Notes on Logical Form and Types of Coreference*

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1. Types of Coreference and Diversity of Pronouns

1.1 It is widely assumed that the relation of linguistically relevant coreference[1] is naturally expressed by means of identical referential indices attached to noun phrases (NP's) at some level of representation.[2] Logically-minded linguists have long recognized that this can be done most successfully with the import of logical formulae containing identical (bound) variables representing the relation of coreference. Thus, the "typical" cases of coreference are exemplified by the use of pronouns in the following sentences. (This, however, needs qualifying.[3])

(1) a. No prudent man_i drives when he_i is drunk.
b. Every $candidate_i$ expects that he_i will lose.

The pronouns occurring in these sentences can be regarded as analogous to the bound variables of formal logic.[4] These sentences are related to the open sentences (or propositional functions) of (2), with the quantified NP's *no prudent man* and *every candidate* binding the relevant variables. (I leave open the exact nature of the processes involved here.)

(2) a. x drives when x is drunk
b. x expects that x will win

Partee (1972, 1975) refers to the type of pronouns just discussed as *pronouns as variables*. In addition, Partee argues that there is another type of pronoun which cannot be so described. Examples of such pronouns are seen in the following sentences.

(3) a. The man_i who gave *his_i paycheck* to his wife was wiser than the man_j who gave *it* to his mistress.
b. A man_i who sometimes beats *his_i wife* has more sense than one_j who always gives in to *her*.[5]

The pronouns *it* and *her* in the sentences of (3) literally go proxy for the antecedent NP's *his paycheck* and *his wife*, respectively. What is extraordinary about these sentences is that the pronouns just mentioned are not related with their antecedents by the relation of coreference: in the normal interpretation, there are two paychecks and two wives, respectively, involved in the situations designated by the sentences of (3). The relevant anaphoric relations in these cases are characterized as the relation of *identity of sense*, instead of coreference. The pronouns so described are referred to as *pronouns of laziness.* [6]

Partee (1975) argues that ordinary pronouns are derived by two processes, viz. as pronouns as variables (hereafter PAV) and as pronouns of laziness (POL). More specifically, she argues that if the antecedent is a proper name or a definite description, the sentence involving the anaphoric relation is "structurally ambiguous". [7] Thus the sentence (4) can be analysed as related to (5), in which *John* binds the variables, or as derived from (6), in which *he* is substituted for the second occurrence of *John.* [8]

(4) John_i expects that he_i will win.
(5) [John-x] [x expects that x will win]
(6) John expects that John will win.

According to her claims, if (4) is derived from (5), the pronoun is used as a PAV, and if (4) is derived from (6), it is used as a POL. Although I do subscribe to the view adopted by Partee that (4) is "structurally ambiguous" in some way or other, I will show in what follows that the distinction between the PAV and POL is in fact irrelevant to the structural ambiguity of (4).

The problem which immediately arises with her analysis is: if *he* is derived by the POL process, since a proper name like *John* is normally regarded as having no *sense* (as opposed to *reference,* in the sense of Frege) [9], is it tenable at all to speak of "identity of sense" between the proper name and its anaphor? Although this question is intutively a legitimate one, and hence is worth serious investigation, it seems to be too philosophically involved, and I will no longer go into the matter here.

A more interesting problem is posed by the following sentences.

(7) a. John's$_i$ brother hates him$_i$.

b. The girl who kissed Bill$_i$ loves him$_i$.

According to Partee's conceptions, the anaphoric relation holding in the sentences of (7) must be unambiguously that of POL, because the anaphoric relation in question cannot be that of PAV, as the impossibility of (8) shows.

(8) a. ?* $\left\{\begin{array}{l}\text{Everyone's}_i\\ \text{No one's}_i\end{array}\right\}$ brother hates him$_i$.[10]

b. ?* The girl who kissed $\left\{\begin{array}{l}\text{everyone}_i\\ \text{no one}_i\end{array}\right\}$ loves him$_i$.

In the sentences of (8), if the anaphoric relation were possible, the relation could only be that of PAV, because the antecedents are such quantified NP's as *everyone* and *no one*. (See fn. 3.) But in these cases the relation of variable binding, which should be at work in the PAV processes, does not hold for the quantified NP's and their anaphors.[11] This shows that the anaphoric relation of PAV is impossible in the parallel structure (7). Therefore only the relation of POL is possible in (7). However, consider the fact that the sentences of (9) are also permissible, where so-called backward pronominalization[12] is involved.

