Describing Discourse Semantics

Claire Gardent
Computational Linguistics
University of the Saarland
Saarbrücken, Germany
claire@coli.uni-sb.de

Bonnie Webber
Computer and Information Science
University of Pennsylvania
Philadelphia PA 19104-6389 USA
bonnie@central.cis.upenn.edu

Descriptions. In recent years, both formal and computational linguistics have been exploiting *descriptions* of structures where previously the *structures* themselves were used.

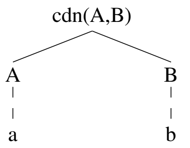
The practice started with (Marcus et al., 1983), who demonstrated the value of (syntactic) tree descriptions for near-deterministic incremental parsing. Vijay-Shankar (Vijay-Shankar and Joshi, 1988; Vijay-Shankar, 1992) used descriptions to maintain the monotonicity of syntactic derivations in the framework of Feature-Based Tree Adjoining Grammar. In semantics, both (Muskens, 1997) and (Egg et al., 1997) have shown the value of descriptions as an underspecified representation of scope ambiguities.

The current paper further extends the use of descriptions, from individual sentences to discourse, showing their benefit for incremental, near-deterministic discourse processing. In particular, we show that using descriptions to describe the semantic representation of discourse permits: (1) a monotone treatment of local ambiguity; (2) a deterministic treatment of global ambiguity; and (3) a distinction to be made between "simple" local ambiguity and "garden-path" local ambiguity.

Discourse descriptions. Suppose we have the discourse:

(1) a. Jon and Mary only go to the cinema
  b. when an Islandic film is playing

On hearing the second sentence, the hearer infers a CONDITIONAL relation (CDN) to hold between the event partially specified in (1a) and the event partially specified in (1b). We associate this with the following description of structure and semantics:

(2)


The dashed lines indicate domination, the plain lines immediate domination. Labels on the nodes are first-order terms abbreviating their associated semantic information. Capital letters indicate variables, lower letters indicate constants, and shared variables indicate re-entrancy. Whenever two node descriptions are identified and taken to refer to the same node, their labels must unify.

The description licenses a local tree whose root semantics is CDN(A,B), where A and B are the semantics of nodes dominating the nodes whose semantics is a and b, respectively. Intuitively, A and B represent the *final* arguments of the CONDITIONAL relation, whereas a and b stand for its *current* arguments.[1] Formally, A/a and B/b nodes are quasi-nodes in the sense of Vijay-Shankar: they are related by dominance and therefore can (but need not) be identical.

Local ambiguity. As (Marcus et al., 1983) has noted, descriptions facilitate a near-deterministic treatment of local attachment ambiguities in incremental parsing. This is also true at the discourse level. For instance (1) can be continued in two ways: additional discourse material can "close off" the scope of the relation

(3) a. so they rarely go.
  b. Semantics: *cause(cdn(a,b),c)*

[1] Descriptions can be formulated more precisely, using tree logic (Vijay-Shankar, 1992). For this paper however, we will use a graphic presentation, as in (2) above, which is easier to read than conjunctions of logical formulae.

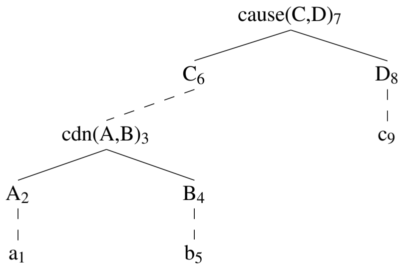
or it can extend it:

(4) a. or the film got a good review in *The Nation*.

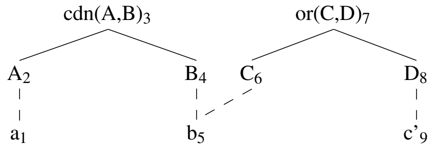
b. Semantics: *cdn(a,or(b,c))*

By using descriptions of trees rather than the trees themselves, we have a representation which is compatible with both continuations: In the first case (continuation 3), addition of the third clause will lead the hearer to infer a CAUSE relation to hold between (1) and (3). This extends the description in (2) to:

(5)

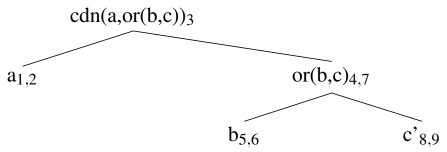


By contrast, if (1) is continued with (4), the initial description is expanded to:



where OR stands for disjunction. Both descriptions are compatible with the initial description (2) and both descriptions can be further constrained to yield the appropriate discourse semantics.

Suppose that no further material is added: now the scope of the discourse relation becomes known. This in turn licenses node identifications which conflate final and current arguments. So if the discourse ends in (4), then node 6 is identified with node 5, fixing to b the left-hand argument of the OR relation. Similarly, nodes 8 and 9 can be identified, thereby fixing the right-hand argument to c'. Given these additional constraints, the minimal tree structure which satisfies the resulting description is:



In summary, dominance permits underspecifying the *syntactic* link between nodes, while *semantically*, quasi-nodes permits underspecifying the arguments of discourse relations. In both cases, monotonicity is preserved by manipulating descriptions of trees rather than the trees themselves.

