

Content Differences in Syntactic and Semantic Representations

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Abstract

Syntactic analysis plays an important role in semantic parsing, but this role remains a topic of ongoing debate. The debate has been constrained by the scarcity of empirical comparative studies between syntactic and semantic schemes, which hinders the development of parsing methods informed by the details of target schemes and constructions. We target this gap, and take Universal Dependencies (UD) and UCCA as a test case. After abstracting away from differences of convention or formalism, we find that most content divergences can be ascribed to: (1) UCCA’s distinction between a Scene and a non-Scene; (2) UCCA’s distinction between primary relations, secondary ones and participants; (3) different treatment of multi-word expressions, and (4) different treatment of inter-clause linkage. We further discuss the long tail of cases where the two schemes take markedly different approaches. Finally, we show that the proposed comparison methodology can be used for fine-grained evaluation of UCCA parsing.

1 Introduction

Semantic representations hold promise due to their ability to transparently reflect distinctions relevant for text understanding applications. For example, syntactic representations are usually sensitive to distinctions based on POS (part of speech), such as between compounds and possessives. Semantic schemes are less likely to make this distinction since a possessive can often be paraphrased as a compound and vice versa (e.g., “US president”/“president of the US”), but may distinguish different senses of possessives (e.g., “some of the presidents” and “inauguration of the presidents”).

Nevertheless, little empirical study has been done on what distinguishes semantic schemes from syntactic ones, which are still in many cases the backbone of text understanding sys-

tems. Such studies are essential for (1) determining whether and to what extent semantic methods should be adopted for text understanding applications; (2) defining better inductive biases for semantic parsers, and allowing better use of information encoded in syntax; (3) pointing at semantic distinctions unlikely to be resolved by syntax.

The importance of such an empirical study is emphasized by the ongoing discussion as to what role syntax should play in semantic parsing, if any (Swayamdipta et al., 2018; Strubell et al., 2018; He et al., 2018; Cai et al., 2018). See §7.

This paper aims to address this gap, focusing on *content* differences. As a test case, we compare relatively similar schemes (§2): the syntactic Universal Dependencies (UD; Nivre et al., 2016), and the semantic Universal Conceptual Cognitive Annotation (UCCA; Abend and Rappoport, 2013).

We annotate 804 UD-annotated sentences with UCCA (§3), and develop a converter to assimilate UD and UCCA, as they use formally different graph structures (§4). We then align their nodes, and identify which UCCA categories match which UD relations, and which are unmatched.

Most content differences are due to (§5):

1. UCCA’s distinction between words and phrases that evoke Scenes (events) and ones that do not. For example, eventive and non-eventive nouns are treated differently in UCCA, but similarly in UD.
2. UCCA’s distinction between primary relations, secondary relations and Participants, in contrast to UD’s core/non-core distinction.
3. Different treatment of multi-word expressions (MWEs), where UCCA has a stronger tendency to explicitly mark them.
4. UCCA’s conflation of several syntactic realizations of inter-clause linkage, and disambiguation of other cases that UD treats similarly.

We show that the differences between the schemes are substantial, and suggest that UCCA parsing in particular and semantic parsing in general are likely to benefit downstream text understanding applications. For example, only 73% of arguments are shared between UCCA and UD, i.e., many semantic participants cannot be recovered from UD.¹ Our findings are relevant to other semantic representations, given their significant overlap in content (Abend and Rappoport, 2017).

A methodology for comparing syntactic and semantic treebanks can also support fine-grained error analysis of semantic parsers, as illustrated by Szubert et al. (2018) for AMR (Banarescu et al., 2013). To demonstrate the utility of our comparison methodology, we perform fine-grained error analysis on UCCA parsing, according to UD relations (§6). Results highlight challenges for current parsing technology, and expose cases where UCCA parsers may benefit from modeling syntactic structure more directly.

2 Representations

The conceptual and formal similarity between UD and UCCA can be traced back to their shared design principles: both are designed to be applicable across languages and domains, to enable rapid annotation and to support text understanding applications. This section provides a brief introduction to each of the schemes, whereas the next sections discuss their content in further detail.²

UCCA is a semantic annotation scheme rooted in typological and cognitive linguistic theory. It aims to represent the main semantic phenomena in text, abstracting away from syntactic forms. Shown to be preserved remarkably well across translations (Sulem et al., 2015), it has been applied to improve text simplification (Sulem et al., 2018b), and text-to-text generation evaluation (Birch et al., 2016; Choshen and Abend, 2018; Sulem et al., 2018a).

Formally, UCCA structures are directed acyclic graphs (DAGs) whose nodes (or *units*) correspond either to words, or to elements viewed as a single entity according to some semantic or cognitive consideration. Edges are labeled, indicating the role of a child in the relation the parent represents.

¹This excludes cases of shared argumenthood, which are partially covered by *enhanced UD*. See §4.1.

²See Supplementary Material for a definition of each category in both schemes, and their abbreviations.

A *Scene* is UCCA’s notion of an event or a frame, and is a description of a movement, an action or a state which persists in time. Every Scene contains one primary relation, which can be either a Process or a State. Scenes may contain any number of Participants, a category which also includes abstract participants and locations. They may also contain temporal relations (Time), and secondary relations (Adverbials), which cover semantic distinctions such as manner, modality and aspect.³

Scenes may be *linked* to one another in several ways. First, a Scene can provide information about some entity, in which case it is marked as an Elaborator. This often occurs in the case of participles or relative clauses. For example, “(child) who went to school” is an Elaborator Scene in “The child who went to school is John”. A Scene may also be a Participant in another Scene. For example, “John went to school” in the sentence: “He said John went to school”. In other cases, Scenes are annotated as Parallel Scenes (H), which are flat structures and may include a Linker (L), as in: “When_L [he arrives]_H, [he will call them]_H”.

Non-Scene units are headed by units of the category Center, denoting the type of entity or thing described by the whole unit. Elements in non-Scene units include Quantifiers (such as “dozens of people”) and Connectors (mostly coordinating conjunctions). Other modifiers to the Center are marked as Elaborators.

UCCA distinguishes *primary* edges, corresponding to explicit relations, from *remote* edges, which allow for a unit to participate in several super-ordinate relations. See example in Figure 1. Primary edges form a tree, whereas remote edges (dashed) enable reentrancy, forming a DAG.

