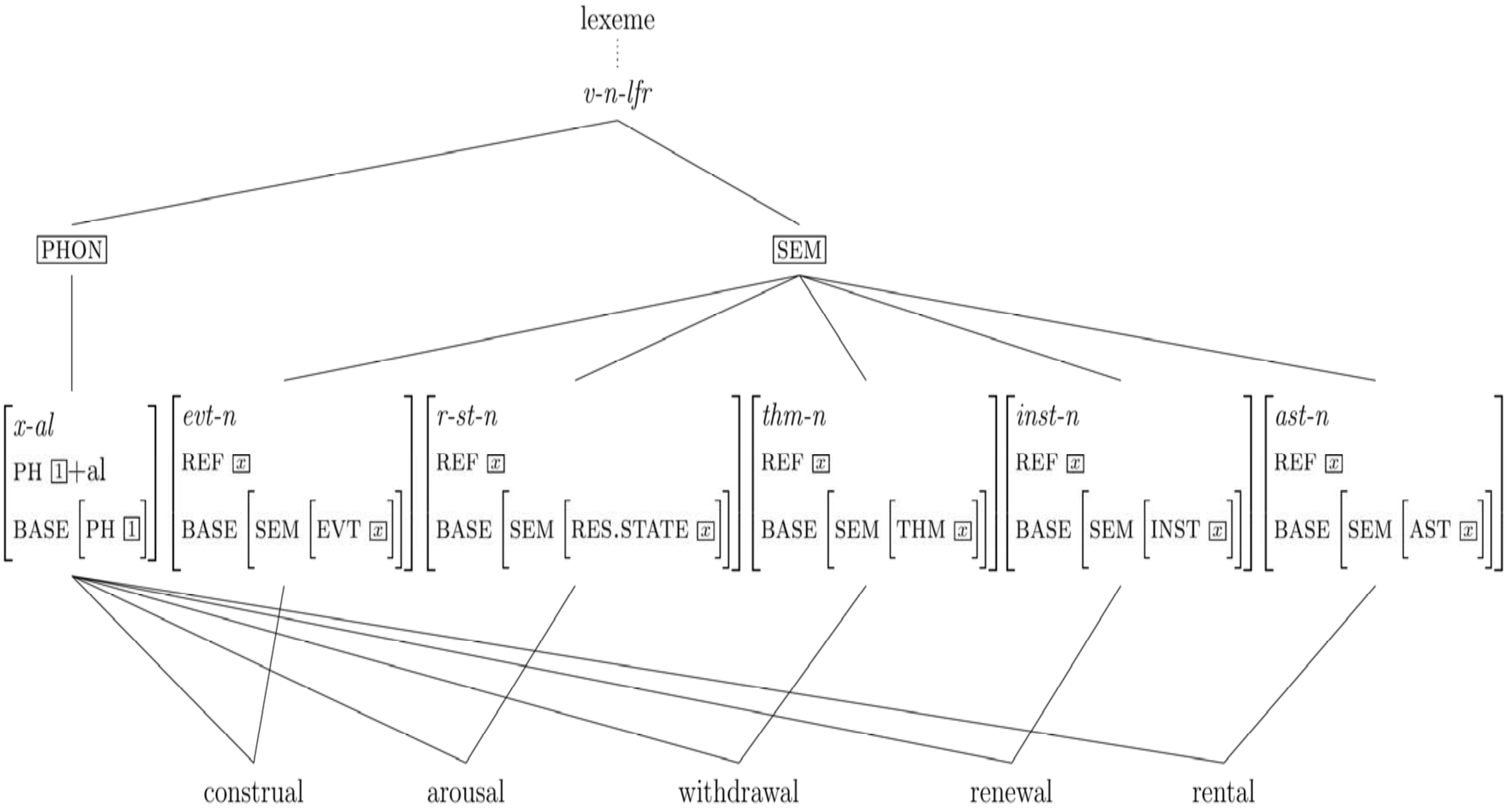
Computational implementations

- XMG (in collaboration with Simon Petitjean)
- Distributional semantics (in collaboration with CRC Stuttgart)

- Andreou and Petitjean (2017, forthcoming) used corpus extracted data to
  - Identify the range of readings of -al derivatives (e.g. *rental*) and
  - Identify prominent constraints on the types of situations and entities -al targets (e.g. animacy).

- Constraints are given in the form of type constraints and specify which arguments in the frame of the verbal base are compatible with the referential argument of the derivative.

