Anchoring a Lexicalized Tree-Adjoining Grammar for Discourse

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Abstract

We here explore a "fully" lexicalized Tree-Adjoining Grammar for discourse that takes the basic elements of a (monologic) discourse to be not simply clauses, but larger *structures* that are *anchored* on variously realized discourse cues. This link with intra-sentential grammar suggests an account for different patterns of discourse cues, while the different structures and operations suggest three separate sources for elements of discourse meaning: (1) a compositional semantics tied to the basic trees and operations; (2) a presuppositional semantics carried by cue phrases that freely adjoin to trees; and (3) general inference, that draws additional, defeasible conclusions that flesh out what is conveyed compositionally.

1 Introduction

In the past few years, researchers interested in accounting for how elements combine in a discourse, have taken to using the adjoining operation found in Tree-Adjoining Grammar (TAG) (Gardent, 1994; Gardent, 1997; Polanyi and van den Berg, 1996; Schilder, 1997; van den Berg, 1996; Webber, 1991). More recently, Cristea and Webber (1997) have argued that a Tree-Adjoining Grammar for discourse would also need the *substitution* operation found in a lexicalized TAG (Schabes, 1990). Here we move further and explore a *fully* lexicalized TAG for discourse, allowing us to examine how the insights of lexicalized grammars – that the basic elements of a clause are not simply words, but *structures* that reflect a word's role and syntactic/semantic scope – carry over to discourse. We show how this suggests explanations for such phenomena as the following:

- that arguments of a coherence relation can be stretched "long distance" by intervening material;
- that multiple discourse cues can appear in a single sentence or even a single clause;
- that when discourse cues appear in the middle of clauses, they contribute to coherence in more specific ways;

- that coherence relations can vary in how and when they are realized lexically.

One way of understanding the current work is that it extrapolates from lexically-based views of how structure and meaning are associated within a sentence to how aspects of discourse structure and meaning might be associated in similar ways. While the idea that discourse-level mechanisms might resemble intra-sentential mechanisms has long been an undercurrent within discourse research, we have come to believe that the framework of lexicalized grammar can be effectively used to demonstrate the validity of this intuition. While we present the ideas in terms of one well-known formalism – Lexicalized TAG – other lexicalized formalisms such as CCG (Steedman, 1996b) might prove equally useful for expressing the same theoretical insights and implementing them for discourse generation and/or interpretation.

A superficial reading of the current proposal might suggest that it is merely a simple embedding of RST (Mann and Thompson, 1988) in TAG. That would be incorrect. First, the primary feature of a fully lexicalized TAG is that each elementary tree in the grammar has an *anchor* that indexes the tree and defines its syntactic/semantic scope. Here, we posit a set of *initial* (non-recursive) trees, whose anchor is a discourse cue. Structurally, some initial trees resemble the nucleus-satellite structures of RST, and some, its joint schema. But the resemblence is only superficial, as initial trees have a purely compositional semantics that makes no assumptions about what the speaker is trying to do.[1]

Secondly, there is a single *auxiliary* tree whose semantics corresponds simply to continuing the description conveyed by the structure to which it is adjoined. Any additional inferences that a listener draws from the resulting adjacency are defeasible,

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[1] The LTAG formalism itself allows an elementary tree to be associated with a meaning that is not compositional with respect to its sub-parts. This is used, for example, for associating meaning with syntactically-flexible idioms. However, we have not found the need to exploit this possibility for discourse, though we leave open the possibility.

and may be cancelled or corrected by material in the subsequent discourse. Our proposal thus factors the combinability of elementary discourse clauses from inferences that may then be drawn, thus providing a tool for sorting out different semantic processes in discourse, instead of lumping them into a single category. Many of these inferences have been given the status of *discourse relations* in RST. However, we argue in Section 2.3 that one can gain from distinguishing what is derived compositionally from what is derived inferentially.

Thirdly, there are auxiliary trees for other discourse cues, that can adjoin to either initial trees or auxiliary trees. These discourse cues contribute meaning (and coherence) through their presuppositions or assertions or both. They can thereby serve to constrain the range of inferences that a listener might draw when a description is extended, limiting them to ones compatible with the contribution of the discourse cue. Similarly, a discourse cue adjoined to an initial tree can either further specify the compositional meaning of the related units or constrain how that initial tree can be used in extending another description. This will explain how several discourse cues can appear in the same sentence or even the same clause, each contributing to either the compositional or presuppositional semantics of the discourse (Section 2.2).

