ON CO-INDEXING RELATIONSHIP IN MONTAGUE GRAMMAR*

HIROSHI YOSHIKAWA
Himeji Institute of Technology

The co-indexing relationship is argued from a syntactic point of view in Chomsky’s theory, and many remarkable results are obtained in it. This paper proposes a semantic version of the co-indexing relationship, especially in the framework created by Richard Montague whose procedure is to directly interpret the surface structure.

By considering this relationship from a different point of view from Chomsky’s, that is, from a semantic point of view, I have found out that the similarity is obtained between noun phrases without a genitive nominal and infinitive clauses with regard to co-indexing and that the other interesting results are also gotten.

1. LOGICAL STRUCTURE AND SCORE RELATION. In this paper, I will argue co-indexing relationships among NPs (henceforth Co-IR) on the basis of Montague Grammar (henceforth MG), and make an attempt to explain the Co-IRs from the semantic point of view. In this chapter, I will briefly survey the features of MG’s approach most relevant to the present article, following the exposition of Ladusaw 1980, and then examine at what structure or level the Co-IRs should be fixed.

(1) Everyone loves someone.

According to Ladusaw, sentences as in 1 receive several interpretations as in 1.1a–1.1d, and have two readings which are equivalent classes of interpretations. These two readings are translated into logical structures as in 1.2a and 1.2b respectively, which represent two meanings of the sentence of 1.

(1.1) a. everyone’ (‘love’(‘someone’))

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b. love’ (x₀, ^someone’) ⟨everyone’, x₀⟩
\[\forall \text{everyone’} (\forall x₀ \text{ love’(}x₀, ^\text{someone’)})\]
c. everyone’ (^love’(x₁)) ⟨someone’, x₁⟩
\[\forall \text{someone’} (\forall x₁ \text{ everyone’}(\forall \text{love’(}x₁)))\]
d. love’ (x₀, x₁) ⟨⟨everyone’, x₀⟩, ⟨someone’, x₁⟩⟩
\[\forall \text{someone’} (\forall x₁ \text{ everyone’}(\forall x₀ \text{ love’(}x₀, x₁))\]

(1.2) a. \[\forall y[\text{one’}(y) \rightarrow \exists x[\text{one’}(x) \land \text{love’}(x, y)]\]
b. \[\exists x[\text{one’}(x) \land \forall y[\text{one’}(y) \rightarrow \text{love’}(x, y)]]\]

What the two interpretations in 1.1a and 1.1b (which one reading is composed of) have in common is that everyone has its scope over someone; in 1.1c and 1.1d, vice versa. Thus, each reading represents scope relations among NPs; the difference in scope relations is, in this instance, also shown in the logical structures (henceforth LS) in 1.2a and 1.2b.

At this point, let me raise the following question: could all Co-IRs be explained by means of or on the basis of the LS which is presumed to represent scope relations among NPs? If Co-IR is fixed on the basis of LSs as in 2.2 and 3.2, the difference in Co-IR will not be made between the sentence in 2 and the one in 3. This is because a big difference between the LSs cannot be seen: the LS in 2.2 is almost similar in an arrangement of arguments to the LS in 3.2.

(2) He liked a book that John read.
(3) Which book that John read did he like?

(2.2) \[\exists x[\text{book’}(x) \land \text{read’}(\forall j, x) \land \text{liked’}(y, x)]\]
(3.2) \[\lambda p \exists x[\text{book’}(x) \land \text{read’}(\forall j, x) \land \neg p \land p=\text{liked’}(y, x)]\]

If Co-IR is fixed on the basis of a similar LS, a wrong predication will be made as follows: if Co-IR is fixed at 3, it will be done at 2 and if it is not fixed at 2, it will not be done at 3. It is certain, however, that each sentence as in 2 and 3 has an intrinsic scope relation relevant to Co-IR, which might enable me to provide a unique Co-IR to each sentence. The above observation bears witness to the fact that not all Co-IRs can be fixed on the basis of LS. It seems, therefore, that if a unique Co-IR must be provided to each sentence as in 2 and 3, it is necessary that another structure which definitely shows some differences between these sentences should be used. That is, if Co-IR is relevant to scope relations between NPs, it should be settled on another level which represents scope relations, rather than on the LS. This leads me to consider at what

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1 To simplify discussion, I will omit to treat the tense. See Karttunen 1977 for complete discussion about wh-questions.
structure the Co-IR is fixed, whether scope relations are relevant to it and by what means a unique Co-IR should be provided to sentences as in 2 and 3.

