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Situation-based Semantics for Adverbs of Quantification

Stephen R. Berman

0. Introduction

In his 1975 article Adverbs of Quantification, David Lewis brought to the attention of linguists and natural language semanticists a new kind of quantifier, to which he gave the name of the title of his paper. These adverbs (henceforth AQ) have the property that they can endow certain kinds of NPs with their quantificational force (henceforth QF). Examples of such AQ-sentences, as I will call them, are the following, taken from Lewis's article:

(1) a. Riders on the Thirteenth Avenue line seldom find seats
  b. A quadratic equation usually has two different solutions
  c. A man who owns a donkey always beats it now and then
  d. Caesar seldom awoke before dawn

The indefinite NPs in (a)-(c) have the QF of their respective AQ; thus (a) speaks of few riders on the Thirteenth Avenue line, (b) of most quadratic equations, (c) of all <man, donkey> pairs such that the man owns the donkey. There is no indefinite in (d), and the name Caesar does not receive a QF from seldom; rather, the sentence speaks of few occasions of Caesar's awaking.

In this paper I will consider two questions pertaining to AQ-sentences: (i) how they are interpreted (truthconditionally); and (ii) what kind of logical form supports their interpretation (I leave for another time an investigation of how the logical form is related to the surface syntactic form). In section 1 I review Lewis's treatment of these questions; in section 2 I discuss two problems it encounters, one of which, the proportion problem (sec.2.1), has received some attention in recent work, while the other, iteration of AQ (sec.2.2), has not to my knowledge been discussed before, at least in this connection. I will briefly review how these problems might be dealt with by various modifications to Lewis's analysis and its heirs: these modifications will be seen to be more or less ad hoc and unrelated (sec.2.3). In light of this, in section 3 I will develope an alternative

approach, suggested by work of Angelika Kratzer's, which has the advantage of accounting for these problems in a way that derives from the modeltheoretic structure of the theory. I will conclude by showing that my analysis straightforwardly accounts for the so-called 'sage plant' sentences discussed in Heim (1982), which have been taken to provide prima facie support for the Lewisian approach.*

1. AQ as Unselective Binders

Lewis's analysis has three major assumptions: (i) AQ are unselective quantifiers, (ii) AQ are restricted quantifiers, and (iii) indefinite NPs can be represented in LF as free variables.[1] Let me elaborate on these points. By treating indefinites as variables (more precisely, as open sentences, or variables with a restriction), Lewis accounts for the fact that they may have various QFs, depending on the quantifier they are in the scope of. Thus he correctly predicts the observed QFs of the indefinites in (1.a-c). Secondly, by making AQ unselective quantifiers, ie quantifiers not specified to bind designated variables but that may, in principle, bind all free variables in their scope, Lewis accounts for the 'donkey' sentence (1.c), where we speak of all donkey-owning men and all donkeys owned by a man: in other words, the AQ _always_ binds and thus supplies its QF to (the variables in LF representing) both _a man_ and _a donkey_. Finally, in treating AQ as restricted quantifiers, Lewis assigns to AQ-sentences a logical form that has a tripartite structure, consisting of (i) the AQ; (ii) the restrictive clause, which constitutes a restriction on the range of values the free variables in the scope of the AQ may take; and (iii) the main clause or 'modified sentence' from which the AQ and restrictive clause have been extracted. We can represent this LF schematically as:

(2) $A : \alpha : \beta$

where A is the AQ, α is the restrictive clause and β is the main clause. Lewis observes that the restrictive clause is often realized syntactically as an _if_- or _when_-clause, although he is careful not to connect these with the material implication operator of propositional logic.[2]

Turning to interpretation, Lewis proposes that an AQ-sentence with LF as in (2) is true in a model iff β is true in A admissible cases, where a case is a sequence of values assigned to the free variables in the sentence, and admissibility is determined by the restrictive clause α.

In addition, Lewis takes the sorts of variables over which AQ quantify to be ontologically heterogeneous: they include at least variables over the set of individuals and those over the set of time-intervals, and perhaps event-variables as well, eg for sentences like (1.d). Finally, since Lewis is taking AQ to be unselective, picking up all free variables in their scope, there is no need to consider alternative value assignments.

To illustrate Lewis's approach I give an analysis of the following sentences:

(3)a. If a film critic dislikes a movie he sees he always pans it
A film critic who dislikes a movie he sees always pans it

Both of these sentences receive the LF in (b) (by various transformations that Lewis posits) and the evaluation in (c):

b. Always : x is a film critic, y is a movie, x sees y, and x dislikes y : x pans y

c. ⟦(3.b)⟧ is true iff under every assignment g of values to the free variables in (3.b) such that g(x) is a film critic, g(y) is a movie, g(x) sees g(y), and g(x) dislikes g(y), g(x) pans g(y).

