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Meaning Representation of English Prepositional Phrase Roles: SNACS Supersenses vs. Tectogrammatical Functors

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Hors d'oeuvre

Han Solo was washing the Millennium Falcon with Chewbacca.

Princess Leia says, ".... Can't you use a sponge?"

credit: https://twitter.com/kelly_knox/

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Semantic Ambiguity

Han Solo was washing the Millennium Falcon **with** Chewbacca.

- Many meaning representation frameworks (word senses, semantic roles) have ways to disambiguate the two readings.

- This work: in-depth comparison of two of them—**SNACS** and **Prague tectogrammatical functors**.

credit: https://twitter.com/kelly_knox/

Semantic Network of Adposition and Case Supersenses (SNACS)

- **SNACS** (Schneider et al. 2018, *inter alia*): a set of lexical semantic classes ("supersenses") designed for disambiguating adpositions in English and other languages

- 52 total supersenses, organized into a hierarchy with 3 branches
  - influenced by VerbNet, FrameNet, AMR/UMR
  - comprehensive annotation
  - semantic criteria (rather than alternations or associations with a predicate lexicon)

Image from SNACS guidelines for English, v2.6 (2022)

SNACS disambiguation

Han Solo was washing the Millennium Falcon **with** Chewbacca.

Ancillary vs. **Instrument**

Princess Leia says, ".... Can't you use a sponge?"

credit: https://twitter.com/kelly_knox/

SNACS: 2 levels available

English: Thanks **for** (noun or verb) **Explanation**

French: Merci **pour** (thing) **Explanation**

French: Merci **de** (action) **Explanation~>Source?**

Prague Tectogrammatical Functors

- In Prague Czech-English Dependency Treebank, a parallel corpus of Wall Street Journal text
  - We use PCEDT v2.0 (Hajič et al., 2012)
  - We focus on the English section (PEDT)
- Multiple Layers of Description
  - **Analytical Layer (a-layer)**
    - Surface Syntax
  - **Tectogrammatical Layer (t-layer)**
    - "Deep syntax" / Semantics
    - Argument structure relations
    - **Formemes** - keep track of surface syntactic realization (e.g. with a preposition)
    - 69 **functors** - mark the relationship between parent / daughter nodes

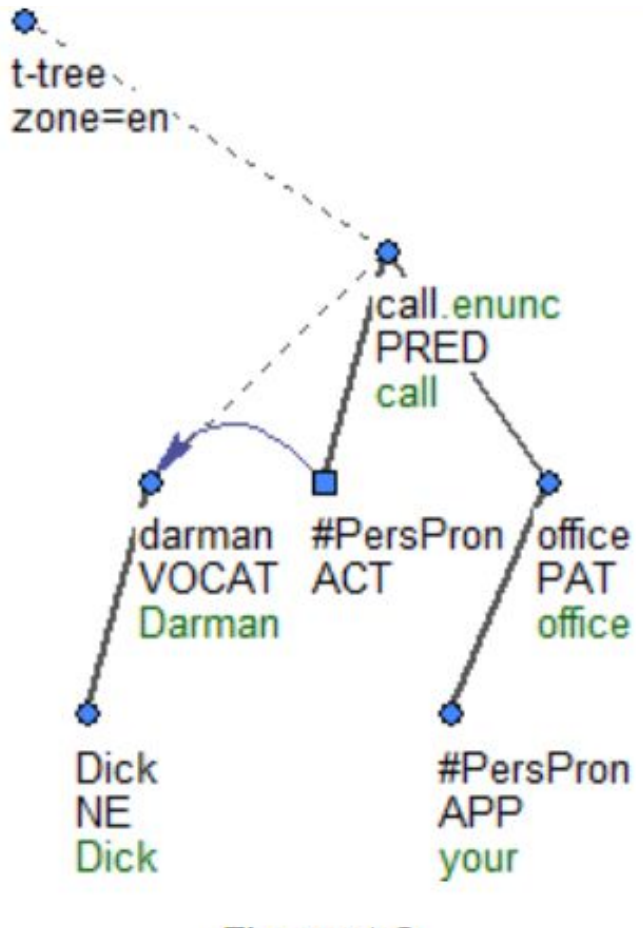


Image Source: https://ufal.mff.cuni.cz/pcedt2.0/

Goal of this Work - Annotation Comparison

- Compare definitions of PEDT functors and SNACS supersenses

- Quantitatively and qualitatively evaluate the overlap between similar tags in the two tagsets