Let me first assume that the Co-IR is fixed on the basis of the scope relations which an interpretive structure (henceforth IS) represents. When saying that the Co-IR is fixed on the basis of the scope relations, I tentatively assume that it is settled in the following way:

(4) In a certain environment in which a pronoun appears, the pronoun may be co-indexed with another NP which has its scope over the pronoun in IS.²

Consider the Co-IRs in the cases of 2–3 and 5–6 along the lines of the above assumption.

(5) He expects that someone will win.
(6) Someone expects that he will win.

When a sentence as in 5 is interpreted by means of NP-storage convention³ (henceforth NP-SC), it has an IS as in 5.1: someone has the widest scope like someone in 6.

(5.1) he'(^expect'(^will-win'(x₀))) ⟨someone', x₀⟩
\[\mapsto \lambda Pɔx[one'('x) \land P[x]](^\lambda x₀ \text{ expect}'(y, ^\text{will-win}'(x₀)))\]

(6.1) \[\lambda Pɔx[one'('x) \land P[x]](^\text{expect}'(^\text{will-win}(y)))\]

It is shown in 5.1 and 6.1 that each IS has the same scope relation between someone and he. If Co-IR is fixed on the basis of 4, the same Co-IR may be provided to 5 and 6 because someone has its scope over he in both ISs. This procedure leads me to a wrong predication. It should, here, be noted that what is most different between 5 and 6 is the positions which the NPs occupy in each sentence. It is, therefore, necessary that the surface positions which pronouns occupy should be considered: the environment as mentioned in 4 should be taken into account. To put it another way, the scope relation in a surface structure should be taken into account: in 5 he is not within the scope over someone but in 6 he is.

The same may be said of 2–3. When the sentence in 2 is interpreted by means of NP-SC, it has such an IS as in 2.1. And a sentence as in 3 has an IS as in 3.1.

(2.1) liked'(y, x₀) ⟨\lambda Pɔx[book'('x) \land read'('j, x) \land P[x]], x₀⟩
\[\mapsto \lambda Pɔx[book'('x) \land read'('j, x) \land P[x]](^\lambda x₀ \text{ liked}'(y, x₀))\]

² Following Ladusaw (1980: 59), I define scope relations as follows: The scope of the meaning of a in interpretation φ is the meaning which is its argument in φ.
It is shown in 2.1 and 3.1 that each IS is almost similar to the other. Thus, if Co-IR is fixed on the basis of scope relations of ISs as in 2.1 and 3.1, the same Co-IR should be provided to each sentence because the scope relation between $^j$ and $y$ is the same in both sentences. This also leads me to a wrong predication. I assume that in this case, the scope relation in a surface structure must also be considered: in 2 the scope over he is wider than the scope over the element including the scope over John and in 3 the scope over he is different from the one over John in scope range. In the case of 5–6, however, the different Co-IR could be fixed at LS in a certain way. (Each sentence as in 5 and 6 is translated into the LSs as in 5.2 and 6.2.)

In 5.2–6.2, the difference in an arrangement of $x$ and $y$, i.e., the difference in an environment where pronouns appear, is represented in LS. So, the difference in Co-IR could be explained at LS. But the case in 2–3 can not be treated from the point of view of LS as mentioned above. Thus, I face the dilemma. Judging from the above observations, in order that Co-IR is fixed, it seems that the following should be taken into account: (i) the scope relation in a surface structure, (ii) the level which represents a scope relation but which is different from LS and (iii) the environment where pronouns appear. This induces me to consider that if it is hoped that a unique Co-IR is settled in each sentence as in 2 and 3, it is necessary to set up the structure which fills at least requirements as in (i) and (ii). Taking the above requirements into account, I assume that the relevant structure which fills them is an IS without using NP-SC as in 5.3 (or 6.3). I will call the structure as SR hereafter.