This is still a "work in progress", with many open questions. However, it may still pique the interest of two historically distinct groups: it may stimulate people working on syntax to look beyond the clause for phenomena familiar to them within it, while it may help people working on discourse to ground their claims and insights in more traditional varieties of linguistic formalisms.

2 Elements of a Lexicalized TAG for Discourse

A lexicalized TAG begins with the notion of a lexical *anchor*, which can have one or more associated tree structures. For example, the verb *likes* anchors one tree corresponding to *John likes apples*, another corresponding to the topicalized construction *Apples John likes*, and a third corresponding to the passive construction *Apples are liked by John*. All in all, there is a tree for each minimal syntactic construction in which *likes* can appear, all sharing the same predicate-argument structure. This syntactic/semantic encapsulation is possible because of the extended domain of locality of LTAG. Trees in such a *tree family* may differ in being licensed by different states of the discourse (i.e., *information structure* (Steedman, 1996a)).

A lexicalized TAG contains two kinds of elementary trees: *initial* (non-recursive) trees that reflect basic functor-argument dependencies and *auxiliary*

trees that introduce recursion and allow elementary trees to be modified and/or elaborated. In our lexicalized discourse TAG, we have so far found the need to posit only two types of initial tree families (Section 2.1) and two types of auxiliary trees (Section 2.2). While the resulting grammar is thus very simple – only one type, only binary predicates – it so far appears expressively adequate.

2.1 Initial Trees

Subordinate conjunctions are one major class of discourse cues, and clause-level LTAG already provides an account of subordinate clauses with overt subordinate conjunctions. Its "verb-centric" account in (XTAG-Group, 1995) appropriately treats subordinate clauses as *adjuncts* – i.e., auxiliary trees. However, from a discourse perspective, we treat two clauses connected by a subordinate conjunction as an *initial tree* whose compositional semantics reflect the subordinate conjunction as predicate (or "functor") and the clauses as arguments. There is an initial tree for each minimal structural pattern of main clause and subordinate clause, including those shown in Figure 1. All such trees share the same predicate (functor) argument structure. As in clause-level tree families, each pattern may have different preconditions on its use that reflect the current state of the discourse (i.e., *information structure*). For example, it has been noted that a "when" clause in initial position presupposes that the situation described therein is in the hearer's *discourse model* (or can be so accommodated), while a "when" clause coming after the main clause is not so constrained.

In Section 3, we discuss reasons for taking the lexical anchors of these initial trees to be feature structures that may correspond to one or more subordinate conjunctions such as "if" and "when". Here we just take them to be specific lexical items.

Now one reason for taking something to be an initial tree is that it has local dependencies that can be stretched long-distance. For example, the dependency between *apples* and *likes* in both *John likes apples* and *apples John likes* is localized in all the trees for *likes*. It can be stretched, however, long-distance as in *Apples, Bill thinks John may like*. In (Cristea and Webber, 1997), we have shown that the same long-distance stretching of dependencies occurs with both subordinate clauses (Ex. 1) and parallel constructions (Ex. 2) – e.g.

1. a. Although John is very generous,
   b. giving money to whoever asks,
   c. when you actually need it,
   d. you'll see that he's a bugger to find.

2. a. On the one hand, John is very generous.
   b. For example, suppose you needed some money.

S
S↓
[ ]
subconj (a)
S
S↓
[ ]
subconj (b)
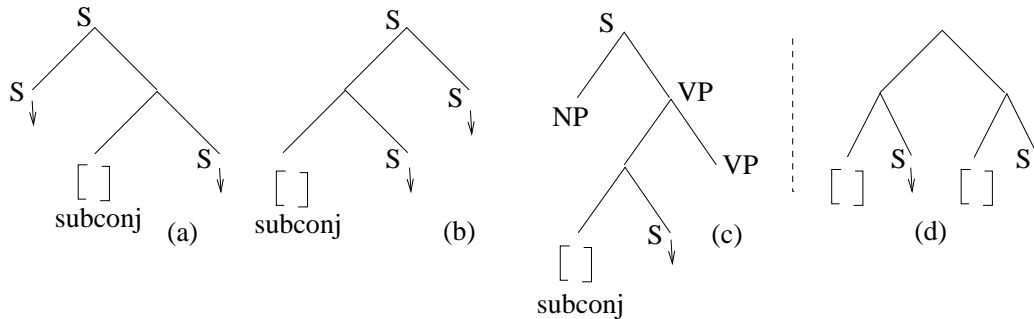S
NP VP
VP
[ ]
subconj
S↓ (c)
[ ] S↓ [ ] S↓ (d)