Example Overlap: SNACS Locus vs PEDT LOC

SNACS Locus Supersense

"Location, condition, or value. May be abstract." (Schneider et al., 2022)

- "I like to sing at.**Locus** the gym."
- "I read it in.**Locus** a book."

PEDT LOC Functor

"A functor for a free modification that specifies the location answering the question "where?", i.e. it indicates the place at which the event or state is situated." (Mikulová et al., 2005)

- "He works in Prague.**LOC**"

Example Overlap 2: SNACS Duration vs PEDT TFHL

SNACS Duration Supersense

"Indication of how long an event or state lasts (with reference to an amount of time or time period/larger event that it spans)." (Schneider et al., 2022)

- "I walked for.**Duration** 20 minutes."
- "I mowed the lawn for.**Duration** an hour."

PEDT TFHL Functor

"A functor for a free modification that expresses a temporal meaning related to the question "for how long?"; it gives the length of duration of a state which is a result of the event expressed by the governing word." (Mikulová et al., 2005)

- "He came to stay for a month.**TFHL**"

Example Overlap 3: SNACS Explanation vs PEDT CAUS

SNACS Explanation Supersense

"Assertion of why something happens or is the case." (Schneider et al., 2022)

- "I went outside because of.**Explanation** the smell."

PEDT CAUS Functor

"The CAUS functor (cause) is assigned to modifications with the meaning of cause of an event or state..." (Mikulová et al., 2005)

- "The losses occurred due to.**CAUS** poor management."

Example Overlap 4: SNACS Gestalt vs PEDT APP

SNACS Gestalt Supersense

"Generalized notion of "whole" understood with reference to a component part, possession, set member, or characteristic."
(Schneider et al., 2022)

- "The blueness of.**Gestalt** the sky."
- The president's.**Gestalt** power".

PEDT APP Functor

"a functor for a free adnominal modification denoting a person or an object, to which the person or object referred to by the governing noun is in the relation of appurtenance."
(Mikulová et al., 2005)

- "My.**APP** castle"
- "The quality of.**APP** the service"

Methodology

1. Use annotation guidelines / descriptions to create heuristic mapping to most likely SNACS **Supersenses** from PEDT **functors**

2. Run an automatic SNACS **Supersense** tagger on a small subset of PEDT (838 sentences, 1837 preposition tokens)

3. Evaluate overlap of predicted SNACS **Supersenses** with the expected corresponding PEDT **functors**

4. Compare results of automatic classifier and heuristic mapping

Heuristic Mapping: Descriptive Overlap

Functor	Supersense	Functor	Supersense	Functor	Supersense	Functor	Supersense	Functor	Supersense
TSIN	StartTime	LOC	Locus	MEANS	Instrument,Means	ACT	Agent,Force	EXT	Cost
TTILL	EndTime	DIR1	Source	MANN	Manner	PAT	Theme,Topic	APP	Gestalt
TFHL	Duration	DIR2	Direction,Path	CAUS	Explanation	ORIG	Originator	COMPL	Identity
THL	Duration	DIR3	Goal	AIM	Purpose	ADDR	Recipient	MAT	QuantityItem
THO	Frequency	EXT	Extent			BEN	Beneficiary	RSTR	Characteristic
TPAR	Time					ACMP	Ancillary	CPR	ComparisonRef
TWHEN	Time								

