Flexible boolean semantics. Coordination, plurality and scope in natural language

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Reviewed by Roger Schwarzschild

Summary by the author

This dissertation is based on the compositional model theoretic approach to natural language semantics that was initiated by Montague (1970) and developed by subsequent work. In this general approach, coordination and negation are treated following Keenan & Faltz (1978, 1985) using boolean algebras. As in Barwise & Cooper (1981) noun phrases uniformly denote objects in the boolean domain of generalized quantifiers. These foundational assumptions, although elegant and minimalistic, are challenged by various phenomena of coordination, plurality and scope. The dissertation solves these problems by developing a **flexible** process of meaning composition, as first proposed by Partee & Rooth (1983). Flexible interpretation involves semantic operations without any phonological counterpart, which participate in the interpretation process and change meanings of overt expressions. The dissertation introduces a novel flexible system where a small number of operations describe the behaviour of complex phenomena such as 'non-boolean' *and*, the scope of indefinites and the semantics of collectivity with quantificational NPs.

The proposed theory is based on a distinction between two features of meanings in natural language:

I. The **semantic category** feature, which describes the distinction between **quantificational** denotations and **predicative** denotations.
II. The **semantic number** feature, which distinguishes between denotations ranging over **atoms** and denotations ranging over **sets of atoms**.

We can describe these features using the notation ±Q and ±S. Flexibility operators shift meanings between the four kinds of denotations that these two features describe.

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The boolean theory of coordination

The basic fact about coordination in many languages is its **cross-categorial** behaviour: morphemes like *and* and *or* can appear in coordinate structures of many different categories, as (partly) illustrated by the following simple sentences.

(1) a. Mary sang and/or Sue danced.
b. Mary and/or Sue sang.
c. Mary sang and/or danced.

Early versions of Transformational Grammar maintained that this property of coordination could be explained by assuming that at deep structure coordinators are sentential only, like the connectives of first order logic. A conjunction reduction transformation was assumed to relate phrasal coordinations at surface structure to sentential coordinations at deep structure. However, it was soon observed that this mechanism, in addition to its ill-founded assumption that first order logic is a linguistically relevant representational tool, also fails to describe many intricate facts about the semantics of coordination. For instance, while conjunction reduction correctly predicts sentence (2a), with VP coordination, to be equivalent to the sentential coordination (2b), it falsely predicts equivalence also between sentences (3a) and (3b). The pattern of correct predictions and false predictions reverses in (4) and (5).

(2) a. Every woman danced and sang.
b. Every woman danced and every woman sang.

(3) a. Some woman danced and sang.
b. Some woman danced and some woman sang.

(4) a. Every woman danced or sang.
b. Every woman danced or every woman sang.

(5) a. Some woman danced or sang.
b. Some woman danced or some woman sang.

We conclude that conjunction reduction is too crude in being sensitive neither to the identity of the coordinator nor to the identity of the quantifier.

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In opposition to the conjunction reduction rule, Boolean Semantics assumes that coordination can apply in **all** semantic domains, not only in the sentential domain of truth values. Thus, the 'logical form' of coordination in boolean semantics can be identical to its surface structure. The reason why coordinators such as *and* and *or* apply in different semantic domains is that all these domains have something in common: they are all boolean algebras. This means (among other things) that they are all ordered in a similar way. For instance, the sentential domain of truth values is ordered by **implication**: truth is 'greater than' falsity, or 1 > 0. The domain of (intransitive) predicates is similarly ordered by **set inclusion**: any set is 'greater than' its proper subsets. Such different order relations are all manifestations of one and the same relation: the **domination** order of boolean algebras. Similarly, the coordinators *and* and *or* denote the boolean operators *meet* and *join*, which apply in all the boolean domains. Keenan and Faltz's boolean semantics of coordination accounts for semantic relations between sentences as in (2)–(5) above in a remarkably elegant way.

The flexible boolean approach to 'non-boolean' *and*

One of the main challenges for the boolean treatment of coordination (as well as for conjunction reduction) comes from the 'collective' interpretation of NP conjunctions as in the following simple sentence.

(6) Mary and John met.

The standard boolean treatment incorrectly predicts (6) to be equivalent to the unacceptable sentence *Mary met and John met*.