Figure 1: Initial Trees (a-c) belong to the tree family for a subordinate conjunction. The symbol ↓ indicates a substitution site, while [ ] stands for a particular subordinate conjunction and its feature structure. (d) is the initial tree for a parallel construction.

c. You would just have to ask for it.
d. On the other hand, he's a bugger to find.

Thus here we also posit an initial tree for parallel structures (Figure 1d). Since there are different ways in which entities are taken to be parallel, we currently assume a different initial tree for *contrast* ("on the one hand" ... "on the other hand" ...), *disjunction* ("either" ... "or" ...), *addition* ("not only" ... "but also" ...), and *concession* ("admittedly" ... "but" ...). Such trees have a *pair* of anchors with two main properties.

The first is that their lexical realization seems optional. In contrastive cases, a medial anchor such as "on the other hand" often appears lexicalized without an initial phrase such as "on the one hand". In fact, there are more cases of this in the Brown Corpus than of the two appearing together. Also optional is the realization of the initial anchor in disjunction (omitting "either"), addition (omitting "not only"), and concession (omitting "admittedly"). But we have recently noted cases where only the initial anchor is realized lexically but not the medial anchor, although this is less common:

> Not only have they [Rauschenberg's blueprints] survived. The process of their creation was recorded by *Life* magazine in April 1951. (*New York Review of Books*, 6 November 1997, p.8)

The second property is that the medial anchor appears realizable in multiple ways. Cristea and Webber (1997) report that, of the eleven instances of "on the one hand" found in the Brown Corpus, four have their contrasting item cued by something other than "on the other (hand)" – including "but" and "at the same time":

3. On the one hand, the Public Health Service declared as recently as October 26 that present radiation levels resulting from the Soviet shots "do not warrant undue public concern" or any action to limit the intake of radioactive substances by individuals or large population groups anywhere in the Aj. **But** the PHS conceded ....(*cb21*)

4. Brooklyn College students have an ambivalent attitude toward their school. On the one hand, there is a sense of not having moved beyond the ambiance of their high school. This is particularly acute for those who attended Midwood High School directly across the street from Brooklyn College. They have a sense of marginality at being denied that special badge of status, the out-of-town school. **At the same time**, there is a good deal of self-congratulation at attending a good college ...(*cf25*)

Other examples occur with "on the other extreme" and "at the other extreme" – cf.

5. On the one hand we have the "All you have to do is buy it" brigade who seem to think the only problem is that we haven't gone and "done it". **On the other extreme** there are groups who think if it has been explored theoretically then it's been done.

In Section 3, we will argue that both these properties can be accommodated by treating the lexical anchors of these initial trees as feature structures.

2.2 Auxiliary Trees

Discourse cues other than subordinate conjunctions are either adverbs (adverbial phrases) or conjunctions. In XTAG (1995), adverbials are handled as simple auxiliary trees (Figure 2a-b). We do the same here, associating each cue with a feature structure that indicates its semantic properties for reasons to be discussed in Section 3. Semantically, such auxiliary trees can be used to elaborate or clarify the discourse relation holding between two discourse units. This may result in the phenomenon of there being more than one discourse cue in a sentence, as in

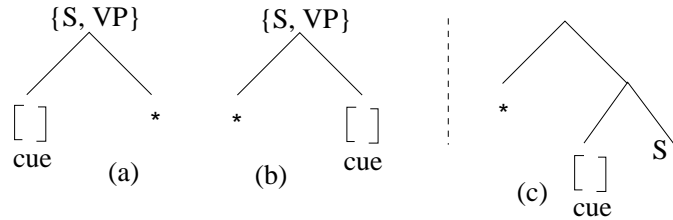6. Stephen Brook, in *Class: Knowing your place in modern Britain*, begins promisingly with

Figure 2: **Auxiliary Trees**. (a) and (b) are auxiliary trees in the tree family for adverbial discourse cues, which serve to modify or constrain the relation holding between discourse units. Trees in the family may be rooted on S or VP. The symbol $*$ indicates the *foot node* of the auxiliary tree. (c) is the auxiliary tree for basic elaboration.

the proposition that "class distinction and class consciousness – they are both with us"....Brook **then**, **however**, runs into trouble because he feels obliged to provide a theory ....

