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QUANTIFIERS, INFERENCE, AND VARIABLE BINDING

Taisuke Nishigauchi

1. Introduction

This paper considers the linguistic and logical problems raised by sentences like the following, which was first presented and discussed by the philosopher, P.T. Geach (1962, 1972).¹⁾

(1) The man who owns a donkey_i beats it_i.

The problem will be briefly stated as follows: what is the correct characterization of the anaphoric relation between the quantified NP *a donkey* and the pronoun that appear in (1)? To put it more technically, our problem will be rephrased as: what is the adequate semantic representation of the anaphoric relation as seen in (1) at the level of logical form (LF)? This problem is not as easy to solve as it appears to be at first sight. The NP *a donkey* is a quantifier phrase associated with the existential quantifier. The necessity for this treatment is validated by the sentence (2), in which there is a scope interaction between the existential quantifier associated with *a donkey* and the universal quantifier associated with *every man*,

*This is a radically revised version of Chapter III, § §3.2.1-3.2.3 of my M.A. thesis. I wish to thank Professor Yoshinobu Mōri for comments and discussions on the earlier version of this paper.

1) Similar examples are presented in Geach (1972), which are the following.

(i) Every/No/Some man who stole a book_i from Snead made a lot of money by selling it_i.

The following example, which is also due to Geach (1972), requires a more elaborate analysis.

(ii) Every man who borrows a book_i from a friend_j eventually returns it_i to him_j.

For an analysis of this sentence along the line of the approach adopted in what follows, cf. § 3.2.6.1 of Nishigauchi (1979)

the latter having wider scope (on the normal interpretation).

(2) Every man who owns a donkey_i beats it_i.

This pronoun cannot be simply viewed as a constant term bearing the same index as *a donkey*, for a quantified NP cannot normally 'bind' a constant: a binding relation holds only between a logical operator and an individual variable that appears in its scope.

Up to the present, there have been two proposals presented for the solution to this problem. One proposal, put forth by Geach (1972) (only as a tentative solution), is to allow *a donkey* to take the whole sentence as its scope. On this analysis, (1) will be assigned a logical form more or less like (3).

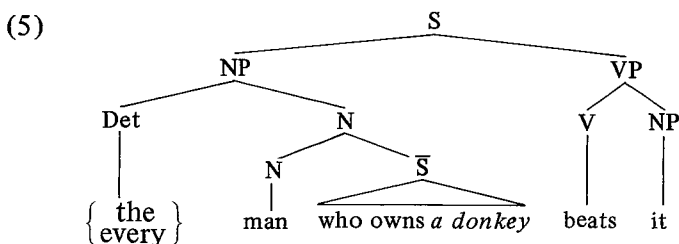
(3) $(\exists x: \text{donkey}) ((\forall y: \text{man}) ((y \text{ owns } x) \wedge y \text{ beats } x))$

If this analysis were correct, then we could regard the pronoun in (1) as a variable bound by the topmost existential quantifier. However, this proposal immediately fails *vis à vis* the example (2): the logical form (4), which is required by this analysis, does not stand for the correct interpretation for this sentence.

(4) $(\exists x: \text{donkey}) ((\forall y: \text{man}) (y \text{ owns } x \rightarrow y \text{ beats } x))$

For, this logical form says that there is a (certain) donkey such that every man (as a group) owns and beats it. However, the sentence (2) does not allow of such an interpretation. Instead, (2) should be construed as 'for every man, if there is a donkey that he owns, then he beats the just-mentioned donkey (that he owns)'. But if this is the case, we would be forced to stipulate that the existential quantifier take narrower scope than the universal. On the other hand, there is an independently motivated principle in the linguistic literature (e.g. cf. Lasnik (1975)), which states that the scope of a quantifier is

specified as the S or NP that dominates it, or in other words, everything that is (c-)commanded by the quantifier. The (near-) surface structure for (1)–(2) would be something like (5) (assuming that semantic rules operate on this structure).²⁾



As this tree diagram indicates, the quantified NP *a donkey* cannot take the root S in its scope, and its scope is specified as \bar{S} that is contained in the relative clause: such being the case, the quantified NP cannot bind the pronoun that appears under VP, which is outside \bar{S} . The observation so far makes it sufficiently clear that the logical forms (3)–(4) are not correct representations for (1)–(2).