Many previous works, notably Hoeksema (1983, 1988), conclude that the purely boolean treatment of *and* is incorrect, and propose that *and* also has a 'non-boolean' denotation. This assumption, unlike the Keenan and Faltz system, is rather stipulative: it does not explain why conjunctive coordinators such as *and* show collective behaviour in striking regularity across different languages of the world. Moreover, as reported in Payne (1985, 17–8), no language was found where other coordinators (e.g. parallel to English *or*) show a 'non-boolean' behaviour. Another general drawback of non-boolean accounts of conjunction is that they do not give a clear picture of the boolean/non-boolean variation in the meaning of *and* across coordinations of different categories. For instance, it is unclear why predicate conjunctions like *big and new* do not show a 'non-boolean' meaning equivalent to *partly big and partly new*.

One of the main observations of the dissertation is that the boolean analysis of *and* has in fact a mathematical property that allows to treat also 'collective' effects as in (6) without any change in the semantics of coordination. A conjunction such as *Mary and John* is standardly treated as a boolean coordination of generalized quantifiers. This is a quantificational denotation that ranges over atoms (+Q −S). However, the set of Mary and John, which is responsible for the collective interpretation of the NP, is in fact present in this 'distributive' quantifier: it is its **minimal set**. By applying a minimum operator, the noun phrase denotation is shifted to a quantifier over this set (a +Q +S denotation). This procedure accounts for the collective meaning of sentences like (6) without any postulation of a special meaning for *and*. The difference between *and* and *or* in such contexts follows directly from their boolean treatment and the formal definition of the proposed operator.

The choice function analysis of indefinites

A surprising semantic property of indefinites, observed by Fodor & sag (1982) among others, is their exceptionally free scopal behaviour when compared to other NPs. For instance, while sentence (7a) can be interpreted as in (7b) this is not the case in the infelicitous sentence (8a), which cannot have the interpretation of (8b). We say that the *some* indefinite in (7a) and the *every* noun phrase in (8a) contrast with respect to their ability to take scope over the conditional.

(7) a. If some woman I know gave birth to John then he has a nice mother.
b. For some woman I know x, if x gave birth to John then he has a nice mother.

(8) a. #If every woman I know gave birth to John then he has a nice mother.
b. For every woman I know x, if x gave birth to John then he has a nice mother (= if one of the women I know is John's mother then she is nice).

No standard mechanism (e.g. Quantifier Raising, Cooper Storage) for treating wide scope effects can account for such clear contrasts. Moreover, if a movement rule such as Quantifier Raising (QR) were responsible for 'wide scope' interpretations as in (7b) for sentences with indefinites, then this rule must have violated island constraints on movement (e.g. the adjunct island introduced by the conditional in (7a)). Such behaviour would contradict all that is known about movement operations in other domains.

Reinhart (1992, 1997) proposes a novel account of the exceptional wide scope interpretation of indefinites. While not introducing any change in the island restricted operation of QR, Reinhart proposes that indefinites should be interpreted using **choice functions**. These are functions that pick an element from every non-empty set. Wide scope readings of indefinites as in (7a) are analyzed as follows.

(9) For some choice function f, if the entity picked by f from the set of women I know gave birth to John, then he has a nice mother.

Under this formulation, there is no need to modify the QR rule, since existential quantification in (9) ('for some f') is obtained using the standard existential closure operator assumed in Discourse Representation Theory, which is independent of the position of the indefinite.

The dissertation shows that also the more complex scopal behavior of **plural** indefinites such as *three women* can be correctly treated using choice functions. It is argued that these NPs show two different scope effects: the scope of **distributivity** of plural indefinites is independent of their **existential** scope and must be captured by a separate distributivity mechanism. A central piece of evidence for this claim comes from the interpretation of sentences like the following.

(10) If three workers (in our staff) have a baby soon then we will have to face some hard organizational problems.

a. *There is* a set *A* of three workers such that *if each x* in *A* has a baby soon we will have to face some hard organizational problems.
   there is > if > each – an available scope relation
b. *There is* a set *A* of three workers such that for *each x* in *A*, *if x* has a baby soon we will have to face some hard organizational problems.
   there is > each > if – an **un**available scope relation

As in Ruys (1992), it is shown that (10b), where distributivity ('each') takes scope over the conditional ('if'), is not an available interpretation of sentence (10). Moreover, the acceptable interpretation in (10a) directly shows two distinct scope positions for the indefinite: one is the scope of the existential quantifier ('there is'), which escapes the conditional island; another is the scope of distributivity, which is restricted to remain within the island. Both this 'double scope' behaviour and the island restricted nature of distributivity are straightforwardly accounted for in the proposed analysis of choice functions and distributivity.

