

Departures from Tree Structures in Discourse: Shared Arguments in the Penn Discourse Treebank

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The term *discourse structure* is used to denote any structure of a text above that of the sentence. Trees have often been posited as a good abstraction when discourse is taken to have a hierarchical structure (Mann and Thompson 1987; Webber *et al.* 2003; Marcu 2000; Egg and Redeker 2008). Nevertheless, periodically researchers have commented on the need to depart from the strict single-parent hierarchy of trees to structures which have *shared daughters*, a move which incorporates multiple inheritance and is therefore an issue for tree representations.

This study follows up on the observation in (Lee *et al.* 2006) about the relative ubiquity of shared structures in the Penn Discourse Treebank or PDTB (Prasad *et al.* 2008; PDTB-Group 2008)), a recently released corpus which annotates discourse relations and their arguments. We limit our investigation here to cases where the shared discourse structure is a *syntactically subordinate clause* introduced by a subordinating conjunction (e.g. *because, although, when*, etc.). We examine annotations in the PDTB where the subordinate clause has been taken to be an argument of both the relation associated with the subordinating conjunction and another relation expressed in the immediately subsequent discourse. We ask what such annotations imply about the link between syntactic subordination and discourse subordination. Our argument is that while syntactic subordination may often correlate with discourse subordination, there are interesting exceptions that might better be captured as *discourse coordination*. We provide some systematic characterization of these exceptions by appealing to well-motivated discourse factors, and discuss their implications for tree structures.

1 Background

In an influential paper, Matthiessen and Thompson (1987) propose that a complex sentence containing a subordinating conjunction is “a grammaticization of the rhetorical organization of discourse”:

...in written English discourse, a certain kind of what linguists have called ‘subordinate clauses’, namely ‘hypotaxis’, can usefully be viewed as a grammaticization of a very general property of the hierarchical structure of the discourse itself ... We will concentrate on *enhancing hypotaxis*¹. Enhancing hypotaxis refers to hypotactic clause combining involving some kind of circumstantial relation like condition, reason, purpose and other kinds of cause, time, space, manner, and means: One clause enhances another clause circumstantially.

The asymmetry between a main clause and a subordinate “enhancing” clause has been described in several ways in the literature – salient/non-salient (terms we will adopt in this paper), nucleus/satellite, ground/figure, prominent/non-prominent, foreground/background, etc. Its functional status aside, the non-salient clause is also typically different in several ways from the salient clause: it might have different morphosyntactic properties, or lack independent speech act properties, information

¹The term ‘enhancing hypotaxis’ is due to Halliday (1985)

structure or illocutionary force (Lambrecht 1994; Cristofaro 2003; Kogomata 2003), but see also Kruijff-Korbayová and Webber (2007); Verstraete (2007).

In addition, subordinate clauses have been observed to behave like other non-salient discourse units in not contributing to the thematic continuity of the discourse. These non-salient units are generally assumed to be background material which support more salient units but by themselves do not function to continue the main theme of the discourse. Thus, Marcu (2000) for example suggests a discourse-based summarizer which identifies the salient (nucleus) parts of a text and removes the non-salient (satellite) constructions. More complex interactions between saliency and thematic continuity of particular discourse relations can be found in the literature (see for example (Noordman 2001) for *although*, (Spooren 1989) for *but*).

In some recent work, there have been more nuanced or even opposing viewpoints regarding the connection between discourse subordination and syntactic subordination. Stede (2008) argues that the position of Matthiessen and Thompson (1987) “generalizes from a mere tendency to a principle”. He points out that saliency in discourse can be due to a variety of factors - intentions, linear order of matrix vs subordinate clause, etc. - and that syntactic subordination is but one of these factors. Blühdorn (2008) takes the even stronger position that adverbial subordinate clause is semantically superordinate to the matrix clause, on the grounds that the subordinate clause determines the interpretation of the main clause and that, as an adjunct, it attributes thematic roles to the matrix clause (Bierwisch 2003). Hence, Blühdorn interestingly argues that the syntactically subordinate adverbial clause is inversely the superordinate in a discourse relation, and there is essentially no parallel between discourse subordination and syntactic subordination.

This study takes a decidedly empirical approach towards examining the link between syntactic and discourse subordination, given the recent availability of the PDTB corpus which, as we will show, is well-suited for this task. In the next two sections, we describe the corpus as well as the investigation carried out on it.