Another proposal, due to May (1977), is that the pronoun in (1)–(2) be treated simply as a ‘free’ variable, a variable that is not bound by any logical operator, and that its value may be satisfied by any entity in the domain of discourse: so, as a possible interpretation for this sentence, May claims, an entity may be chosen that is a member of the domain of the antecedent quantifier phrase *a donkey*, for the assignment of the value to the free variable. However, such an analysis also fails, given sentences like the following.

- (6) a. *The man who doesn't own a donkey_i beats it_i.
 b. *The man who owns $\left\{ \begin{array}{c} \text{every} \\ \text{each} \end{array} \right\}$ donkey_i beats it_i.

2) Although the purpose of this paper is not to argue for any specific theoretical framework, I will tentatively adopt the framework of interpretive semantics. However it is fairly easy to translate the notations adopted here into the generative semantics framework.

If the pronoun *it* is allowed to be free, and furthermore, to be assigned ‘any arbitrary entity’ as its value, as May assumes, then, why is it impossible to assign it an entity that is a member of the domain specified by *each/every donkey* in (6b)? Furthermore, the impossibility of the anaphoric relation in (6a) would be a mystery altogether for such an approach. (To this, we will return below.) Intuitively, the difference between (1) and (6) with respect to the anaphora possibility seems to be attributable to the different properties of the quantifiers associated with the antecedent NP’s. So, May’s proposal will be radically weakened to the extent that it gets deprived of its theoretical interest, because his claim is now shown to be adequate only for the anaphoric relations whose antecedent NP is associated with the existential quantifier (in the non-negative context). In other cases, such as (6), his logic cannot be maintained.

The discussion thus far has made it clear (i) that the pronoun that appears in (1)–(2) cannot be simply regarded as a constant term, nor as a bound variable, or a ‘free’ variable; and (ii) that what makes the anaphoric relations in (1)–(2) possible is the special property of the existential quantifier associated with the antecedent NP, in contrast to other quantifiers as seen in examples like (6).

2. Discourse Referent Formation Rule

2.1 On closer inspection, it turns out that the anaphoric relations as seen in (1)–(2) are very akin, or substantially identical to, the phenomenon of ‘discourse referents’, as seen in (7).

(7) John has a car_i . He keeps it_i in the garage.

For detailed discussion, cf. Karttunen (1969). In (7), the

indefinite NP introduced in the first sentence is referred to in the second sentence by means of the definite pronoun. The anaphoric relation as seen in (7) is identical to that involved in (1)–(2), in that in either case the indefinite NP is related to a pronoun that appears outside the c-command domain of the antecedent.³⁾ Furthermore, as the following paradigm shows, the anaphoric relation as seen in (1)–(2) is subject to the same constraint as that on sentences like (7): if the indefinite NP is commanded by the negative, modal, or a verb of propositional attitude (or, so-called ‘opaque’ verb), the anaphora possibility is ruled out.

- (8) a. John doesn’t have a car_i. *He keeps it_i in the garage.
 b. *The man who doesn’t own a donkey_i beats it_i.
- (9) a. John may have a car_i. ?*He keeps it_i in the garage.
 b. ?*That man, who may own a donkey_i, beats it_i.
- (10) a. Mary believes that John has a car_i. (*It_i’s in the garage.
 b. (*The man who wants to own a donkey_i beats it_i.

However, it should also be noted that if both the antecedent indefinite and the pronoun appear in the (c-)command domain of the negative, modal, and the opaque verb, the anaphoric relation is permitted.