Inheritance hierarchy



Frame to XMG

$$
\boxed{0}\begin{bmatrix}
\textit{causation event} & & \\
\text{AGENT } \boxed{1} & & \\
\text{PATIENT } \boxed{2} & & \\
\text{INSTRUMENT } \boxed{3} & & \\
\text{CAUSE} & \boxed{4} & \begin{bmatrix} \textit{activity} \\ \text{AGENT } \boxed{1} \\ \text{PATIENT } \boxed{2} \\ \text{INSTRUMENT } \boxed{3} \end{bmatrix} \\
\text{EFFECT} & \boxed{5} & \begin{bmatrix} \textit{change-of-state} & \\ \text{INITIAL STATE } \boxed{6} & \begin{bmatrix} \textit{state} \\ \text{PATIENT } \boxed{2} \end{bmatrix} \\ \text{RESULT STATE } \boxed{7} & \begin{bmatrix} \textit{state} \\ \text{PATIENT } \boxed{2} \end{bmatrix} \end{bmatrix}
\end{bmatrix}
$$

```
class renew
export ?X0
declare ?X0 ?X1 ?X2 ?X3 ?X4 ?X5 ?X6 ?X7
{<frame>{
 ?X0[causation,
        agent: ?X1[entity, animacy:[animate]],
        patient: ?X2,
        instrument: ?X3[entity],
        cause: ?X4[activity,
                    agent:?X1,
                    patient:?X2,
                    instrument:?X3[entity, animacy:[animate]]
                      ],
        effect : ?X5[change_of_state,
                    initial -state: ?X6[ initial state , patient:?X2],
                    result -state: ?X7[result state , patient:?X2] ] ]

                    }

}
```

XMG rule application

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```
class al_nominal
import rent[]
declare ?Ref
{
  <frame>{
    [al-lexeme,
      m-base:[event,
                sem:?X0]
      ref:?Ref
    ]
    ;
    ?X0 >* ?Ref;
  }
}
```