(9) a. His$_i$ brother hates John$_i$.[13]

b. The girl who kissed him$_i$ loves Bill$_i$.

This observation apparently leads us to the hypothesis that the backward pronominalization is possible (only) between a POL and its antecedent.

However, that this hypothesis is incorrect is shown by the following examples.

(10) a. Rockford claims to have found Smith's murderer$_i$ but Columbo also claims to have found him$_i$.

b. Although Columbo claims to have found him$_i$, Rockford also claims to have found Smith's murderer$_i$.

The sentence (10a) is ambiguous: it can be interpreted as involving either only one 'Smith's murderer' or two persons suspected as such.[14] In the former reading, the pronoun *him* is related with its antecedent by the

(normal) relation of coreference. In the latter reading, the anaphoric relation is that of "identity of sense". Note that the use of pronoun in the latter case is a typical example of a POL. But consider (10b). In this sentence, only the "coreference-reading" is possible, in which only one *Smith's murderer* (in its referential use) is involved.[15] This fact convincingly indicates that the backward-pronominalization is impossible between a POL and its antecedent.

Now the facts (7)–(10) show that the notion of POL is irrelevant to cases like (4): the pronouns of (7) could be only POL's, as is shown by the impossibility of (PAV's) in (8). But, although the backward pronominalization is permissible in the parallel structure (9), the backward pronominalization is in fact impossible between a "genuine" POL and its antecedent, as is shown by the absence of the POL reading in (10b). Therefore it is reasonable to abandon the notion of POL in the cases (4) and (7), and reserve it for cases like (3) and (10a). Nevertheless, I still subscribe to the view that sentences like (4) are "structurally ambiguous". Then, how should the structural ambiguity be characterized ? I will turn to this problem in the next section.

1.2 Intuitively, Partee's analysis of (4), to the effect that it can be derived either from (5) or from (6), seems to be legitimate.What makes it questionalbe is her use of the notion of POL in the latter case, for the reasons I have mentioned above.

A closer look at the sentence (4) shows that it can be viewed in two ways, without adopting such notions as POL.

(4) John_i expects that he_i will win.

This can be done in terms of the notion *property*. One way to look at (4) is to regard *John* as having the property "x expects that x will win", or the property of expecting-oneself-to-win, and another way to look at it is to regard *John* as having the property "x expects that John will win". At first sight, this analysis may seem to be identical with Partee's, the difference being that in the present analysis the pronoun in the latter reading is not derived via the process of POL: rather, its derivation is triggered by the relation of *coreference between constants* (i.e. between

two occurrences of *John,* in this case), in contrast to the relation of *coreference between variables,* as seen in (5). Such being the case, we must stipulate that there are two types of coreference: one type of coreference is represented in terms of identity of (bound) variables, and the other type of coreference is represented in terms of identity of constant terms at the level of logical form.[16] For convenience, I will refer to those pronouns which are related with their antecedents by the relation of identity of variables (or variable binding) as *pronouns of (bound) variable coreference* (PVC) and those related with their antecedents by the relation of identity of constants as *pronouns of constant coreference* (PCC). Now it will be seen that the "structural ambiguity" of (4) should be characterized in terms of PVC and PCC. Why such a distinction is necessary will be made clearer in the next chapter.

2. Types of Coreference and "Sloppy Identity"

2.1 Problems concerning verb phrase deletion (VPD) have been discussed extensively in such recent papers as Sag (1976, 1977) and Williams (1977). These two authors assume that the level of representation relevant to VPD is the level of logical form[17], and they also agree in adopting the crucial device of the *lambda-calculus* in the logical representation. The lambda-calculus is a logical device by means of which one can express some individual's property.[18] Thus consider the following sentence.

(11) Betsy$_i$ loves her$_i$ dog, and Sandy$_j$ does ___, too.

The right conjunct, which has undergone VPD, is ambiguous: on one reading, Sandy loves Betsy's dog, and on the other reading, Sandy loves her own dog. In the latter reading, the deleted VP contains the pronoun *her*$_j$ which is not referentially identical with the pronoun contained in the antecedent VP of the left conjunct. In this case, the identity condition on VPD ignores difference of pronominal reference. Hence the term "sloppy identity" as against Chomsky's (1965) notion of "strict identity" condition.[19] In what follows, I will use the term "sloppy reading" to refer to the reading involving sloppy identity (i.e. the latter

reading), and "non-sloppy reading" to refer to the reading involving strict identity (i.e. the former reading).