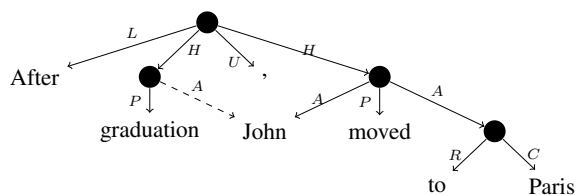


Figure 1: Example UCCA graph. Dashed: a remote edge.

UD is a syntactic dependency scheme used in many languages, aiming for cross-linguistically consistent and coarse-grained treebank annotation. Formally, UD uses bi-lexical trees, with edge labels representing syntactic relations.

³Despite the similar terminology, UCCA Adverbials are not necessarily adverbs syntactically.

One aspect of UD similar to UCCA is its preference of lexical (rather than functional) heads. For example, in auxiliary verb constructions (e.g., “is eating”), UD marks the lexical verb (*eating*) as the head, while other dependency schemes may select the auxiliary *is* instead. While the approaches are largely inter-translatable (Schwartz et al., 2012), lexical head schemes are more similar in form to semantic schemes, such as UCCA and semantic dependencies (Oepen et al., 2016).

An example UD tree is given in Figure 2. UD relations will be written in typewriter font.

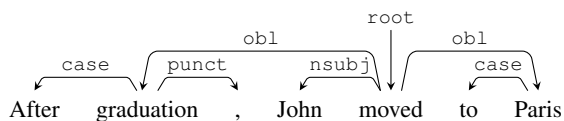


Figure 2: Example UD tree.

3 Shared gold-standard Corpus

We annotate 163 English passages, containing 804 sentences from the reviews section of the English Web Treebank (EWT; Bies et al., 2012). Text is annotated by two UCCA annotators according to v2.0 of the UCCA guidelines⁴ and cross-reviewed.⁵ As these sentences are included in the UD English_EWT treebank, this is a *shared* gold-standard UCCA and UD annotated corpus.

The data contains 11,103 tokens—4% of the full UD English_EWT treebank, and 20% of its reviews section. Of the UCCA-annotated sentences, 546 belong to the UD training set, 143 to the development set and 115 to the test set.

4 Comparison Methodology

To facilitate comparison between UCCA and UD, we first assimilate the graphs by abstracting away from formalism differences, obtaining a similar graph format for both schemes. We then match pairs of nodes in the converted UD and UCCA trees if they share all terminals in their yields.

UD annotates bi-lexical dependency trees, while UCCA graphs contain non-terminal nodes. In §4.1, we outline the unified DAG converter by Herscovich et al. (2018a,b),⁶ which we use to reach a common format. In §4.2, we describe a

number of extensions to the converter, which abstract away from further non-content differences.

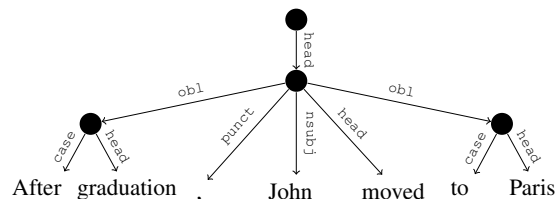


Figure 3: Converted UD tree. Intermediate non-terminals and *head* edges are introduced by the unified DAG converter.

4.1 Basic Conversion

Figure 3 presents the same tree from Figure 2 after conversion. The converter adds pre-terminals per token, and attaches them according to the original dependency tree: traversing it from the root, for each head it creates a non-terminal parent with the edge label *head*, and adds the dependents as children of the created non-terminal. Relation subtypes are stripped, leaving only universal relations. For example, the language-specific definite article label *det : def* is replaced by the universal *det*.

Reentrancies. Remote edges in UCCA enable reentrancy, forming a DAG together with primary edges. UD allows reentrancy when including *enhanced dependencies*⁷ (Schuster and Manning, 2016), which form (bi-lexical) graphs, representing phenomena such as predicate ellipsis (e.g., gapping), and shared arguments due to coordination, control, raising and relative clauses.

UCCA is more inclusive in its use of remote edges, and accounts for the entire class of implicit arguments termed *Constructional Null Instantiation* in FrameNet (Ruppenhofer et al., 2016). For example, in “The Pentagon is bypassing official US intelligence channels [...] in order to create strife” (from EWT), remote edges mark *Pentagon* as a shared argument of *bypassing* and *create*. Another example is “if you call for an appointment [...] so you can then make one”, where a remote edge in UCCA indicates that *one* refers to *appointment*. Neither is covered by enhanced UD.

In order to facilitate comparison, we remove remote edges and enhanced dependencies in the conversion process. We thus compare basic UD and UCCA trees, deferring a comparison of UCCA and enhanced UD to future work.

⁴github.com/UniversalConceptualCognitiveAnnotation/docs

⁵github.com/danielhers/UCCA_English-EWT

⁶github.com/huji-nlp/semstr

⁷universaldependencies.org/u/overview/enhanced-syntax.html

4.2 Extensions to the Converter

We extend the unified DAG converter to remove further non-content differences.

Unanalyzable units. An unanalyzable phrase is represented in UCCA as a single unit covering multiple terminals. In multi-word expressions (MWEs) in UD, each word after the first is attached to the previous word, with the *flat*, *fixed* or *goeswith* relations (depending on whether the expression is grammaticalized, or split by error). We remove edges of these relations and group the corresponding terminals to one unit.

Promotion of conjunctions. The basic conversion generally preserves terminal yields: the set of terminals spanned by a non-terminal is the same as the original dependency yield of its head terminal (e.g., in Figure 3, the yield of the non-terminal headed by *graduation* is “After graduation”, the same as that of “graduation” in Figure 2).

Since UD attaches subordinating and coordinating conjunctions to the following conjunct, this results in them being positioned in the same conjunct they relate (e.g., *After* will be included in the first conjunct in “After arriving home, John went to sleep”; *and* will be included in the second conjunct in “John and Mary”). In contrast, UCCA places conjunctions as siblings to their conjuncts (e.g., “[After] [arriving home], [John went to sleep]” and “[John] [and] [Mary]”).

To abstract away from these convention differences, we place coordinating and subordinating conjunctions (i.e., *cc*-labeled units, and *mark*-labeled units with an *advcl* head such as *when*, *if*, *after*) as siblings of their conjuncts.

5 Analysis of Divergences

Using the shared format, we turn to analyzing the content differences between UCCA and UD.

