LExical DIAchronic SEMantic MAps (Le Diasema)
From simple networks to mixed multi-edge graphs

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28.06.2018
University of Liège
Outline of the talk

- Inferring (classical) semantic maps from large-scale polysemy data
  - Basic principle
  - Plotting weighted maps
  - Graphs vs feature projection (MDS, t-SNE, etc.)
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  - Focus on the lexicon and diachrony
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  - Focus on the lexicon and diachrony
- A protocol for diachronic maps
  - Plotting,
  - Dynamicizing,
  - and enriching a map of time-related meanings
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Inferring semantic maps
Inferring semantic maps

“ideally (...) it should be possible to generate semantic maps automatically on the basis of a given set of data”
(Narrog & Ito 2007: 280)
Inferring semantic maps

Limitation of the semantic map method: practically, it is impossible to handle large-scale crosslinguistic datasets manually

“not mathematically well-defined or computationally tractable, making it impossible to use with large and highly variable crosslinguistic datasets”

(Croft & Poole 2008: 1)
Regier, Khetarpal, and Majid showed that the semantic map inference problem is “formally identical to another problem that superficially appears unrelated: inferring a social network from outbreaks of disease in a population” (Regier et al. 2013: 91)
Inferring semantic maps

• What’s the idea?
  • Let’s consider a group of social agents (represented by the nodes of a potential graph)
What’s the idea?

If one observes the same disease for five of these agents (technically called a constraint on the nodes of the graph)
• What’s the idea?
  • One can postulate that all the agents met, so that all the nodes of the graph are connected (10 edges between the 5 nodes)
Inferring semantic maps

• What’s the idea?
  • This is neither a very likely, nor a very economic explanation
Inferring semantic maps

- What’s the idea?
  - But this is precisely what a colexification network does
What’s the idea?

- The goal would be to find a more economical solution and to have all the social agents connected with as few edges as possible accounting for all the observations.
Inferring semantic maps

• How does it transfer to semantic maps?
Inferring semantic maps

- How does it transfer to semantic maps?
  - Nodes are meanings
Inferring semantic maps

- How does it transfer to semantic maps?
  - Nodes are meanings
  - Constraints are polysemic items (connectivity hypothesis)
Inferring semantic maps

- How does it transfer to semantic maps?
  - Nodes are meanings
  - Constraints are polysemic items (connectivity hypothesis)
  - One connects the nodes economically based on these constraints

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Inferring semantic maps

- How does it transfer to semantic maps?
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  - One connects the nodes economically based on these constraints, starting with the edge(s) that accounts for the most frequent constraint(s)
Inferring semantic maps

• How does it transfer to semantic maps?
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  • Constraints are polysemic items (connectivity hypothesis)
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Inferring semantic maps

- Regier et al. (2013): the approximations produced by the Angluin et al. algorithm are of high quality
  - Tested on the crosslinguistic data of Haspelmath (1997) and Levinson et al. (2003)

Figure. Haspelmath’s (1997: 4) original semantic map of the indefinite pronouns functions
Inferring semantic maps

<table>
<thead>
<tr>
<th>Language</th>
<th>Word</th>
<th>Specific Known</th>
<th>Specific Unknown</th>
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Inferring semantic maps

### INPUT
(lexical matrix)

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### ALGORITHM
(pyton script)

```python
# MAIN LOOP
objfn = CG(6,T)
while (objfn != 0):
    print("objective fn is currently", objfn)
    max_score = 0
    # choose next edge greedily: the one that increases objfn the most
    for e in Posen:
        # temporarily add e to graph G
        G.add_edge(e)
        score = CG(6,T) - objfn
        G.remove_edge(e)
        if (score > max_score):
            max_score = score
            max_edge = e
```
Inferring semantic maps

**INPUT** (lexical matrix)

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**ALGORITHM** (python script)

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    max_score = 0
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        G.add_edge("e")
        score = CC(G,T) - objfn
        G.remove_edge("e")
        if (score > max_score):
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```

**RESULT** (semantic map)

- Specific known
- Specific unknown
- Irrealis non-specific
- Question
- Indirect negation
- Direct negation
- Conditional
- Comparative
- Free choice