2 The Penn Discourse Treebank

The Penn Discourse Treebank (PDTB) contains annotations of discourse relations and their arguments on the 1-million word Wall Street Journal text corpus.² The PDTB annotates semantic (aka *informational*) relations holding between two (and only two) Abstract Objects (AOs) (Asher 1993), expressed either explicitly via lexical items or implicitly via adjacency. For the former, the lexical items anchoring the relation are annotated as Explicit connectives, which are identified from three grammatical classes: subordinating conjunctions (e.g., *because*, *when*), coordinating conjunctions (e.g., *and*, *or*), and discourse adverbials (e.g., *however*, *otherwise*). For simple adjacency, the implicit inferable relations are annotated by inserting an Implicit connective that best expresses the inferred relation.

Arguments of connectives in the PDTB are simply labelled Arg2 for the argument appearing in the clause syntactically bound to the connective, and Arg1 for the other argument.³ In (1), the subordinating conjunction *since* is an Explicit connective anchoring a TEMPORAL relation between the event of the earthquake hitting and a state where no music is played by a certain woman:

(1) *She hasn't played any music since **the earthquake hit**.* (0766)⁴.

An example of a relation inferred due to adjacency is given in (2), where the CAUSAL relation between the AOs denoted by the two adjacent sentences is annotated with *because* as the Implicit connective:

²The PDTB is available through the Linguistic Data Consortium (<http://www ldc.upenn.edu/Catalog/CatalogEntry.jsp?catalogId=L>)
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³In this section, Arg 1 appears in italics while Arg2 appears in bold. The connective is underlined.

⁴The four-digit number in parantheses refers to the underlying WSJ file

- (2) *Also unlike Mr. Ruder, Mr. Breeden appears to be in a position to get somewhere with his agenda.* Implicit=because (CAUSE) **As a former White House [...], he is savvy in the ways of Washington.** (0955)

There are three crucial features of the PDTB relevant to this paper. First, each individual discourse relation was annotated independently of every other relation. Annotators actually did not get to see any previous annotations when working on the current discourse relation. Indeed, the objective of the PDTB was to encode elementary discourse relations, not to build higher level discourse structures out of these elementary relations. Secondly, discourse saliency was not annotated in the PDTB either explicitly or implicitly. Only annotated is the existence of a relation between two arguments (and, in the case of implicit connectives, how the relation is best expressed). And finally, annotators were not constrained as to the extent or location of each discourse argument. A few guidelines aside, they were free to select whichever text span deemed to be the correct argument to a relation.

3 Methodology and Findings

The low-level theory-neutral approach to annotation of the PDTB makes the corpus an ideal testbed for investigating the contributions of syntactically subordinate clauses to discourse continuity. Consider for example the case where we have a text containing a complex sentence like “X although Y”. The conjunction “although” is the explicit connective in this case, while X and Y are the arguments to the connective (note that Y is a subordinate clause here). Given that the annotator does not get to see the annotation of this “X although Y” sentence again when annotating other relations in the text, we can thus examine the completed annotated text to check whether the subordinate clause Y is ever *reselected* to be the argument of any other discourse connective in the text.

This is the case in (3) where the subordinate clause introduced by *although* has been selected as the first argument to the subsequent contrast relation (indicated by *however*). The *however* relation in fact becomes incoherent if the matrix clause is chosen as its first argument. This would make both arguments to *however* statements about the weakness of the London index.⁵

- (3) The London index finished 2.4% under its close of 2233.9 the previous Friday, although it recouped some of the sharp losses staged early last week on the back of Wall Street’s fall. London was weak throughout Friday’s trading, however, on what dealers attributed to generally thin interest... (1505)

For ease of exposition, we will refer to the discourse relation which the subordinate clause continues as the “external relation”. In (3), the external relation is the contrast relation signaled by “however”.

We examined the 12 most common subordinating conjunctions annotated in the PDTB - *after, although, as, because, before, if, since, though, unless, until, when, while*. For these 12 connectives, we found 349 instances where the subordinate clause (and only the subordinate clause) was selected as the argument to an external relation (Table 1). This is a relatively low percentage (4.2%), about three times less than the rate at which the matrix clause (12.4%) was selected. The full sentence containing both clauses was by far the most commonly selected argument of the external relation (83.4%).