5.1 Confusion Matrix

Table 1 presents the confusion matrix of categories between the converted UD and UCCA, in the shared EWT corpus. In case of multiple UCCA units with the same terminal yield (i.e., units with a single non-remote child), we take the top category only, to avoid double-counting. Excluding punctuation, this results in 12,893 yields in UCCA and 13,294 in UD. Of these, 11,541 are common, meaning that a UCCA “parser” developed this way would get a very high F1 score of 88.1%, if given

	Participant (A)	Center (C)	Adverbial (D)	Elaborator (E)	Function (F)	Ground (G)	Parallel Scene (H)	Linker (L)	Connector (N)	Process (P)	Quantifier (Q)	Relator (R)	State (S)	Time (T)	NOMATCH
acl	8			101	2		15						1		49
advcl	2	2					103	1		4					97
advmod	61	9	399	51	12	33	3	61		2	10	6	5	117	71
amod	1	33	99	197	2		7			3	27		97	2	60
appos	1	10		8			5				1		4		10
aux			96		285										2
case	1	5	2	14	34			48	6	1	1	489	50		75
cc			1					305	71		1	1			11
ccomp	78						8						1		41
compound	23	24	8	176	2					1	1	1	3	3	164
conj	2	88	1				265			2			3		90
cop					333					3		1	24		3
csubj	2														8
dep												1			
det	2	1	19	763	1	1					19	2			26
discourse		1			1	6	13	3					1		1
expl					22										2
iobj	19														
list		2					8								2
mark		2	3		186	1		134	1			53	1	1	18
nmod	100	1	1	233			6						3	4	110
nsubj	993				14		2	9		3		24	1		37
nummod	4	7		6			3				50				24
obj	439	7	5	1	1	1	1		8	1	6			4	92
obl	247	1	21	7	2	4	4	4			3	2		69	132
orphan	1														1
parataxis	1			1	2	79			1				2		39
vocative	9					3									
xcomp	44	1	2	2			1			5					116
head	125	1,402	152	37	91	18	652	2	1	961	18	9	353	1	524
NOMATCH	329	172	34	56	6	5	466	29		141	27	7	98	11	

Table 1: UD-UCCA confusion matrix calculated from EWT gold-standard annotations (§3), after applying our extended converter to UD (§4), by matching UD vertices and UCCA units with the same terminal yield. The last column (row), labeled NOMATCH, shows the number of edges of each UD (UCCA) category that do not match any UCCA (UD) unit. Zero counts are omitted.

the gold UCCA label for every converted edge.

Only 73% of syntactic arguments (*ccomp*, *csubj*, *iobj*, *nsubj*, *obj*, *obl* and *xcomp*) are Participants, and only 73% of Participants are syntactic arguments—a difference stemming from the Scene/non-Scene (§5.2) and argument/adjunct (§5.3) distinctions. Moreover, if we identify predicates as words having at least one argument and Scenes as units with at least one Participant, then only 86% of UD predicates correspond to Scenes (many of which are secondary relations within one scene; see §5.3), and only 79% of Scenes correspond to predicates (e.g., due to eventive nouns).

Examining the *head* row in Table 1 allows us to contrast the schemes’ notions of a head. *head*-labeled units cover units that have at least one dependent in UD, or single-clause sentences (technically, they are non-terminals added by the converter). 77.5% correspond to Processes, States, Parallel Scenes or Centers, which are UCCA’s notions of semantic heads. 12.1% of the *head* units are left unmatched, mostly due to MWEs analyzed in UD but not in UCCA (§5.4). Another

source of unmatched units is inter-Scene linkage, which tends to be flatter in UCCA (§5.5). The rest (10.4%) are mostly due to head swap (e.g., “*all of Dallas*”, where *all* is a Quantifier of *Dallas* in UCCA, but the head in UD).

In the following subsections, we review the main content differences between the schemes, as reflected in the confusion matrix, and categorize them according to the UD relations involved.

5.2 Scenes vs. Non-Scenes

UCCA distinguishes between Scenes and non-Scenes. This distinction crosses UD categories, as a Scene can be evoked by a verb, an eventive or stative noun (*negotiation, fatigue*), an adjective or even a preposition (“this is *for* John”).

Core syntactic arguments. Subjects and objects are usually Participants (e.g., “*wine* was excellent”). However, when describing a Scene, the subject may be a Process/State (e.g., “but *service* is very poor”). Some *wh*-pronouns are the subjects or objects of a relative clause, but are Linkers or Relators, depending on whether they link Scenes or non-Scenes, respectively. For example, “who” in “overall, Joe is a happy camper *who* has found a great spot” is an *nsubj*, but a Linker. Other arguments are Adverbials or Time (see §5.3), and some do not match any UCCA unit, especially when they are parts of MWEs (see §5.4).

Adjectival modifiers are Adverbials when modifying Scenes (“*romantic* dinner”), States when describing non-Scenes (“*beautiful* hotel”) or when semantically predicative (“such a *convenient* location”), or Elaborators where defining inherent properties of non-Scenes (“*medical* school”).

Nominal and clausal modifiers. Most are Participants or Elaborators, depending on whether they modify a Scene (e.g., “discount *on services*” and “our decision *to buy when we did*” are Participants, but “*my car’s* gears and brakes” and “Some of the younger kids *that work there*” are Elaborators). Unmatched *acl* are often free relative clauses (e.g., in “the prices were worth what *I got*”, *what* is the *obj* of *worth* but a Participant of *I got*).

Case markers. While mostly Relators modifying non-Scenes (e.g., “the team *at* Bradley Chevron”), some case markers are Linkers linking Scenes together (e.g., “very informative website *with* a lot of good work”). Others are Elaborators (e.g., “*over* a year”) or States when used

as the main relation in verbless or copula clauses (e.g., “it is right *on* Wisconsin Ave”).

Coordination. Coordinating conjunctions (*cc*) are Connectors where they coordinate non-Scenes (e.g., “Mercedes *and* Dan”) or Linkers where they coordinate Scenes (e.g., “outdated *but* not bad”). Similarly, conjuncts and list elements (*conj, list*) may be Parallel Scenes (H), or Centers when they are non-Scenes.⁸

Determiners. Articles are Elaborators, and so are determiners that modify non-Scenes (e.g., “I will never recommend this gym to *any* woman”). However, where modifying Scenes (mostly negation) they are marked as Adverbials. For example, “*no* feathers in stock”, “*what* a mistake”, and “the rear window had *some* leakage” are all Adverbials.