The reason is that these SRs clearly show that the scope relation in 5.3 is different from the one in 6.3 and that 2.3 is different from 3.3 in scope relations. Given a condition as in 4, I believe that the difference in Co-IR could be explained on the basis of SR, because each SR represents an intrinsic scope relation and a difference in scope relations between 2–3 and between 5–6; it is by means of such a structure as SR that the intrinsic scope relation could provide a unique Co-IR to each sentence,
and that the difference in Co-IR could be explained. I will discuss below how the different SR produces the different Co-IR.

It should be noted, however, that not all Co-IRs are fixed on the basis of SR. It should also be considered what on earth the environments as mentioned in 4 are.

(7) John loves him.
(8) John loves himself.

In such cases as 7-8, the Co-IRs depend on the environments where pronouns or reflexives appear: the features which pronouns or reflexives have. In what follows, let me first consider features of theirs, taking SR and LS into account, and then discuss Co-IR on the basis of their features, SR and LS.

2. FEATURES OF PRONOUNS AND REFLEXIVES, AND LOCAL CONTEXT.

(8) John loves himself.
(9) Everyone loves himself.
(10) *Himself loves John.
(11) John believes her to have washed herself.

Each SR and LS for 8–10 is roughly represented as follows:

(8.1) John'(^love'(^himself'))
(9.1) everyone'(^love'(^himself'))
(10.1) *Himself'(^love'(^John'))
(8.2) love'(^j, ^ăPP{x0})
(9.2) ∃x[one'(x)→love'(x, ^ƒÉPP{x0})]
(10.2) *love'(x0, ^ăPP[^j])

(In this paper, I assume that all pronouns and all reflexives are directly interpreted and represented at LS as they are, as in 8.2 and 9.2, and then are co-indexed as in 8.0 and 9.0, when filling some requirements.)

(8.0) love'(^j, ^j)
(9.0) ∃x[one'(x)→love, '(x, x)]

Judging from the fact that sentences as in 8 and 9 are acceptable and one as in 10 is not, the features of reflexives may be briefly described as follows: a reflexive must be co-indexed with the antecedent that has the reflexive within its own scope in SR, and furthermore the antecedent must also be an argument under the verb that is interpreted as a function taking as immediate arguments both the antecedent and the reflexive in LS. Here we must take care not to confound the function in LS with the one in SR: the function/argument relation in SR shows a scope relation among NPs in a surface structure and the function/argument relation in
LS represents a relation among meanings which words express. Note that I have distinguished the two relations.

Consider a sentence as in 11 by means of the features of reflexives. It is interpreted as the SR in 11.1 and is translated into the LS in 11.2.

(11.1) John' (\textasciitilde{\text{believe}}(\textasciitilde{\text{to-have-washed}}(\textasciitilde{\text{herself}}))(\textasciitilde{\text{her}}))

(11.2) believe'(\textasciitilde{j}, \lambda PP[y], \lambda x_1 \text{have-washed}'(x_1, \lambda PP[x_0]))

As assumed earlier, in LS the reflexive is first interpreted as $\lambda PP[x_0]$ and then $\lambda PP[x_0]$ will be co-indexed with an element that fills the requirements that reflexives have as mentioned above. When filling them, the reflexive is co-indexed with the element, so that the LS is translated into the following: believe'(\textasciitilde{j}, \lambda PP[y], \lambda x \text{have-washed}'(x, x)). The variable $x_1$ in this LS is also transformed into $y$ by means of control relation, which I will discuss below. The final logical structure of 11 will become as follows: believe'(\textasciitilde{j}, y, have-washed'(y, y)).

Next, I will examine the features of pronouns.

(12) John hates him.
(13) He hates John.