In the system developed by Sag and Williams, the non-sloppy reading is represented by the logical form (12).[20]

(12) Betsy$_i$ λx (x loves her$_i$ dog) and Sandy$_j$ λy (y loves her$_i$ dog)

In (12) λx (...) and λy (...) are alphabetic variants[21], guaranteeing the possibility of VPD. On the sloppy reading of (11), the semantic rules first derive the formula (13).

(13) Betsy$_i$ λx (x loves her$_i$ dog) and Sandy$_j$ λy (y loves her$_j$ dog)

Applying a semantic rule which Sag calls PRO→BV to both the conjuncts[22], we obtain the logical form (14).

(14) Betsy$_i$ λx (x loves x's dog) and Sandy$_j$ λy (y loves y's dog)

Again, λx (...) and λy (...) are alphabetic variants, allowing deletion.

The basic idea underlying the approach adopted by Sag and Williams is that VPD is possible only if the individuals denoted by the NP's in the subject positions of both the conjuncts have an *identical property*, which is represented by the alphabetic variance of the lambda-calculi. More plainly, on the non-sloppy reading represented by the formula (12), Betsy and Sandy share the property of loving Betsy's dog, and on the sloppy reading represented by the formula (14), Betsy and Sandy share the property of loving their respective dogs. And also to be noted is that Sag and Williams implicitly assume that the real root of the ambiguity of the right conjunct of (11) is the "structural ambiguity" of the *left* conjunct, and this ambiguity is to be characterized in our terms as follows: in the logical form (12) which expresses the non-sloppy reading, the pronoun *her$_i$* is represented as an *individual constant*, while in the logical form (14), which expresses the sloppy reading, the pronoun is represented as a *variable* bound by the lambda-operator. Now it is obvious that this ambiguity correlates with the "structural ambiguity" characterized in terms of the PVC and PCC, which we have seen in §1.1. In the following sections, I will present several arguments for the correlation between the sloppy/non-sloppy ambiguity and the PVC/PCC ambiguity.

2.2.1. Consider the following sentence.

(15) Every philosopher$_i$ thinks that he$_i$ is terrific, and that linguist$_j$ does ____, too.

This sentence does not show the ambiguity present in such sentences as (11): only the sloppy reading on which that linguist$_j$ thinks that he$_j$ is terrific is possible, and it is impossible to interpret the right conjunct as:

(16) ... and that linguist$_j$ thinks that he$_i$ (=every philosopher) is terrific.

This is a natural consequence of our assumption that the pronoun *he$_i$* in the left conjunct of (15), its antecedent being a quantified NP *every philosopher,* can only be a PVC.[23] (See also fn. 3.) Thus the logical form for the sentence (15) is represented only by (17).

(17) $\forall x_{\text{philosopher}}$ (x λy (y thinks that y is terrific)) and [that linguist]$_j$ λp (p thinks that p is terrific)[24]

In this formula, λy (...) and λp (...) are alphabetic variants, and deletion is permitted. The present analysis differs from the one developed by Sag and Williams, in that in our analysis, the logical form (17) is derived from (15) directly, while in theirs this logical form is derived via PRO→BV. (See, however, §3.)The problem with Sag and Williams is that in cases like (15), where the antecedent of a pronoun is a quantified NP, the rule PRO→BV would apply *obligatorily,* whereas this rule is, by definition, *optional.*[25] But if we dispense with it, and if we derive the formula (17) directly, what we have to do is to determine whether the relevant pronoun is a PVC or a PCC, the pronoun in the present example being a typical PVC, because its antecedent is a quantified NP *every philosopher,* which directly follows from the discussion in §1.1.[26]

2.2.2 The sentences of (18) are unambiguously non-sloppy.

(18) a. John's$_i$ father hates him$_i$, and Harry's$_j$ father does ____, too. (____ = hate him$_i$)

b. The girl who kissed Max$_i$ loves him$_i$, and the girl who kicked Jim$_j$ does ____, too. (____=loves him$_i$)

The fact that these sentences lack the sloppy reading is directly connected with what we have observed about the sentences (7)–(9)

above: the pronouns occurring in the left conjunct of the sentences in (18) can neither be PVC's (as can be seen from (8)) nor POL's (as can be seen from (9) and (10b)), and they can only be PCC's. Thus the only logical form possible for (18) is represented by (19).