5.3 Primary and Secondary Relations

UD distinguishes core arguments, adverb modifiers, and obliques, which in English UD mostly correspond to prepositional dependents of a verb. UCCA distinguishes Participants, including locations and abstract entities, from secondary relations (Adverbials), which cover manner, aspect and modality. Adverbials can be verbs (e.g., *begin, fail*), prepositional phrases (*with disrespect*), as well as modals, adjectives and adverbs.

Adverbs and obliques. Most UD adverb modifiers are Adverbials (e.g., “I *sometimes* go”), but they may be Participants, mostly in the case of semantic arguments describing location (e.g., *here*). Obliques may be Participants (e.g., “wait *for Nick*”), Time (e.g., “for *over 7 years*”) or Adverbials—mostly manner adjuncts (*by far*).

Clausal arguments are Participant Scenes (e.g., “it was great *that they did not charge a service fee*”, “did not really know *what I wanted*” or “I asked them *to change it*”). However, when serving as complements to a secondary verb, they will not match any unit in UCCA, as it places secondary verbs on the same level as their primary relation. For example, *to pay* is an *xcomp* in “they have to pay”, while the UCCA structure is flat: *have to* is an Adverbial and *pay* is a Process. Single-worded clausal arguments may correspond to a Process/State, as in “this seems *great*”.

⁸While in UD the conjunction *cc* is attached to the following conjunct, in UCCA coordination is a flat structure. This is a convention difference that we normalize (§4.2).

Auxiliary verbs are Functions (e.g., “do not forget”), or Adverbials when they are modals (e.g., “you *can* graduate”). Semi-modals in UD are treated as clausal heads, which take a clausal complement. For example, in “able to do well”, UD treats *able* as the head, which takes *do well* as an `xcomp`. UCCA, on the other hand, treats it as an Adverbial, creating a mismatch for `xcomp`.

5.4 Multi-Word Expressions

UD and UCCA treat MWEs differently. In UD they include names, compounds and grammaticalized fixed expressions. UCCA treats names and grammaticalized MWEs as unanalyzable units, but also a range of semantically opaque constructions (e.g., light verbs and idioms). On the other hand, compounds are not necessarily unanalyzable in UCCA, especially if compositional.

Compounds. English compounds are mostly nominal, and are a very heterogeneous category. Most compounds correspond to Elaborators (e.g., “*industry* standard”), or Elaborator Scenes (e.g., “*out-of-place* flat-screen TV”), and many are unanalyzable expressions (e.g., “*mark* up”). Where the head noun evokes a Scene, the dependent is often a Participant (e.g., “*food* craving”), but can also be an Adverbial (e.g., “*first time* buyers”) depending on its semantic category. Other compounds in UD are phrasal verbs (e.g., “*figure* out”, “*cleaned* up”), which UCCA treats as unanalyzable (leading to unmatched units).

Core arguments. A significant number of subjects and objects are left unmatched as they form parts of MWEs marked in UCCA as unanalyzable. UD annotates MWEs involving a verb and its argument(s) just like any other clause, and therefore lacks this semantic content. Examples include light verbs (e.g., “*give* a try”), idioms (“*bites* the dust”), and figures of speech (e.g., “*when it* comes to”, “*offer* a taste (of)”), all are UCCA units.

Complex prepositions. Some complex prepositions (e.g., *according to* or *on top of*), not encoded as MWEs in UD, are unanalyzable in UCCA.

5.5 Linkage

Head selection. UCCA tends to flatten linkage, where UD, as a dependency scheme, selects a head and dependent per relation. This yields scope ambiguities for coordination, an inherently flat structure. For instance, “unique gifts and cards” is am-

biguous in UD as to whether *unique* applies only to *gifts* or to the whole phrase—both annotated as in Figure 4a. UCCA, allowing non-terminal nodes, disambiguates this case (Figure 4b).

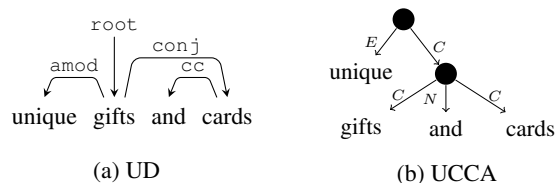


Figure 4: Example for coordination in UD and UCCA.

Clausal dependents. UD categorizes clause linkage into coordination, subordination, argumenthood (complementation), and parataxis. UCCA distinguishes argumenthood but conflates the others into the Parallel Scene category. For example, “We called few companies before *we* decided to hire them” and “Check out The Willow Lounge, *you’ll be happy*” are Parallel Scenes.

Note that while in UD, *mark* (e.g., *before*) is attached to the dependent adverbial clause, a UCCA Linker lies outside the linked Scenes. To reduce unmatched `advcl` instances, this convention difference is fixed by the converter (§4.2). Many remaining unmatched units are due to conjunctions we could not reliably raise. For instance, the marker *to* introducing an `xcomp` is ambiguous between Linker (purposive *to*) and Function (infinitive marker). Similarly, *wh*-pronouns may be Linkers (“he was willing to budge a little on the price *which* means a lot to me”), but have other uses in questions and free relative clauses. Other mismatches result from the long tail of differences in how UD and UCCA construe linkage. Consider the sentence in Figure 5. While *moment* is an oblique argument of *know* in UD, *From the moment* is analyzed as a Linker in UCCA.

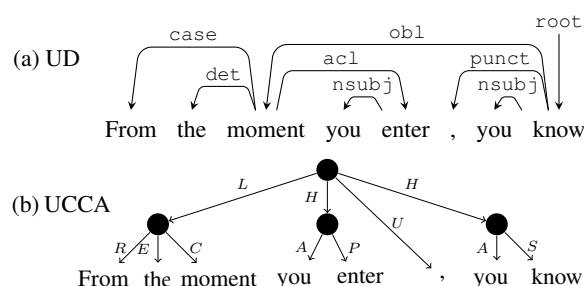


Figure 5: Example for clause linkage in UD and UCCA.

5.6 Other Differences

Appositions in UD always follow the modified noun, but named entities in them are UCCA Cen-

ters, regardless of position (e.g., in “its sister store Peking Garden”, the UD head *its sister store* is an Elaborator, while *Peking Garden* is the Center).

Copulas. UCCA distinguishes copular constructions expressing identity (e.g., “This *is* the original Ham’s restaurant”) where the copula is annotated as State, and cases of attribution (e.g., “Mercedes and Dan *are* very thorough”) or location (e.g., “Excellent chefs *are* in the kitchen”), where the copula is a Function.