2. Problems for Unselective Binding

There are two salient properties of AQ as unselective binders: (i) they bind all of the free variables in their scope; (ii) in consequence of this, the number of value-assignments to each of the free variables in a given sentence depends directly on the AQ. These properties give rise to two types of problems which call into question the treatment of AQ as unselective quantifiers.

2.1. The Proportion Problem

Consider, as an example of the first problem, the following sentence (after one in Baeuerle and Egli (1985)) on the reading given in the Lewisian LF in (b):

(4)a. If a letter arrives for me, I'm usually at home

b. Usually : x is a letter & x arrives for me at t : I'm at home at t

Since the AQ is usually, in evaluating this LF we count 'most' assignments of values to free variables, (the number in a given situation may depend on contextual or other factors):[3]

(4)c. ⟦(4.b)⟧ is true iff for more than 50% (say) of the assignments g of values to the free variables in (4.b) such that g(x) is a letter and g(x) arrives for me at g(t), I'm at home at g(t).

Now suppose that (4.a) is uttered in the following situation: during the interval over which (4.a) holds there are 29 times at which one letter arrives for me and I'm not at home when any of those letters arrives; on one occasion, however, 50 letters arrive for me and I am at home when they arrive. Then according to (c), (a) (on the reading in (b)) is true in about 63% (50 out of 79) of the admissible assignments, which falls within the range of usually. So according to this analysis, (4.a) is true in the situation described; nevertheless, it intuitively strikes one as false.

Nirit Kadmon has dubbed this the 'proportion problem' (cf Kadmon (1986); it is also discussed in Root (1986) and Rooth (1986); a variant of this problem was observed by Partee (1984)). It is liable to arise in sentences with AQ that supply a QF of greater than existential but less than universal force, such as usually, often, seldom, etc.[4] Moreover, Baeuerle and Egli (1985) observe that sentences in which there is no anaphoric relation (of individual variables) between the restrictive and the main clause are especially liable to the proportion problem. When there is such an anaphoric relation, the proportion problem may not obtain; sentence (1.a) of Lewis's (his (9)), repeated here as (5.a), contains one of these AQ, and yet his analysis works in this case, in contrast to (4) above:

(5)a. Riders on the Thirteenth Avenue line seldom find seats

On the reading of this sentence given in the LF (5.b), it receives the evaluation in (5.c):

(5)b. Seldom : x is a person & x rides the Thirteenth Avenue line at t : x finds a seat at t

c. [[(5.b)]] is true iff for less than 30% (say) of the assignments g of values to the free variables in (5.b) such that g(x) is a person and g(x) rides the Thirteenth Avenue line at g(t), g(x) finds a seat at g(x).

Note that the individual variable x occurs in both clauses in the (5.b). Lewis observes that (5.a) "may be true even though for 22 hours out of every 24--all but the two peak hours when 86% of the daily riders show up--there are plenty of seats for all."

2.2. Iteration

Another problem for the unselective binding analysis arises with sentences that contain more than one AQ, like the following:

(6) If I'm expecting company, I usually vacuum twice

For me, this sentence has an interpretation represented by the following paraphrase:

(7) Most time-intervals in which I'm expecting company are such that there are two time-intervals in each of them in which I vacuum

This reading cannot be obtained on an analysis that treats both AQ uniformly as unselective binders.[5] To show this we need to determine an appropriate LF. While both AQ seem to quantify over time-intervals, the one _twice_ quantifies over is contained within the one over which _usually_ quantifies. Given this embedding relation between the two AQ, we may plausibly assume (8) as the LF for (6):

(8) usually : I'm expecting company at t_1 :
[twice : t_2 is contained within t_1 :
I vacuum at t_2]

Putting aside the unaccounted fact that we have to stipulate the embedding relation of the restrictive clause for _twice_, (8) will not give the correct interpretation: t_1 is unselectively bound to two different quantifiers, thus receives two different QFs, and the relation between my expecting company and my vacuuming is not established.

2.3. Modifications to unselective binding

These two problems for the unselective binding approach derive precisely from treating every free variable in the restrictive and main clauses of the LF for AQ-sentences as bound to the same quantifier. In the case

of iterated AQ, doing this results in the wrong truthconditions because different AQ bind and thus supply different QFs to the same variables. In the proportion sentences, the wrong truthconditions stem from the fact that unselective binding treats all variable assignments on a par, whereas in such sentences there is an evident asymmetry among the variables.