- (11) a. You can’t eat a cake_i and have it_i.
 b. It is not the case that the man who owns a donkey_i beats it_i.
 c. No man who owns a donkey_i beats it_i.
- (12) a. You may have a cake_i and eat it_i.
 b. It is possible that the man who owns a donkey_i beats it_i.

3) A node α ‘c(onstituent)-commands’ a node β if neither α nor β dominates the other and the first branching node which dominates α dominates β . Reinhart (1976) claims that a quantifier phrase can bind a pronoun (as a variable) only if the former c-commands the latter.

- (13) a. John wants to catch a fish_i and eat it_i.
 b. John believes that the man who owns a donkey_i beats it_i.

In all the cases in (8)–(13), the indefinite NP is used non-specifically. Although the matter is by no means clear-cut, I take it that an indefinite NP is used nonspecifically iff that NP does not admit of the implication that the referent of that NP exists (in the domain of discourse), or it does not admit of the inference of Existential Generalization. Thus, it is a common property shared by such logical predicates as the negative, modal, and the opaque verb to block Existential Generalization with respect to the indefinite NP that appears in the (c-)command domain of these predicates.⁴⁾ (For detailed discussion, cf. Ioup (1977) and Nishigauchi (1979).) Now, it is a significant generalization obtained from the discussion so far that a nonspecific indefinite cannot be linked with a definite pronoun that appears outside the (c-)command domain of the predicate which does not admit of Existential Generalization, but that a nonspecific indefinite surely can be linked with a pronoun that also appears in the (c-)command domain of the nonspecificity-inducing predicate. This is exactly what is happening in (11)–(13).⁵⁾

4) There are other predicates that show the same property: negative implicative verbs and other predicates which have the negative implication in their complement sentences (for details, cf. Karttunen (1971)), and so-called 'creative' verbs such as *make*, *write*, etc., among others, do not admit the indefinite that appears in their complement to be linked with a pronoun outside its c-command domain.

(i) Mary prevented John from buying a typewriter_i. (??) It_i was an IBM.
 (negative implicative)

(ii) Erica is writing a novel. (??) She likes it_i. (ok on the reading 'she likes writing the novel')
 cf. Erica is copying a novel_i. She likes it_i.

5) The matter is further complicated by facts like the following.

(i) *John may take a girl_i to the party and he must kiss her_i.
 (ii) John must take a girl_i to the party and he may kiss her_i.

These sentences suggest that anyone working on this problem has to take into account the inclusion relations of possible worlds between modals and other

2.2 In this paper, I shall try to incorporate a somewhat modified version of 'Invoking Description Rule', originally proposed by Nash-Webber (1978a,b), into the framework of the currently available semantic theory. This rule, which I refer to as 'Discourse Referent Formation Rule' (DRFR), is roughly stated below.

(14) *Discourse Referent Formation Rule (DRFR):*

$$V - (\exists x_i) (\alpha \dots Fx_i \dots) - W - G(\text{pro}_i) - Y \rightarrow$$

$$(\exists z) (z = (tx_i) (\alpha \dots Fx_i \dots) - W - Gz)$$

where, F and G are arbitrary predicates.

This rule roughly says that if there is a pronoun outside the scope of the existential quantifier, and if this pronoun bears the same (referential) index as the indefinite NP associated with the existential quantifier, then a definite description is invoked which is of the form 'the x such that x F's'. However, in light of facts (8)–(13), this rule needs some constraint. The statement of DRFR therefore, has to include a constraint, more or less of the form:⁶⁾

(15) DRFR does not apply, if V contains a predicate which does not admit of existential generalization such that it (c-)commands everything in α but does not (c-)command *pro*.

This rule, I believe, rules out cases (8)–(10) while allowing (11)–(13). Another merit of this constraint is that it captures almost all the facts that Jackendoff's (1972, 1975) *Modal* relevant predicates. However, we will not go into the realm of possible world semantics in the present context. For discussion, cf. Lakoff (1972) and Jackendoff (1972).