The dissertation makes two other contributions to the theory of choice functions in natural language:

I. The formal semantics of choice functions is defined within the boolean framework in a way that solves a central problem for this approach: the interpretation of indefinites with an empty N′ denotation, as in *some intelligent unicorn*.
II. The choice function mechanism is introduced as a **general** existential flexibility mechanism from predicative NPs to quantificational NPs. In the flexibility scheme that emerges, this is the inverse operator to the minimum operator responsible for the interpretation of 'non-boolean' conjunction.

The atom/set distinction and plural quantifiers

Consider the following contrasts between the (a) and (b) sentences:

(11)
a. All the/exactly five girls gathered in the hall.
b. *Every/exactly one girl gathered in the hall.

(12)
a. All the/exactly five girls gathered in the hall. (=(11a))
b. *All the/exactly five girls are the team that won the cup.

(13)
a. The (five) girls are the team that won the cup.
b. *All the/exactly five girls are the team that won the cup. (=(12b))

Each of these pairs illustrates another factor that affects the possibility to get a collective reading with quantificational NPs. The pair in (11) illustrates the necessity of plural number in order to get a collective reading. The pair in (12) illustrates the observation in Dowty (1986) that there are two kinds of collective predicates: predicates such as *gather*, that allow collectivity with *all* and other plural quantifier, and predicates such as *be the team that won the cup*, which resist collectivity in such contexts. The pair in (13) exemplifies a distinction between 'referential' NPs and 'quantificational' NPs with respect to the availability of collective interpretations.

The dissertation proposes a general account of such complex patterns, which is based on the following principles:

I. Flexibility operations that shift a denotation ranging over atoms to a denotation ranging over sets are allowed only with **morphologically plural** expressions.
II. With respect to the semantic number feature ±S, there are two kinds of predicates in natural language: predicates of feature -S like *sleep* or *be the team that won the cup*, which range over atoms, and +S predicates like *meet* or *gather* that range over sets of atoms. This new 'atom/set' typology is independent of the traditional distributive/collective distinction between predicates.
III. 'Referential' plural NPs like *the* (*five*) *girls* have an 'atom reading' following Landman (1996).

It is shown how these principles allow us to obtain a more general theory of plural quantification that develops existing treatments in the generalized quantifier school (Scha, 1981; Van der Does, 1993).

Additional topics

Three other main topics are treated in detail within the framework of the dissertation:

I. The status of distributivity operators in semantic theory. It is argued that these operators are **unary** (apply to only one argument of the predicate at a time) and **atomic** (range over atoms rather than on arbitrary sets of atoms).
II. The apparent 'non-boolean' behaviour of *and* in **predicate conjunctions**, as in the sentence *the books are old and new*, which is not equivalent to *the books are old and the books are new*. It is shown

how such effects are handled using a generalization of the **strongest meaning hypothesis** on reciprocals proposed in Dalrymple et al. (1998).

III. The 'wide scope' interpretation of coordination as in sentences like *every man and woman*. Such cases are treated using a revision of the boolean treatment, which assumes that *and* (unlike *or*) is meaningless, and its semantic function of boolean *meet* is carried by a (universal) grammatical operation.

1. Predicate-quantifier flexibility (Chapter 4)

In this chapter various 'flexibility operations' are discussed. One of them, ε_{cf}, is a generalization of the choice-function approach to indefinites, allowing the functions to apply to various set denoting expressions, not just indefinites.

Another operator, ε_{min}, is essentially a predicativizer. In a sense, it is a generalization of Partee's (1987) BE operator. Finally, as we will see below, the composition of ε_{cf} with ε_{min} effectively yields the operation of Winter (1996) that produces a collective reading out of the conjunction of two generalized quantifier denoting names. There is a third operator whose exclusion here will not affect the main point. The chart below provides further details on these operators.

Null element	Syntax	Meaning operation	What it does	An example
ε_{min}	$D'_p \rightarrow \varepsilon_{min} D'_q$	min	takes a set of sets returns a set containing the smallest one	min (λP.P (j)) = {{j}}
ε_{cf}	$D'_q \rightarrow \varepsilon_{cf} D'_p$	<f>	applies a choice function f to a set S and gives the set of sets containing f (S). Exception: if S is empty, <f> is empty.	Let A= {j,k,l} Let f (A) = k <f> (A) = λP.P (k)

Review by Roger Schwarzschild

Chapters 2 and 3 of this dissertation are largely based on previous work on conjunction (Winter, 1996) and on the use of choice functions to explain apparent wide-scope indefinites (Winter, 1997). In chapters 4 and 5 these two lines of investigation are drawn together in an interesting way. The result is a rich theory covering all three topics mentioned in the subtitle.

