

Chapter 8. Conclusion

This chapter contains a summary of the dissertation and briefly outlines two future extensions of the present work.

Summary

Handling the semantic connections established and elaborated upon in extended discourse represents a key challenge for understanding the notion of meaning involved in natural language interpretation. Devising a precise compositional interpretation procedure is particularly difficult for discourses involving complex descriptions of multiple related objects (individuals, events, times, propositions etc.), as for example, the discourses in (1), (2) and (3) below.

1. Every person who buys a^u computer and has a^u credit card uses it_u to pay for it_u.
2. **a.** Harvey^u courts a^u girl at every^u convention.
b. She_u always_u comes to the banquet with him_u.

(Karttunen 1976)

3. **a.** If^p a^u man is alive, he_u must_p find something pleasurable.
b. Therefore, if_p^p he_u doesn't have any spiritual pleasure, he_u must_p have a carnal pleasure.

(based on Thomas Aquinas)

The main achievement of this dissertation is the introduction of a representation language couched in classical type logic in which we can compositionally translate natural language discourses like (1), (2) and (3) above and capture their truth-conditions and the intricate anaphoric dependencies established in them.

The dissertation argues that discourse reference involves two equally important components with essentially the same interpretive dynamics, namely reference to *values*, i.e. (non-singleton) sets of objects (individuals and possible worlds), and reference to *structure*, i.e. the correlation / dependency between such sets, which is introduced and incrementally elaborated upon in discourse.

To define and investigate structured discourse reference, a new dynamic system couched in classical (many-sorted) type logic is introduced which extends Compositional DRT (Muskens 1996) with plural information states, i.e. information states are modeled as sets of variable assignments (following van den Berg 1996), which can be represented as matrices with assignments (sequences) as rows – as shown in the table in (4) below. A plural info state encodes both values (the columns of the matrix store sets of objects) and structure (each row of the matrix encodes a correlation / dependency between the objects stored in it).

4. Info State I	...	u	u'	p	p'	...
i_1	...	x_1 (i.e. ui_1)	y_1 (i.e. $u'i_1$)	w_1 (i.e. pi_1)	v_1 (i.e. $p'i_1$)	...
i_2	...	x_2 (i.e. ui_2)	y_2 (i.e. $u'i_2$)	w_2 (i.e. pi_2)	v_2 (i.e. $p'i_2$)	...
i_3	...	x_3 (i.e. ui_3)	y_3 (i.e. $u'i_3$)	w_3 (i.e. pi_3)	v_3 (i.e. $p'i_3$)	...
...

Values (sets of individuals or worlds): $\{x_1, x_2, x_3, \dots\}$, $\{w_1, w_2, w_3, \dots\}$ etc.

Structure (relations between individuals and / or worlds): $\{\langle x_1, y_1 \rangle, \langle x_2, y_2 \rangle, \langle x_3, y_3 \rangle, \dots\}$, $\{\langle x_1, y_1, w_1 \rangle, \langle x_2, y_2, w_2 \rangle, \langle x_3, y_3, w_3 \rangle, \dots\}$, $\{\langle w_1, v_1 \rangle, \langle w_2, v_2 \rangle, \langle w_3, v_3 \rangle, \dots\}$ etc.

In Plural Compositional DRT (PCDRT), sentences denote relations between an input and an output plural info state. Indefinites and conditional antecedents non-deterministically introduce both values and structure, i.e. they introduce structured sets of individuals and possible worlds respectively; pronouns, verbal moods and modal verbs are anaphoric to such structured sets. Quantification over individuals and over possible worlds is defined in terms of matrices instead of single assignments and the semantics of the non-quantificational part becomes rules for how to fill out a matrix.

Given the underlying type logic, compositionality at sub-clausal level follows automatically and standard techniques from Montague semantics (e.g. type shifting) become available.

PCDRT enables us to account for a variety of phenomena, including: (i) mixed reading (weak & strong) relative-clause donkey sentences (chapter 5), instantiated by example (1) above, (ii) quantificational subordination (chapter 6), exemplified by discourse (2), and (iii) the complex interactions between entailment particles (i.e.

therefore), modal anaphora and modal subordination exhibited by discourse (3) above (chapter 7).