In 12 and 13, when John and him are co-indexed, the sentences become unacceptable. (Each SR for 12 and 13 is represented as in 12.1 and in 13.1, and each LS as in 12.2 and in 13.2.)

(12.1) John' (\textasciitilde{\text{hate}}(\textasciitilde{\text{him}}))
(13.1) he' (\textasciitilde{\text{hate}}(\textasciitilde{\text{John}}))
(12.2) hate' (j, \lambda PP[x]) $\Rightarrow$ hate' (j, x)
(13.2) hate' (x, \lambda PP[j]) $\Rightarrow$ hate' (x, j)

It is shown in 12.1 and 12.2 that him is within the scope over John in SR and that both are immediate arguments in LS under hate which is interpreted as a function, and in 13.1 and 13.2 that he and John are immediate argument in LS under hate and that he is not within the scope of John in SR. In 12 and 13, the Co-IR must not be settled between he and John. Thus, the features of pronouns can be described as follows: when a pronoun is, in LS, an immediate argument along with an element under the same verb, it must not be co-indexed with the element. That is, the pronoun in such an environment must be interpreted as a free variable. Hereafter I will say that when an element is in an argument-relation under verb in LS, the element is in the local context under the verb.

Here I will briefly explain the local context.

(14) He loves her.
(15) He thinks that she will come.
Each LS for 14 and 15 is as follows:

(14.2) love’ (x, \(\lambdaPP[y]\)) \(\Rightarrow\) love*'(x, y)

(15.2) think’ (x, \(\lambda\text{will-come'}(y)\))

In 14.2, he and her are immediate arguments for love, and thus both pronouns are in the same local context under love. And in 15.2, in the same local context under think are he and that he will come, and what constitutes the same local context under will-come is only she. The local context is roughly defined along the lines of Bach and Partee 1980⁴ as follows:

(16) Local Context: The element that constitutes the immediate argument for a verb \(\alpha\) in LS is in the local context under \(\alpha\).

As mentioned earlier, the function/argument relation in the two concepts, namely SR and LS, is different respectively. I assume that SR is what is determined by the function/argument relations directly defined by compositional rules and what shows an intrinsic scope relation relevant to Co-IR, and local context is what is determined by the function/argument relation in LS. Let me define the features of reflexives and pronouns on the basis of local context and SR as in the following 17 and 18.

(17) A reflexive \(\alpha\) must be co-indexed with \(\beta\) which constitutes a local context together with \(\alpha\) on condition that \(\alpha\) is the element that is within the scope of \(\beta\) in SR.

(18) A pronoun \(\beta\) must not be co-indexed with any element which constitutes a local context together with \(\alpha\).

In what follows, I will argue how to co-index among NPs by using the two concepts, namely SR and local context.

3. Scope Realm and Control.⁵

(19) John expects him to win.

(20) John expects that he will win.

(19.1) John’ (\(\lambda\text{expect'}(\lambda\text{to-win}(\text{him'}))\))

(20.1) John’ (\(\lambda\text{expect'}(\lambda\text{he'}(\lambda\text{will-win'}))\))

⁴ See Bach and Partee 1980 for a complete discussion.

⁵ Manzini (1983: 430) observes that there are two cases of control: all PROs in object sentences pattern differently from all PROs in subject sentences. And Williams 1980 also points out that there are two kinds of control: Obligatory Control and Non-obligatory Control. I will discuss only the cases which Manzini regards as PROs in object sentences and which Williams defines as Obligatory Control.
(19.2) \( \text{expect}' (\text{`j}, \text{^\lambda PP}[x_2], \text{^\lambda x}_3 \text{\ \text{win}'(x_3)}) \)

The SR for 19 is represented as in 19.1 and the LS for 19 as in 19.2. Judging from the LS in 19.2, \( j, \text{^\lambda PP}[x_2] \) and \( \text{^\lambda x}_3 \text{\ \text{win}'(x_3)} \) are in the same local context under \text{except}. In this case, \text{him} is not co-indexed with \text{John} because \text{him} which is translated into \( \text{^\lambda PP}[x_2] \) must not be co-indexed with any element being in the same local context under \text{except} via 18. At this stage of LS, the variable \( x_2 \) is different from \( x_3 \), though \( x_3 \) is finally co-indexed with \( x_2 \) by means of control relation. On the other hand, the sentence in 20 has an SR as in 20.1 and an LS as in 20.2.