As explained in the abstract above, on Winter's view, *and*, even when collectively understood, has a meaning derived from propositional conjunction (so called boolean conjunction). Since propositions are elements of type t, I will call this view 't-only-conjunction'. As is the nature of a rich system such as Winter's, decisions in one part can affect how things develop in another part and one can often understand the system by trying to tease the various strands apart. My goal here will be to look at some of the results in chapters 4 and 5 and to trace the effects of adopting t-only-conjunction. Somewhat surprisingly, in chapter 4 we will find that it has consequences in the syntax. In chapter 5, we will find that t-only-conjunction leads to a view of type-shifters as the locus of a lexical generalization in the area of generalized quantifier theory.

This is a marvelous dissertation chock-full of interesting analyses of various phenomena. I recommend it highly. I couldn't possibly say everything I'd like to about it in this short review.

These operators are used in an analysis of the syntax of copular sentences in Hebrew, following discussion by Doron (1983). The central body of data revolves around the fact that the pronominal copula is obligatorily present in some cases but not in others. It must be present, for example, when followed by a name (1a)–(1b) but it may be omitted when followed by a bare indefinite (1c):

(1)

a. ha-xavera haxi tova šeli
the-friend most good mine
hi Dana
COPULAR-PRONOUN Dana
'My best friend is Dana'

b. *ha-xavera haxi tova šeli Dana
the-friend most good mine Dana
'My best friend is a Dana'

c. ha-xavera haxi tova šeli
the-friend most good mine
(hi) mora
COPULAR-PRONOUN teacher
'My best friend is a teacher'

Winter's analysis begins by assigning names to the category of D'_q with meanings of type <<e,t>,t>, while definites and indefinites (without an *eize* '*some*') are treated as D'_p and denote sets of singularities or pluralities. Here is a set of sample denotations in a model where John and Mary are lawyers, John is the man and Mary is the woman:

Expression	Syntactic category	Semantic type	Meanings
John	D'_q	ett	λP.P (j)
Mary and John	D'_q	ett	λP.P (m) & P (j)
the woman	D'_p	et	{m}
the lawyers	D'_p	ett	{ {j,m} }
a lawyer	D'_p	et	{j,m}

Simplifying a bit, syntactically the predicative position must contain an expression in D'_p and the copula is obligatory if an operator has applied in the formation of that expression (see (107) on p. 192: expressions like *every man* are in DP_q and are therefore forbidden to appear in predicate position). This automatically guarantees that simple indefinites and definites can appear in predicative position without the copula. As for names, they are generated as D'_q so they could only appear in predicative position if the ε_{min} operator applied. The singular case is slightly more involved so let's look at the plural. If ε_{min} applies to the D'_q *Mary and John* we get a D'_p with exactly the meaning of *the lawyers*. This is a fine predicate but since an operator applied a copula is required, thus explaining data like in (1b). This system derives a number of impressive results beyond just capturing the copula generalization stated so far. The first result has to do with Doron's (1983, 191) observation 'that when bare indefinites appear in copula-less predicative position they must be interpreted with narrowest scope'. The sentence *Rina asked if Dani is a pianist whose name I had forgotten* has a wide-scope reading according to which Rina was asking about a particular pianist. If the sentence is translated without a copula, this reading is missing. In Winter's system, the choice function operator ε_{cf} is a tool for generating wide-scope indefinites. In other words, to get the wide-scope you need an operator, if you need an operator, you must have a copula. The operator analysis of obligatory copula explains another surprising fact. While the copula is not necessary when a simple indefinite is in predicative position, as in (1c) above, it becomes necessary, according to Winter, with conjoined indefinites:

(2) *štey ha-našim halalu soferet ve-mora
two-of the-women those author and-teacher
'those two women are an author and a teacher'

(3) štey ha-našim halalu *hen*
two-of the-women those PRONOUN-COPULA
soferet ve-mora
author and-teacher
'those two women are an author and a teacher'

Even though it is possible to generate a D'_p from two indefinites without the aid of any operators, it turns out that to get the relevant reading of (3) operators must be used and this again predicts the obligatory presence of the copula.