In more detail, example (1) is a mixed reading (weak & strong) relative-clause donkey sentence which is interpreted as follows: for any person that is a computer buyer and credit card owner, for *every* (strong) computer s/he buys, s/he uses *some* (weak) credit card of her/his to pay for the computer. In particular, note that the weak indefinite *a'* *credit card* co-varies with, i.e. is dependent on, the strong indefinite *a'* *computer* (I can buy my Dell desktop with a MasterCard and my Toshiba laptop with a Visa) despite the fact that the two indefinites are syntactically trapped in their respective VP-conjuncts. The notion of plural info state employed in PCDRT enables us to capture this kind of non-local structured anaphoric dependencies (i) across VP-conjuncts and (ii) across clauses, i.e. between the two indefinites in the restrictor of the quantification in (1) and the two pronouns in the nuclear scope.

The PCDRT account successfully generalizes to the mixed reading DP-conjunction donkey sentences in (5) and (6) below, where the same pronoun is intuitively interpreted as having two distinct indefinites as antecedents – and the two indefinites have different readings (one is weak and the other is strong).

5. (Today's newspaper claims that, based on the most recent statistics:)
Every^{u'} company who hired a^{str:u'} Moldavian man, but no^{u''} company who hired a^{wk:u'} Transylvanian man promoted him_{u'} within two weeks of hiring.
6. (Imagine a Sunday fair where people come to sell their young puppies before they get too old and where the entrance fee is one dollar. The fair has two strict rules: all the puppies need to be checked for fleas at the gate and, at the same time, the one dollar bills also need to be checked for authenticity because of the many faux-monnayeurs in the area. So:)
Everyone^{u'} who has a^{str:u'} puppy and everyone^{u''} who has a^{wk:u'} dollar brings it_{u'} to the gate to be checked.

The above mixed reading DP-conjunction donkey sentences pose problems for the family of D-/E-type approaches to donkey anaphora because such approaches locate the

weak / strong donkey ambiguity at the level of the donkey pronouns. However, there is only one pronoun in both (5) and (6) above – and two distinct donkey readings associated with it. The PCDRT account, which locates the ambiguity at the level of the donkey indefinites, seems more plausible.

Furthermore, the PCDRT account predicts that the same indefinite cannot be interpreted as strong with respect to one pronoun (or any other kind of anaphor, e.g. a definite) and weak with respect to another pronoun – and this prediction seems to be borne out. By the same token, D-/E-type approaches predict the exact opposite: according to them, the same indefinite should be able to be interpreted as strong with respect to one pronoun and as weak with respect to another – which seems to be an incorrect prediction.

Discourse (2) is an instance of quantificational subordination. Crucially, its interpretation contrasts with the interpretation of discourse (7) below, whose first sentence is identical to (2a) above. Sentence (2a/7a) is ambiguous between two quantifier scopings: Harvey courts the same girl vs. a possibly different girl at every convention. Discourse (7) as a whole allows only for the "same girl" reading, while discourse (2) is compatible with both readings.

7. **a.** Harvey_u courts a_{u'} girl at every_{u''} convention. **b.** She_{u'} is very pretty.
(Karttunen 1976)

The non-local, cross-sentential interaction between quantifier scope and anaphora, in particular the fact that a *singular* pronoun in the second sentence can disambiguate between the two readings of the first sentence, can be captured in PCDRT because plural information states enable us to store both quantifier domains (i.e. values) and quantificational dependencies (i.e. structure), pass them across sentential boundaries and further elaborate on them, e.g. by letting a pronoun constrain the cardinality of a previously introduced quantifier domain.

The contrast between the two Karttunen examples is derived by giving a suitable dynamic reformulation of the independently motivated static meanings for generalized quantifiers and singular number morphology. In the process, we see how generalized

quantifiers enter anaphoric connections as a matter of course, usually functioning simultaneously as both indefinites and pronouns.

Finally, adding (discourse referents for) possible worlds to PCDRT enables us to account for discourse (3) above, which is a more explicit version of the naturally occurring discourse in (8) below.

8. [A] man cannot live without joy. Therefore, when he is deprived of true spiritual joys, it is necessary that he become addicted to carnal pleasures.