- 32 of 52 Supersenses have a descriptively similar PEDT functor
- Many PEDT functors are probably not relevant to SNACS hierarchy (e.g. **CONJ**, **VOCAT**)
- Mapping from PEDT to remaining 20 supersenses (many of which are in the Configuration branch) remains unclear

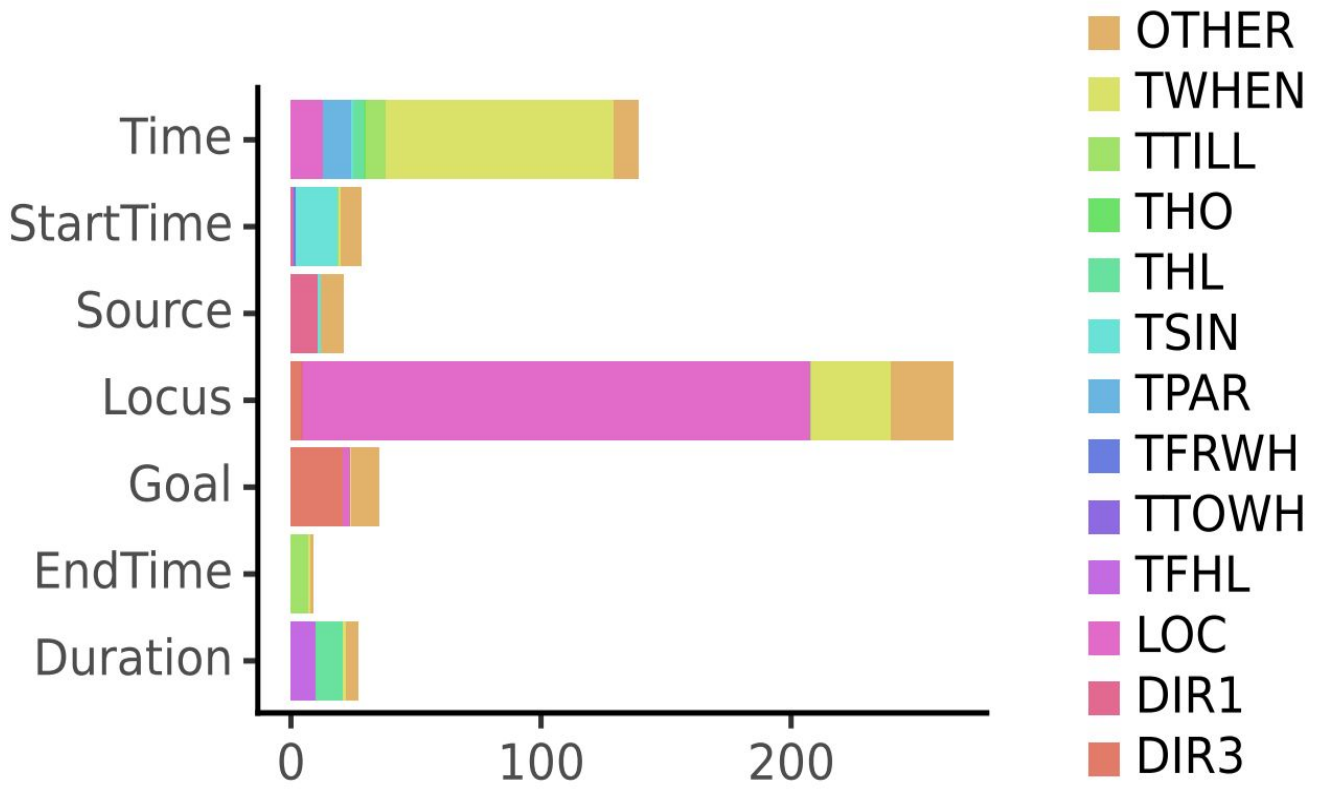
Empirical Comparison - Heuristic vs Classifier Overlap

- How do our expected Supersenses (from our heuristic mapping) compare to automatically predicted SNACS Supersenses?
- Well, they don't align as well as we would hope 😕
- Heuristic for functors aligning with Circumstances are more accurate than functors aligning with Configurations