Le Diasema
Plotting weighted maps

Weighted semantic maps

- Generate the map with a modified version of the algorithm of Regier et al. (2013)
  - **PRINCIPLE:** for each edge that is being added between two meanings of the map by the algorithm, check in the lexical matrix how many times this specific polysemy pattern is attested, and increase the weight of the edge accordingly

```python
edgeWeight = 0
for sns in sensesTupleList:
    if (max_edge[0] in sns) and (max_edge[1] in sns):
        edgeWeight += 1
G.add_edge(*max_edge, weight=edgeWeight)
```
Plotting weighted maps

Weighted semantic maps

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• Based on the data of Haspelmath (1997), kindly provided by the author, the result between a non-weighted and a weighted semantic map are markedly different
Plotting weighted maps

Weighted semantic maps

Automatically plotted semantic maps: non-weighted vs. weighted (data from Haspelmath 1997)

The graph is visualized in Gephi® with the Force Atlas algorithm
Plotting weighted maps

Weighted semantic maps

Automatically plotted semantic maps: non-weighted vs. weighted (data from Haspelmath 1997)

The graph is visualized in Gephi® with the Force Atlas algorithm and modularity analysis (Lambiotte et al. 2009)
Graphs vs feature projections

- If the data can be turned into a polysemy matrix, the graphs have some advantages over feature projections based on techniques of dimensionality reduction

  1. Readability and interpretability
Graphs vs feature projections

Graph vs t-SNE projection of the same dataset

t-SNE projection
Graphs vs feature projections

Graph vs t-SNE projection of the same dataset

Very lopsided data!
Graphs vs feature projections

- If the data can be turned into a polysemy matrix, then the graphs have significant advantages over feature projections based on techniques of dimensionality reduction:

1. Readability and interpretability
2. Visual expressiveness
3. Modifiability
4. Statistical tools
   - Filtering
   - Clustering
   - Visualizing
Objectives: 1) Add directionality to semantic maps of content words
Objectives: 2) Plot diachronic and weighted semantic maps automatically

- **Diachronic semantic maps** are much more informative than regular semantic maps, because they visually provide information about possible pathways of change.

  “[T]he best synchronic semantic map is a diachronic one”
  (van der Auwera 2008: 43)

- **Weighted semantic maps** are much more informative than regular semantic maps, because they visually provide information about the frequency of polysemy patterns.
Objectives: 3) Provide information about the *cognitive* and *cultural* factors behind the development of the various meanings
Today’s talk

1. Add directionality to semantic maps of content words
2. Plot diachronic and weighted semantic maps
3. Provide information about the cognitive and cultural factors behind the development of the various meanings

We present:
• A protocol to construct lexical diachronic semantic maps based on a case-study:
  The semantic extension of time-related lexeme
• A way to visualize and analyze the results
The semantic extension of time-related lexemes
Protocol to construct a (lexical) diachronic semantic map

1. Choose the concepts / domains
2. Identify cross-linguistic polysemy patterns
3. Build a lexical matrix
4. Plot a weighted semantic map
5. Remove infrequent polysemy patterns
6. Select languages with diachronic data
7. Ensure comparability
8. Add diachronic information
9. Visualize the complete result
Protocol to construct a (lexical) diachronic semantic map

Choice of concepts

• For the purpose of universality and stability, we chose the entries for time-related concepts in the Swadesh 200-word list (Swadesh 1952: 456-457)

• DAY/DAYTIME
• NIGHT
• YEAR

THE TEST VOCABULARY

- in, to kill, to know (cons), fake, to laugh, left (hand), let, to lie (on side), to love, lower, long, house, man (male human), many, near (fish), mother, mountain, much, own, narrow, near, next, new, night, nose, not, old, one, other, person, to play, to put, to push, to rain, red, right (correct), right (hand), roof, road (or walk), root, rope, rotten (especially big), to rub, salt, sand, to say, to search (has with fingers), to see, to sing, to sit, skin (person), sky, to sleep, small
- to smell (persuasive odor), smoke (of fire), smoke, snow, stone, to spit, to spout, to spread, to stab (or stick), to stand, star (sticks of wood), stone, straight, to take, sun, to smell, tall, that, there, they, thin, there, to think, this, this, three, to throw, to lie, imagine, tooth (front rather than molar), tree, to turn (change one's direction), two, to walk, warm (of weather), to wash
- water, we, what, when, where, white, who, wide, wife, wind, wing, to wipe, with (accompanying), woman, woods, wave, ye, year, yellow