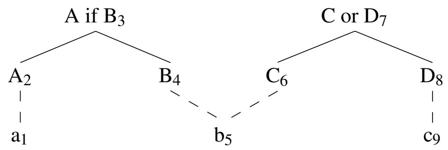
Global ambiguity Discourse exhibits global scope ambiguities in much the same way sentences do:

(6) a. I try to read a novel

b. if I feel bored

c. or I am unhappy.

This discourse means either that the speaker tries to read a novel under one of two conditions (boredom or unhappiness), or that the speaker is unhappy if s/he can't read a novel when bored. Discourse-level scope ambiguities can be captured as in (Muskens, 1997) by leaving the structural relations holding between scope bearing elements underspecified. For example, the (ambiguous) structure and semantics of (6) can be captured in the description:



In the absence of additional information (i.e. when the respective scope of the discourse relations remains unspecified), no additional constraints come into play, so that not one but two trees satisfy the description: one with root semantics *a if (b or c)* and the other with root semantics *(a if b) or c*.

Defaults, underspecification and preferences. We assume that a cognitive model of incremental discourse processing should distinguish between those cases of "simple" local ambiguity which do not trigger repair when they are resolved by information later in the discourse and those cases of "garden path" ambiguity that do.

Now there is a continuum of ways to deal "economically" with local ambiguity, without generating all the possible readings. At one end is a pure *default* approach, commiting to one reading and discarding the others. At the other end is a pure *underspecification* approach, with a single compact representation of all possible readings but no indication of the reading of the text so far.

Neither of these "pure" approaches suffices to distinguish simple local ambiguity from garden path ambiguity in either sentence-level processing or discourse. While defaults can be subsequently overridden, there is no difference between overriding a simple local ambiguity and overriding a garden path. On the other hand, underspecification, which does not "commit" to any specific choice, provides no indication of the reading of the text so far and thus again, no way of distinguishing simple local ambiguity from cases where the reader garden-paths.

However, in between these polls are approaches that combine features of both. One that seems able to meet the cognitive criteria given above is an approach that combines underspecification with a preference system that highlights a specific reading corresponding to the hearer's currently preferred interpretation. Such a proposal was suggested in (Marcus et al., 1983), and is the one we are currently exploring for discourse. The two aspects of the approach we want to discuss here are: (1) partial underspecification, and (2) biases in choosing a preferred reading.

Partial Underspecification. The degree of underspecification in a description is usually only partial: there is always something that it commits to. For example, while underspecifying domination, the structural descriptions used above still rigidly distinguish each branch of a tree from its sisters. Similarly, while allowing underspecification in each individual argument to a predicate, the descriptions used here still rigidly distinguish one argument from another. We take this to be a "feature" with respect to making a cognitive distinction between simple local ambiguity and local ambiguity that leads to garden paths.

In particular, we associate simple local ambiguity with domination underspecification, whether it be at the sentence-level or in discourse: the local ambiguity associated with "my aunt" after processing "I saw my aunt ..." – whether it continues

(7) a. I saw my aunt.
    b. I saw my aunt's cat.
    c. I saw my aunt's cat's litter box.

– is purely a matter of how the domination relation eventually resolves itself.

On the other hand, the ambiguity associated with "raced" after processing "The horse raced ..." – whether it continues

(8) a. The horse raced past the barn.
    b. The horse raced past the barn fell

– is a matter of choosing whether "raced" takes "the horse" as its argument or whether it acts as a modifier of "the horse" (in distinguishing this horse from other ones, cf. (Crain and Steedman, 1985)). This ambiguity cannot be captured by domination underspecification. As such, it can only be represented as a (disjuctive) alternative, a matter of non-deterministic or preferential choice. If the choice is incorrect, revision is required, thus providing a way of making the desired distinction between simple and garden-path local ambiguity.

Biases in choosing a preferred reading. In any abductive process, there are many ways of explaining the given data, and *biases* are used to identify one that is preferred. For example, in plan recognition (identifying the structure of goals and subgoals that give rise to what is usually taken to be a sequence of observed actions), Kautz (Kautz, 1990) suggested a "goal minimization" bias that preferred a tree with the fewest goals (non-terminal nodes) able to "explain" the sequence of actions. Where goal minimization is known to produce the wrong explanation, some other bias is needed to yield the one that is preferred (Gertner and Webber, 1996).

Similarly, in associating a preferred reading with a compact underspecified representation, (Marcus et al., 1983) proposed a bias towards a tree that minimised the dominance relation. That is, if two node names stand in a dominance relation, they are taken to refer to one and the same node, provided nothing rules it out. Of course, such a "min_dom" bias might yield several trees, each of which are equally minimal. Typically, this is true of global ambiguities as in (6) above, where dominance can be minimised by identifying node 5 either with node 4 or with node 6, each move resulting in an equally minimal tree.