Class of Functors	# of Tokens	Percent Overlap
circumstantials	818	50.3
spatials	446	52.7
temporals	212	66.5
other	160	21.9
participants	500	47.0
ACT	113	55.8
PAT	238	58.0
other	149	22.8
configurations	386	36.0

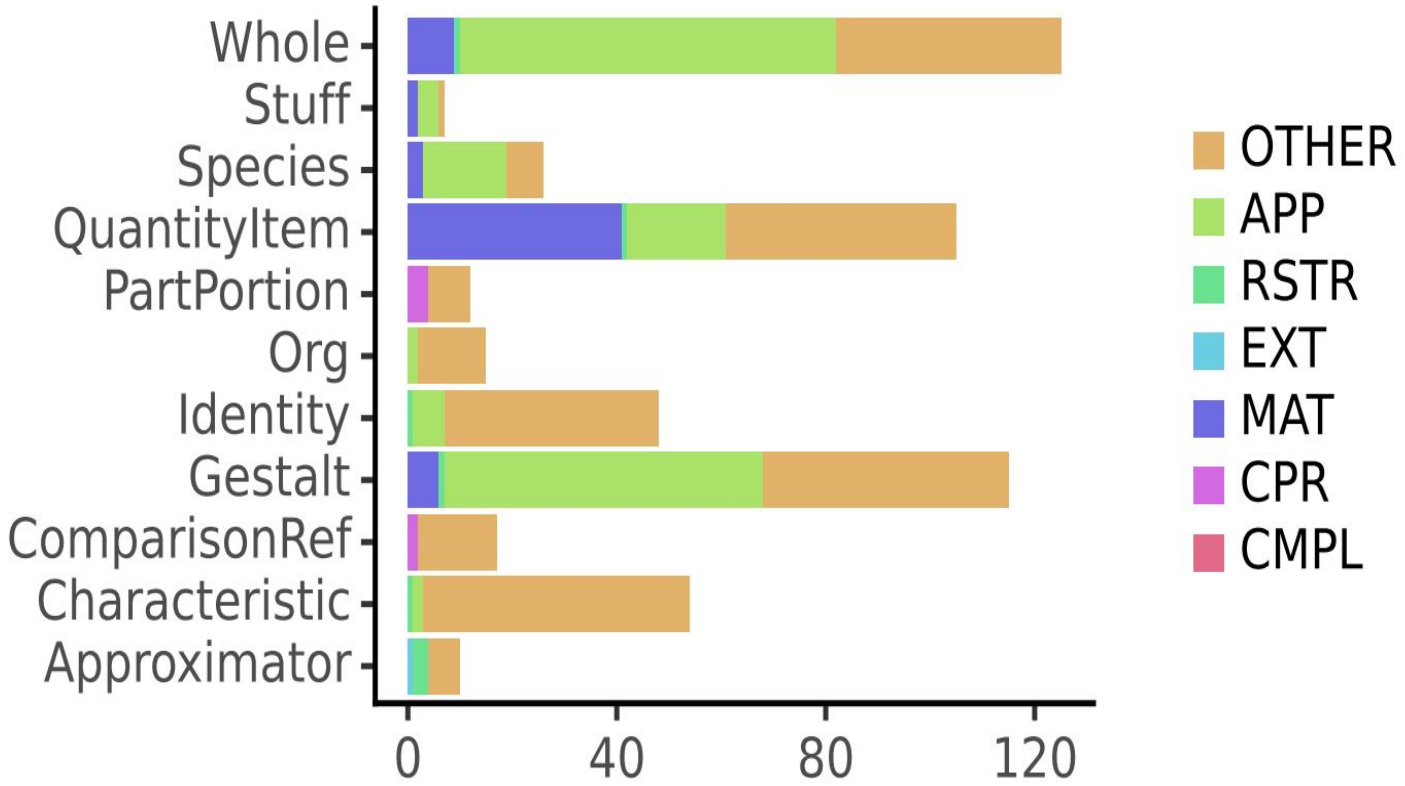
Empirical Comparison - SNACS Spatiotemporals