Le Diasema
Protocol to construct a (lexical) diachronic semantic map

Choice of concepts

• We chose the entries for time-related concepts also for the sake of comparability
  (see, e.g., Youn et al. 2016)
Protocol to construct a (lexical) diachronic semantic map

Identify cross-linguistic polysemy patterns

- $N$ of lgs: 221
- $N$ of lg families: 64
- $N$ of concepts: 1280

- Identify in CLICS (List et al. 2014) the main polysemy patterns attested for these three meanings [16 meanings]
Protocol to construct a (lexical) diachronic semantic map

Identify cross-linguistic polysemy patterns

- Identify in CLICS (List et al. 2014) the main polysemy patterns attested for these three meanings [16 meanings]

  - **DAY/DAYTIME**: CLOCK/TIMEPIECE, HOUR, SEASON, SUN, TIME, WEATHER
  - **NIGHT**: DARK (in color), DARKNESS, BLACK, OBSCURE
  - **YEAR**: AGE, SPRING, SUMMER
Protocol to construct a (lexical) diachronic semantic map

Identify cross-linguistic polysemy patterns

- All the colexification patterns attested for these 16 meanings were gathered from the CLICs source files (http://clics.lingpy.org/download.php):

  381 colexification patterns
Protocol to construct a (lexical) diachronic semantic map

Convert the polysemy patterns into a lexical matrix

```
Tmap = [Tsenses]
for t in Tclean:
    split_langWord = t[2].split('//')
    for couple in split_langWord:
        langWord = couple.split(':')
        line = [langWord[0], langWord[1]]
        for i in range(2, len(Tsenses)):
            line.append('0')
        line[Tsenses.index(t[0])] = '1'
        line[Tsenses.index(t[1])] = '1'
        Tmap.append(line)
```

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<tr>
<td>mi_std</td>
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<td>0</td>
</tr>
<tr>
<td>bbb_std</td>
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<td>0</td>
</tr>
<tr>
<td>khv Khvarshi</td>
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<td>0</td>
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</tbody>
</table>

1 when a meaning is attested for one form

Python script \( \alpha \)

Lexical matrix
A method to extract the community structure of large networks. Here, the different colors point to modules (also called clusters or communities) with dense connections between the nodes within the network.

* Full semantic map for time-related senses, visualized with modularity analysis* (Blondel et al. 2008) in Gephi
Semantic map of time-related senses
(colexification patterns attested in 2+ languages)

Two connected sub-networks
- NIGHT/DARKNESS/DARK
- DAY/TIME/AGE/YEAR
Semantic map of time-related senses (collexification patterns attested in 2+ languages)

Two connected sub-networks
- NIGHT/DARKNESS/DARK
- DAY/TIME/AGE/YEAR

Remove infrequent polysemy patterns
Protocol to construct a (lexical) diachronic semantic map

Remove infrequent polysemy patterns

- In order to investigate directionality of change, 13 meanings that are connected on this map in at least 8 different languages were kept.
Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

• The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)
Protocol to construct a (lexical) diachronic semantic map

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(1) *Meanings*: tree *(source)*—forest *(target)* (ID: 600); *Form*: dar; *Language*: Aghul; *Realization Type*: **synchronous polysemy**
Protocol to construct a (lexical) diachronic semantic map

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1) Meanings: tree (source)—forest (target) (ID: 600); Form: dar; Language: Aghul; Realization Type: synchronic polysemy

2) Meanings: doll (source)—nymph, chrysalis (target) (ID: 927); Form: kukla; Language pair: Russian — Czech; Realization Type: Cognate
Protocol to construct a (lexical) diachronic semantic map

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• The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)

(1) Meanings: tree (source)—forest (target) (ID: 600); Form: dar; Language: Aghul; Realization Type: **synchronic polysemy**

(2) Meanings: doll (source)—nymph, chrysalis (target) (ID: 927); Form: kukla; Language pair: Russian —Czech; Realization Type: **Cognate**