Demonstrating why operators are needed here will give the reader a quick summary of much of chapters 2 and 4 of this dissertation. The story begins with the boolean assumption that conjunction always denotes intersection. Now, if the meanings of the predicates *author* and *teacher* are simply intersected we get the set of individuals each of which is both an author and a teacher. But that is not the intended reading here. We are after a reading in which one of the women is an author and the other is a teacher. How can this be achieved in this system? Since (the Hebrew equivalents of) *an author* and *a teacher* are D'_p the ε_{min} operator is **syntactically** out of the question at this point. Instead we apply the ε_{cf} operator to each expression and we get:

(4) a. ε_{cf} (an author) $\Rightarrow \lambda$P[P (f (author'))]
b. ε_{cf} (a teacher) $\Rightarrow \lambda$P[P (g (teacher'))]

Combining these with intersective conjunction we now get:

(5) [ε_{cf} (an author) and ε_{cf} (an teacher)] $\Rightarrow$
(λP.P (f (author')) $\cap$ λP.P (g (teacher')))
=λP.P (f (author')) & P (g (teacher'))

Assuming for a moment that f picks Mary from among the authors and g picks John from among the teachers, this meaning is just the meaning of *Mary and John* given in the chart above. The expression is a D'_q because that is what ε_{cf} produces, so, as we did earlier, we apply ε_{min} to the result to get a D'_p. This gives us:

(6) ε_{min} (ε_{cf} (an author) and ε_{cf} (an teacher))
= {{f (author'), g (teacher')}}

This is now a predicate that holds of just one plurality, which is fine for us. (3) now says that those two women are a plurality consisting of one author and one teacher (the function variables are freely existentially quantified in Winter's system). And again, we correctly predict that there should be a copula in this case because operators have applied.

The result in (6) is a predicate so if we wanted to use this in non-predicative position, we would have to apply ε_{cf} again. This would give us a generalized quantifier over the plurality, that is, a set of sets each containing the author-teacher plurality. This means that something very important has happened. Winter has successfully produced a collective reading for nominal conjunctions without departing from his assumption that *and* always means intersection (see below for why this would be desirable). The last step in which ε_{cf} is applied to a predicate to get a generalized quantifier is quite general and would be used to create subject phrases out of the other predicative expressions discussed above: *the lawyers*, *a teacher*, *the lawyer*, *the woman*, ε_{min} (*John and Mary*).

One final fact which is explained by this approach to copular constructions has to do with at-least/exactly readings of numeral indefinites like *two lawyers*. As an indefinite, *two lawyers* is interpreted as a set of pluralities, each plurality is a set of two lawyers. To say that those women over there are two lawyers is to say that the predicate *two lawyers* applies to the plurality of those women over there. This entails that there are exactly two women over there. On the other hand, if I want to use *two lawyers* in non-predicative position I have to use ε_{cf}. In this case, to say that two lawyers were sitting over there is to say that there is a plurality of two lawyers over there. This allows that there could be more lawyers. Thus, Winter's system accounts for the fact that numeral indefinites have an exactly reading in predicative position but not (necessarily) in non-predicative position.

This proposal has a semantic and a syntactic component unlike the proposal of Partee (1987), which forms the starting point for Winter's discussion. Whereas Partee relies on a semantic characterization of a predicative NP along with semantically driven type-shifting principles, Winter relies on syntax to define the predicative position and he uses null operators in the syntax. This last point is significant. These operators must be syntactically present both to regulate the kinds of phrases they apply to and the kinds of phrases they produce. If these operators applied freely, constrained only by the semantic type of their arguments, havoc would ensue, as the chart below demonstrates:

Undesirable collocation	What it would mean	What prevents it
ε_{min} (*each man*)	the men	*each man* is not a D'_p
ε_{cf} (*each man*)	the men by themselves or with others	*each man* is not a D'_q
[ε_{min} (*John*)] *left*	only John left	[ε_{min} (*John*)] is D'_p, subjects are D'_q
[ε_{cf} (*John*)] *paid $100*	John by himself or with others paid $100	*John* is a D'_q, ε_{cf} applies to D'_p
[*the boys*] *left*	only the boys left	*the boys* is a D'_p, subjects are D'_q

The presence of these syntactic structures raises a number of questions. Is there independent motivation for the different kinds of D′? Is there syntactic evidence for the null operators? Are they overt in any language? If they were, then, for example, wide-scope indefinites would look different than narrow scope ones and conjoined NPs would look different and more complex when collectively interpreted than when distributively interpreted. We might also expect to find further syntactic restrictions on the use of these operators translating into syntactic constraints on the presence of collective readings (Winter's neat discussion of *both…and* on pp. 183–4 seems to point in this direction). Since the syntactic differences between D'_p and D'_q (not to mention a third category D'_-) do not correlate with semantic type, could we expect a language where the syntactic categories are reversed, that is, a language where *John* is a D'_p and where *the boys* is a D'_q?