As a point of comparison, we also examined the 3 most common coordinating conjunctions - *and, but, or* - and noted the number of times the first and second conjuncts as well as the entire sentence were selected as the argument to an external relation (Table 2). Here we see that the rates at which the first and second conjuncts were selected were relatively equal (15.0% vs 20.2% respectively).⁶

⁵Since we are dealing with a pair of discourse relations from here on, we will abandon the markup conventions used in earlier examples. From now on, the shared argument will be in boldface, but the other arguments are not specially marked. Both connectives will be underlined.

⁶The higher number for the second conjunct is due to the higher number for the second conjunct of *but*. It has been noted that the second conjunct of *but* is more “salient” than the first (Elhadad and McKeown 1990)

Subordinate clause reselected	Matrix clause reselected	S selected	TOTAL
349 (4.2%)	1021 (12.4%)	6881 (83.4%)	8251

Table 1: Complex sentences containing subordinating conjunctions - the table above shows the number of times the subordinate clause, matrix clause or entire sentence (S) were selected as arguments to an external relation.

First conjunct reselected	Second conjunct reselected	S selected	TOTAL
1524 (15.0%)	2054 (20.2%)	6583 (64.8%)	10161

Table 2: Complex sentences containing coordinating conjunctions - the table above shows the number of times the first conjunct, second conjunct or entire sentence (S) were selected as arguments to an external relation.

Distributionally then, it does seem to be the case that there is a correspondence between syntactic coordination and subordination on the one hand, and symmetric or asymmetric salience of discourse arguments on the other. Syntactic conjuncts - paratactic structures - are more or less equally salient in discourse judging by their availability as arguments to an external relation (15.0% vs 20.2% : for a 0.74 ratio). Relative to its matrix clause, the subordinate clause is correspondingly less salient in discourse - 4.2% vs 12.4% for a ratio of only 0.34).

Hence, the hypothesis of Matthiessen and Thompson (1987) regarding the link between syntactic structure and discourse structure appears to be distributionally borne out by a corpus study of the PDTB. However, the contention of Stede (2008) that this is all still generalizing from a “tendency to a principle” remains an open question, since we do find exceptions to the general pattern. In particular, there are the 349 subordinating clauses which were reselected as arguments of an external relation to be accounted for.

These exceptions are discussed in the next section. We observe that while certain cases can be explained away upon closer examination, many others are indeed true exceptions and require further investigation.

4 Discussion

We begin this section by looking at another example which appears to be categorically different from the case we saw in (3):

- (4) They won’t buy *if the quality is not there*. *Or* if they feel the wine is overpriced. (0071)

Here, even though the subordinate clause “the quality is not there” is also reselected as an argument to the external relation indicated by *Or*, it is clear nevertheless that the whole disjunction is *embedded* under *if*. This sort of embedding can easily be captured by a tree structure, as shown in (5i) (X, Y and Z represent discourse arguments).

In contrast, with example (3) which we saw above, the intuition is that there is more of a “sequential” reading, one in which the subordinate *although* clause plays an equally prominent role as the other two discourse arguments irrespective of its syntactically less salient status. We suggest that when there is no clear indication of embedding even when the text is contextualized in the larger discourse, then perhaps there is no actual need to fit the discourse into some hierarchical tree structure.

One straightforward way to capture the fact that a clause functions as the argument to two discourse relations might be to simply posit a node with multiple inheritance, as shown in (5i).⁷

- (5) (i) { X IF (Y OR Z) } (ii) { X ALTHOUGH (Y } HOWEVER Z)

We thus have a more formal way now of describing how a discourse segment *continues the discourse*. A discourse segment continues the discourse when its external relation is *outside the scope* of its internal relation. In (5ii), the external relation of Y realized by (HOWEVER) is not dominated by the internal relation realized by (ALTHOUGH), hence Y is said to continue the discourse here. What we are capturing here is essentially a notion of *discourse coordination* between two relations and three arguments, one of which is shared by both relations. In contrast to this, the external relation realized by (OR) in (5i) is within the scope of IF, so Y does not continue the discourse in this case, i.e. is properly subordinated in discourse.

(5i) is an unsurprising find, since we do not expect the subordinate clause (represented by Y) to be playing a major role in moving the discourse forward. (5ii) is the obvious interesting case. Not only is the syntactic subordination overridden at the discourse level in this case, but the discourse structure which appears to be most suitable for capturing this pattern involves non-tree-like shared structures.