(3) Meanings: arc (source) → rainbow (target) (ID: 393); Form: Bogen → Regenbogen; Language: German; Realization Type: **Morphological derivation**
Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

- The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)

(1) **Meanings**: tree (source) → forest (target) (ID: 600); **Form**: dar; **Language**: Aghul; **Realization Type**: **synchronic polysemy**

(2) **Meanings**: doll (source) → nymph, chrysalis (target) (ID: 927); **Form**: kukla; **Language pair**: Russian — Czech; **Realization Type**: **Cognate**

(3) **Meanings**: arc (source) → rainbow (target) (ID: 393); **Form**: Bogen → Regenbogen; **Language**: German; **Realization Type**: **Morphological derivation**

(4) **Meanings**: to count (source) → speech (target) (ID: 11); **Forms**: ratio → Rede; **Languages**: Latin (donor) → German (target); **Realization Type**: **Borrowing**
Select languages with diachronic data

- The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)

(1) **Meanings**: tree *(source)* — forest *(target)* (ID: 600); **Form**: dar; **Language**: Aghul; **Realization Type**: **synchronic polysemy**

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(3) **Meanings**: arc *(source)* → rainbow *(target)* (ID: 393); **Form**: Bogen → Regenbogen; **Language**: German; **Realization Type**: **Morphological derivation**

(4) **Meanings**: to count *(source)* → speech *(target)* (ID: 11); **Forms**: ratio → Rede; **Languages**: Latin *(donor)* → German *(target)*; **Realization Type**: **Borrowing**

(5) **Meanings**: to catch *(source)* → to hunt *(target)* (ID: 415); **Forms**: capto → cacciare; **Languages**: Latin → Italian; **Realization Type**: **Diachronic semantic evolution**
Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

• The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)
Protocol to construct a (lexical) diachronic semantic map

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Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

- The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)

<table>
<thead>
<tr>
<th>ID</th>
<th>Source</th>
<th>Direction</th>
<th>Target</th>
<th>Status</th>
<th>Contributed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>1446</td>
<td>time</td>
<td>→</td>
<td>journal, magazine</td>
<td>Accepted</td>
<td>IG</td>
</tr>
</tbody>
</table>

Comments:
Ср. греч. хронограф, откуда могут быть кальки.
Confirmed by 3 Guru(s)
Derivation: German Zeit → Zeitung, Zeitschrift 'newspaper, journal'

Polysemy: Polish czas 'time' — 'journal'
Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

• The Catalogue of Semantic Shifts in the Languages of the World (Zalizniak, 2006; Zalizniak et al., 2012; http://semshifts.iling-ran.ru/)
  • Relies predominantly on synchronic polysemy
  • Mirrors the polysemous view of semantic change

• We share this view, but:
  • **Our focus**: diachronic semantic developments of individual lexemes in the course of their semantic history
  • **Advantage**: theorize about semantic change based on actual data
  • **Disadvantage**: not many languages with significant diachronic data!
Protocol to construct a (lexical) diachronic semantic map

Select languages with diachronic data

- **Ancient Greek** (8th c. BC – 4th c. AD)
  - Perseus digital library (http://www.perseus.tufts.edu/hopper/), TLG (http://stephanus.tlg.uci.edu)
  - Cunliffe (*A lexicon of the Homeric Dialect*), LSJ
  - Dictionary of Selected Synonyms in the Principal Indo-European Languages (Buck, 1949)
  - Etymological dictionaries (e.g., Beekes, 2010)

- **Ancient Egyptian** (26th c. BC – 10th c. AD)
  - Corpora
    - Thesaurus Linguae Aegyptiae (http://aaew.bbaw.de/tna/)
    - Ramses Online (http://ramses.ulg.ac.be)
  - Lexical resources (Dictionaries and Coptic etymological dictionaries)
Protocol to construct a (lexical) diachronic semantic map

Ensure comparability

• Provide definitions for the 13 concepts
  • Use Concepticon (http://concepticon.clld.org)
    (a) the concept sets are given a unique definition
    (b) CLICS is one of the lists included in Concepticon*