(19) a. $[_{NP}$John's$_i$ father$]_j$ λx(x hates him$_i$) and
$[_{NP}$Harry's$_k$ father$]_l$ λy (y hates him$_i$)

b. $[_{NP}$The girl $[_S$who kissed Max$_i]]_j$ λx (x loves him$_i$) and
$[_{NP}$the girl $[_S$who kicked Jim$_k]]_l$ λy (y loves him$_i$)

Sag (1977) purports to get over this problem by setting up a constraint on PRO→BV, restated here as (20).

(20) The only pronouns that can become bound variables are those that bear the same index as the argument of the λ-predicate, which ... is the surface subject. (Sag (1977), pp. 92–93.)

But such a constraint in fact lacks explanatory value: the reason why the pronoun *him$_i$* cannot be converted into a variable *x* is simply that *him$_i$* is not coreferential with *x*, which is coreferential with NP$_j$, and this suffices to explain the phenomenon at hand. Rather, there should be a constraint which bars such logical forms as:

(21) a. *John λx ([x's father] hates x)

b. *Max λx ([the girl [who kissed x]] hates x)

Intuitively, a sentence like "John's father hates him" cannot be used to attribute properties to *John;* rather, this is a statement about *John's father.* The constraint against the logical forms of (21) makes this intuition explicit. Indeed the existing semantic theory is already equipped with such a constraint, in terms of the "scope" of variable binding. See fn. 11. The facts we have seen so far lend support to the view that the pronouns occurring in (18) can only be PCC's, and that there is a correlation between the distributions of PCC's and the non-sloppy reading.

2.2.3 It will be seen in this section that the actual distribution of the sloppy/non-sloppy ambiguity is subject to the preceding contexts which specify whether the pronouns used in the subsequent discourse should be a PVC or a PCC. Thus consider the sentence (22).

(22) Melvin$_i$ claims that he$_i$ is poor, and Pete$_j$ does ——, too.

The sentence (22) in isolation is ambiguous, having the reading on which Pete claims that Melvin is poor (=non-sloppy) and the reading on which Pete claims that he himself is poor (=sloppy). But the same sentence in the following discourse is no longer ambiguous.

(23) *Speaker A:* Whoever$_i$ claims that he$_i$ is poor is actually rich.[27]
Speaker B: Then, Melvin and Pete are rich, for Melvin$_j$ claims that he$_j$ is poor, and Pete$_k$ does ——, too.

In this discourse, the same sentence as (22) has only the sloppy reading, because in this context *he* in "Melvin claims that he is poor" can only be a PVC, for the normal interpretation here is that the property of claiming-oneself-to-be-poor is at issue, and that this property, which is naturally represented by the use of bound variables, is being attributed to Melvin and Pete. Thus, the logical form for this reading is (24).

(24) Melvin$_j$ λx (x claims that x is poor) and Pete$_k$ λy (y claims that y is poor)

For Sag and Williams, it would be necessary to set up a condition stating that PRO→BV is obligatory in contexts like these. But we have only to state that the relevant pronoun is a PVC.

Next consider the discourse (25), which contains the same sentence as (22).

(25) *Speaker A:* Who claims that Melvin is poor?
Speaker B: Well, Mélvin$_j$ claims that he$_j$ is poor, and Péte$_k$ does ——, too.

This time, the same sentence is unambiguously non-sloppy. This follows from the fact that what is at issue here is the property of claiming-Melvin-to-be-poor, and this property is being attributed to Melvin and Pete. In this case, only (26), which represents the non-sloppy reading, is the proper logical form.

(26) Melvin$_j$ λx (x claims that he$_j$ is poor) and Pete$_k$ λy (y claims that he$_j$ is poor)

The pronoun *he$_j$* in this logical form is straightforwardly a PCC. Again, for Sag and Williams, it would be necessary to set up a condition which blocks PRO→BV in cases like this. But the present analysis, which has

recourse to the distinction between a PVC and a PCC, accounts more naturally for the presence or absence of the ambiguity in sentences like (22).

2.2.4 In §1.2 I have characterized the "structural ambiguity" of the sentence (4) in terms of whether the pronoun occurring there is a PVC or a PCC. Now consider the sentence (27), in which quantification is involved.