7. **Although** the episodic construction of the book often makes it difficult to follow, it **nevertheless** makes devastating reading.

We will discuss the semantics of such examples shortly, and also the conjunctions "so" and "but".

As noted in Section 1, an auxiliary tree (here shown in Figure 2c) is used to adjoin to a structure and continue the description of the entity (object, event, situation, state, etc.) that it conveys. Such a tree would be used in the derivation of a simple discourse such as:

8. John went to the zoo. He took his cell phone with him.

Here, the foot node of the auxiliary tree in Figure 2c would be adjoined to the root of the tree for the first clause, and its substitution site filled by the tree for the second. The tree's anchor may have no lexical realization (as here, between main clauses), or it may be realized by "and" (as in embedded clauses – e.g. "Fred believes that John went to the zoo and that he took his cell phone with him"). The compositional meaning associated with adjoining this tree is simply that the meaning of the second clause continues the description of the same entity as the first. Other aspects of meaning – such as there being a causal connection or temporal relation between its sub-parts, or an evidential relation between them – would be derived inferentially, and hence possibly be found inconsistent, given the subsequent discourse.

When an adverbial discourse cue is adjoined to a clause, it can constrain how the clause can be interpreted as continuing the already-started description – for example,

9. John went to the zoo. **However**, he took his cell phone with him.

Following Knott and others (1996), we take the semantics of such discourse cues to be *presupposi-*

tional. For example, according to Knott, "however" presupposes the existence of a (shared) defeasible rule, some or all of whose antecedents are licensed by the previous discourse, but which fails to hold either because the clause so marked contradicts either the conclusion or an antecedent. In Example (9), the defeasible rule might be something like

When people go to the zoo, they leave their work behind.

So the clause marked by "however" in (9) both continues the description of the event of John's going to the zoo (compositional semantics) and conveys that the above rule fails to hold because its conclusion is contradicted (presuppositional semantics).

Of course, since these relation-modifying auxiliary trees are adverbials, they can, at least in English, be adjoined elsewhere in the structure, not just at the anchor – e.g.

10. Cracked and broken plastic tableware will attract germs, so it should be thrown away, never mended. Plastic furniture and toys, **however**, can be repaired successfully with the appropriate adhesive.

We speculate that such medially-occuring discourse cues (of which we are acquiring a growing corpus of naturally-occuring examples) occur at the boundary between a sentence's topic or *theme* (i.e., the question under discussion) and its comment or *rheme* (i.e., the contribution made towards that question) (Steedman, 1996a). There are then three possibilities:

- The cue merely makes the boundary explicit, while its presuppositional semantics remains tied to the proposition as a whole;
- The presuppositional semantics of the cue is grounded in whichever informational unit (theme or rheme) occurs to its left;
- The presuppositional semantics of the cue is grounded in the theme (wherever it occurs), specifying how the theme links to the discourse (i.e., *how* it is the question under discussion).

Deciding among these alternatives requires more time for thought and analysis of both constructed and such "naturally-occuring" examples as

11. A soldering iron is a much more specialized tool, which you will rarely need. **If** the occasion does arise when you need to solder two pieces of metal together, **however**, choose a large electric soldering iron with a tapered head.

and Examples (6) and (7) above. In (11), the subordinate clause itself is the theme. Such examples as (7) and (11) call into question RST's assumption that *satellites*, which these subordinate clauses would be taken to be, can be omitted without a great change in meaning to a discourse. These certainly cannot.

Another open question (but more of a technical detail) is the appropriate handling of conjunctions such as "so" and "but". On the one hand, their semantics can best be seen as presuppositional – presupposing a defeasible rule grounded in the previous discourse that succeeds in the case of "so" and fails in the case of "but" (Knott, 1996). On the other hand, they can only occur in the same position as "and", which we treat as a possible lexical realization of the anchor of the description-extending auxiliary tree, but which is not presuppositional. It is not yet clear to us which is the more appropriate way to treat them.