(20.2) \( \text{expect}' (\text{`j}, \text{^\lambda will-win}(x)) \)

According to the LS in 20.2, \( j \) and \( \text{will-win}(x) \) are in the same local context under \text{expect} but \( j \) and \( x \) are not in the same local context. And according to the SR in 20.1, \text{John} takes wider scope than \text{him}. It is thought in this case that there is a possibility that the Co-IR between both will be fixed via 18 and 4. Once this Co-IR is established, the LS in 20.2 is changed into the LS in 21. Generally speaking, when a pronoun that constitutes a local context under a verb \( \text{\beta} \) is within the scope over the element \( \text{\alpha} \) that constitutes a higher local context than \( \text{\beta} \) (henceforth, an upper local context), the pronoun may be co-indexed with \( \text{\beta} \) and then can be interpreted as a variable bound by \( \text{\beta} \).

(21) \( \text{expect}' (\text{`j}, \text{^\lambda will-win}'(\text{`j})) \)

Although the Co-IR holds good between \text{John} and \text{he} in the sentence of 20, it does not always hold in the similar construction: a sentence sensitive to Wh-Movement is an example in point.

Let me examine the case with the following sentences.

(22) Which boy does he think will hurt himself?
(23) Which boy thinks he will hurt himself?

It is assumed that the sentence in 22 has an SR as in 22.1 and an LS as in 22.2. See Karttunen (1977) for Wh-questions.

(22.1) \( \text{which-boy}' (\text{`he}'(\text{\`think'(z(\text{\`will-hurt'(\text{`himself')})))}) \)
(22.2) \( \forall p \exists x[\text{boy}'(x) \land \text{\`p} \land p=\text{\`think'(y, \text{\`will-hurt'(z, \text{\`PP}[z])})} \]
(22.4) \( z (\text{\`will-hurt'(z)}) \)

As a reflexive must have an element that is co-indexed with it in the same local context via 17, \( z \text{ will hurt himself } \) should be represented as in 22.4. Since \( \text{he}' (\text{\`think'(z(\text{\`will-hurt'(\text{`himself')})))}) \) in 22.1 has a similar IS to the one in 20.1, that is, they have the same SR, and \( \text{he} \) and \( z \) is not in the local context under the same verb, there is a possibility that a Co-IR may be established between \( z \) and \( \text{he} \); and furthermore, since \( \text{he} \) has wider scope than \( z \), \( z \) would be co-indexed with \( \text{he} \). If done so, the
sentence in 22 will have such an LS as in 24.

\[
\lambda p \exists x[\text{boy}'(x) \land \neg p \land p=\text{think}'(y, \text{will-hurt}'(y, \lambda PP[y]))]
\]

The LS in 24 is a formula that is not interpreted as an acceptable one because the variable \(y\) is not properly bound in the LS. This explanation leads me to the conclusion that the Co-IR between \(he\) and \(z\) should not be established. On the other hand, the sentence in 23 has such an SR as in 23.1 and such an LS as in 23.2.

\[
\lambda p \exists x[\text{boy}'(x) \land \neg p \land p=\text{think}'(x, \text{will-hurt}(z, \lambda PP[z]))]
\]

The \(x\)-think'(\(^\text{he}'(\text{will-hurt}(^\text{himself})))\) in 23.1 has also a similar SR to the one in 20.1. As the scope over \(x\) is wider than the one over \(he\), and \(x\) and \(he\) are not in the same local context under the verb think, the sentence in 23 will have an LS as in 25 on condition that \(he\) is co-indexed with \(x\).

\[
\lambda p \exists x[\text{boy}'(x) \land \neg p \land p=\text{think}'(x, \text{will-hurt}(x, \lambda PP[x]))]
\]

The LS in 25 is the one that can be appropriately interpreted, because the variable \(x\) is properly bound in the LS. Judging from the above argument, in the sentence of 22, \(he\) should not be co-indexed with which boy because 24 can not be appropriately interpreted. But the interpretation for the sentence of 23 is a possible one even if \(he\) is co-indexed with which boy, because 25 is a possible interpretation. From what is said of the sentences in 22 and 23, I will assume that variables must be properly bound after the Co-IR has been settled.