6) I am forced to leave open the problem of whether 'command' or its revised notion 'c-command' (cf. n.3) is relevant to the determination of quantifier-scope. I am inclined to adopt the former view though, because if we adopt the c-command theory we cannot account for the fact that there are some speakers who can interpret (i) in such a way that *everyone*, which is c-commanded by *someone*, takes wide scope.

(i) Someone is watching everyone.

Projection Rules are intended to cover, and that in a much more concise way, without, furthermore, having to adopt such ad hoc features as *unrealized*, *future*, *possible*, *image*, and perhaps many many more.

I assume that DRFR applies to the output of a rule that assigns scope relations and anaphoric relations to a given (near-)surface structure, which I refer to as *Scope-Binding Rule*, of the following form:⁷⁾

(16) *Scope-Binding Rule*:

$$[{}_S W - Q_i - Y - \text{Pro}_i - Z] \rightarrow [{}_S (Qx_i) (W - x_i - Y - x_i - Z)]$$

Condition: (i) Q_i (c-)commands everything in S ; and

(ii) Q_i c-commands Pro_i .

Now, the rule (16) applies to (7), and gives the partially translated formula (17). The pronoun *it* in the second sentence cannot be converted into a variable because it is not c-commanded by *a car*.

(7) John has a car_i . He keeps it_i in the garage $\xrightarrow{\text{Scope-Binding}}$

(17) $(\exists x_i: \text{car})$ (John has x_i) and he keeps it_i in the garage.

This formula meets the structural description of DRFR. If this rule applies to (17), we obtain the final interpretation, viz. (18).

(18) $(\exists x_i: \text{car})$ (John has x_i) and $(\exists z)$ ($z = (\iota x_i: \text{car})$

(John has x_i) and John keeps z in the garage)

The latter half of the formula (18) roughly says: 'John keeps *the car that he has* in the garage'. Intuitively, DRFR has the effect of forming a definite description out of an indefinite NP that appears in the preceding discourse.

7) This rule is distinct from the 'Quantifier Rule' as envisaged by Williams (1977), May (1977), etc. in that (16) simultaneously determines scope relations and binding relations. This might look very strange to the just-mentioned theorists because they assume that quantifier scope is determined by the Sentence Grammar Component and that binding relation is to be represented by the Discourse Grammar Component. However I have already pointed out several problems with this line of approach in Nishigauchi (1978).

This line of procedure can easily be extended to the cases (1)–(2). First, the Scope-Binding Rule yields the following partially translated formulae.

- (19) a. $(\iota x_i: \text{man}) ((\exists y_j: \text{donkey})[x_i \text{ owns } y_j] \wedge x_i \text{ beats } it_j)$
 b. $(\forall x_i: \text{man}) ((\exists y_j: \text{donkey})[x_i \text{ owns } y_j] \rightarrow x_i \text{ beats } it_j)$

In either of the formulae, the square brackets specify the scope of the existential. Note also that the iota operator and the universal quantifier respectively take the topmost scope. The pronoun it_j here cannot be converted into a variable because it appears outside the c-command domain of $a \text{ donkey}_j$. As it stands, these are ill-formed formulae, but do meet the structural description of DRFR. By the application of this rule, we obtain the discourse referent as shown in (20).

- (20) $(\exists z) (z = (\iota y_j: \text{donkey})[x_i \text{ owns } y_j] \wedge x_i \text{ beats } z)$

However, as it is, this is an open sentence, because the variable x_i is not bound to any logical operator. Only when the formula (20) is embedded into the logical forms in (19) can we get the proper representations.