Both of these problems may be dealt with by modifying the primary assumptions of the unselective binding approach (points (i) and (ii) mentioned at the beginning of this section). In fact, no sooner had Lewis proposed treating AQ as unselective quantifiers than he pointed out that they cannot be strictly unselective (1975, 8); subsequently Heim (1982) incorporated this realization into her theory of quantification by formulating an algorithm to select which variables the AQ will quantify over. We can avoid the iteration problem by employing such 'selective unselectivity'. Thus, we may give (6) the following LF:

(9) usually(t_1) : I'm expecting company at t_1 :
    [twice(t_2) : t_2 is contained within t_1 :
    I vacuum at t_2]

While this LF does yield the correct interpretation for (6), it only does so becaue we have stipulated the embedding relation between the two time variables.

As for the proportion problem, that may be handled by modifying assumption (ii) of the unselective binding approach; namely, that all variables bound to an AQ receive the same QF. The proportion problem belies this assumption; as Partee (1984, 278) put it, the question is "how to individuate proper embeddings [in the sense of Kamp's (1981) DR theory] of the antecedent clause [= the restrictive clause]." One way to answer this question is to treat AQ as quantifiers over entities that allow, in certain circumstances, considering groups of individuals, rather than to have them directly quantify over individuals. Thus in (4.a), for example, we would quantify over something like deliveries of letters, not <letter,time> pairs; (4.a) would then correctly be evaluated as false in the situation described above. Accounts of the proportion problem along these lines have been worked out in various ways in Baeuerle and Egli (1985), Root (1985), Rooth (1986), and Kadmon (1986).

So the proportion and iteration problems can be handled; note, however, that the solutions sketched above

to each of these problems result from unrelated and ad hoc modifications to the hypothesis of unselective binding. In particular, the stipulation of the embedding relation between the two AQ in (9), needed to solve the iteration problem, has no motivation from the architecture of the theory to which it is added, and the asymmetric treatment of variables, needed to solve the proportion problem, is incompatible with their being uniformly unselectively bound by the AQ. In view of this, I would like now to present an analysis of AQ-sentences, which, sharing features of these solutions that enables it to solve the proportion and iteration problems, yet does so in a way that derives directly from the very modeltheoretic structure of the theory itself.

3. AQ as quantifiers over situations

3.1. Kratzer's situation-based modelstructure

For my analysis I adopt apects of the semantics developed in recent work by Angelika Kratzer for the analysis of counterfactuals and generics. Kratzer (1986) bases her theory on the notion of a possible 'situation', which she takes as a basic entity of the model structure. Intuitively, a possible situation is a 'part of the world' (Kratzer (1986, 3); she borrowed this characterization from Lewis (1986)). In addition, there is a partial ordering on the set S of all possible situations that relates members of S to each other in such a way that for any situation s $\in$ S there is a unique maximal situation of which it is a part, its possible world.[6] In other words, in a given subset of S, some situations are 'part of' others, up to and including the maximal situation for this subset, the possible world of these situations.

3.2. A situation-based analysis of AQ-sentences

The basic idea of this situation-based approach is to treat AQ as quantifiers over possible situations; thus, I am rejecting Lewis's assumption that AQ are unselective quantifiers over variables. I do, however, retain his assumptions that AQ are restricted quantifiers and that indefinite NPs can be represented in LF as free variables. Since such variables are not directly dependent on the AQ for the assignment of their values, the way I propose that they get their value is simply that for each situation we have to consider in evaluating a sentence, there must be some admissible value assignment to each free variable in the sentence. In effect, then, free variables are directly bound to an existential quantifier. In short, I am suggesting that an AQ-sentence is evaluated with

respect to both possible situations and value assignments (cf the standard analysis of modalized sentences as evaluated with respect to both possible worlds and value assignments).[7] Another feature of my evaluation algorithm derives from the tripartite LF I am adopting from Lewis together with the part-of relation on the set of possible situations: we consider the number situations the AQ tells us to in which the restrictive clause is true (under some value assignment), and for each of these situations, we consider an extension of it, a more inclusive situation, in which the main clause is true. The sentence as a whole is true iff both the restrictive and the main clause are so satisifled.

Before I present the formal truth definition, two issues must be addressed, that concern the situations and the value assignment functions. First, for AQ that require considering either all possible situations that satisfy the restrictive clause or just one (such as always or (at least) once, ie, the AQ corresponding to the standard first-order quantifiers), it does not matter how big a situation we choose to consider; in particular, it does not matter whether the situation contains irrelevant information. However, a problem is liable to arise if we consider a subset of S with more than one member, that satisfies α, as we do with AQ like exactly twice. The following sentence illustrates the problem:

(10) A man sneezed (exactly) twice

According to the situation-based modelstructure I am employing, this sentence would be true even if exactly one man sneezed exactly once--for example, in the two situations in which (i) a man sneezed in the livingroom, and (ii) the same man sneezed at exactly the same time in the house the livingroom is part of. This problem stems from the mereological nature of situations: it is always possible, within the latticestructure of possible situations, to pick a more inclusive situation (a larger element in the lattice) than a given one, up to the possible world of that situation; however, the bigger situation may be so in ways that are completely irrelevant to the sentence in question--in the case at hand, the situation in which the man sneezed in the house includes but is not included in the situation in which the man sneezed in the livingroom (thus the latter is a part of, though distinct from, the former), but this is irrelevant to the fact of the man's sneezing, which is all the sentence is about.