```
?X0 >* ?Ref;
{ ?Ref[ result_state ] | ?Ref[causation]
| ?Ref[entity, animacy:[inanimate]] }
```

Result

- The introduction of constraints into the semantics of an affix allows one to **predict** and **generate**
  - Readings which are possible for a given derivative and,
  - **Rule out** those readings which are not possible.

- As a **proof of concept**, the output resulting of the XMG description was consistent with the range of readings observed in the corpus.

- Problem: Disambiguating newly derived words in context
- Can a Distributional Semantics model do the job?
- Co-occurrence vectors: a toy example

Context \ Target	*t-shirt*	*tie*	*lawyer*	*judge*
wear	9	7	2	4
law	1	3	7	9

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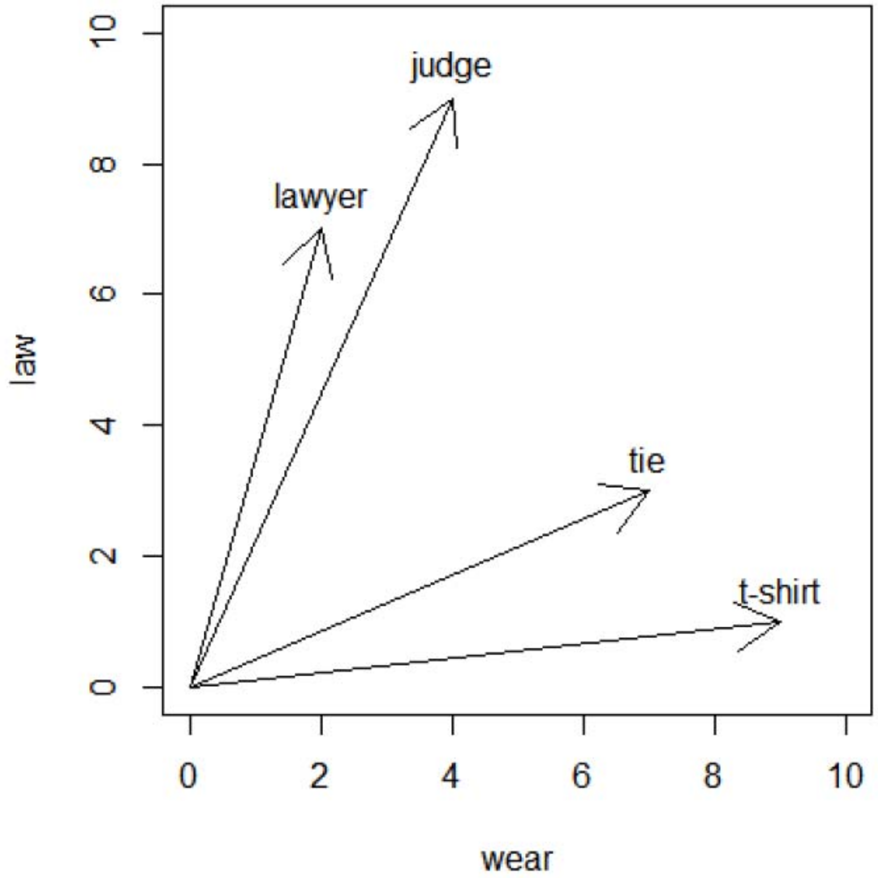
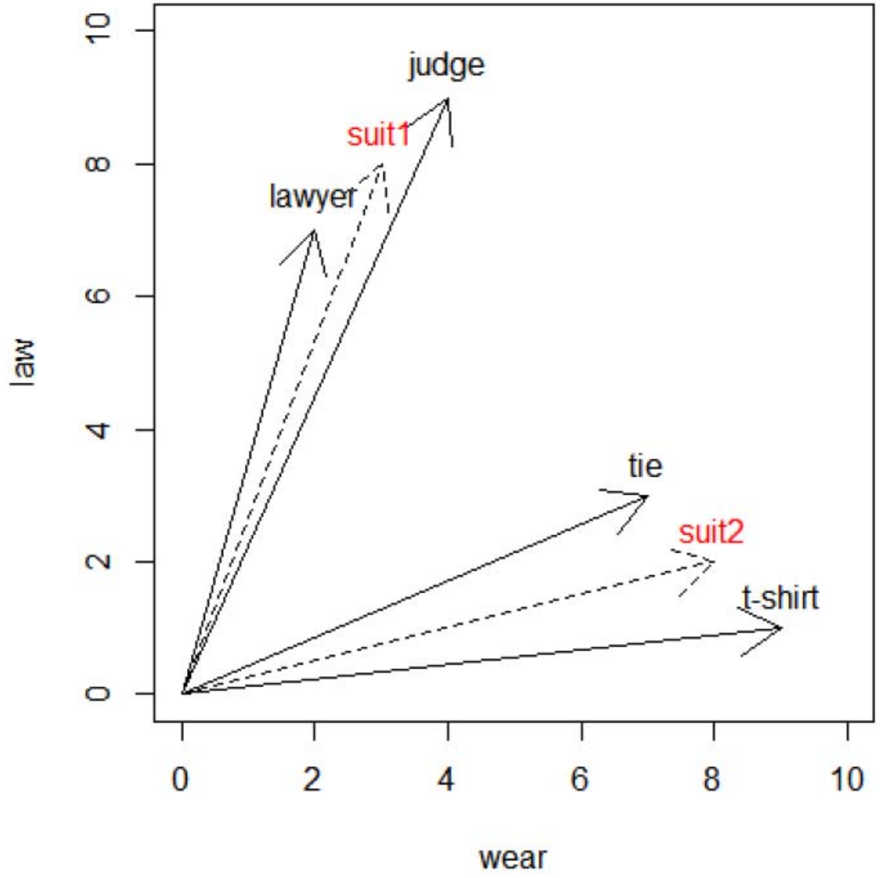
Context \ Target	*t-shirt*	*tie*	*lawyer*	*judge*
wear	9	7	2	4
law	1	3	7	9

Disambiguation:
suit$_1$ 'process in a law court'
suit$_2$ 'ensemble of matching garments'





Method

- Low frequency deverbal *-ment* nominalizations (55 types, 406 tokens)
- Manually annotated: eventive, non-eventive, ambiguous
- Disambiguation by comparing
  - vectors of **training nouns**

TRAINING NOUNS
accident → EVENT