2.3 Compositional vs. Inferential Semantics

One consequence of this approach is that clauses linked by an explicit subordinate conjunction have a different structural analysis than do clauses that are simply adjacent. This might appear problematic because the perceived meaning of such discourses is usually the same. For example,

12. The City Council refused the women a permit because they feared violence.
13. The City Council refused the women a permit. They feared violence.

In our approach, (12) derives from the initial tree given in Figure 3a, while (13) derives from adjoining an auxiliary tree (Figure 3b) to the tree for the first clause and substituting the tree for the second clause at ↓. Herein lies the difference between the two: In (12), the causal connection is derived compositionally, while in (13), one infers from the second utterance continuing the description started in the first, that the speaker intends the situation described in the second utterance to serve as an explanation for that described in the first. Thus, the causal connection is defeasible in (13) but not in (12). This can be seen by trying to continue each with "But that wasn't the reason for their refusal." The extended

version of (12) seems ill-formed, while the extended version of (13) seems perfectly coherent.

Another reason for distinguishing a limited compositional semantics from an open inferential semantics is illustrated by the following example:

14. My car won't start. It may be out of gas.

An RST analysis would simply decide what relation held between the two clauses – perhaps *non-volitional cause*. However, non-volitional cause does not capture the different modal status of the two clauses, which in turn affects the modal status of the perceived relation: it is the car's *possibly* being out of gas that is *possibly* the cause of its not starting. We believe it is more systematic to just decide what description is being continued (here, the one begun in the first clause) and then derive further inferences that reflect the different modal status of the two clauses. That the above inference is defeasible can be seen by continuing the discourse in (14) with "But that's not a possible reason for its not starting".

2.4 Brief Example

Here we illustrate our approach by considering Example 9 (repeated below) in more detail.

9. John went to the zoo. However, he took his cell phone with him.

Three types of elements participate in the analysis: (1) the syntactic analyses (trees) of the two clauses ("John went to the zoo, "he took his cell phone with him") labelled α and β in in Figure 4., along with their respective meanings (call them $p_1(j)$ and $p_2(j)$); (2) the auxiliary tree for the discourse cue "however", labelled γ, along with its feature structure; and (3) the description-extending auxiliary tree labelled δ.

As the derivation in Figure 4 (below the arrow) shows, γ adjoins at the root of α, β substitutes into δ, and δ adjoins at the root of β. The semantics is as described earlier in Section 2.2.

3 Cue Phrases as Feature Structures (Knott, 1996)

Earlier we noted that there was benefit to be gained from taking the anchors of elementary trees to be feature structures into which discourse cues (whose semantics was also in terms of feature structures) could substitute. Here we briefly argue why we believe this is so.

First, in viewing discourse cues in terms of feature structures, we are following recent work by Knott (1996; 1996). Knott's study of the substitutability patterns of discourse cues reveals that their four common patterns – synonymy, exclusivity, hypernymy/hyponymy and contingent substitutability –
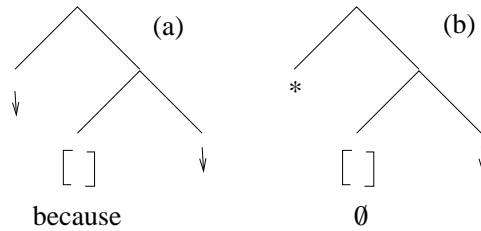
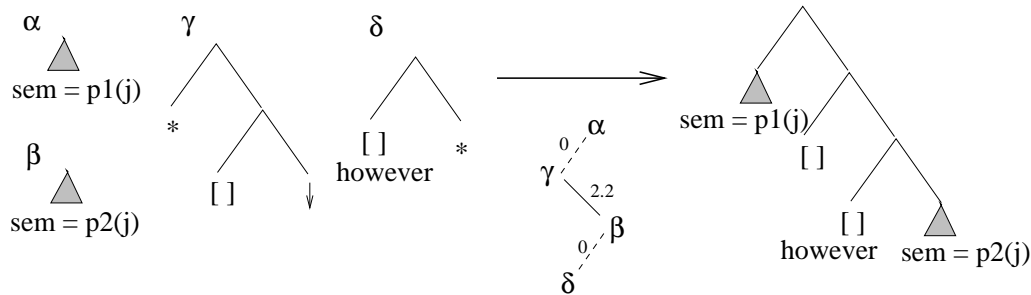Figure 3: Trees used in the derivation of Ex. 12 and Ex. 13