Discourse markers and interjections. Units relating a Scene to the speech event or to the speaker’s opinion are Ground (e.g., “*no*, Warwick in New Jersey” and “*Please* visit my website”). On the other hand, discourse elements that relate one Scene to another are Linkers (e.g., *anyway*).

Vocatives are both Ground and Participants if they participate in the Scene *and* are the party addressed. For example, *Mark* in “Thanks *Mark*” is both the person addressed and the one thanked.⁹

Expletives and subjects. Expletives are generally Functions, but some instances of *it* and *that* are analyzed as *nsubj* in UD and as Function in UCCA (e.g., “*it*’s like driving a new car”).

Excluded relations. We exclude the following UD labels, as they are irrelevant to our evaluation: *root* (always matches the entire sentence); *punct* (punctuation is not annotated in UCCA); *dep* (unspecified dependency), *orphan* (used for gapping, which is represented using remote edges in UCCA—see §4.1); *fixed*, *flat* and *goeswith* (correspond to parts of unanalyzable units in UCCA, and so do not represent units on their own—see §4.2).

6 Fine-Grained UCCA Evaluation

In §5 we used our comparison methodology, consisting of the conversion to a shared format and matching units by terminal yield, to compare gold-standard UD and UCCA. In this section we apply the same methodology to parser outputs, using gold-standard UD for fine-grained evaluation.

6.1 Experimental Setup

Data. In addition to the UCCA EWT data (§3), we use the UCCA English Wikipedia corpus v1.2.3 (Wiki), and the UD v2.3 English_EWT

treebank (Nivre et al., 2018),¹⁰ filtering it to get only the 804 sentences that were also annotated in UCCA. We additionally use UDPipe v1.2 (Straka et al., 2016; Straka and Straková, 2017), trained on English_EWT,¹¹ to parse Wiki to UD. We apply the extended converter to UD as before (§4.2).

Parser. We train a UCCA parser, TUPA v1.3 (Hershcovich et al., 2017, 2018a), on Wiki, and evaluate it on EWT. We evaluate this out-of-domain scenario as we have both UCCA and UD gold-standard annotations for this test set. By default, TUPA is trained and tested using syntactic features predicted by spaCy.¹² As using UDPipe in training and gold UD in testing yielded very similar results, we only report the default setting.

Evaluation by gold-standard UD. UCCA evaluation is generally carried out by considering a predicted unit as correct if there is a gold unit that matches it in terminal yield and labels. Precision, Recall and F-score (F1) are computed accordingly. For the fine-grained analysis, we split the gold-standard, predicted and matched UCCA units according to the labels of the UD relations whose dependents have the same terminal yield (if any).

6.2 Results

Table 2 shows fine-grained evaluation by UD relations. TUPA does best on determiners, which are mostly one word Elaborators. For nominal subjects, TUPA correctly categorizes only 87% of the correctly delineated units, although 95% of gold subjects are Participants. This is possibly since their training set ratio is only 88%, suggesting domain adaptation techniques may be applicable.

Copulas, coordinating conjunctions and conjuncts undergo similar distribution shift. They are mostly Functions, Linkers and Parallel Scenes in EWT, respectively, while the distribution in Wiki is less peaked, with more of the units annotated as States, Connectors and Centers. This is a distinction between identity and attribution for copulas, and between Scenes/non-Scenes for coordination.

TUPA does relatively well on auxiliaries, numerical modifiers and markers, despite the heterogeneous test distribution (Table 1), possibly by making lexical distinctions (e.g., modals and auxiliary verbs are both UD auxiliaries, but are annotated as Adverbials and Functions, respectively).

⁹UCCA allows marking more than one category over an edge, although this functionality is not used often for English.

¹⁰hdl.handle.net/11234/1-2895

¹¹hdl.handle.net/11234/1-2898

¹²spacy.io

	det	nsubj	aux	case	nummod	cop	obj	advmod	mark	expl	obj	nmod	compound	cc	ccomp	obl	amod	adl	conj	adcl	xcomp	appos	vocative	parataxis	discourse	csbj	list
(a) Labeled F1 %	92	81	78	70	67	67	63	62	61	60	58	56	51	50	50	41	40	39	34	33	31	29	13	12	12	0	0
Unlabeled F1 %	96	94	97	92	81	98	81	91	96	88	73	82	79	93	59	65	90	53	75	49	56	63	50	55	96	29	67
Total in UD #	834	1083	383	727	94	364	19	840	400	24	566	458	406	400	128	496	528	176	451	209	178	39	12	125	26	10	12
Match Gold #	808	1046	381	652	70	361	19	769	382	22	474	346	239	388	87	364	467	127	361	112	62	29	12	86	25	2	10
(b) Match Predicted #	778	959	363	680	61	354	13	697	375	21	335	303	238	358	61	234	435	70	265	51	60	19	4	45	25	5	5
Labeled Correct #	728	815	291	465	44	239	10	454	230	13	233	181	122	187	37	122	180	38	106	27	19	7	1	8	3	0	0
Unlabeled Correct #	759	941	361	616	53	351	13	670	363	19	296	266	188	347	44	194	408	52	234	40	34	15	4	36	24	1	5
Labeled/Unlabeled %	96	87	81	75	83	68	77	68	63	68	79	68	65	54	84	63	44	73	45	68	56	47	25	22	13	0	0
(c) Majority Gold %	96	95	75	75	76	92	100	68	42	100	93	67	73	79	90	68	47	80	73	92	71	34	75	92	52	100	80
Majority Train %	98	88	91	90	80	49	90	59	46	87	80	62	82	55	68	61	83	78	58	86	71	53	100	83	31	86	100
(d) Average Words #	1.0	1.6	1.0	1.0	1.2	1.0	1.1	1.2	1.0	1.0	3.1	2.4	1.2	1.0	7.4	3.8	1.2	5.1	5.3	6.0	5.8	2.9	1.6	5.7	1.0	3.3	2.0

Table 2: Fine-grained evaluation of TUPA on EWT. (a) Columns are sorted by labeled F1, measuring performance on each subset of edges. Unlabeled F1 ignores edge categories, evaluating unit boundaries only. (b) Instances of each UD relation; of them, matching UCCA units in gold-standard and in TUPA’s predictions; their intersection, with/without regard to categories. (c) Percentage of correctly categorized edges; for comparison, percentage of most frequent category in gold (see Table 1) and in the Wiki training set (by UDPipe-predicted dependencies). (d) Average number of words in corresponding terminal yields.