<table>
<thead>
<tr>
<th>CONCEPT</th>
<th>DEFINITION IN CONCEPTICON</th>
<th>ADJUSTED DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>The period of time that a person, animal or plant has lived or is expected to live.</td>
<td></td>
</tr>
<tr>
<td>DAY/DAYTIME</td>
<td>The period between sunrise and sunset where one enjoys daylight.</td>
<td></td>
</tr>
<tr>
<td>SUN</td>
<td>The particular star at the centre of our solar system, from which the Earth gets light and heat.</td>
<td>The star that is the source of light and heat for the planets in the solar system (Wordnet)</td>
</tr>
</tbody>
</table>

* The elicitation of the data in CLICS precedes the addition of the definitions in Concepticon
## Protocol to construct a (lexical) diachronic semantic map

### Ensure comparability

- Proceed onomasiologically

<table>
<thead>
<tr>
<th>Concept</th>
<th>Definition in Concepticon</th>
<th>Adjusted Definition</th>
<th>Lexeme in AEG</th>
<th>Lexeme in AG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>The period of time that a person, animal or plant has lived or is expected to live</td>
<td>j3k.t, šms, snhy.t, j3w (old age), jz.t (age, decline)</td>
<td>hēlikia</td>
<td></td>
</tr>
<tr>
<td>Day/Daytime</td>
<td>The period between sunrise and sunset where one enjoys daylight.</td>
<td>hrw, hd.t, r5w (nb), sw (calenderic)</td>
<td>êmar, ēós</td>
<td></td>
</tr>
<tr>
<td>Sun</td>
<td>The particular star at the centre of our solar system, from which the Earth gets light and heat.</td>
<td>The star that is the source of light and heat for the planets in the solar system (Wordnet)</td>
<td>r5w, šw, jtn, etc.</td>
<td>hēlios or ēlēios</td>
</tr>
</tbody>
</table>

Table. Definitions of concepts and lexemes expressing the concepts
Protocol to construct a (lexical) diachronic semantic map

Ensure comparability

• Proceed onomasiologically
• Proceed semasiologically
  • List the different meanings of the lexemes identified
    • Dictionary-based
    • Other available resources
    • Corpus queries
  • Collect at least two text examples of each of the meanings
Protocol to construct a (lexical) diachronic semantic map

Add diachronic information

• Include directionality of change
  • Add arrows to the existing synchronic map
  • Enrich the existing synchronic map with additional nodes and add arrows (if necessary)
• Visualize the (complex) results

+ Semantic analysis
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - SEASON-TIME-HOUR
The semantic extension of time-related lexemes

**Ancient Greek:** *hóra* ‘season’

- Proto Indo-European root *Hieh,-r-, Hiob,-r- ‘year’ (Beekes, 2010: 1681)

(1)  

```
<table>
<thead>
<tr>
<th>hóssá</th>
<th>te</th>
<th>phúlla</th>
<th>kai</th>
<th>ánthea</th>
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<tr>
<td>REL.NOM.PL.N</td>
<td>PTC</td>
<td>leaf:ACC.PL.N</td>
<td>CONJ</td>
<td>flower:ACC.PL.N</td>
</tr>
</tbody>
</table>
```

\[ \text{gíngetai} \quad \text{hórei} \]

become:PRS.3SG season:DAT.SG.F

‘as are the leaves and the flowers in their *season*’ (Homer, *Iliad* 2.468)

**hórai (seasons):**

- **spring** (*éaros hórei* ‘spring season’; *Iliad* 6.148),
- **winter** (*hórei kheimeríei* ‘in wintry season’; *Odyssey* 5.485)
- **summer/autumn** (*hórai epibríseian* ‘in rainy seasons’; *Odyssey* 24.344)
The semantic extension of time-related lexemes

**Ancient Greek: hóra ‘time/moment’**

(2) óphra  Poseidáōni  kai  állois  athanátoisin
CONJ  Poseidon:DAT.SG.M  CONJ  other:DAT.PL  immortal:DAT.PL

speísantes  koítoio  medómetha:
pour.libation:PART.AOR.NOM.PL.M  bed:GEN.SG.M  think.of:PRS.1PL.SUBJ.M/P

toîo  gâr  hórē
DEM.GEN.SG  PTC  time:NOM.SG.F

‘that when we have poured libations to Poseidon and the other immortals, we may bethink us of sleep; for it is the time thereto’ (Homer, *Odyssey* 3.333-334)
The semantic extension of time-related lexemes