- (21) a. $(\iota x_i: \text{man}) ((\exists y_j: \text{donkey})[x_i \text{ owns } y_j] \wedge (\exists z) (z = (\iota y_j: \text{donkey})[x_i \text{ owns } y_j] \wedge x_i \text{ beats } z))$
 b. $(\forall x_i: \text{man}) ((\exists y_j: \text{donkey})[x_i \text{ owns } y_j] \rightarrow (\exists z) (z = (\iota y_j: \text{donkey})[x_i \text{ owns } y_j] \wedge x_i \text{ beats } z))$

The formulae in (21) are (very roughly) paraphrased as:

- (22) $\left\{ \begin{array}{l} \text{The} \\ \text{Every} \end{array} \right\} \text{man}_j \text{ who owns a donkey}_i \text{ beats the donkey that } he_j \text{ owns.}$

where the pronoun he_j is a variable bound to the quantified description *the/every* . . . which can take the whole S in its scope because it commands (and c-commands) everything dominated by S. (See tree diagram (5).) This, I believe, is in keeping with the intuitive claim exhibited by Geach (1972),

who opted for the interpretation (22).⁸⁾

3. Some Extensions

3.1 *Opaque Contexts* Ioup (1977) observes that if an indefinite NP appears in what Quine (1960) calls *opaque contexts*, i.e. those contexts in which extensionally identical terms are not interchangeable *salva veritate*, the indefinite NP is normally interpreted nonspecifically, or as having no specific referent. This kind of contexts is most typically induced in the complement of such verbs as *believe*, *want*, *try*, etc. Although I argued in Nishigauchi (1979) that it is incorrect to identify nonspecificity with referential opacity and that the latter cannot be a necessary condition for the former, although it surely is a sufficient condition, for the present discussion, I endorse the above-mentioned claim.⁹⁾ Ioup also claims that a nonspecific indefinite NP cannot be linked with a definite pronoun, or a discourse referent, outside the c-command domain.¹⁰⁾ With this much in mind, consider the following, oft-quoted examples.

8) Cooper (1978) also shows that sentences like (1)–(2) require logical representations more or less of the form (21), though he does not give any specific rule for deriving these formulae.

9) In §3.1.2 of Nishigauchi (1979) I have pointed out five arguments which show that referential opacity does not correlate with (non)specificity.

10) The following discourse may be taken as counter-evidence for this claim.

(i) A man sitting by the door touched his [Albert's] sleeve. 'Stay awhile and read [a prayer book] with us.'

'Excuse me, I'd like to, but I am looking for a *friend*.'

'Look,' said the man, 'maybe you'll find *him*.' (B. Malamud, *Rembrandt's Hat*.)

Since *look for* is an opaque verb, and, furthermore, the man with whom Albert is talking does not know who he is looking for, the use of *him* by this man may sound quite odd; but it is not. I conjecture that the indefinite NP here is used specifically (and transparently) and that it is also used *attributively* (in Donnellan's (1966) sense): Ioup claims that attributiveness is essentially a pragmatic notion and is independent of scopal relations (which I assume determines (non)specificity), which I think is correct. Thus, specificity and attributiveness are no longer incompatible notions. The following example, due to Partee (1972), can be

(23) a. (*)John wants to catch a fish_i and he eats it_i for
supper

b. John wants to catch a fish_i and eat it_i for supper.

What distinguishes these sentences is that in (23a) the indefinite NP *a fish* has to be interpreted specifically, because it is linked with a definite pronoun that appears outside the *want*-context, while in (23b) both the indefinite NP and the pronoun appear within the *want*-context, and (probably) for this reason, the indefinite NP can be (or should be) interpreted nonspecifically. Interestingly, on this reading, the definite pronoun *it* in (23b) is more readily paraphrased by (24a) than by (24b). (This fact is pointed out in Dean (1968) and Partee (1972).)

(24) a. 'the fish that John catches'

b. 'the fish that John wants to catch'

This factual claim can be elegantly captured by DRFR. Notice that this rule does not work for (23a) (on its opaque reading) because *believe*, which is an instance of verbs of propositional attitude, commands its complement sentence in which the antecedent indefinite NP appears, but does not (c-)command the pronoun *it*; thus the constraint (15) correctly rules it out. On the other hand, DRFR does apply to (23b) because the verb *believe* (c-)commands both *a fish* and the pronoun *it*, and thus (15) does not prevent DRFR from applying. This sentence will be processed in the following manner.¹¹⁾

(25) a. (23b) $\xrightarrow{\text{Scope-Binding Rule}}$

construed in such a way that the indefinite NP *a doctor* is used both specifically and attributively.