Next let me examine cases where the definite difference in Co-IR is shown up by scope relations among NPs.

\(26\) John expects that he will win.

\(27\) He expects that John will win.

In the sentence of 26, the Co-IR between John and \(he\) is fixed as said in 20. That is, as the scope over \(John\) is wider than the one over \(he\) in SR and both do not constitute the same local context, there is a possibility that \(he\) may be co-indexed with \(John\) via 4. What about the case of 27? The SR and LS for 27 are the following like 27.1 and 27.2 respectively.

\[
\text{he}'(\text{expect}'(\text{\(^\text{John}'(\text{\(^\text{will-win}'\))))})
\]

\[
\text{expect}'(x, \text{\(^\text{will-win}'(\neg j))}
\]

In 27, no Co-IR is settled via 4 because \(he\) is not within the scope over \(John\) in SR. And the pronoun in this case is interpreted as a free variable. This observation shows that scope relations in SR play an important role in fixing Co-IR.
To sum up, the features of pronouns may be described succinctly with regard to co-indexing as follows:

(18–I) Pronoun (which is regarded as a bound variable): In the cases where in LS a NP $\alpha$ and a pronoun $\beta$ are not in the same local context and in SR $\alpha$ has $\beta$ within its own scope, $\beta$ may be co-indexed with $\alpha$ and interpreted as a bound variable.

What 18–I says is that when $\alpha$ is a function which takes as its argument a certain constituent including $\beta$ in SR, $\beta$ may be co-indexed with $\alpha$, as said in 4. Here let me introduce a new concept to clarify scope relations between NPs; namely, scope realm. The concept is, roughly speaking, such that if scope relations in SR can be determined between NPs, I may say that they are in the same scope realm. It will be defined in terms of function/argument relations in SR as follows:

(28) Scope Realm: (i) When in SR an NP $\alpha$ is the function which takes as its argument the one including an NP $\beta$, that is, $\alpha(\ldots(\beta))$, $\alpha$ and $\beta$ are in the same scope realm.
(ii) When the function including $\alpha$ is the one taking $\beta$ as its argument, that is, $(\ldots(\alpha))(\beta)$, $\alpha$ and $\beta$ are not in the same scope realm.

Let me explain the Co-IRs in the following sentences of 29 and 30 via local context and scope relation. Each SR and LS for 29 is represented as in 29.1 and in 29.2.

(29) He liked every book that John read.
(30) Which book that John read did he like?

(29.1) $he(\overline{\text{liked}}(\overline{\text{every-book}}(\overline{\text{John}}(\overline{\text{read}}(x)))))$
(29.2) $\overline{\text{liked}}(x, \overline{\forall y[\text{book}(y) \land \text{read}(j, y) \rightarrow P[y]]})$

What 29.1 and 29.2 say is that though he and John are not in the same local context, he is not within the scope over John. Thus, I can say that the Co-IR between he and John isn’t established in the case of 29. On the other hand, the sentence in 30 has an SR as in 30.1 and an LS as in 30.2.