(27) Only Nixon_i believes that he_i is innocent.

This sentence is "semantically ambiguous", i.e. the two readings of this sentence differ in truth conditions. On one reading, Nixon and no other person than Nixon believes that he (himself) is innocent; it can still be true if someone else believes than Nixon is innocent. In other words, on this reading, Nixon and no other person than Nixon has the property "x believes that x is innocent". On the other reading, this sentence is true if Nixon and no other person than Nixon believes that Nixon is innocent; it can still be true if someone other than Nixon believes that he himself is innocent. In other words, on this reading, only Nixon and no one else has the property "x believes that Nixon is innocent". This ambiguity is conveniently represented by the use of the lambda-calculus.

(28) only Nixon_i λx (x believes that he_i is innocent)

(29) only Nixon_i λx (x believes that x is innocent)

The logical form (29) represents the first reading, and the logical form (28) represents the latter reading. The semantic ambiguity in question is characterized by the distinction between the PVC and PCC, which are derived separately in the present analysis. Note that this sentence poses a very difficult problem for Sag and Williams: they are forced to derive (29) from (28) via PRO→BV. But (28) and (29) are semantically distinct. Such being the case, if they are to stick to this rule, they will have to admit of a semantic rule (i.e. PRO→BV) which *changes meaning.* But there is no such rule known to exist in the literature in print, regardless of whether one takes the interpretive semantics or the generative semantics position. Thus if they are to treat sentences like (27) properly, they are forced to abandon PRO→BV, and derive the two logical forms, (28) and

(29), directly.[28]

3. Final Remarks

Throughout this paper I have argued that the distinction between the constant and the variable is effective in the semantic analysis of pronominal anaphora. But I. have left open the precise nature of the mechanism involved in determining whether a given pronoun should be treated as a variable (PVC) or as a constant (PCC). This problem awaits further investigations.

However, the need for the distinction between the two types of coreference is by now obvious, as seen in the treatment of the so-called "sloppy identity" that is associated with VPD. Sag and Williams have implicitly assumed that such a distinction at the level of logical form *is* at work, but their analyses are faced with a lot of difficulties, mainly due to their failure to observe the theoretical significance of the distinction in question. A rule like PRO→BV could not have been argued for, if they had been fully aware of the real status of such a semantic rule.[29]

The validity of the distinction between the PVC and the PCC seems to have further empirical implications. More specifically, it has been recognized, since Postal (1970), that the anaphoric relations with non-definite NP's as antecedents are subject to stronger constraints than those with definite antecedents,[30] and these "stronger" constraints could be essentially identical with those on variable binding, which I have given in fn. 11. If this is the case, we would have another case in which the distinction between the variable and constant in logical form is of empirical and theoretical validity.

NOTES

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1) By "linguistically relevant coreference" I refer to the relation of coreference in which anaphoric devices (typically, pronouns) are involved, and exclude such cases as:
   (i) *The morning star* is more beautiful than *the evening star.*
   (ii) *The unicorn* finally discovered *a round square.*
   In (i), the italicized NP's denote the identical object, and in this sense they are coreferential. In (ii), the italicized NP's are coreferential in the sense that they have no referents. But in neither of these cases is anaphora involved, and therefore such cases should be excluded from the linguistic considerations. I leave the detailed discussion on the "linguistically relevant identity" to my M. A. thesis. See Postal (1970), pp. 439–442, for discussions.
2) I leave open the question of what is the relevant level of representation for specifying the relation of coreference. In this paper I will not be committed to any specific theoretical framework.
3) This remark needs qualifying because it will invite objections, which would be directed to the idea that coreference is "typically" involved in the sentences of (2), because the antecedent NP's are quantified NP's *no prudent man* and *every candidate,* which have no referents. It is perfectly normal to ask, "How can you speak of coreference when no referent is involved?" Indeed Partee (1972) Lasnik (1976) and others argue that the anaphoric relations of (2) are not the relation of coreference, but the relation of variable binding. However, I regard the anaphoric relations in these examples as those of coreference holding between the arbitrary members of a set specified by the relevant quantified NP in the domain of discourse. This idea is implicit in Wasow (1972), pp. 168–169.
4) The resemblance between the pronouns of natural language and the variables of formal logic has been repeatedly emphasized by logicians. E.g. see Quine (1953), pp. 102–103.
5) The example (3a) is a famous example from Karttunen (1969) and the example (3b) is taken from Geach (1976).
6) The term "pronoun of laziness" is due to a philosopher P. T. Geach.
7) Partee (1975) has adopted the term "structural ambiguity" to refer to the ambiguity in question, because the two processes of the derivation often lead to the equivalent interpretation. However, see the discussion in § 2.2.4.
8) In the derivation from (5), the NP *John* is used essentially as a quantifier. This treatment of NP's is characteristic of Montague Grammar. See Partee (1975b).
9) This remark may be objected to on the basis of such examples as:
   (i) Giorgione was so-called because of his size.
   As Quine (1953, pp. 139–141) observes, given that "Giorgione = Barbarelli", (ii) cannot be true when (i) is true.
   (ii) Barbarelli was so-called because of his size.
   This may be eivdence for the claim that proper names do have *sense* (or intension): otherwise the referential opacity of (i) would not have arised. Incidentally, in Montague Grammear all NP's are treated primarily as intensional. This problem seems to be worth further investigations. See Partee (1975b) for discussions.