The worst performance is on relatively rare relations, which do not contribute much to the overall parser score. However, inter-clause linkage, which TUPA also struggles with, is quite common. Although the match between UCCA and UD is not perfect in these cases, it is overall better than TUPA’s unlabeled performance. The same pattern recurs when using gold-standard syntax as features for TUPA. TUPA is a transition-based parser, which uses UD parses as features. Our results then suggest that encoding syntax more directly, perhaps using syntactic scaffolding (Swayamdipta et al., 2018) or guided attention (Strubell et al., 2018), may assist in predicting unit boundaries.

Finally, TUPA often fails to make distinctions that are not encoded in UD. For example, it does poorly on distinguishing between noun modifiers of Scene-evoking nouns (Participants) and modifiers of other nouns (Elaborators), obtaining roughly the same performance as a majority baseline based on the UD relation. Lexical resources that distinguish eventive and relational nouns from concrete nouns may alleviate this problem. In the similar case of compounds, lexical resources for light verbs and idioms may increase performance.

7 Related Work

The use of syntactic parsing as a proxy for semantic structure has a long tradition in NLP. Indeed, semantic parsers have leveraged syntax for output space pruning (Xue and Palmer, 2004), syntactic features (Gildea and Jurafsky, 2002; Ribeyre et al., 2015; Hartmann et al., 2017), joint modeling (Surdeanu et al., 2008; Hajič et al., 2009), and multi-task learning (Swayamdipta et al., 2016,

2018; Strubell et al., 2018). Some syntactic representation approaches, notably CCG (Steedman, 2000), directly reflect the underlying semantics, and have been used to transduce semantic forms using rule-based systems (Basile et al., 2012).

However, empirical study of the differences between syntactic and semantic schemes is still scarce. Zhang et al. (2017) evaluated PredPatt (White et al., 2016), a framework for extracting predicate-argument structures from UD, on a large set of converted PropBank annotations. Szubert et al. (2018) proposed a method for aligning AMR and UD subgraphs, finding that 97% of AMR edges are evoked by words or syntactic relations. Damonte et al. (2017) refined AMR evaluation by UD labels. Similarly, our conversion protocol allows fine-grained evaluation of UCCA parsing.

A related line of work tackles the transduction of syntactic structures into semantic ones. Reddy et al. (2016) proposed a rule-based method for converting UD to logical forms. Stanovsky et al. (2016) converted Stanford dependency trees into proposition structures (PROPS), abstracting away from some syntactic detail.

8 Conclusion

We evaluated the similarities and divergences in the content encoded by UD and UCCA. After annotating a portion of the English Web Treebank with UCCA, we used an automated methodology to evaluate how well the two schemes align, abstracting away from differences of mere convention. We provided a detailed picture of the content differences between the schemes. Notably, we quantified the differences between the notions

of syntactic and semantic heads and arguments, finding substantial divergence between them. Our findings highlight the potential utility of using semantic parsers for text understanding applications (over their syntactic counterparts), but also expose challenges semantic parsers must address, and potential sources for improvement.