In view of this problem, it will not do in general to consider just any type of situation with respect to which which the restrictive clause is satisfied under some value assignment; we must confine ourselves to the minimal situations in which the restrictive clause is true. In this way, we simply exclude irrelevant information from the evaluation, which makes sense, since if such information were relevant to the interpretation of the utterance, we would expect it to be recorded (or accomodated) somehow in the discourse.[8]

The second issue I want to bring up before presenting the truth definition arises because (i) I retain Lewis's tripartite LF for restricted quantification, with the requirement that the restrictive clause be satisfied for the sentence as a whole to be true; and (ii) the existentially quantified assignment function introduced in the evaluation is within the restrictive clause (as it must be to be within the scope of the AQ). The evaluation is, as I summarized it above, a two-step procedure; let me reiterate it more explicitly now: first, we determine the truth of the restrictive clause for however many situations the AQ specifies, by looking for some value assignment that satisifies the conditions on the free variables of the restrictive clause; next, we determine the truth of the main clause by, for each situation we considered in evaluating the restrictive clause, considering some extension of that situation that is satisified by the same assignment of values to the free variables in the main clause. The problem arises if there is more than one satisfying value assignment--we must somehow guarantee that we use the same assignment for evaluating the extension of a given situation as we did for evaluating the situation itself. Although this is intuitively easy to comprehend, it is not clear to me how to express this formally. In effect the alternative assignment function with respect to which the main clause is evaluated is a kind of metalinguistic donkey pronoun, because it is outside of the scope of the existential quantifier that introduced it. For a certain class of sentences, this does not lead to problems, given our treatment of AQ as quantifiers over minimal situations, as characterized above. I return to this in section 3.3.1; but now let me present the formal situation-based truthcondition for AQ-sentences.

My formulation of the truth definition follows the standard practices in first-order predicate logic and in quantified modal logic of considering, respectively, alternative value assignments and alternative possible

worlds (or, in this case, possible situations). I employ the following notation: $\leq$ is the part-of ordering on S, thus $s \leq s'$ means that s' is an extension of s; and $g' \sim g$ means that the only assignments on which g' and g might differ are those to the free variables in the sentence being evaluated relative to g'.

(11) For all g, for all $s \in S$, $[\![A{:}\alpha{:}\beta]\!]^{s,g}$ is true iff for A minimal[9] $s' \in S$ such that $s' \leq s$ and there is a $g' \sim g$ such that $[\![\alpha]\!]^{s',g'}$ is true, then there is an $s'' \in S$ such that $s' \leq s'' \leq s$ and $[\![\beta]\!]^{s'',g'}$ is true.

To illustrate this analysis, let us apply (11) to the LF of (3.a), repeated here, with its evaluation in (12):

(3)b. Always : x is a film critic, y is a movie, x sees y, and x dislikes y : x pans y

(12) For all g, for all $s \in S$, $[\![(3.b)]\!]^{s,g}$ is true iff for A minimal $s' \in S$ such that $s' \leq s$ and there is a $g' \sim g$ such that $[\![$x is a film critic, y is a movie, x sees y, and x dislikes y$]\!]^{s',g'}$ is true, then there is an $s'' \in S$ such that $s' \leq s'' \leq s$ and $[\![$x pans y$]\!]^{s'',g'}$ is true.

3.3. The proportion problem

Now let us see how this analysis handles the proportion problem, exemplified by (4.a), repeated here as (13.a). Applying (11) to its LF (13.b),[10] gives (13.c):

(13)a. If a letter arrives for me, I'm usually at home

b. Usually: x is a letter & x arrives for me : I'm at home

c. For all g, for all $s \in S$, $[\![(14.b)]\!]^{s,g}$ is true iff for most minimal $s' \in S$ such that $s' \leq s$ and there is a $g' \sim g$ such that $[\![$x is a letter & x arrives for me$]\!]^{s',g'}$ is true, then there is an $s'' \in S$ such that $s' \leq s'' \leq s$ and $[\![$I'm at home$]\!]^{s'',g'}$ is true.

Whether (13.c) yields the correct evaluation or not depends on just what counts as a minimal situation. If it is one in which there is exactly one letter, then (13.c) would wrongly evaluate the sentence as true. However, since in my analysis the AQ does not directly supply variables with its QF, there is some latitude as regards what can count as a minimal situation.