(ii) Since I heard that from *a doctor* (I know), I'm inclined to take it seriously. *He* also said that aspirin would help.

11) The dummy symbol used in (25b) stands for a null-element derived via Equi NP Deletion. Although I believe that this element should also be represented as a variable, to be bound to the matrix subject, the precise logical representation for this binding relation is left open here.

- b. $\text{John}_i \text{ wants } [(\exists x_i : \text{fish})(\Delta_j \text{ catch } x_i) \text{ and } \Delta_j \text{ eat it}_i] \xrightarrow{\text{DRFR}}$
- c. $\text{John}_j \text{ wants } [(\exists x_i : \text{fish}) (\Delta_j \text{ catch } x_i) \text{ and } (\exists z) (z = \underline{(\iota x_i : \text{fish}) (\Delta_j \text{ catch } x_i)} \wedge \Delta_j \text{ eat } z)]$

The logical form (25c) is roughly equivalent to:

- (26) $\text{John}_j \text{ wants to catch a fish}_i \text{ and eat the fish that he}_j \text{ catches.}$

Note that the underlined portion in (25c) explicitly represents the description (24a). Thus this line of approach captures the intuitive factual claim, put forth by Dean and Partee, in a formal, and mechanical manner.

3.2 *Whichever Antecedent* Karttunen (1977) presents some extremely interesting examples of anaphoric relations involving disjunction (*or*) as seen in:

- (27) a. If Mary has a car_i or John has a bicycle_j , $\text{it}_{i,j}$ is in the garage.
- b. If Mary has a car_i or a bicycle_j , $\text{it}_{i,j}$ is in the garage.

The interpretation of *it* in (27a) is something like ‘the car which Mary has (if she has a car), or the bicycle that John has (if he has a bicycle), whichever of these it is that exists.’ The pronoun in (27b) is also construed in a similar way.¹²⁾

I regard this type of anaphora as deriving from the properties of inference induced by disjunction, in conjunction with the rule of forming a discourse referent, viz., DRFR. There are two rules of inference associated with disjunction, whose validity has been acknowledged in standard logic: Disjunction Introduction and Disjunction Elimination. The former rule states that if the truth of a sentence p has been established, then we can infer a disjunction between p and any

12) Nash-Webber (1978a, b) also considers this problem, but she does not attempt to provide a formal representation for sentences (27).

other sentence, say q . ($p \rightarrow p \vee q$ or $q \rightarrow p \vee q$) The other rule, Disjunction Elimination, says that if (i) the disjunction $p \vee q$ is true, (ii) p implies r , and (iii) q implies r , then the truth of r can be asserted. ($[(p \vee q) \wedge (p \rightarrow r) \wedge (q \rightarrow r)] \rightarrow r$)¹³⁾

Now, because of Disjunction Introduction and DRFR, we can guarantee that the following inference is logically valid (though pragmatically inappropriate).

(28) Mary has a car. Therefore, Mary's car or John's bicycle exists (in the domain of discourse).

A formal representation of the inference (28) will be something like the following.¹⁴⁾

(29) $(\exists x_i: \text{car}) (\text{Mary has } x_i) \rightarrow (\exists z)[z = (u) [u \in \{x_i, y_j |$
 $(x_i: \text{car}) (\text{Mary has } x_i) \vee (y_j: \text{bicycle}) (\text{John has } y_j) \}]]$

That is to say, if Mary has a car, then we can guarantee the truth of the claim that there is a unique entity u such that u belongs to a set that consists of either Mary's car or John's bicycle. On the other hand, Disjunction Introduction also guarantees the truth of the following form.

(30) John has a bicycle. Therefore, Mary's car or John's bicycle exists (in the domain of discourse).

If this is the case, then the formula of the form " $(\exists y_j: \text{bicycle}) (\text{John has } y_j)$ " logically implies that the right-hand side of the material implication sign in (29) is true.