(Thomas Aquinas)

Discourse (3) exhibits complex interactions between entailment particles (i.e. *therefore*), modal anaphora and modal subordination: on the one hand, *therefore* relates the propositional contents (formalized as sets of possible worlds) contributed by the premise (3a) and the conclusion (3b) and tests that they stand in an entailment relation; on the other hand, the premise and the conclusion themselves are modal quantifications and, consequently, relate a restrictor and a nuclear scope set of possible worlds.

Moreover, the propositional contents of the two modalized conditionals in (3a) and (3b) can be determined only if we are able to capture: (i) the donkey anaphoric connection between the indefinite *a^u man* in the antecedent of (3a) and the pronoun *he_u* consequent of (3a) and (ii) the fact that the antecedent of the conditional in (3b) is modally subordinated to the antecedent of (3a), i.e. (3b) is interpreted as if the antecedent of (3a) is covertly repeated, i.e. as *if a man is alive and he doesn't have any spiritual pleasure, he must have a carnal pleasure*.

The discourse is analyzed in PCDRT as a network of structured anaphoric connections and the meaning (and validity) of the Aquinas argument emerges as a consequence of the intertwined individual-level and modal anaphora. Moreover, modal subordination is basically analyzed as quantifier domain restriction via structured modal anaphora; that is, the antecedent of (3b) is simultaneously anaphoric to the set of worlds and the set of individuals introduced by the the antecedent of (3a) and, also, to the quantificational dependency established between these two sets.

The dissertation is located at the intersection of two major research programs in semantics that have gained substantial momentum in the last fifteen years: (i) the development of theories and formal systems that unify different semantic frameworks and (ii) the investigation of the semantic parallels between the individual, temporal and modal domains. As the dissertation shows, one of the outcomes of bringing together these two research programs is a novel compositional account of non-local (modal and individual-level) quantificational dependencies as *anaphora to structure*.

The unification of different semantics frameworks, in particular Montague semantics, situation semantics and dynamic semantics (see Janssen 1986, Groenendijk & Stokhof 1990 and Muskens 1995a, 1995b, 1996 among others) enables us to incorporate the generally complementary strengths of these different frameworks and allows for an easy cross-framework comparison of alternative analyses of the same phenomenon.

Building on the Compositional DRT (CDRT) of Muskens (1996), chapters 2 through 4 of the dissertation incrementally develop a formal system couched in classical type logic which unifies dynamic semantics, in particular its account of basic kinds of cross-sentential / cross-clausal anaphora, and Montague semantics, in particular its compositional interpretation procedure and its account of generalized quantification.

The resulting CDRT+GQ system can compositionally account for a variety of phenomena, including cross-sentential anaphora, bound-variable anaphora, quantifier scope ambiguities and a fairly diverse range of relative-clause and conditional donkey sentences. Moreover, the analysis of donkey anaphora avoids the proportion problem and can account for simple instances of weak / strong donkey ambiguities. But CDRT+GQ cannot account for the three phenomena instantiated in (1), (2) and (3) above, i.e. mixed reading (weak & strong) relative-clause donkey sentences, quantificational subordination and the interaction between quantifier scope and number morphology on cross-sentential anaphora and modal anaphora, modal subordination and their interaction with entailment particles.

Plural Compositional DRT (PCDRT) pushes the framework unification program further and unifies in classical type logic the compositional analysis of selective

generalized quantification in Montague semantics, its account of quantifier scope ambiguities and singular number morphology with Dynamic Plural Logic (van den Berg 1994, 1996a, b). A novel, compositional account of mixed reading relative-clause donkey sentences (chapter 5) and an account of quantificational subordination and its interaction with singular anaphora (chapter 6) are some of the immediate benefits of this unification.

The introduction of (dref's for) possible worlds enables us to further extend PCDRT and unify it with the static Lewis (1973) / Kratzer (1981) analysis of modal quantification. The resulting Intensional PCDRT (IP-CDRT) system enables us to capture structured modal anaphora and modal subordination (chapter 7).

The account brings further support to the idea that the dynamic turn in natural language semantics does not require us to abandon the classical approach to meaning and reference: I show that the classical notion of truth-conditional *content* (as opposed to *meaning*, which I take to be context-change potential) can be recovered within IP-CDRT and this enables us to analyze the entailment particle *therefore* as involving structured discourse reference to (propositional) contents, contributed by the premise(s) and the conclusion of an argument.