10) Not all speakers find the sentence (8a) unacceptable on the relevant reading. Reinhart (1976) discusses this sentence in connection with (9a). See fn. 13.

11) For discussions on the "scope" of variable binding, see Postal (1970, fn. 13), and Lasnik (1976). In sum, variable binding is considered to be possible only if the quantified antecedent both precedes and "kommands" (a revised notion of Langacker's "command", due to Lasnik) its anaphor. In connection with my remarks in fn. 3, we can safely say that variable binding is a special case of coreference.

12) By "backward pronominalization" I refer to the cases in which a pronoun occurs to the left of its antecedent in the surface configuration.

13) Note that although (9b) can be accounted for by the conditions on pronominalization proposed by Ross (1967) and Langacker (1969) in terms of "precede-command", (9a) is left unaccountable for. Some notions like "kommand" (see fn. 11) would be necessary. Reinhart (1976) observes that those speakers who accept (8a) find (9a) unacceptable, and those who accept (9a) find (8a) unacceptable. This fact is captured by her notion of the "c-command domain".

14) This ambiguity correlates with the ambiguity (referential/attributive use) of definite descriptions discussed by Donnellan (1966). When the definite description is used referentially, the "coreference reading' in which only one *murderer* is involved arises, and when it is used attributively, the "POL reading" in which two persons described as such are involved arises.

15) This observation is essentially due to Wasow (1972, pp. 171–172). Put in another way, the backward pronominalization is impossible between a non-referential NP and its anaphor. A fuller characterization of the backward pronominalization with a non-referential antecedent will be seen in my M. A. thesis (in preparation).

16) This implies that at the level of logical representation coreference must be represented in two ways: one type of coreference is specified by the use of variables, and another type of coreference by the use of constants with identical indices attached to them.

17) Their work is essentially within the framework outlined in Chomsky (1975). For them, logical form is the output of semantic interpretation rules working on surface structure, although there are minor differences between their approaches, deriving mainly from their different conceptions of the notion "surface structure".

18) An ordinary logical representation of (i) is something like (ii).

(i) John loves Mary

(ii) love (John, Mary)

By means of the lambda-calculus, one can *abstract* the argument which serves as the subject, which is followed by the expression corresponding to the predicate, as in (iii). (Hence, the lambda-operator is also dubbed *abstraction operator.*)

(iii) λx (love (x, Mary)) [John]

Although (iii) is a usual form of representation, I follow the convention adopted by Sag, which reflects the word order of natural language as in:

(iv) John λx (x loves Mary)

This logical form is interpreted as "John has the property of loving Mary". For detailed accounts of the lambda-calculus, see Carnap (1958, pp. 129ff) and Allwood et al. (1977, pp. 155–157). Sag and Williams have independently borrowed this idea from Partee's transformational extension of Montague Grammar. See Partee (1975b) pp. 265–269.

19) See Chomsky (1965), pp. 145–147. The happy term "sloppy identity" is due to Ross (1967b, pp. 189–191; 1969, pp. 268–275). Note that this phenomenon is not confined to VPD; it is also associated with Sluicing, as in (i), and with so-called "semantic anaphora" as in (ii).
   (i) Harold$_i$ knows how to crane his$_i$ neck, but I$_j$ don't know how
   (ii) Fred$_i$ kissed his$_i$ wife, and Jack$_j$ imitated him$_i$.