Given the rule of Disjunction Elimination, it is now possible to maintain that the following logical form is well-formed, because it conforms to the general structural description outlined above.

(31) $(\exists x_i: \text{car}) (\text{Mary has } x_i) \vee (\exists y_j: \text{bicycle}) (\text{John has } y_j)$
 $\rightarrow (\exists z)[z = (u) [u \in \{x_i, y_j | (x_i: \text{car}) (\text{Mary has } x_i) \vee$
 $(y_j: \text{bicycle}) (\text{John has } y_j) \}]] \wedge z \text{ be in the garage]}$

13) For more detailed discussion, cf. Allwood et al. (1977).

14) The curly brackets ({ }) stand for a set or a class, following the practice of mathematics.

Thus, we can conclude that the discourse referent established in (27a) is a unique object that belongs to the set described as: $\{x_i, y_j \mid (\iota x_i: \text{car})(\text{Mary has } x_i) \vee (\iota y_j: \text{bicycle})(\text{John has } y_j)\}$, or a set made up of {either Mary's car or John's bicycle}. Essentially the same reasoning works for (27b) as well.

Incidentally, the *or* as seen in these sentences seems to be the so-called *exclusive or*, which is defined by the truth function (32a), in contrast to 'logical disjunction', or *inclusive or*, whose truth table is exhibited in (32b), because the use of singular pronoun *it* in the case where both 'Mary has a car' and 'John has a bicycle' are true in (32a) would be inappropriate.

(32) a. Exclusive *Or*

p	q	p v q
T	T	F
T	F	T
F	T	T
F	F	F

b. Inclusive *Or*

p	q	p v q
T	T	T
T	F	T
F	T	T
F	F	F

However, it is not necessary, and in fact not correct, to represent the disjunctive as in (32a) in logical form: first, it is unclear whether the exclusive *or* is subject to the rules of inference discussed above; in fact, the validity of those rules presupposes the inclusive disjunction. Second, the use of the iota-operator at the top of the set-description has the function of picking up only one member of the disjunction.¹⁵⁾

15) Consider the following examples.

- (i) Each girl gave John *a rose* or *a lilac*. He arranged *them* artfully in the empty bottle.
- (ii) The man to whom each girl gave either *a rose* or *a lilac* arranged *them* artfully in the empty bottle.

The plural pronoun used in these examples stands for a mixed set consisting of *both* roses and lilacs (although it is not necessary that this should be so). Though I used to believe that this fact serves as a piece of evidence that the *or* relevant here is the inclusive disjunction, Professor Mōri has suggested to me that it cannot support the aforementioned claim. Without further specific evidence as for (i) and (ii), I leave the status of these sentences with respect to the inclusive/exclusive controversy for a future research. For an attempt to represent (i)–(ii) in the logical calculus, cf. Nishigauchi (1979, pp.146–148). It should be added here that the plurality of the discourse referents here requires a Set Formation Rule, which has the effect of forming a set description out of an indefinite NP that takes narrow scope.

Note also that the procedures (28) – (31) do not involve the introduction of any otherwise unmotivated rule: all the rules made use of here are those whose necessity has been established independently in the semantic literature. All we need is the rule of Discourse Referent Formation Rule, accompanied with the rules of Disjunction Introduction and Disjunction Elimination.

4. Conclusion

In this paper I have attempted to incorporate the rule of DRFR into the framework of interpretive semantics. It has been shown that this rule provides an elegant solution to the so-called ‘Donkey Paradox’ as seen in (1) – (2): its effect was to give an adequate interpretation while preserving the representation of correct scope-relation. Furthermore, this line of approach has offered additional support to the scopal analysis of referential opacity and nonspecificity: the problem raised by such examples as (8) – (13) and (23) have been dealt with in terms of DRFR and the constraint imposed on this rule, viz. (15), without having to adopt such arbitrary features as [\pm specific] (as in Dean (1968)), or so-called ‘Modal Operators’ (as in Jackendoff (1972, 1975)).