One way of exploiting this flexibility is to recognize that certain events (or certain situations, etc) are vague with respect to how they may be individuated (cf Davidson (1980), and references therein, and much other discussion in the philosophical literature), and consequently too, with respect to how many individuals may participate in them for the situation still to count as minimal. Thus, given the fact of our world that letters typically arrive in bunches constituting a single delivery, letter-arriving is plausibly classified as such a vague situation, wherein the arrival of 50 letters is ordinarily on a par with that of a single letter; this skewed individuation results in the proportion problem for unselective binding that (13.a) gives rise to. In contrast, the situation of busriders-finding-a-seat typically enforces maximal individuation, one rider to a seat-finding constituting a minimal situation, and that is why the proportion problem does not contradict the unselective binding approach in (5.a).

Note that the vagueness hypothesis is not translatable into the (unmodified) unselective binding approach, because there truth is not determined with respect to situations, but simply by counting the members of a predicate's extension; therefore, one cannot remain within the spirit of that analysis and still encode sensitivity to situation/event individuability.

The notion of event-individuability is a notoriously slippery one, depending on many factors, such as world-knowledge, the lexical semantics of the predicates involved, the semantics of groups, and so on. I will not pursue these considerations further in this paper; cf the references cited above. Nor will I pursue here the question of how vagueness should be formally treated; cf Kamp (1975) for one such treatment.

3.3.1. Some remarks on the 'donkey' assignment functions

I noted above that the alternative value assignment in the truth definition (11) behaves like a metalinguistic donkey pronoun, which had potentially bad consequences for certain sentences, but, given quantification over minimal situations, not for others. Among the latter are the Baeuerle and Egli sentences like (13), in which the indefinite NP in the restrictive clause is not anaphorically resumed by a pronoun in the main clause. In such cases it does not matter if there is more than one satisfying assignment; since there are no free variables in the main clause (cf the LF (13.b)), the outcome will be the same no matter how many satisfying assignments there

are.

Actually, definition (11) works all right even if there is an anaphoric relation between the restrictive and main clauses, as in the following sentence:

(14) If a letter arrives for a student, she is usually at home

as long as the variable corresponding to an indefinite in the restrictive clause that is pronominally resumed in the main clause does not have more than one satisfying value in the model per minimal situation. Thus, in (14), the minimal situation in which the restrictive clause is true may well include more than one letter, but not more than one student; in such a case, my definition makes the correct prediction.

In sentences in which, however, there is more than one satisfying value assignment to the variable corresponding to an indefinite and its donkey pronoun, we are squarely faced with the above-discussed problem of guaranteeing identical values to the variables that appear in both the restrictive and the main clause. There are two types of cases where we have to consider multiple assignments, exemplified by the following sentences:

(15) If a farmer owns a donkey, he always feeds it
(16) If a letter arrives for me, it usually brings bad news

The interpretation usually assigned to (15)--the classic donkey sentence--is that every farmer feeds every donkey he owns; that is the prediction of most previous analyses of these sentences (eg Lewis (1975), Kamp (1981), Heim (1982), Hornstein (1984), and May (1985), among others), as well as of mine. If, however, (15) can be true if a farmer who owns more than one donkey feeds some but not all of them, as has sometimes been suggested (eg Haïk (1984)), then my account would have trouble.[11] In (16), the restrictive clause is identical to that in (13.a), for which we appealed to vagueness to explain the proportion problem. If vagueness works the same way in this case, so that the minimal situation in which the restrictive clause in (16) is true can contain more than one letter, then my analysis would have trouble; if it contains only one letter, we are all right.

While sentences of this type do indeed constitute potential problems for my formal analysis, it is worth pointing out that intuitions about the conditions under

which such sentences are true or false are notoriously insecure and dependent on a variety of factors, such as choice of predicate and intonation (as Kadmon (1986) observed). In fact, it could be argued that it is a benefit of my analysis that its predictions are uncertain in just those kinds of cases where our own intuitions of the truthconditions are often uncertain. Moreover, in those cases where, on the other hand, our intuitions are quite secure, such as the classic proportion cases of Baeuerle and Egli, the predictions of my analysis are certain, and in accord with our intuitions.

3.4. Iteration

Let me now show how my analysis treats the iteration problem. First, the logical form I propose for an AQ-sentence with more than one AQ (henceforth interated AQ-sentences) is a generalization of the Lewisian LF A : α : ß in (2): a sentence with n AQ is to be analyzed as consisting of n AQ-sentences, one embedded within the other, with an embedded AQ-sentence constituting the main clause of the immediately dominating AQ-sentence. This may be schematically represented as follows:

(17) $A_1 : \alpha_1 : [A_2 : \alpha_2 : [...[A_n : \alpha_n : \beta]]]$

where $A_1,....,A_n$ are AQ and $\alpha_1,....,\alpha_n$ are their respective restrictive clauses. If n = 1, this reduces to (2). As for the interpretation of such an LF, I propose that it is evaluated simply by recursively applying the truth definition (11).