**Ancient Greek:** hóra ‘time/moment’

(3) makrá moi neísthai kat’ amaksitón:

long:NOM.SG.F 1SG.DAT go:PRS.INF.M/P DIR.INFR highway:ACC.SG.M

hóra gàr sunáptei

time:NOM.SG.F PTC join.together:PRS.3SG

‘Returning home by highway is too long; for time is approaching’

(Pindar, *Pythian 4.247*)
The semantic extension of time-related lexemes

**Ancient Greek:** *hora* ‘time/moment’ ⇒ ‘hour’

(4) *oukhì dôdeka hôrai eisin tês hêméras;*

NEG twelve hour:NOM.PL be.PRS.3PL ART.GEN.SG.F day:GEN.SG.F

‘Aren’t there twelve **hours** of daylight?’ (New Testament, John 11.9.2)

➢ *hora* conveyed the meaning ‘hour’ as early as the 4th c. BC
The semantic extension of time-related lexemes

**Metonymy**: due to the correlation between the canonical time periods and the time these take to unfold
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

• The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  • SEASON-TIME-HOUR
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - **TIME-AGE-YEAR-SEASON**: Reintegrating edges
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - **TIME-AGE-YEAR-SEASON**: Reintegrating edges

\[(5) \quad \begin{array}{llllll}
dôke & \text{dé} & m' & \text{ekdeíras} & \text{askòn} \\
give: \text{AOR.3SG} & \text{PTC} & 1\text{SG.ACC} & \text{strip.off:PTCP.AOR.NOM.SG.M} & \text{skin:ACC.SG.M} \\
boòs & \text{enneóroio,} \\
\text{ox:GEN.SG.M} & \text{nine.years.old:GEN.SG.M} \\
\end{array}\]

‘He gave me a wallet, made of the hide of an ox **nine years old**, which he flayed’ (Homer, *Odyssey* 10.19)
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
- **TIME-AGE-YEAR-SEASON**: Reintegrating edges

Loose colexifications:
ennéoros (lit. ‘in the ninth season’)
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - SUN-DAY
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - **SUN-DAY**

(6) pán ἐmar pherómên, háma d’
whole:ACC.SG.N day:ACC.SG.N carry:IMPF.1PL.M/P ADV PTC

ēelíoi katadúnti käppeson en Lémnoi
sun:DAT.SG.M set:PTCP.AOR.DAT.SG.M fall:AOR.1PL in Lemnos:DAT.SG
‘the whole day long I was carried headlong, and at sunset I fell in Lemnos’
(Homer, *Iliad* 1.592-593)

Approx. 8th c. BC
Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
- **SUN-DAY**

(7) ἐκῆις, ἤγο ὑπὲρ ὑπὲρ ἕληιος δὲ
have:PRS.2SG 1SG.NOM PTC 2SG.ACC sun:ACC.PL.M PTC

murίος mólis dieλθὴν ἐισθομὲν
infinite:ACC.PL.M ADV pass:PTCP.AOR.NOM.SG.M perceive:AOR.1SG.MID

tà tῆς theου
ART.ACC.PL.N ART.GEN.SG.F god:GEN.SG

‘You have me, and I have you; although it was hard to live through so many days, I now understand the actions of the goddess.’ (Euripides, *Helen* 652-653)
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - SUN-DAY

\[(\text{Praise: SBJV-3SG.M} \quad 2\text{SG.M})\]

‘(You should pray god non-stop,) so that he praise you every day.’
(P. Chester Beatty IV, v° 4,10)
The semantic extension of time-related lexemes

Add arrows to the existing synchronic map

- The diachronic material allows us to add diachronic information (graphically, oriented edges) between frequent colexification patterns
  - SUN-DAY
The semantic extension of time-related lexemes

• **SUN-DAY**

Snapshot from Youn et al. (2016) showing polysemy patterns of celestial objects and natural settings.
The semantic extension of time-related lexemes

Enriching the map

- The material allows us to add new polysemy patterns, and to provide a diachronic account
  - SUMMER:
The semantic extension of time-related lexemes