Perhaps the most important point here is that this syntactic machinery turns out to be a fairly direct result of Winter's analysis of collective conjunction. Hence an argument for or against the syntax counts as an argument for or against that analysis. This is a rather surprising result which bears elaboration. Winter's method for collective conjunction relies on the fact that at the 'bottom' of a quantifier like $\lambda P[P(m) \& P(j)]$ lies a set, {j,m}. To capitalize on this fact (a) we need an operation that applies to quantifiers and (b) we need to identify pluralities with sets, more generally, a plurality has to be identified with a **predicate** meaning. Each of the problematic collocations in the chart above can be traced to one or both of these assumptions. What this means is that one should in principle be able to pick and choose here, keeping Winter's striking analysis of the copula, without adopting t-only-conjunction. Here's a sketch of what Winter's analysis might look like without t-only-conjunction:

I. Pluralities are members of the domain of entities.
II. Names are uniformly type e expressions, definites and indefinites are uniformly type <e,t>
III. $and_{<<e,e>,e>}$ denotes plurality formation, indicated with a + (Link, 1983).
IV. Optional choice function operators apply to expressions of type <et> to produce expressions of type e with no reflex in the syntax. (section 3.5, and possible objections in sections 3.4.1, 3.4.2)
V. **Q** is an e → <e,t> type-shifter: $\mathbf{Q} = \lambda x.\{x\}$ (p. 146)
VI. Predicative positions are uniformly type <e,t>. (Partee, 1987).
VII. In Hebrew, the pronominal copula is obligatory only if **Q** has applied.

The facts discussed above all follow on this system. Names need a copula because they require the use of Q. Wide-scope indefinites need a choice function and that produces type-e meanings so that again Q is pressed into service and the copula becomes obligatory. Q also becomes necessary to achieve the intended reading of the predicate *be a teacher and an author*:

(7) $Q(f([\![author]\!]) + g([\![teacher]\!]))$

The exactly reading of predicative NPs follows in the same way. Expressions like *every boy* are excluded from predicate position for type reasons.

In section 2.3.7 there are a number of reasons for adopting the t-only-conjunction view, and the above system doesn't necessarily answer these. However, there is one initially rather persuasive argument for t-only-conjunction which is worth revisiting now. Winter's method for arriving at collective conjunction correctly produces the collective reading of the *and* in (62) according to which it entails (63) (repeated below as (8) and (9):

(8) Mary and (either) [Sue or John] met. (=Winter's (62))

(9) Mary and Sue met or Mary and John met. (=Winter's (63))

The claim in chapter 2 is that collective *and* in type <<e,e>,e> is no match for the disjunctive *Sue or John*. However once we learn about choice functions the argument weakens. The 'Winter minus t-only-conjunction' system sketched above assigns the subject of (8) the meaning in 10:

(10) $m + f(Q(s) \cup Q(j)) = m + f(\{s,j\})$

Here we capitalize on Winter's discovery (p. 175) that the choice function mechanism allows "disjunction to 'take scope' over the collectivization process". Depending on what individual f chooses from {s,j}, either Mary met with Sue or she met with John, as (9) claims.

A result of separating t-only-conjunction from the rest of Winter's system is that barring any type-shifting operations, names denote in type e rather than Winter's <<et>,t>. This means that we should **not** expect NP-based distributivity for name conjunctions. While there are potential objections to such a move in section 6.1.3, there may be arguments in its favor outside of simplicity. With NP based distributivity excluded, the locus of distributivity will always be in the predicate. A potential argument for such a setup might develop from cases in which for a given NP subject, distributivity is possible for some predicates but not for others. The examples in (11)–(14) afford us such a case. While (11) cannot mean (12), (13) can mean (14).

(11) Bill Clinton and Al Gore are the President or the Vice President.

(12) Bill Clinton is the President or the Vice President and Al Gore is the President or the Vice President.

(13) Bill Clinton and Al Gore weigh over 150 lbs.

(14) Bill Clinton weighs over 150 lbs and Al Gore weighs over 150 lbs.

2. Plural quantification (chapter 5)

A centerpiece of chapter 5 is the analysis of plural quantificational noun phrases such as *exactly 2 ducks*. Winter has cleverly combined insights from Scha and Van der Does into a single type-shifter *dfitw*, which operates on determiner meanings. The penultimate proposal (123 on p. 249) is repeated below:

(15) $\text{dfitw}(D) = \lambda A\, \lambda B.D\,(\cup A)\,(\cup (A \cap B))\ \&$
$[A \cap B \neq \varnothing \rightarrow \exists W \in A \cap B[D\,(\cup A)\,(W)]]$

dfitw has three main features. First, it incorporates the idea that quantification always 'counts' singularities, never pluralities. *exactly 2 ducks* counts two individual ducks and not two duck pluralities. This is the reason for all the union symbols. The next feature has to do with the existential in the consequent of the conditional. Winter (p. 243) finds it false or highly marked to say:

(16) Exactly 5 students drank a glass of beer together. (=Winter's 107)

to describe a situation where three students drank one beer together and two other students drank a second beer. In this situation there are exactly 5 cooperating beer drinking students, so the first conjunct will hold true:

(17) [exactly-5] (∪ [students']) (∪ (students' ∩ drink-a-beer-together'))

But there is **no** group of five students that drank together and that is what the consequent of the conditional requires. Finally, the effect of the antecedent of the conditional is to nullify this requirement when the quantifier is monotone decreasing, unlike in previous analyses (though see Nerbonne, 1995). We do not, for example, want to give existential import to a noun phrase like *no boys*. I assume Winter also had in mind universal cases. This formulation allows *all the boys drank together* to be vacuously true if there are no boys.

I'd like to focus on the status of *dfitw* as a type-shifter. The motivation for the type-shifting mechanism can be appreciated in the context of the following two examples:

(18) All the committees reached a decision together last week. (=Winter's (94))

(19) Every committee reached a decision together last week. (=Winter's (95))

According to Winter, (18) has two readings which correlate with an ambiguity he posits in the meaning of plural nouns. On one reading, (18) is synonymous with (19). This reading is explained by taking *all* and *every* to have the same meaning and allowing that a plural noun has the meaning of the corresponding singular (ignore the definite article in (18)). On the second reading of (18), the committees meet with each other. This reading is achieved by applying *dfitw* to the meaning of *all* and then combining it with the other meaning of *committees*, a set of sets of committees. I will symbolize this second meaning of *committees* with Winter's operator *pdist* which just forms the power set minus the empty set:

(20) dfitw (all') (pdist-committee') (reach a decision together')

Assuming there are committees, (20) requires the plurality consisting of all the committees to be in the extension of *reach a decision together*. *dfitw* comes in to shift the type of the determiner when its argument is semantically plural.

I use the term 'semantically plural' because this shift really only cares about semantics and doesn't help or hinder the syntax. Since *diftw* is a type-shifter it would apply if *every* combined with plural nouns, but English syntax disallows that. And, since *every* and *all* have the same meaning, *all* could be combined with the meaning of a singular noun if only the syntax allowed the combination. This is all to say that the syntax of determiners is completely irrelevant to *dfitw*.

Whereas in Scha and Van der Does' analyses, there are several shifts leading to an ambiguity in the meanings of **plural determiners**, Winter has collapsed them into one, leading to what appears to be a univocal meaning. In this regard, it is interesting to note that diftw could easily be modified so as to be applicable to any determiner, regardless of what the semantics of its arguments is. Instead of extracting singularities using the union operator, we can use the operator defined below:

(21) $\underline{\cup}A = \{x: x \in A \text{ or } \exists W \in A: x \in W\}$

Making this substitution and modifying the antecedent of the conditional in dfitw slightly we arrive at:

(22) $\underline{\text{dfitw}}\ (D) = \lambda A\ \lambda B.D\ (\underline{\cup}A)\ (\underline{\cup}\ (A \cap B))$
$\&\ [\ (\exists W \in A \cap B) \rightarrow \exists W \in A \cap B[D\ (\cup A)\ (W)]]$

This operation can apply now to all quantifiers. If A, B contain only singularities, then the conditional becomes trivially true (W is a variable over pluralities) and $\underline{\cup}$ is harmless. If A, B contain pluralities, $\underline{\cup}$ amounts to ∪, and the antecedent of the conditional says what it said before. Since dfitw applies in all cases, we might wonder whether it really should be implemented as type-shifter at all. Could we not just view dfitw as general fact about the true meanings of determiners? For example, could we just say that universals like *every* or *all* simply denote the relation *dfitw* (D) where D is just the subset relation and *exactly 2* just means *dfitw* (2!) where 2! relates two sets just in case the cardinality of their intersection is 2? This question leads us right back to t-only-conjunction. Winter's method for achieving collective conjunction depends on the fact that pluralities are the same type as predicate meanings. This means that semantically plural common nouns denote in a different type from singular ones, hence a type-shifter is needed to allow a determiner meaning to combine with both singular and plural nouns. On the other hand, if we allowed that pluralities and singularities were the same type of thing, we actually couldn't have a **type**-shift here.