References

- Omri Abend and Ari Rappoport. 2013. [Universal Conceptual Cognitive Annotation \(UCCA\)](#). In *Proc. of ACL*, pages 228–238.
- Omri Abend and Ari Rappoport. 2017. [The state of the art in semantic representation](#). In *Proc. of ACL*, pages 77–89.
- Laura Banarescu, Claire Bonial, Shu Cai, Madalina Georgescu, Kira Griffitt, Ulf Hermjakob, Kevin Knight, Martha Palmer, and Nathan Schneider. 2013. [Abstract Meaning Representation for semantic banking](#). In *Proc. of the Linguistic Annotation Workshop*.
- Valerio Basile, Johan Bos, Kilian Evang, and Noortje Venhuizen. 2012. Developing a large semantically annotated corpus. In *Proc. of LREC*, pages 3196–3200.
- Ann Bies, Justin Mott, Colin Warner, and Seth Kulick. 2012. English web treebank. *Linguistic Data Consortium, Philadelphia, PA*.
- Alexandra Birch, Omri Abend, Ondřej Bojar, and Barry Haddow. 2016. [HUME: Human UCCA-based evaluation of machine translation](#). In *Proc. of EMNLP*, pages 1264–1274.
- Jiaxun Cai, Shexia He, Zuchao Li, and Hai Zhao. 2018. [A full end-to-end semantic role labeler, syntactic-agnostic over syntactic-aware?](#) In *Proc. of COLING*, pages 2753–2765.
- Leshem Choshen and Omri Abend. 2018. [Reference-less measure of faithfulness for grammatical error correction](#). In *Proc. of NAACL-HLT*.
- Marco Damonte, Shay B. Cohen, and Giorgio Satta. 2017. [An incremental parser for Abstract Meaning Representation](#). In *Proc. of EACL*.
- Daniel Gildea and Daniel Jurafsky. 2002. [Automatic labeling of semantic roles](#). *Computational Linguistics*, 28(3).
- Jan Hajič, Massimiliano Ciaramita, Richard Johansson, Daisuke Kawahara, Maria Antònia Martí, Lluís Màrquez, Adam Meyers, Joakim Nivre, Sebastian Padó, Jan Štěpánek, Pavel Straňák, Mihai Surdeanu, Nianwen Xue, and Yi Zhang. 2009. [The CoNLL-2009 shared task: Syntactic and semantic dependencies in multiple languages](#). In *Proc. of CoNLL*, pages 1–18.
- Silvana Hartmann, Ilia Kuznetsov, Teresa Martin, and Iryna Gurevych. 2017. [Out-of-domain framenet semantic role labeling](#). In *Proc. of EACL*, pages 471–482.
- Shexia He, Zuchao Li, Hai Zhao, and Hongxiao Bai. 2018. [Syntax for semantic role labeling, to be, or not to be](#). In *Proc. of ACL*, pages 2061–2071.
- Daniel Hershcovich, Omri Abend, and Ari Rappoport. 2017. [A transition-based directed acyclic graph parser for UCCA](#). In *Proc. of ACL*, pages 1127–1138.
- Daniel Hershcovich, Omri Abend, and Ari Rappoport. 2018a. [Multitask parsing across semantic representations](#). In *Proc. of ACL*, pages 373–385.
- Daniel Hershcovich, Omri Abend, and Ari Rappoport. 2018b. Universal dependency parsing with a general transition-based DAG parser. In *Proc. of CoNLL*. To appear.
- Joakim Nivre, Mitchell Abrams, Željko Agić, Lars Ahrenberg, Lene Antonsen, Katya Aplonova, Maria Jesus Aranzabe, Gashaw Arutie, Masayuki Asahara, Luma Ateyah, Mohammed Attia, Aitziber Atutxa, Liesbeth Augustinus, Elena Badmaeva, Miguel Ballesteros, Esha Banerjee, Sebastian Bank, Verginica Barbu Mititelu, Victoria Basmov, John Bauer, Sandra Bellato, Kepa Bengoetxea, Yevgeni Berzak, Irshad Ahmad Bhat, Riyaz Ahmad Bhat, Erica Biagetti, Eckhard Bick, Rogier Blokland, Victoria Bobicev, Carl Börstell, Cristina Bosco, Gosse Bouma, Sam Bowman, Adriane Boyd, Aljoscha Burchardt, Marie Candito, Bernard Caron, Gauthier Caron, Gülşen Cebiroğlu Eryiğit, Flavio Massimiliano Cecchini, Giuseppe G. A. Celano, Slavomír Čéplö, Savas Cetin, Fabricio Chalub, Jinho Choi, Yongseok Cho, Jayeol Chun, Silvie Cinková, Aurélie Collomb, Çağrı Çöltekin, Miriam Connor, Marine Courtin, Elizabeth Davidson, Marie-Catherine de Marneffe, Valeria de Paiva, Arantza Diaz de Ilaraza, Carly Dickerson, Peter Dirix, Kaja Dobrovoljc, Timothy Dozat, Kira Droganova, Puneet Dwivedi, Marhaba Eli, Ali Elkahky, Binyam Ephrem, Tomaz Erjavec, Aline Etienne, Richárd Farkas, Hector Fernandez Alcalde, Jennifer Foster, Cláudia Freitas, Katarína Gajdošová, Daniel Galbraith, Marcos Garcia, Moa Gärdenfors, Sebastian Garza, Kim Gerdes, Filip Ginter, Iakes Goenaga, Koldo Gojenola, Memduh Gökırmak, Yoav Goldberg, Xavier Gómez Guinovart, Berta Gonzáles Saavedra, Matias Grioni, Normunds Grūzītis, Bruno Guillaume, Céline Guillot-Barbance, Nizar Habash, Jan Hajič, Jan Hajič jr., Linh Hà Mỹ, Na-Rae Han, Kim Harris, Dag Haug, Barbora Hladká, Jaroslava Hlaváčová, Florinel Hociung, Petter Hohle, Jena Hwang, Radu Ion, Elena Irimia, Olájidé Ishola, Tomáš Jelínek, Anders Johannsen, Fredrik Jørgensen, Hüner Kaşıkara, Sylvain Kahane, Hiroshi Kanayama, Jenna Kanerva, Boris Katz, Tolga Kayadelen, Jessica Kenney, Václava Kettnerová, Jesse Kirchner, Kamil Kopacewicz, Natalia Kotsyba, Simon Krek, Sookyoung Kwak, Veronika