Enriching the map

- **SUMMER**

<table>
<thead>
<tr>
<th>Concept</th>
<th>IDS-Key</th>
<th>Occurrences</th>
<th>Families</th>
<th>Languages</th>
<th>Network</th>
<th>Forms</th>
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<td>reach, arrive</td>
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<td>1</td>
<td>1</td>
<td>COM</td>
<td>SUB</td>
</tr>
</tbody>
</table>

(http://clics.lingpy.org/all.php?gloss=summer)
The semantic extension of time-related lexemes

Enriching the map

- Ancient Greek: théros ‘summer’ ⇒ ‘harvest’*

(9) autàr επὲν ἐλθέισι  ἄρα t’ ὀπόρη
PTC when come:AOR.SBJ.3SG summer:NOM.SG.M another:NOM.SG.F

‘But when summer comes and rich autumn’ (Homer, Odyssey 11.192)

(10) καίτ’ ἀνὴρ ἐδοξεν eἶναι, τάλοτριον
ADV man:NOM.SG.M seem:AOR.3SG be.INF another:GEN.SG

amôn reap.corn:PTCP.PRS.SBJ.3SG summer:ACC.SG.N

‘he has only made himself a name by reaping another’s harvest’
(Aristophanes, Knights 392)

*In Homer, karpós is used for ‘harvest’
The semantic extension of time-related lexemes

Enriching the map

Ancient Egyptian: šmw ‘summer’ ⇒ šmw ‘harvest’*

*In OEg, another lemma is used for ‘harvest’ (żḥ)

Old Kingdom

Middle Kingdom

Le Diasema
The semantic extension of time-related lexemes

Enriching the map

• The material allows us to add new polysemy patterns and to provide a diachronic account
  • SUMMER

Metonymy:
A particular period linked to a salient activity associated with the period
The semantic extension of time-related lexemes

Enriching the map

• The material allows us to add new polysemy patterns and to provide a diachronic account
  • SEASON
# The semantic extension of time-related lexemes

## Enriching the map

- **SEASON** → **YOUTH**

(11)  

<table>
<thead>
<tr>
<th>eph’</th>
<th>hois</th>
<th>prosékei</th>
<th>semmúsesthai</th>
<th>tèn</th>
<th>pólin,</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUPR</td>
<td>REL.DAT.PL.M</td>
<td>belong:PRS.3SG</td>
<td>exalt:INF.M/P</td>
<td>ART.ACC.SG.F</td>
<td>city:ACC.SG.F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>eàn</th>
<th>kállei</th>
<th>kai</th>
<th>hórai</th>
<th>dienegkóntes</th>
</tr>
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<tbody>
<tr>
<td>CONJ</td>
<td>beauty:DAT.SG.N</td>
<td>CONJ</td>
<td>youth:DAT.SG.F</td>
<td>differ:AOR.PTCP.NOM.PL.M</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ekpléksósi</th>
<th>tinas</th>
<th>kai</th>
<th>perimákhêtoi</th>
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<tr>
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<td>be.AOR.SUBL.3PL.MID</td>
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‘of whom the city may well be proud, if by their surpassing beauty and youthful charm they infatuate one person or another’ *(Aeschines, Against Timarchus 1.134)*
The semantic extension of time-related lexemes

Enriching the map

• The material allows us to add new polysemy patterns and to provide a diachronic account
  • *SEASON*

• The life cycle is conceptualized as a season along the lines of the *LIFE IS A YEAR* metaphor

The semantic extension of time-related lexemes

Language-specific colexification patterns

• The material allows us to highlight unexpected pathways of change:
  • From temporal proximity to spatial proximity

• What about the TIME IS SPACE Metaphor?
  • (Cross-linguistically Time to Space transfers are extremely rare; cf. French depuis; Haspelmath 1997)
The semantic extension of time-related lexemes

Ancient Egyptian

(12) m rk ḫm-f nswt-bity nb-kꜣw-rᶜ
in time Majesty-3SG.M King of U. and L. Egypt Nebkaure

‘(Now, the peasant spoke these word) during the time of his Majesty, the King of Upper and Lower Egypt, Nebkaure (the justified)’ (= Parkinson 1991: 19)