My assumption of (17) as the LF for iterated AQ-sentences gives rise to two questions: (i) how do we determine the embedding relations among AQ-sentences; in other words, how do we determine the relative scopes of the various AQ; and (ii) what constitutes the restrictive clause for each AQ? General answers to these questions are hard to give, and I will not attempt to do so in this paper.[12] I will, however, consider a particular case: the iterated AQ-sentence (6), repeated here:

(6) If I'm expecting company, I usually vacuum twice

The restrictive clause of _usually_ is simply the _if_-clause: we are looking for all minimal situations in which I'm expecting company. The restrictive clause for _twice_, however, is not so straightforward: although _twice_ appears to be quantifying over minimal situations in which I vacuum, we need to have both a restrictive clause and a main clause according to (17); if 'I vacuum' is the

restrictive clause, what is the main clause? I claim instead that 'I vacuum' in fact constitutes the main clause of twice, and I assign (6) the following LF:

(18) Usually : I'm expecting company : [twice : T : I vacuum]

The restrictive clause for twice is T, which stands for a necessarily true sentence, a tautology. What I am proposing is that, when the syntactic representation of an embedded AQ-sentence does not have both a restrictive and a main clause, then the truth of the sentence depends wholly on the truth of the main clause. This position accords with the usual assumption about the semantics of natural language conditionals, reflected in Lewis's tripartite LF for AQ-sentences and his evaluation algorithm for it, that if the antecedent is true, then the sentence as a whole is true if the consequent is. Thus, (18) will be true iff each of most minimal situations in which I'm expecting company can be extended to two minimal situations which are necessarily true, both of which in turn can be extended (as of course they can, by default) to a situation in which I vacuum; this amounts, for the embedded AQ-sentence, to saying that there are two situations in which I vacuum.

Note that (18) is similar to the LFs for (6) I discussed when considering the unselective binding approach and its modifications. There is a key difference, however: on my analysis it is not necessary to stipulate the embedding relation between the iterated AQ. Such a relation follows directly from the modeltheoretic structure on which the truth definition is based; that is, the inherent part-whole ontology of situations.[13] I take this to be the chief advantage of my approach to iterated AQ-sentences over the modified unselective binding approach that I sketched out in section 2.3.

There is a technical matter in the evaluation of iterated AQ-sentences that I would like to briefly discuss. My assumption that an iterated AQ-sentence is evaluated simply by recursively applying definition (11) to the LF works without complication for a sentence like (6), in which the embedded AQ-sentence contains no free variables that also appear in a higher AQ-sentence. But consider the following sentence, and its associated LF:

(19)a. When a postman brings good news, he always rings twice

b. always : x is a postman & x brings good news : [twice : T : x rings]

Recursively applying definition (11) to (b) we get:

c. For all g, for all s ∈ S, $[\![(19.b)]\!]^{s,g}$ is true iff for all minimal s′ ∈ S such that s′ ≤ s and there is a g′ g such that $[\![$x is a postman & x brings good news$]\!]^{s',g'}$ is true, then there is an s′′ ∈ S such that s′ ≤ s′′ ≤ s and $[\![$twice : T : x rings$]\!]^{s'',g'}$ is true,
iff
there are two minimal situations s^3 and s^4 ∈ S such that $s^3 \leq s''$ and $s^4 \leq s''$ and $s^3 \neq s^4$ and there is a g′′ g′ such that $[\![T]\!]^{s^3,g''}$ and $[\![T]\!]^{s^4,g''}$ are true, then there are s^5 and s^6 ∈ S such that $s^3 \leq s^5 \leq s$ and $s^4 \leq s^6 \leq s$ and $[\![$x rings$]\!]^{s^3,g''}$ and $[\![$x rings$]\!]^{s^4,g''}$ are true.

The problem in (c) has to do with the assignment function g′′. As I mentioned when I introduced definition (11), I follow the standard practice of employing alternative assignment functions that differ at most only on the free variables within the sentence currently under evaluation; this is what g′ is with respect to g above. But when we go on to evaluate the embedded AQ-sentence, following the algorithm we introduce yet another alternative assignment, g′′, and with it, the problem: for we must guarantee that g′′ will assign the same values to the free variable x in the embedded AQ-sentence as g′ assigned to the same variable in the immediately dominating sentence.