So, under what circumstances does the subordinate clause become salient enough to be able to continue the discourse? Are there patterns to be discerned and generalizations that can be made? In what follows, we make several observations which we believe to be pertinent to a number of the cases that we have come across. We should emphasize that at this juncture, these observations are not exhaustive and are simply just that - observations. We leave theoretical analyses for future work once we have gained a more complete picture of the data.

Firstly, so far two general patterns seem to always hold whenever we have shared arguments:

- The subordinate clause is always postposed. (e.g. “The dilligent boy passed the exam because **he studied hard**”). A preposed (“Because **he studied hard**, the dilligent boy passed the exam”) or interposed clause (“The dilligent boy, because **he studied hard**, passed the exam.”) were never selected to continue the discourse, although there may be real exceptions.
- The external relation is limited to the following senses – contrast, cause, consequence. Other types of relations, particularly the conjunctive/disjunctive type or those with elaboration or temporal senses, only appeared as structural embedding, as in (2).

In addition to these two observations, one or more of the following frequently held when the subordinate clause continues the discourse:

Anaphoric matrix clause: The matrix clause had a clear antecedent in the text. In (6), the Saudi Arabian support of the Iranian proposal, expressed in the matrix clause of the sentence containing *because*, refers back to the group endorsement of the said proposal by all the OPEC countries.

- (6) (Antecedent: The concept of disproportionate quotas for those with unused capacity, advanced there in an Iranian proposal, was generally endorsed by the ministers (of the OPEC countries).) ...the Saudi Arabians supported Iran’s proposal **because it would have left the Saudi percentage of the OPEC total intact....** Some of the proposed modifications since,

⁷An analogy with intersective adjectives might be useful here. In a phrase like “big tall buildings”, the outcome is the same whether we restrict the set of buildings to “tall buildings” first and then pick out the big ones from that restricted set, or vice-versa (that we pick out “big buildings” first and then pick out the tall ones). A shared structure thus might be a good way to encode just such an agnostic view regarding semantic composition whether at the syntactic or discourse level. This suggestion here is related somewhat to the proposal of Egg and Redeker (2008), where they propose an underspecified representational framework which can yield a number of possible discourse structures depending on interpretation. We propose however that there are cases where shared structures might well be the actual appropriate level of representation in discourse.

however, call on Saudi Arabia to “give back” to the production-sharing pool a token 23,000 barrels. (1428)

Reduced matrix clause: The matrix clause is reduced to a simple deictic or pronoun along with a light predicate. In (7), the matrix is simply “it may be”:

- (7) (Antecedent: If this seems like pretty weak stuff around which to raise the protectionist barriers,)

it may be *because* **these shows need all the protection they can get.** (*Implicit-CAUSE*)
European programs usually target only their own local audience, and often only a small portion of that. (2361)

The cases in (6) and (7) might be two of the same kind in that, in both cases, the main clause has an antecedent in the preceding text. The “given-ness” of the main clause reduces its saliency in the discourse, particularly in relation to the corresponding subordinate clause. Thus, any discrepancy in the discourse saliency of the main clause and the subordinate clause is more or less neutralized here. The result is a complex sentence which, at the discourse level, consists of two discourse arguments whose relationship to one another is more paratactic than hypotactic. The “subordinate” clause is thus freer to continue the discourse in this case.

The subordinate clause is introduced by a “coordinating”-type subordinating conjunction: There have been discussions in the literature regarding the discourse behavior of clauses introduced by certain subordinating conjunctions - *although* and *because*, in particular. Common to these studies is the argument that the relationship between the subordinate clause and the main clause becomes relatively symmetric under certain circumstances, making it equally likely that either one may continue the discourse. Thus, Verstraete (2007) notes that clauses introduced by *although*, *because* or *for* are sometimes similar to their coordinating counterparts (*and*, *but*, etc.) in that they can have independent illocutionary force. Kruijff-Korbayová and Webber (2007) points out that certain subordinate clause concession statements have distinct theme/rheme structure from the main clause. Noordman (2001) points out that with concessive *although* sentences (but not denial-of-expectation *although* sentences), the main or subordinate clauses are equally likely to contribute to the thematic continuity of the discourse.