At this point, we've drawn a line from Winter's implementation of t-only-conjunction through to the status of *dfitw* as a type-shifter. Here are some considerations for addressing that issue. Should the use of type shifting be restricted? If so how? Partee (1987) talks about 'natural type shifts'. Is *dfitw* natural? Another issue stems from the fact that *dfitw* applies to a whole class of lexical items and doesn't have to apply within the course of derivation. Is it correct to use type-shifters to express these lexical generalizations? For comparison, consider van Benthem's (1984, 446) observation that 'the behaviour of Q is completely specified by the couples of cardinalities (a,b), with $a = |A-B|$, $b = |A \cap B|$, for all E, A, B such that $Q_E AB$'. Should we capture this generalization by letting determiners denote relations between numbers and have a type shifter that takes their syntactic arguments and delivers $|A-B|$ and $|A \cap B|$?

These are very big questions and we aren't about to settle them here. The main conclusion I'd like to draw from *dfitw* is that the explanatory value of Winter's proposal is not diminished by removing it from the t-only-conjunction setting and that doing so has important consequences.

Finally, it is important to see that the issue of the status of *dfitw* is orthogonal to the other part of the chapter 5 proposal. In a nutshell, Winter claims that while both *gather* and *be a team* can be predicated of plural DPs like *the girls*, *gather* is +S and has pluralities in its extension while *be a team* is −S and has only singularities in its extension, though these singularities are teams. Assume the girls are a team that gathered in the park. This means that the girl team is in the extension of *be a team* and the plurality of its members are in the extension of *gather*. The following holds (girl' is the set of girls):

(23)
a. girl' ∩ be-a-team' = ∅ pdist-girl' ∩ be-a-team' = ∅
b. girl' ∩ gather' = ∅ pdist-girl' ∩ gather' ≠ ∅

These equations explain the judgements in (11) and (12) of Winter's discussion above, even if *dfitw* is part of the meaning of any determiner. The judgement in (13) relies on an independent and special treatment of the plural definite.

3. The Boolean viewpoint

In Winter's summary, it is explained that the coordinators *and* and *or* denote the boolean operators meet and join in various domains. It is then pointed out that problems arise with collectives such as (6) *John and Mary met*. 'The standard boolean treatment incorrectly predicts (6) to be equivalent to the unacceptable sentence *Mary met and John met*.' This is so because the standard boolean treatment applies only to domains of type t or those derived from type t. This entails a treatment of *John and Mary* as in the chart given earlier.

But the algebraic perspective allows for a different picture of how *and* works according to which there is no problem with collectives. On this view *and* simply denotes one of the boolean operators, regardless of whether or not the domain is 't-based'. This picture should of course be sketched in such a way that it is the same operator in all domains.

When defined, join and meet are operations over partially ordered sets. Consider then the following plausible orderings (read ≥ as 'is greater than or equal to'):

(24)
Propositions: $p \geq q$ iff: p entails q
Properties: $P \geq Q$ iff: having P entails having Q
Entities: $x \geq y$ iff x includes y

The intuition behind these orderings can be appreciated by thinking about more or less ordinary uses of *include*:

(25)
Propositions: John's erasing his last sentence *included* John's erasing some of the words in his last sentence.
Properties: walking *includes* leg-moving
Entities: the American Presidents *include* Bill Clinton

For any domain with elements a and b where meets and joins exist we have:

(26)
a. meet (a,b) = the greatest element c such that: $a \geq c$ and $b \geq c$
b. join (a,b) = the smallest element c such that: $c \geq a$ and $c \geq b$

Intuitively, meet (a,b) gets you minimally at or below a and b, join (a,b) gets you minimally at or above a and b. Working through a few examples, one finds that *and* corresponds pretty closely to join in all three of the domains listed above. For example, if we take the properties of walking and riding and join them, we get a property that entails both walking and riding, that is, the property denoted by *walking and riding*. And if we join John and Mary we get the plurality which includes the two of them. That plurality can perform collective acts that neither of its members performs.

Winter reports that Payne has observed that no language was found where *or* shows 'non-boolean' behavior. This leads us to wonder what the status of *or* is on the picture just sketched. In t-based domains, *or* denotes meet, but not in the domain of entities. To some extent this makes sense. For any two propositions, there is a proposition that both of them entails, but for many pairs of entities, for example John and Mary, there is no entity that both of them includes. But this will not explain everything. Even if John is included in the doctors and the lawyers, we cannot refer to him with *the doctors or the lawyers*. We are left then with the puzzle of why *or* cannot denote meet in a domain where meet is **partially** defined. But I don't see that this puzzle is particular to the view outlined here. It arises as soon as we posit that *or* denotes a boolean operator and go on to ascribe to the entity domain a structure on which such operations are defined.

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