Here is one way to address this problem. We can think of the free variables within the scope of an AQ, and the assignment functions from which they get their respective values, as belonging to that AQ, since they are introduced with it. What we need is a way of keeping track of which variables belong to which AQ, and have only those variables that belong to a given AQ A supplied values by the assignment function g^A that also belongs to A: variables within the scope of A but not belonging to it, but rather to a higher AQ, will get their values not from g^A but from the assignment function that belongs to that higher AQ. In effect, what I am proposing is that the AQ binds the variables introduced under it, as well as any occurrences of them that appear under the scope of a more embedded AQ. This proposal is similar to familiar selective binding of variables, but quantification remains crucially different: the AQ still does not supply its QF directly to the variables--these still get their values

from the assignment functions. AQ, in short, although they bind variables, still quantify over minimal situations; therefore, our treatment of the proportion problem remains unaffected.

On this proposal, then, the LF for (19.a), instead of (19.b), might take the following form:

(20) Always(x) : x is a postman & x brings good news : [twice : T : x rings]

Thus, x will be assigned values only by the assignment function belonging to always, not by that belonging to twice.

While this idea seems to me on the right track, how to formulate an algorithm for achieving it may not be quite so straightforward. It would be easy enough to stipuate a logical form that respected the requisite AQ/variable relationship, as in (20), but deriving such an LF from the syntactic representation is another matter; perhaps something along the lines of Heim's (1982) indexing mechanisms might be employed. The issue involves such matters as the determination of the restrictive and main clauses, as well as that of the relative scopes of the AQ; and these questions require a treatment of the syntax-LF mapping, an issue I have not addressed in the present paper, and which I leave for future research.

3.5. Sage plant sentences

My analysis of AQ-sentences also accounts for the so-called 'sage plant' sentences, which have been taken to constitute one of the strongest arguments for the unselective binding analysis of donkey sentences. Consider the following example (modified after Heim's (1982, 89(12)), where the problem is first discussed):

(21) If someone buys a sage plant here he usually buys eight others along with it

The problem, which Heim raised as a criticism of analyses of donkey sentences in the spirit of Evans (1977, 1980), is that there is no uniqueness-implication on the anaphoric it (which an Evans-type analysis predicts there to be unless more is said); unselective binding accounts for this, since both the pronoun and its indefinite antecedent are bound by the AQ.

On my analysis (21) has the following LF:

(22) Usually : x is a person & y is a sage plant & x buys y here : x buys eight others along with y

By evaluating this according to (11), we also avoid the uniqueness-implication: we consider minimal situations in which a person buys a sage plant, and look for some value assignment satisfying this; then we look for an extension of such minimal situations in which eight other sage plants are bought; since the assignment function remains the same in both cases, and in the restrictive clause we considered an arbitrary sage plant (whatever value satisfied the conditions on the free variable), the pronoun in the main clause is not interpreted as referring to a specific sage plant.

This result crucially depends on evaluating AQ-sentences with respect to both minimal situations and value assignments. If we evaluated AQ-sentences only with respect to minimal situations, the uniqueness-implication could not be avoided. This is because, in the absence of value assignments to free variables (there would be no variables in the LF) the minimal situations over which the AQ quantifies would have to contain exactly one person and exactly one sage plant--thus, specific individuals--such that the person buys the sage plant; then we would look for extensions of these situations in which _the_ person buys eight other sage plants in addition to _the_ one he bought; that is, we would not be able to consider arbitrary individuals. It is only free variables supplied values by assignment functions that gives us the requisite arbitrariness.

4. Conclusion

In this paper I have attempted an analysis of AQ-sentences that I consider an improvement over Lewis's original account in terms of unselective binding. Lewis's analysis is faced with two debilitating problems: (certain kinds of) proportion sentences, and iteration. While these problems can be handled by modifying unselectivity and stipulating embedding relations, such solutions are merely addenda to the semantic framework, not inspired by it. In contrast, my approach, drawing on Kratzer's situation-based modelstructure, solves these problems in ways deriving from the underlying structure of the semantic theory itself. Situations have a mereological ontology; thus we get embedding for free. And having AQ quantify over situations rather than variables, we can handle--indeed, we expect to find--situations consisting

of groups of individuals. Finally, by introducing an assignment function with each situation, we can handle arbitrary individuals and as a consequence, the sage plant sentences. The next step is to develope a comprehensive algorithm for generating the tripartite LF for AQ-sentences from their syntactic structure.

Notes

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1. As Heim (1982, 128-129) points out, Lewis is not committed to point (iii); but Heim's own work and that of Kamp (1981) have provided considerable evidence for it, at least in the context of AQ-sentences.