bike → NOT EVENT

  - with vectors of **nominalizations in their context**

ANNOYMENT.1 : ?
"Such an *annoyment* already happened"
ANNOYMENT.2 : ?
"Fix this *annoyment*!"

Results

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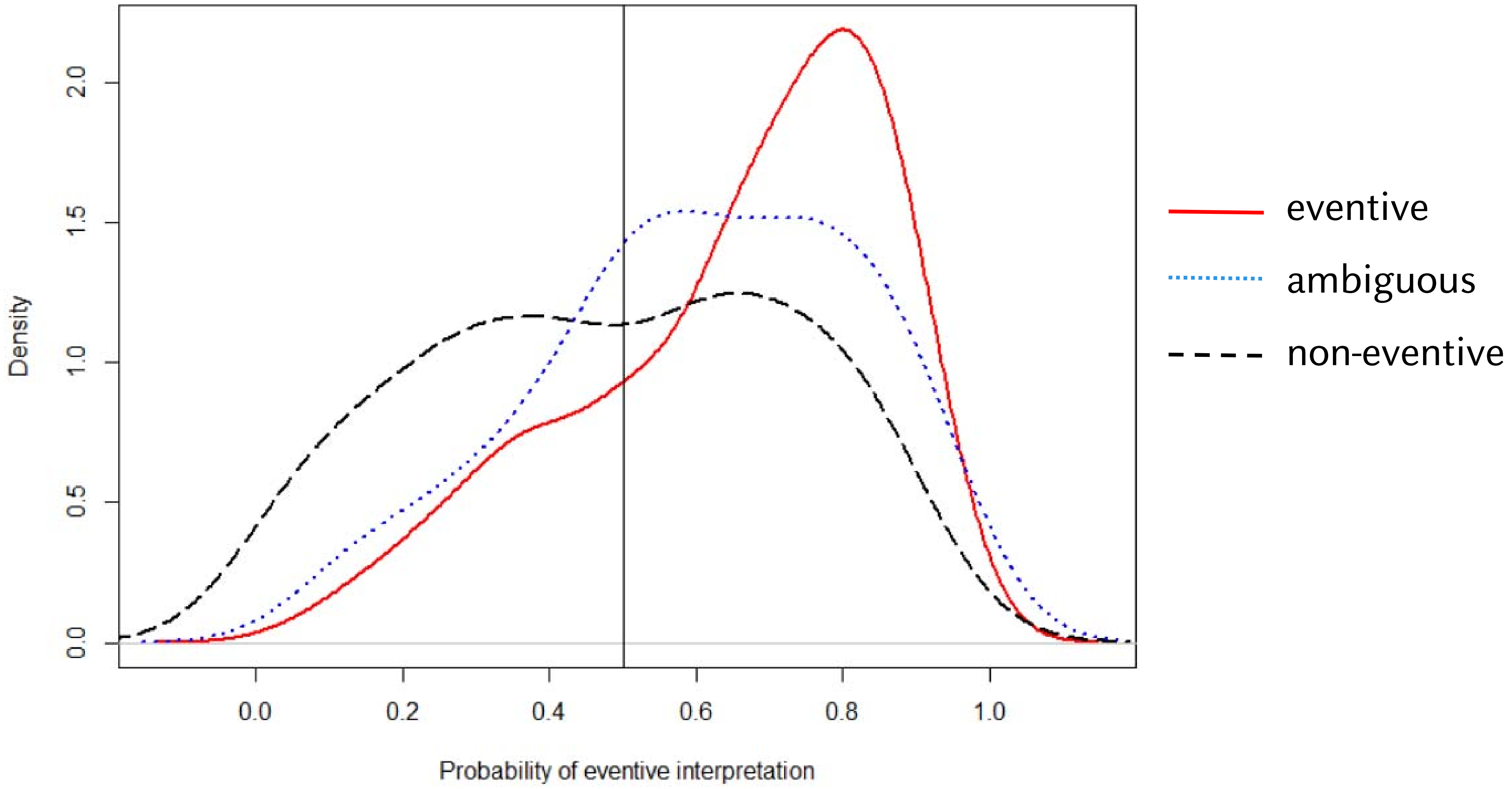
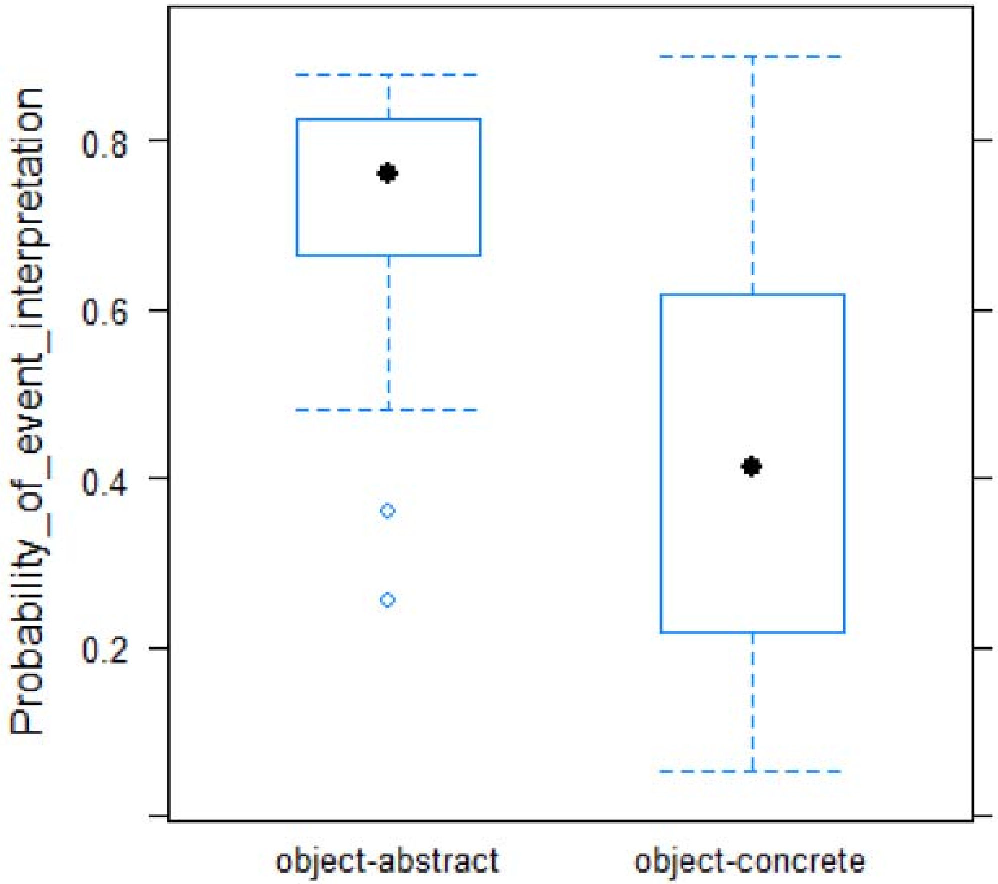
Predictions \ Annotations	eventive	non-eventive	ambiguous
eventive	0.78	0.47	0.73
non-eventive	0.22	0.53	0.27

Results


Density
0.0
0.5
1.0
1.5
2.0
0.0
0.2
0.4
0.6
0.8
1.0
Probability of eventive interpretation
eventive
ambiguous
non-eventive

Non-eventive nominalizations



Summary disambiguation

- It is possible to use distributional semantics to disambiguate the meaning even of newly formed words.
- This demonstrates the usefulness of the context in disambiguation.
- A window with two content words on each side suffices to make good predictions.
- Non-eventive derivatives are hard to classify as such.
- Non-eventive **abstract nouns** and **eventive nouns** are not only similar in their semantic properties, they may also occur in the same contexts. Both facts make disambiguation of such nouns a hard task.
- There are quite a few cases (15%) in which the interpretation of new words remains unclear, even for humans.

- A framework for the analysis of derivational semantics
- Analyses of individual morphological categories
- Computational implementations

The future

- Analyses of more categories
- Eventive interpretations without verbal bases
- Scalar interpretations
- Computational modeling (XMG and Analogy)

Thank you very much for your attention!

Publications

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a) Peer-reviewed publications and books

Arndt-Lappe, Sabine & Ingo Plag (eds.). 2015. *The semantics of derivational morphology: Special issue of Morphology 25.4*

Andreou, Marios. 2017a. Lexical Semantic Framework for Morphology. In Mark Aronoff (ed.), *Oxford research encyclopedias: Linguistics*, vol. 1, Oxford: Oxford University Press. doi: \url{10.1093/acrefore/9780199384655.013.255}

Andreou, Marios. 2017c. Stereotype negation in Frame Semantics. *Glossa* 2(1). 79, 1–30. doi: \url{10.5334/gjgl.293}

Andreou, Marios & Simon Petitjean. 2017. Describing derivational polysemy with XMG. In Iris Eshkol & Jean-Yves Antoine (eds.), *Actes de TALN 2017, 24e Conférence sur le Traitement Automatique des Langues Naturelle: Volume 2*, 94–101

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