Figure 4: Derivation of Example 9

can, by assuming inheritance (that, except for contingent substitutability, a substitution pattern that holds for a discourse cue also holds for all its hyponyms), follow from interpreting cues in feature-theoretic terms:

- If cue α is *synonymous* with cue β, they signal the same values of the same features.
- If α is *exclusive* with β, they signal different values of at least one feature.
- If α is a *hypernym* of β, β signals all the features that α signals, as well as some features for which α is undefined.
- If α and β are *contingently substitutable*, α and β signal some of the same features, but α is also defined for a feature for which β is undefined and β is defined for a feature for which α is undefined.

Drawing on the extensive literature devoted to individual cue phrases, Knott provided semantics for some of these features in terms of *preconditions* on their use and/or their *communicative effects*.

Following Knott in treating discourse cues in terms of feature structures, it also appears beneficial to treat tree anchors as feature structures as well, distinct from those of discourse cues.

The reason for treating the anchor of subordinate clause initial trees as feature structures is one of representational efficiency: we can posit fewer such trees if we take their anchors to be features structures that allow the (possibly contingent) substitution of any subordinate conjunction with a compatible feature structure. For example, we can have one tree whose anchor has the feature *restricted-situation*, that can be realized as either "if" or

"when" in some texts, but only "when" in others – e.g.:

15. Emergency parking regulations are in force [when, if] more than six inches of snow has fallen.
16. I found 30 new messages had arrived [when, *if] I logged on this morning.

(Knott and Mellish, 1996) distinguish "if" and "when" by their different values for the feature *modal status*: "when" has the value *actual*, while "if" has the value *hypothetical*. One can therefore say that other semantic features in Ex. 16 conflict with the value *hypothetical*, only allowing "when". (N.B. One could also take "when" as being unmarked for modal status, its hypothetical reason begin synonymous with "whichever". The conflict with "if" in Ex. 16 would still follow.)

The argument for treating the pair of anchors of parallel structures as feature structures follows from the variability in the realization of the medial anchor noted in Section 2.1. One way to account for this is that the anchor has features separate from those of the discourse cues. Any cue can then be used to realize the anchor, as long as it is either

- less specific than the anchor, as in Ex. 3 – "but" has few features in Knott's taxonomy;
- more specific than the anchor, as in Ex. 5 – "on the other extreme", although it does not appear in Knott's taxonomy, intuitively appears to mean more than just "side".
- partially overlapping with the anchor, as in Ex. 4 – "at the same time" has temporal

features, but does not seem intrinsically contrastive. This corresponds to Knott's concept of *contingent substitutability*.

It also appears as if the clause/discourse within the scope of an anchor can either reinforce its features (as in Ex. 17 below) or convey features of the anchor when it is not itself realized lexically, as in Ex. 18:

17. On the one hand, according to Fred, John is very generous. On the other hand, according to everyone else, he will only give if he sees an angle.
18. According to Fred, John is very generous. According to everyone else, he will only give if he sees an angle.

But this part of our work is more speculative and the subject of needed future work.

4 Summary

One way of seeing a grammar for discourse is as a story grammar – i.e., a semantic grammar with components marked for the role they play in the story or some sub-part. Alternatively, a discourse grammar can, like a sentence-level grammar, merely specify how structural units fit together and how the semantics of the whole would be derived. This is one such grammar. While previous authors have adopted only certain aspects of TAG or LTAG, here we have explored the possibility of a "fully" lexicalized TAG for discourse, which allows to examine how the basic insights of a lexicalized grammar carry over to discourse.

Our proposal allows us to construct a smooth bridge between syntactic clauses and discourse clauses, each anchored on a lexical item (at times empty but always carrying the appropriate features). It also allows us to factor out three separate sources for elements of discourse meaning, thus providing a tool for sorting out different processes in discourse and modeling them individually. As such, we believe the approach provides some new insights and tools for investigating discourse structure and discourse relations.

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