2. Lewis states, "the _if_ of our restrictive if-clauses should not be regarded as a sentential connective. It has no meaning apart from the adverb it restricts (p.11)." In other words, _if_ is semantically empty, it just serves as a syntactic marker of a restriction on the domain of quantification of an AQ. Lewis observes (footnote, p.11) that _if_ could serve as a sentential connective if the modeltheory contains a third truthvalue, which is assigned to the sentence if the _if_-clause is not true, and if only those cases which do not make the sentence third-valued count as admissible. Farkas and Sugioka (1983) adopt a similar analysis of _if_-clauses, though they do not employ a third truthvalue, which may be problematical.

3. Åqvist, Hoepelman, and Rohrer (1980) present a variant of this analysis, in which a proportion of the n-tuples satisfying the intersection of α and β to the m-tuples satisfying α is set up. I believe this version is susceptible to the criticisms I am raising against the pure Lewisian one, so I will not pursue it.

4. Lewis noted (footnote 2, p.7) another problem these quantifiers give rise to: if all the infinitely many variables in the domain of the assignment function are

assigned values, the satisfying assignments for these quantifiers will always be the same proportion, namely ∞/∞. Therefore, we should consider only assignments to variables occurring in the sentences we are evaluating.

5. The same is true of Lewis's (10) (= (1.c)) where, I would argue, now and then is an AQ; though Lewis himself does not mention the possibility of iterating AQ, despite this example.

6. Technically, a finite subset of S so ordered forms a complete joinsemilattice, of which the maximal element is the unique possible world of those situations.

7. Kadmon (1986) presents a conceptually somewhat similar analysis, couched within Kamp's (1981) discourse representation theory, in which truth is relative to both embedding functions and assignments of values to free variables; however, the ontology of Kamp's theory is rather different from that which I am assuming, and I suspect it would need additional assumptions that I do not in order to handle iteration; vide infra.

8. The need to resort to minimality is recognized in Bauerle and Egli (1985); though they do not use situations like those I employ (theirs are more akin to the notion of situations in Barwise and Perry (1983), ie, tuples of a time variable and a sequence of individual variables), and consequently their characterization of minimality is different from mine (vide note 9.)

9. I use the following definition of minimality for situations, which is relativized to the conditions expressed by the restrictive clause:

> A situation $s \in S$ is minimal with respect to the conditions expressed by α if, for some g, $[\![\alpha]\!]^{s,g}$ is true and for all $s' \in S$ such that $s' \leq s$, if $[\![\alpha]\!]^{s',g}$ is true then $s' = s$.

10. Unlike the Lewisian LF (4.b) for (4.a), it is not necessary to have an explicit time variable in the LF (14.b), since on my approach the situation with respect to which the main clause is evaluated is an extension of the situation with respect to which the restrictive clause is evaluated; thus the clauses are related in virtue of the evaluation algorithm and the part-whole ordering on the set of possible situations.

11. Actually, Haïk made that claim with reference to the

relative clause version of (16): every farmer who owns a donkey feeds it; I do not know if she would say the same about the *if*-clause variant. Note too that the relative clause does not contain an AQ; I do not claim that my present analysis should hold for such cases, which may well involve another kind of quantification. My own judgment is that (16) would indeed be false if meant to describe a situation in which not every donkey owned by a farmer is fed by him, whereas the relative clause version may be true in such a case, though I am less sure of my judgment here.

12. I believe that focus can play an important role in the answer to question (ii); see Rooth (1985) for relevant discussion. As for question (i), some preliminary research I have done suggests that here too focus and intonation interact with word order and lexical properties of individual AQ, to help determine the scope relations. While I will not go into details here, some examples may help to illustrate the point:

(i)a. A postman often rings twice
b. Often, a postman rings twice
c. A postman rings twice, often
d. Twice, a postman rang often
e.*Twice, a postman rings often
f.(*Twice,) a postman often rings
g. A postman rings often

(a) and (b) mean that there are many situations of a postman ringing twice; (c) means this too, showing that linear order does not (always) determine relative scope. (d) means that in two situations, a postman rang many times. *Twice* cannot be used generically; that is why (e) is bad (unless understood as a contemporaneous report, or the 'historic present'). The situations over which *often* quantifies appear to differ according to whether it precedes of follows the verb: if the former, it quantifies over situations of a postman ringing; if the latter, it quantifies over just the ringings. This accounts for the judgment in (f): the sentence is good without *twice*, and means that there are many situations in which a postman rings; but with *twice* it is bad for the same reason as (e), because then the sentence is generic. In (g), with *often* quantifying only over ringings, the meaning is that in 'all', or 'generically many', situations, a postman rings many times; that is, there is an implicit AQ with a 'generic' QF (cf Farkas and Sugioka (1983) and Wilkinson (1986) for arguments for such a generic operator). These facts give just some indication of the kinds of questions

that remain to be investigated. The topic is a wide-open one, in which semantics, syntax, and phonology all interact.

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