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, highlighting both challenges and potential sources for improvement. The substantial differences between the schemes suggest that semantic parsers are likely to benefit downstream text understanding applications beyond their syntactic counterparts.

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 systems. 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 §8.

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).

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

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

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. 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.

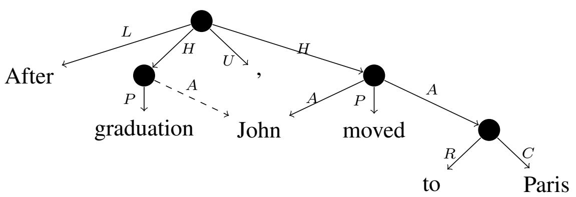

Figure 1: Example UCCA graph. Dashed: a remote edge.

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

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. Being a dependency representation, UD is thus underspecified: it is not possible in UD to mark the distinction between an element modifying the head of the phrase and the same element modifying the whole phrase (de Marneffe and Nivre, 2019).

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.

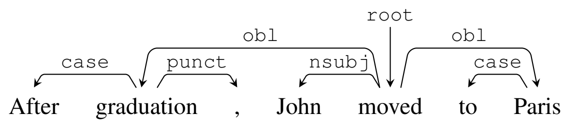

Figure 2: Example UD tree.

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 guidelines[4] 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 Hershcovich 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.

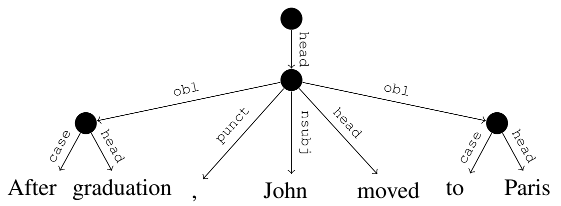

Figure 3: Converted UD tree. Intermediate non-terminals and *head* edges are introduced by the unified DAG converter.

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

[4] `github.com/UniversalConceptualCognitiveAnnotation/docs`
[5] `github.com/danielhers/UCCA_English-EWT`
[6] `github.com/huji-nlp/semstr`
[7] `universaldependencies.org/u/overview/enhanced-syntax.html`

[...] 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.

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 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*

	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			7		116
head	125	1402	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.

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*".

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

[8] While 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).

and dependent per relation. This yields scope ambiguities for coordination, an inherently flat structure. For instance, "unique gifts and cards" is ambiguous 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).

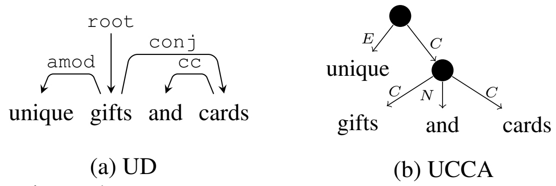

Figure 4: Example for coordination in UD and UCCA.

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.

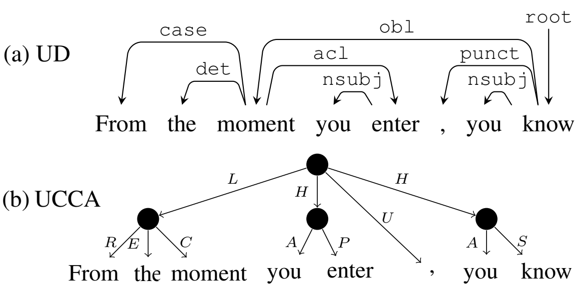

Figure 5: Example for clause linkage in UD and UCCA.

5.6 Other Differences

Appositions in UD always follow the modified noun, but named entities in them are UCCA Centers, 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.

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

		`det`	`nsubj`	`aux`	`case`	`nummod`	`cop`	`iobj`	`advmod`	`mark`	`expl`	`obj`	`nmod`	`compound`	`cc`	`ccomp`	`obl`	`amod`	`acl`	`conj`	`advcl`	`xcomp`	`appos`	`vocative`	`parataxis`	`discourse`	`csubj`	`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
(b)	**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
	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
(c)	**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
	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.

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).

[10] `hdl.handle.net/11234/1-2895`
[11] `hdl.handle.net/11234/1-2898`
[12] `spacy.io`

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).

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 Discussion

NLP tasks, such as paraphrasing, text simplification, machine translation, and question answering, often require semantic distinctions that are difficult to extract from syntactic representations.

As a case in point, consider the example sentence "after graduation, John moved to Paris" again. While the word *graduation* evokes a Scene, as annotated in UCCA (Figure 1), in UD it is an oblique modifier of *moved*, just like *Paris* is (Figure 2). The Scene/non-Scene distinction (§5.2) would benefit structural text simplification systems, which should preferably paraphrase the sentence to "John graduated. (Then,) John moved to Paris", such that each Scene would occupy a single sentence (Sulem et al., 2018a).

Another example is machine translation—translating the same sentence into Hebrew, which does not have a word for *graduation*, would require a clause to convey the same meaning. The mapping would therefore be more direct using a semantic representation, and we would benefit from breaking the utterance into two Scenes.

8 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.

9 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.

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