At the same time, Intensional PCDRT (IP-CDRT) pushes further the second research program, namely the investigation of anaphoric and quantificational parallels across domains.

The anaphoric (and quantificational) parallels between the individual and temporal domains have been noticed at least since Partee (1973, 1984) and they have been extended to the modal domain by Stone (1997, 1999) and, subsequently, by Bittner (2001, 2006) and Schlenker (2003, 2005b) among others.

IP-CDRT extends this research program and brings further support to the conjecture that our semantic competence is domain neutral by providing a point-for-point parallel account of quantificational and modal subordination. For example, the quantificational subordination discourse in (2) above is analyzed in the same way as the modal subordination discourse in (9) below; in particular, the interaction between *a^u girl-every*

convention and *she_u-always* in (2) is captured in the same way as the interaction between *a^u wolf-might* and *it_u-would* in (9).

9. *A^u wolf might^p come in. It_u would_p attack Harvey first.*

(based on Roberts 1989)

IP-CDRT – which builds on and unifies Muskens (1996), van den Berg (1996a) and Stone (1999) – is, to my knowledge, the first dynamic system that systematically captures the anaphoric and quantificational parallels between the individual and modal domains (from the types of the discourse referents to the form that the translations of anaphoric and quantificational expressions have) while, at the same time, keeping the underlying logic classical and preserving the Montagovian approach to compositionality.

PCDRT differs from most previous dynamic approaches in at least three respects. The first difference is conceptual: PCDRT captures the idea that discourse reference to structure is as important as discourse reference to value and that the two have the same dynamics and should therefore be treated in parallel (contra van den Berg 1996a among others).

The second difference is empirical: the motivation for plural information states is provided by *singular* and *intra-sentential* donkey anaphora, in contrast to the previous literature which relies on *plural* and *cross-sentential* anaphora (see van den Berg 1996a, Krifka 1996b and Nouwen 2003 among others).

Finally, from a formal point of view, PCDRT accomplishes two non-trivial goals for the first time. On the one hand, it is not obvious how to recast van den Berg's Dynamic Plural Logic in classical type logic, given that, among other things, the former logic is partial and it conflates discourse-level plurality, i.e. plural information states, and domain-level plurality, i.e. non-atomic individuals (for more on this distinction, see the discussion of plural anaphora and quantification below).

On the other hand, previous dynamic analyses of modal quantification in the spirit of Lewis (1973) / Kratzer (1981), e.g. the ones in Geurts (1995/1999), Frank (1996) and Stone (1999), are not completely satisfactory insofar as they fail to associate modal quantifications with the propositional contents that they express (in a particular context)

and they fail to explicitly introduce these contents in discourse. Consequently, within these approaches, we cannot account for the fact that the entailment particle *therefore* relates such contents (across sentences), as shown, for example, by the Aquinas discourse in (3) above.

Two Extensions

The mostly foundational research pursued in this dissertation can be extended in various directions. I will outline here only two of them, namely:

- a cross-linguistic analysis of the interpretation and distribution of verbal moods when they occur under (particular kinds of) attitude verbs and in (particular kinds of) conditional structures;
- extending PCDRT with an account of plural anaphora and quantification.

De Se Attitudes and the Romanian Subjunctive B Mood

Intensional PCDRT seems to provide a suitable framework for a cross-linguistic investigation of aspect / tense / mood systems. I will illustrate the kind of issues that arise by briefly examining the interpretation and distribution of the subjunctive B mood in Romanian.

Romanian is the most widely spoken Romance language in the Balkan Sprachbund. Its distinctive position in the Indo-European spectrum has provided Romanian with a rich verbal morphology system, including two subjunctive (i.e. non-indicative finite) moods. The moods' distribution in intensional contexts is clearly interpretation-driven and the fine-grained distinctions drawn between different kinds of attitude reports and conditional structures suggest the existence of previously unnoticed semantic universals.

We will focus on the interpretation of the Romanian subjunctive B mood when embedded under attitude verbs like *crede* (believe), as shown in example (10) below. The main idea of the analysis is that subjunctive B is temporally and propositionally *de se* – thus extending the parallel between pronouns, tenses and moods to *de se* readings.