- Laippala, Lorenzo Lambertino, Lucia Lam, Tatiana Lando, Septina Dian Larasati, Alexei Lavrentiev, John Lee, Phng Lê Hồng, Alessandro Lenci, Saran Lertpradit, Herman Leung, Cheuk Ying Li, Josie Li, Keying Li, KyungTae Lim, Nikola Ljubešić, Olga Loginova, Olga Lyashevskaya, Teresa Lynn, Vivien Macketanz, Aibek Makazhanov, Michael Mandl, Christopher Manning, Ruli Manurung, Cătălina Măranduc, David Mareček, Katrin Marheinecke, Héctor Martínez Alonso, André Martins, Jan Mašek, Yuji Matsumoto, Ryan McDonald, Gustavo Mendonça, Niko Miekka, Margarita Misirpashayeva, Anna Missilä, Cătălin Mititelu, Yusuke Miyao, Simonetta Montemagni, Amir More, Laura Moreno Romero, Keiko Sophie Mori, Shinsuke Mori, Bjartur Mortensen, Bohdan Moskalevskyi, Kadri Muischnek, Yugo Murawaki, Kaili Müürisep, Pinkey Nainwani, Juan Ignacio Navarro Horňáček, Anna Nedoluzhko, Gunta Nešpore-Bērzkalne, Lng Nguyễn Thị, Huyền Nguyễn Thị Minh, Vitaly Nikolaev, Rattima Nitisaroj, Hanna Nurmi, Stina Ojala, Adédayo Olúðokun, Mai Omura, Petya Osenova, Robert Östling, Lilja Øvrelid, Niko Partanen, Elena Pascual, Marco Passarotti, Agnieszka Patejuk, Guilherme Paulino-Passos, Siyao Peng, Cenel-Augusto Perez, Guy Perrier, Slav Petrov, Jussi Piitulainen, Emily Pitler, Barbara Plank, Thierry Poibeau, Martin Popel, Lauma Pretkalniņa, Sophie Prévost, Prokopis Prokopidis, Adam Przepiórkowski, Tiina Puolakainen, Sampo Pyysalo, Andriela Rääbis, Alexandre Rademaker, Loganathan Ramasamy, Taraka Rama, Carlos Ramisch, Vinit Ravishankar, Livy Real, Siva Reddy, Georg Rehm, Michael Rießler, Larissa Rinaldi, Laura Rituma, Luisa Rocha, Mykhailo Romanenko, Rudolf Rosa, Davide Rovati, Valentin Roca, Olga Rudina, Jack Rueter, Shoval Sadde, Benoît Sagot, Shadi Saleh, Tanja Samardžić, Stephanie Samson, Manuela Sanguinetti, Baiba Saulīte, Yanin Sawanakunanon, Nathan Schneider, Sebastian Schuster, Djamé Seddah, Wolfgang Seeker, Mojgan Seraji, Mo Shen, Atsuko Shimada, Muh Shohibussirri, Dmitry Sichinava, Natalia Silveira, Maria Simi, Radu Simionescu, Katalin Simkó, Mária Šimková, Kiril Simov, Aaron Smith, Isabela Soares-Bastos, Carolyn Spadine, Antonio Stella, Milan Straka, Jana Strnadová, Alane Suhr, Umüt Sulubacak, Zsolt Szántó, Dima Taji, Yuta Takahashi, Takaaki Tanaka, Isabelle Tellier, Trond Trosterud, Anna Trukhina, Reut Tsarfaty, Francis Tyers, Sumire Uematsu, Zdeňka Urešová, Larraitz Uriá, Hans Uszkoreit, Sowmya Vajjala, Daniel van Niekerk, Gertjan van Noord, Viktor Varga, Eric Villemonte de la Clergerie, Veronika Vincze, Lars Wallin, Jing Xian Wang, Jonathan North Washington, Seyi Williams, Mats Wirén, Tsegay Wolde-mariam, Tak-sum Wong, Chunxiao Yan, Marat M. Yavrumyan, Zhuoran Yu, Zdeněk Žabokrtský, Amir Zeldes, Daniel Zeman, Manying Zhang, and Hanzhi Zhu. 2018. [Universal dependencies 2.3](#). LINDAT/CLARIN digital library at the Institute of Formal and Applied Linguistics (ÚFAL), Faculty of Mathematics and Physics, Charles University.
- Joakim Nivre, Marie-Catherine de Marneffe, Filip Ginter, Yoav Goldberg, Jan Hajic, Christopher D. Manning, Ryan McDonald, Slav Petrov, Sampo Pyysalo, Natalia Silveira, Reut Tsarfaty, and Daniel Zeman. 2016. [Universal dependencies v1: A multilingual treebank collection](#). In *Proc. of LREC*.
- Stephan Oepen, Marco Kuhlmann, Yusuke Miyao, Daniel Zeman, Silvie Cinkova, Dan Flickinger, Jan Hajic, Angelina Ivanova, and Zdenka Uresova. 2016. [Towards comparability of linguistic graph banks for semantic parsing](#). In *Proc. of LREC*.
- Siva Reddy, Oscar Täckström, Michael Collins, Tom Kwiakowski, Dipanjan Das, Mark Steedman, and Mirella Lapata. 2016. [Transforming dependency structures to logical forms for semantic parsing](#). *TACL*, 4:127–141.
- Corentin Ribeyre, Eric Villemonte de la Clergerie, and Djamé Seddah. 2015. [Because syntax does matter: Improving predicate-argument structures parsing with syntactic features](#). In *Proc. of NAACL-HLT*, pages 64–74.
- Josef Ruppenhofer, Michael Ellsworth, Miriam R. L. Petruck, Christopher R. Johnson, Collin F. Baker, and Jan Scheffczyk. 2016. [FrameNet II: Extended Theory and Practice](#).
- Sebastian Schuster and Christopher D. Manning. 2016. [Enhanced English Universal Dependencies: An improved representation for natural language understanding tasks](#). In *Proc. of LREC*. ELRA.
- Roy Schwartz, Omri Abend, and Ari Rappoport. 2012. [Learnability-based syntactic annotation design](#). In *Proc. of COLING*, pages 2405–2422.
- Gabriel Stanovsky, Jessica Fidler, Ido Dagan, and Yoav Goldberg. 2016. Getting more out of syntax with PropS. *arXiv preprint arXiv:1603.01648*.
- Mark Steedman. 2000. *The Syntactic Process*. MIT Press, Cambridge, MA.
- Milan Straka, Jan Hajič, and Jana Straková. 2016. UD-Pipe: trainable pipeline for processing CoNLL-U files performing tokenization, morphological analysis, POS tagging and parsing. In *Proceedings of the 10th International Conference on Language Resources and Evaluation (LREC 2016)*, Portoro, Slovenia. European Language Resources Association.
- Milan Straka and Jana Straková. 2017. [Tokenizing, POS tagging, lemmatizing and parsing UD 2.0 with UDPipe](#). In *Proceedings of the CoNLL 2017 Shared Task: Multilingual Parsing from Raw Text to Universal Dependencies*, pages 88–99, Vancouver, Canada. Association for Computational Linguistics.
- Emma Strubell, Patrick Verga, Daniel Andor, David Weiss, and Andrew McCallum. 2018. [Linguistically-informed self-attention for semantic role labeling](#). In *Proc. of EMNLP*, pages 5027–5038.

- Elior Sulem, Omri Abend, and Ari Rappoport. 2015. [Conceptual annotations preserve structure across translations: A French-English case study](#). In *Proc. of S2MT*, pages 11–22.
- Elior Sulem, Omri Abend, and Ari Rappoport. 2018a. Semantic structural annotation for text simplification. In *Proc. of NAACL*.
- Elior Sulem, Omri Abend, and Ari Rappoport. 2018b. Simple and effective text simplification using semantic and neural methods. In *Proc. of ACL*.
- Mihai Surdeanu, Richard Johansson, Adam Meyers, Lluís Màrquez, and Joakim Nivre. 2008. [The CoNLL 2008 shared task on joint parsing of syntactic and semantic dependencies](#). In *Proc. of CoNLL*, pages 159–177.
- Swabha Swayamdipta, Miguel Ballesteros, Chris Dyer, and Noah A. Smith. 2016. [Greedy, joint syntactic-semantic parsing with stack LSTMs](#). In *Proc. of CoNLL*, pages 187–197.
- Swabha Swayamdipta, Sam Thomson, Kenton Lee, Luke Zettlemoyer, Chris Dyer, and Noah A. Smith. 2018. [Syntactic scaffolds for semantic structures](#). In *Proc. of EMNLP*, pages 3772–3782.
- Ida Szubert, Adam Lopez, and Nathan Schneider. 2018. [A structured syntax-semantics interface for English-AMR alignment](#). In *Proc. of NAACL-HLT*. To appear.
- Aaron Steven White, Drew Reisinger, Keisuke Sakaguchi, Tim Vieira, Sheng Zhang, Rachel Rudinger, Kyle Rawlins, and Benjamin Van Durme. 2016. Universal decompositional semantics on universal dependencies. In *Proc. of EMNLP*, pages 1713–1723.
- Nianwen Xue and Martha Palmer. 2004. Calibrating features for semantic role labeling. In *Proceedings of the 2004 Conference on Empirical Methods in Natural Language Processing*.
- Sheng Zhang, Rachel Rudinger, and Benjamin Van Durme. 2017. [An evaluation of PredPatt and open IE via stage 1 semantic role labeling](#). In *IWCS*.