(13) sbty ḏr m rk mšᶜ-f
rampart strong in time army-3SG.M

(talking about the King, who is described as)
‘A strong rampart around his army, (their shield in the day of fighting)’
The semantic extension of time-related lexemes

Ancient Egyptian

(Stage I)

\( rk \)

‘temporal proximity’

(Stage II)

\( rk \)

‘spatial proximity’
The semantic extension of time-related lexemes

Ancient Egyptian

(14) \[ m \ bAw nb \ t3-wj \ nb-p\text{h}.tj-\text{r}^e \]
in prox-time lord land-DU Nebphtire

(And then I became a soldier (...),)
‘during the time of the lord of the Two Lands, Nebpehtire (justified, when I was a young man, not having a wife yet)’ (= Urk. IV, 2,13)

(15) \[ m \ bAw \ nh.t \]
in prox-space Sycamore

‘(I crossed the place called The Two Truths,) in the vicinity of The Sycamore” (and I landed at The Island of Snefru)” (= Koch 1990: 14)
The semantic extension of time-related lexemes

Ancient Egyptian

(Stage I)

(Stage II)
The semantic extension of time-related lexemes

Ancient Egyptian

(Stage I)

<table>
<thead>
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(Stage II)

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Le Diasema
The semantic extension of time-related lexemes

Ancient Egyptian

- "temporal proximity"
- "spatial proximity"

(Stage I)

(Stage II)

Le Diasema
From simple networks to mixed multi-edge graphs
From simple networks to mixed multi-edge graphs
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From simple networks to mixed multi-edge graphs

Can we infer directionalities automatically?
From simple networks to mixed multi-edge graphs

- Expand the lexical matrix so as to include information about diachrony

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From simple networks to mixed multi-edge graphs

• Expand the lexical matrix so as to include information about diachrony

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The diachronic stages are indexed by numbers: 0, 1, 2, etc.
From simple networks to mixed multi-edge graphs

- Expand the lexical matrix so as to include information about diachrony

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The meaning of a word can change from one stage to another (e.g., Word_2 of Language_2 expresses the meaning Wood during stage 0 and Wood & Forest during stage 1)
From simple networks to mixed multi-edge graphs

- Expand the lexical matrix so as to include information about diachrony
- Generate the graph with the weighted version of the algorithm of Regier et al. (2013)
From simple networks to mixed multi-edge graphs

• Expand the lexical matrix so as to include information about diachrony

• Generate the graph with the weighted version of the algorithm of Regier et al. (2013)

• Enrich the graph with oriented edges (where relevant)
  • **PRINCIPLE:** for each edge in the graph, if the meaning of node A is attested for one diachronic stage, while the meaning of node B is not, check in the lexical matrix if there is a later diachronic stage of the same language for which this specific word has both meaning A and B (or just meaning B). If this is the case, we can infer a meaning extension from A to B.
From simple networks to mixed multi-edge graphs

**INPUT**
(diachronic lexical matrix)

**ALGORITHM**
(pyhton script for inferring oriented edges)

**RESULT**
(dynamic semantic map)

```
G = G.to_directed()   # convert the graph 'G' into a directed Graph 'H' in order to explore all the possibilities regardless of the relationship between the nodes (i.e., both A -> B and B -> A for all connected nodes, crucially not only A -> B)
	nx.set_edge_attributes(H, 'type', 'undirected')   # set the default value to "undirected" for all edges in the DiGraph 'H'

for u, v, e in H.edges(data=True):  # loop over all edges in the DiGraph 'H'
    for t in T_full:  # look at the metadata and senses for one line in 'T_full'
        if t.count(u) == 1 and t.count(v) == 0:  # if the meaning of node 'u' in the line is a Tree while the meaning of node 'v' is Wood
            H.add_edge(u, v, type='Tree')  # add an oriented edge 'u' to 'v' with type Tree
```

### Table: Source of constraint vs. Constraint name

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</table>
Upload the lexical matrix (.xls file)
Upload the lexical matrix (.xls file)
Conclusions

- Lexical matrix uploaded ✓
- Generate the map
  - Weighted ✓
  - Diachronic
Conclusions

Thanks!

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athanasios.georgakopoulos@uliege.be