These observations are borne out by our data - *because*, *although* and *though* clauses are the most likely to be reselected by an external argument. Of the 349 cases encountered, 189 involve one of these three connectives. In (8), there is a strictly concessive (non-denial of expectation) relationship between the *although* subordinate clause and its corresponding main clause. Moreover the subordinate clause reads more like a “commentary” on the main clause with independent illocutionary force, paraphrasable perhaps by a question statement such as “although who’s to know if Washington was singly responsible for Wall Street’s woes?”.

- (8) Politicians tried to finger each other for the blame (for the government’s bad economic policy), *although* **many analysts doubt that Washington was singly responsible for Wall Street’s woes.** *But* Mr. Butcher’s comments make one thing clear: Some on Wall Street wonder if anyone is in charge of economic policy. (2384)

In passing, we should also note that there are a number of cases where the external relation is realized by a discourse adverbial which selects the subordinate clause as an argument, as in (3) earlier with *however* and in (9) with *Instead*:

- (9) Mr. Rivkin insists that the 10 pages weren’t pulled *because* **they were too bullish.** *Instead*, he says, “they were cautious...” (1644)

Depending on one’s theory, a relation realized by a discourse adverbial may not get its first argument (Arg1) structurally. Under the D-LTAG approach (Webber *et al.* 2003), for example, adverbials like *instead* are argued to take their first argument anaphorically (here paraphrasable as *instead of THAT*), and anaphoric links (as with pronouns) do not have structural implications – including no implication of shared structure.

5 Structural Implications

In this paper, we argued for the existence of a shared structure as modeled in (10):

- (10) { X conn1 (Y } conn2 Z) where X, Y, Z are discourse arguments, conn1 is a subordinating conjunction and conn2 is contrast, cause or consequence

Underlying this shared structure analysis is the notion that the three discourse segments in question are not related hierarchically but rather sequentially in the discourse. The subordinate status of clause Y in this case is overridden at the discourse level when the particular factors that we have discussed hold, leading to a sequence of paratactic relationships.

One might ask whether this particular case of shared argument is just an isolated idiosyncrasy, and that we should perhaps not dispense with tree structures in discourse simply to integrate this one case. In actual fact, shared structures have cropped up before in discourse. For example, Mann and Thompson (1987) recognizes the need for a multi-satellite schema within the framework of Rhetorical Structure Theory to cover cases where two satellites are symmetrically related to a single nucleus. This essentially creates a shared structure with one node acting as the nucleus to two separate satellites. Marcu (2000) and Stede (2004) both suggest splitting such multi-satellite constructions into two binary parts, subordinating one rhetorical relation under another depending on context, thereby creating a hierarchical tree structure. But this might not always be an empirically valid option. Egg and Redeker (2008) - who propose to model discourse structure using binary trees - nevertheless recognize the real problem that multi-satellite constructions pose for the tree-ness of discourse, acknowledging that there might indeed be circumstances, perhaps genre-dependent, when two satellites are actually symmetrically related to the same nucleus.

In fact, there might be even more obvious cases of shared structures in discourse. Consider for example a list of three or more elements conjoined by a simple conjunction like *and* : X and Y and Z. The most obvious model for the list here is simply as a sequence of three elements. Marcu (2000) points out that, while one may encode this list in a nested tree structure - (A and (B and C)) - this is essentially putting a hierarchical structure over elements that actually share equal status in the discourse. Another solution is to use non-binary trees, but this begs the question of how to incorporate the two *and* conjunctions into the structure.

Even at the syntactic level, a growing body of work also invoke shared structures to deal with various issues of coordination and movement within syntactic structure (see for example Wilder (2008)), or with particular constructions like resultatives (see Goldberg (1995)). In other approaches, such cases are avoided by introducing dummy elements such as traces– not an attractive proposition at the discourse level. Furthermore, tree structures create problems for other phenomena like parantheticals and sentential relatives that might not be solved using traces.

Without belaboring the point then, it seems clear that while trees are an attractive way of organizing and constraining semantic information in discourse, a distinction should be made between imposing tree structures as a *convention* and careful usage based on empirical evidence. We might ask if trees are used in discourse simply based on the historical precedence of trees being widely used in syntax. Given that what hierarchical structures are relevant at the sentence level is not a settled issue, it is not surprising that the corresponding issue at the discourse level is not settled either. Trees might not be fully adequate for representing discourse structure (or syntactic structure), but our research

goal is not to simply dismiss trees out of hand but rather to examine more carefully the conditions under which such departures from tree structures are truly needed.

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