20) For the rest of this paper, I follow Sag's notation rather than Williams', who assumes that VPD is a semantic rule that copies the antecedent VP into the position of the missing VP, which is empty from the beginning. (For him, VPD is not a transformation.) Thus, for Williams the logical form for (11) would be something like (i).
   (i) Betsy$_i$ [$_{VP}$ λx (x loves her$_i$ dog)] and Sandy$_j$ [$_{VP}$ △ △ △]
   But this difference is not as large as it appears, the reason mainly deriving from their conceptions of "surface structure".

21) For the purpose of this paper, it is sufficient to note that two lambda-expressions are "alphabetic variants" if they differ only with regard to variable letters. By this, one can conveniently represent the "identical property".

22) The rule PRO→BV converts those pronouns that bear the same index as the argument of the lambda-expression into variables (optional). Williams also proposes a rule to the same effect, which is dubbed "Pronoun Rule", and Chomsky (1975, 1977) assumes a similar rule. Note that this rule is a rule that *converts constants (pronoun) into variables.* It is questionable whether such a rule is permissible on the logical ground, except for *existential generalization,* which says that from F(a) one can infer that ∃xF(x). E.g., from "Socrates is mortal" one can infer that "there is at least one man such that he is mortal". But PRO→BV has nothing to do with such logical inferences. More problems for PRO→BV will be presented in §2.2.

23) It is possible to account for this fact from a different angle: one can say that the reason for the impossibility of the reading (16) is simply that the scope of variable binding with the quantified NP's is strictly sentence-bound. (See Chomsky (1977), p. 34.) The logical form (i), which purports to represent the non-sloppy reading, is ill-formed because the right conjunct contains a free variable (*y*).
   (i) *∀xphilosopher (x λy (y thinks that y is terrific)) and that linguist$_j$ λp (p thinks that y is terrific)
   But this explanation is also based on the assumption that the relevant pronoun should be represented as a variable in logical form.

24) This logical form is radically simplified.

25) See fn. 22. This is clearly stated in Sag (1977), p. 90.

26) See fn. 3. The property of variable binding is not limited to those NP's quantified by such items as *every* and *no.* Consider the following examples.

(i) { The typical American / The average politician / Either Bill or Fred } thinks that he is competent.

It seems that those NP's which do not function as individual constants have the property of being related with their anaphors by the relation of variable binding.

27) *Wh*-words like *whoever* have essentially the same characteristics as quantifier words. Note that this idea is not entirely new: e.g. see Jespersen (1924), pp. 302–305. Also see fn. 30.

28) There is a way out for them: if they assume that *only* is semantically complex, as Lakoff (1970, p. 393) argues, they can avoid the difficulty. On this analysis, the sentence (27) would have the following two logical forms.
   (i) Nixon_i λx (x believes that he_i is innocent) and [no one other than Nixon_i]$_j$ λy (y believes that he_i is innocent)
   (ii) Nixon_i λx (x believes that x is innocent) and [no one other than Nixon_i]$_j$ λy (y believes that y is innocent)

   The logical forms (i) and (ii) are essentially identical with (28) and (29), respectively. The derivation from the surface (27) onto (i) and (ii) (if one follows the interpretivist framework) would be analogous to a reversed process of Conjunction Reduction.

29) Sag (1977, p. 90) explicitly notes that the logical forms (ii) and (iii), which derive from (i), are "logically equivalent".
   (i) Betsy_i loves her_i dog.
   (ii) Betsy_i λx (x loves her_i dog) ⇢ PRO→BV
   (iii) Betsy_i λx (x loves x's dog)

   However, as it obvious from the discussion so far, the really interesting point is not their "logical equivalence", but, rather, how they differ. Sag's remarks concerning the rule PRO→BV make me wonder how he conceives of the real implications of this rule.

30) Chomsky's (1977) analysis of anaphora indicates that this is not confined to the non-definite anaphora cases: he argues that nondefinite NP's, *wh*-words which 'cross-over', and stressed NP's behave the same way with respect to anaphora, as seen in the following.
   (i) ?*The woman he_i loved betrayed a politician_i.
   (ii) ?*Who_i did the woman he_i loved betray *t*?
   (iii) ?*The woman he_i loved betrayed JOHN_i.

   These facts suggest that the analysis of pronouns in terms of the distinction between variables and constants will turn out to be valid in a wider range of anaphoric phenomena than we assume at present.

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