An alternative bias combines "min_dom" with "right-association" (Frazier, 1995; Chen and Vijay-Shankar, 1997), yielding a preference for a structure in which the incoming unit attaches "low in the tree" and can be obtained by minimising the most recent dominance link. In example 6, this means identifying node 6 with node 5 first so that the default reading in this case is the reading where *if* scopes over *or*.

Other biases are possible: Crain and Steedman (Crain and Steedman, 1985) argue for a preference for referring forms that distinguish one already-evoked (discourse) entity from possible alternatives. We believe it is worth exploring what bias best models the preferences people have in discourse interpretation, and how it resembles their preference at the sentence level.

Comparison with related work. A related approach to discourse structure and semantics is presented in (Webber and Joshi, 1998), where Lexicalised Tree Adjoining Grammar (LTAG) is used to construct the compositional semantics of discourse. Although the basic structures used here are different, we foresee no difficulty in modifiying them in order to integrate the additional information included in the LTAG discourse trees. Essentially, the atomic labels representing the relations should be mapped into the feature structures used in (Webber and Joshi, 1998) and this information used to label not the root node of a local tree but its anchor. Second, the LTAG approach has focussed on describing the *compositional* semantics of discourse – that is, the semantics explicitely given by the text (as opposed to what can be inferred). In contrast, the present approach does not differentiate between compositional and inferred semantics, though again, the difference does not seem essential as the description based approach could be either *extended* to explicitely distinguish (e.g. by means of features) between compositional and inferential information, or *restricted* to describe those aspects of discourse semantics that are compositional. Third, the LTAG proposal does not address the focus of the current approach – incrementality and underspecification. On the whole then, the two systems are complementary rather than antagonistic.

Conclusion. We have argued that a technique developed to handle well-known problems in sentence processing can also benefit the processing of monologic discourse. First, it provides a well-defined framework for monotonically describing the incremental construction of discourse semantics. This departs from approaches in the discourse literature which give up either monotonicity (Asher, 1993) or incrementality (Hob90; MT87). Second, it has a well-understood formal basis in tree logic. Third, it permits a clear-cut distinction between local ambiguities that lead the hearer down the garden path and those that don't.

Acknowledgements. The authors would like to thank Mark Steedman and Aravind Joshi for comments and suggestions. An early draft of this paper was presented at the *Workshop on Underspecification*, Bad Teinach, Germany, May 1998. Claire Gardent is grateful to the Deutsche Forschungsgesellschaft for financial support within the SFB 378, C2.

References

N. Asher. 1993. *Reference to abstract objects in discourse*. Kluwer, Dordrecht.

J. Chen and K. Vijay-Shankar. 1997. Towards a Reduced Commitment, D-Theory Style TAG Parser *Proc. Int'l Workshop on Parsing Technologies*.

S. Crain and M. Steedman. 1985. On not being led up the garden path: The use of context by the psychological parser. In D. Dowty, L. Kartunnen and A. Zwicky (eds.), *Natural Language Parsing: Psychological, computational and Theoretical Perspectives*, Cambridge University Press.

M. Egg, J. Niehren, P. Ruhrberg and F. Xu 1998. Constraints over Lambda Structures in Semantic Underspecification *Proc. COLING/ACL*, Montreal CA.

L. Frazier. 1995. Issues of Representation in Psycholinguistics. In J.L. Miller and P.D. Eimas, eds., *Speech, Language and Communication*. Academic Press, New York.

A. Gertner and B. Webber. 1996. A Bias towards Relevance: Recognizing plans where goal minimization fails. *Proc. 1996 National Conference on Artificial Intelligence (AAAI-96)*, Portland OR, pp. 1133-1138.

J. Hobbs. *Literature and Cognition*. CSLI Lecture Notes, Number 21. 1990.

H. Kautz. A circumscriptive theory of plan recognition. In Jerry Morgan Philip R. Cohen and Martha E. Pollack, editors, *Intentions in Communication*. Bradford Books, 1990.

W. C. Mann and Sandra A. Thompson. Rhetorical structure theory. Technical Report RS-87-190, USC/ISI, 1987.

M. P. Marcus, D. Hindle, and M.M. Fleck. 1983. Talking about talking about trees. In *Proceedings of ACL*, Cambridge, MA.

R. Muskens. 1997. Order-independence and underspecification. University of Tilburg.

L. Vijay-Shankar and A. Joshi. 1988. Feature based tags. *Proceedings of ACL*, Budapest.

K. Vijay-Shankar. 1992. Using descriptions of trees in a tree-adjoining grammar. *Computational Linguistics*.

B. Webber and A. Joshi 1998. Anchoring a lexicalized Tree-Adjoining Grammar for discourse. *Proceedings of COLING/ACL workshop on Discourse Relations and Discourse Markers*, Montreal CA.