(30.1) $(\text{which-book}(\overline{\text{John}}(\overline{\text{read}}(x))))(\overline{\text{he}}(\overline{\text{liked}}(y)))$
(30.2) $\lambda p \exists x[\text{book}(x) \land \text{read}(j, x) \land \overline{p} \land p = \overline{\text{liked}}(z, \overline{\lambda P P[x]})$

I can see from what is shown in 30.1 and 30.2 that John and he are neither in the same local context nor in the same scope realm. An SR as in 30.1

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6 For example, in 29.1 he and John are in the same scope realm but not in 30.1.
produces a possibility that the Co-IR between *he* and *John* may be established, because the scope relation is not fixed between both NPs, each of which is in a different scope realm. The pronoun in this case is such that the Co-IR will be determined from the context, and it is different from the one in 18-I that is interpreted as a bound variable.\footnote{The pronoun in point is interpreted as a laziness of pronoun. See Cooper (1974: 141) and Reinhart (1983: 74-77).} When the Co-IR is established between *John* and *he* from a context, the LS will be changed into the following as in 30.4, for a variable \( z \) is co-indexed with *John*.

\[
(30.4) \lambda p \exists x[\text{book}'(x) \land \text{read}'(\hat{j}, x) \land \neg p \land p = \neg \text{liked}'(\hat{j}, \lambda \text{PP}[x])]
\]

Even if the Co-IR is established between *John* and *he*, the LS in 30.4 is an interpretable formula in contrast to 24. Here I will sum up the features of pronouns as in 18-II:

(18-II) \[\begin{array}{ll}
[I] & \text{When an NP } \alpha \text{ and a pronoun } \beta \text{ are in the same local context, } \beta \text{ is not co-indexed with } \alpha. \\
[II] & \text{When } \alpha \text{ and } \beta \text{ are not in the same local context and are} \\
[II-1] & \text{in the same scope realm, and furthermore (i) } \beta \text{ is within the scope over } \alpha, \beta \text{ is co-indexed with } \alpha, \\
& \text{and is interpreted as a bound variable.} \\
[II-2] & \text{not in the same scope realm, } \beta \text{ is interpreted as a context-dependent variable.}
\end{array}\]

18-II can be briefly represented as follows:

[I] same local context \((\alpha, \beta)\) \(\rightarrow\) \(\neg\) co-index \((\alpha, \beta)\)

[II-1-i] \(\neg\) same local context \((\alpha, \beta)\) \& same scope realm \((\alpha > \beta)\)

\(\rightarrow\) co-index \((\alpha, \beta)\) (bound variable)

[II-1-ii] \(\neg\) same local context \((\alpha, \beta)\) \& same scope realm \((\alpha < \beta)\)

\(\rightarrow\) \(\neg\) co-index \((\alpha, \beta)\)

[II-2] \(\neg\) same local context \((\alpha, \beta)\) \& \(\neg\) same scope realm \((\alpha, \beta)\)

\(\rightarrow\) co-index \((\alpha, \beta)\) (context-dependent variable)

Next, let me consider the relationship between co-indexing and con-
trolling. To start with, I will briefly explain the treatment for controlling in MG.

(31) John tried to win.
The SR and the LS for 31 are represented as follows:

(31.1) John’(‘try’(‘to-win’))
(31.2) try’(‘j, ‘λx₀ win’(x₀))

Controlling is considered as follows: the variable x₀ in λx₀α is the variable which must be bound by an NP and is co-indexed with the NP. The question considered here is which NP controls the INF.

Let me tentatively assume that the controller is the NP which first joins with the INF in syntactic analysis, in order that John is the NP in question in 31. To put it from a point of view of LS, the NP which is first connected with the INF occupies the position that is just to the left of the one occupied by the INF: in 31.2 the x₀ in λx₀α is controlled by ‘j because ‘j is just to the left of λx₀ win(x₀). Here I will tentatively define the controller as follows:

(18-III) Controller: In LS, the controller is the NP which is just to the left of INF.

Now examine controlling in 32 with the above in mind.

(32) Emily expects Mary to love her.
The infinitive in the sentence 32 has an LS as in 33 via 18, so that the whole sentence has an LS as in 32.2.