- Most supersenses are mapped from one functor the majority of the time
- **Duration** is predicted from **THL** and **TFHL** as expected
- **Source** maps from **DIR1** as predicted, but also **LOC**
- **Goal** aligns with **DIR3** but also **LOC**



Empirical Comparison - SNACS Configuration Branch

- Large “other” percentage
- Significant portion of predicted supersenses are aligning with unexpected functors
- Best matches: **APP** with **Whole** / **Gestalt**, **MAT** with **QuantityItem**



Empirical Comparison - Overview

- We see for most spatiotemporal categories there is an alignment between PEDT and predicted supersenses
  - Most reliable correspondences are between **TWHEN** and **Time**, **LOC** and **Locus**, and **TSIN** and **StartTime**, **TTILL** and **EndTime**
  - **DIR1** and **Source**, **DIR3** and **Goal** do align, but **LOC** seems to overlap with **Source** and **Goal**

- Configuration: less clear patterns, supersenses don't seem to line up with any one functor
  - **APP** has representation across multiple Supersenses

Qualitative Error Analysis

Why do the overlaps diverge from expectations?

1. Errors by the automatic SNACS tagger
   - WSJ is out-of-domain for SNACS classifier (which achieves ~80% F1 in-domain)

2. Errors relating to SNACS scene/function distinction
   - **LOC** vs **Locus ~> Goal**, **ACMP** vs **Agent ~> Ancillary**

3. Errors due to unexpected systematic divergent usages of categories in the two sets
   - **CPR** vs **ComparisonRef**, **DIR3** vs **Goal**, **DIR2** vs **Direction**

Scene Role vs. Coding Function

1. The new plant, located in Chinchon about 60 miles **from.DIR1.Locus~>Source** Seoul, will help meet increasing and diversifying demand for control products in South Korea, the company said.

2. Moscow has settled pre-1917 debts **with.ACMP.Agent~>Ancillary** other countries in recent years at less than face value.

Unexpected Divergences

1. A seat on the Chicago Board of Trade was sold for $350,000, down $16,000 **from.CPR.Locus~>Source** the previous sale last Friday.
   - ***CPR*** *and* ***ComparisonRef*** *used differently*

2. A disaffected, hard-drinking, nearly-30 hero sets off **for.DIR3.Direction** snow country in search of an elusive sheep…
   - ***DIR3*** *(“where to”) is closer to* ***Direction*** *than* ***DIR2*** *(“which way”)*
   - *SNACS groups* ***Direction*** *as subtype of* ***Path***

Conclusions

- Similar descriptions for some functors and supersenses lead to broad overlap
  - Predominantly for temporal / spatial relationships

- However, descriptively similar categories do not always demonstrate good alignment in practice

- In particular, more work is needed to investigate more complex mappings from PEDT functors onto **Configuration** supersenses

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- Circumstance
  - Temporal
    - Time
      - StartTime
      - EndTime
    - Frequency
    - Duration
    - Interval
  - Locus
    - Source
    - Goal
  - Path
    - Direction
    - Extent
  - Means
  - Manner
  - Explanation
    - Purpose

- Participant
  - Causer
  - Force
    - Agent
  - Theme
    - Topic
    - Content
  - Ancillary
  - Stimulus
  - Experiencer
  - Originator
  - Recipient
  - Cost
  - Beneficiary
  - Instrument

- Configuration
  - Identity
  - Species
  - Gestalt
    - Possessor
    - Whole
    - Org
    - QuantityItem
  - Characteristic
    - Possession
    - PartPortion
      - Stuff
    - OrgMember
    - QuantityValue
      - Approximator
  - Ensemble
  - ComparisonRef
  - SetIteration
  - SocialRel