Although the metatheoretical implications of DRFR have yet to be worked out in a more detail, I hope to have shown that the rule of DRFR is effective in a wide range of discourse anaphora phenomena.¹⁶⁾

16) Specifically, the present discussion has further complicated the problem of how coreferentiality should be represented at the level of logical form. I think that what it suggests is that a logical approach to the explication of coreferentiality has to take care of the identity relation that holds between logical calculi. The need for an approach along this line has already been argued for by Sag (1977), with reference to Verb Phrase Anaphora. That this notion should be extended to Pronominal Anaphora is shown not only by the present discussion: I have argued in Nishigauchi (1979, Chapter IV, pp.207–221) the explication of ‘Identity of Sense’ Pronominal Anaphora as seen in (i) also requires a consideration along this line.

(i) The man who gives *his paycheck* to his wife is wiser than the man who gives *it* to his mistress.

REFERENCES

- Allwood, Jens, Lars-Gunnar Anderson, and Östen Dahl (1977) *Logic in Linguistics*, Cambridge University Press.
- Cooper, Robin (1978) "Variable Binding and Relative Clauses," in F. Guenther and S.J. Schmit (eds.) *Formal Semantics and Pragmatics for Natural Language*, D. Reidel.
- Dean (Fodor), Janet (1968) "Nonspecific Noun Phrases in English," in S. Kuno (ed.) *Report No. NSF-20*, Harvard University.
- Donnellan, Keith (1966) "Reference and Definite Descriptions," *Philosophical Review* 75.
- Geach, Peter T. (1962) *Reference and Generality*, Cornell University Press.
 ——— (1972) *Logic Matters*, Blackwell.
- Ioup, Georgette (1977) "Specificity and the Interpretation of Quantifiers," *Linguistics and Philosophy* 1.
- Jackendoff, Ray S. (1972) *Semantic Interpretation in Generative Grammar*, MIT Press.
 ——— (1975) "On Belief-Contexts," *Linguistic Inquiry* 6.1.
- Karttunen, Lauri (1969) "Discourse Referents," reprinted in J. McCawley (ed.) (1976) *Notes from the Linguistic Underground*, Academic Press.
 ——— (1971) "The Logic of English Predicate Complement Constructions," Indiana University Linguistics Club.
 ——— (1977) "Whichever Antecedent," *The CLS Book of Squibs*, The University of Chicago.
- Lakoff, George (1972) "Linguistics and Natural Logic," in D. Davidson and G. Harman (eds.) *Semantics of Natural Language*, D. Reidel.
- Lasnik, Howard (1975) "On the Semantics of Negation," in D. Hockney et al. (eds.) *Contemporary Research in Philosophical Logic and Linguistic Semantics*, D. Reidel.
- May, Robert (1977) "Logical Form and Conditions on Rules," *NELS* 7.
- Nash-Webber, Bonnie Lynn (1978a) *A Formal Approach to Discourse Anaphora*, Ph. D. dissertation, Harvard University.
 ——— (1978b) "Description Formation and Discourse Model Synthesis," *TINLAP* 2, University of Illinois.
- Nishigauchi, Taisuke (1978) "Notes on Logical Form and Types of Coreference," *Osaka Literary Review* 17.
 ——— (1979) *Reference and Pronominal Anaphora in English*, M. A. thesis, Osaka University.
- Partee, Barbara Hall (1972) "Opacity, Coreference, and Pronouns," in D. Davidson and G. Harman (eds.).
- Quine, Willard v. Orman (1960) *Word and Object*, MIT Press.
- Reinhart, Tanya (1976) *The Syntactic Domain of Anaphora*, Ph.D. dissertation, MIT.
- Sag, Ivan A. (1977) *Deletion and Logical Form*, Ph.D. dissertation, MIT.
- Williams, Edwin (1977) "Discourse and Logical Form," *Linguistic Inquiry* 8.1.