(33) λx₀ love’(x₀, ‘λPP{y})
(32.1) Emily’(‘expect’(‘to-love-her’))(‘Mary’)
(32.2) expect’(‘e, ‘λPP{m}, ‘λx₀ love’(x₀, ‘λPP{y}))

I can say from 32.1 and 32.2 that y directly constitutes the local context neither with Emily nor with Mary and is in the same scope realm with only Emily which takes wider scope than y. Thus, it is possible that y can be co-indexed with Emily via 18-II-[II-1-i]. And y may also be co-indexed with Mary via 18-II-[II-2] because Mary and to love her are not in the same scope realm. In 32.2, since the translation of NP which is just to the left of the INF is ‘λPP[m], it is Mary that can control 33; in consequence the Co-IR is established between y and Emily via 18-II-[II-1-i], that is, y≠Mary on account of x₀≠y and x₀=Mary.

Now, let me examine the controlling in detail with examples as in 34 and 35: the surface structure in 34 is almost similar to the one in 35, particularly in an argument arrangement, but the controlling relation is different between the two sentences.

(34) John persuaded Mary to go out.

...
(35) John promised Mary to go out.
Let me consider why the different controlling relation is provided to each sentence. As Bach 1979 points out, there are some syntactic differences in these sentences as follows:

(36) Mary was persuaded to go. (Passive)
(37) *Mary was promised to go out.
(38) ?What John persuaded Mary was to go out. (Pseudo Cleft)
(39) What John promised Mary was to go out.
(40) Who did John persuade to go out? (Question)
(41) ?Who did John promise to go out?
I can see, in comparing 38 with 39, that persuade has a stronger connection with INF than promise. The reason is that when persuade is separated from INF as in 38 the sentence becomes less acceptable, and that when the verb is joined with INF as in 40 the sentence becomes more acceptable. On the other hand, even if promise is separated from INF as in 39, the sentence is acceptable, but when the verb is separated from the object NP as in 37 and 41, the sentences become less acceptable. These observations lead me to the conclusion that INF is the first element that persuade connects with in the derivation where IV is constructed. It is also seen in 36 and 40 that the object NP of persuade can be moved somewhere, while in 37 and 41 the object NP of promise cannot. To put it another way, the object of promise has a stronger connection with the verb than any other element: promise is joined in an earlier stage of the derivation with the object NP than with INF. (Bach 1980 observes that such connections as promised Mary and persuaded to go out is syntactically coherent.) It follows from the above observations that persuade and promise are analysed as the following syntactic category:

(42-1) persuade: (IV/NP)/INF
(42-2) promise: (IV/INF)/NP

8 The verb promise also has another syntactic category.

(i) John promised Mary to go out.
(ii) John promised Mary to be allowed to go out.
The sentence (i) seems similar to the one (ii) in appearance, NP+ V+ NP+ to INF, but promise in (i) behaves differently from the one in (ii): the verb in (ii) can take the passive though the verb in (i) cannot.

(i') *Mary was promised to go out.
(ii') Mary was promised to be allowed to go out.
When translated into LS along the lines of such syntactic analyses as in 42-1 and 42-2, the sentences of 34 and 35 have the LSs as follows:

(43) persuaded(\(^j, \lambda x_0 \text{go-out}(x_0)\))
(44) promised(\(^j, \lambda x_0 \text{go-out}(x_0), \lambda \text{PP}(\text{m})\))

If controlling relation is determined on the basis of an assumption as in 18-III, the sentence’s meaning determined in such a way corresponds with the meaning which I want to apply to the sentences. Thus, the assumption seems to be right. I will examine further each Co-IR in 45 and 46 on the basis of this assumption that INF gets controlled by the NP which is just to the left of the INF in SL.

(45) John promised Mary to shave himself/*herself.
(46) John persuaded Mary to shave *himself/herself.

The INF in each sentence of 45 and 46 has the same LS as in 47, because via 17 a reflexive must have in the local context an element that it is co-indexed with. 45 has an LS an in 45.2, and 46 has an LS as in 46.2.

(47) \(\lambda x_0 \text{shave}(x_0, \lambda \text{PP}(x_0))\)
(45.2) promised(\(^j, \lambda x_0 \text{shave}(x_0, \lambda \text{PP}(x_0)), \lambda \text{PP}(\text{m})\))
(46.2) persuaded(\(^j, \lambda \text{PP}(\text{m}), \lambda x_0 \text{shave}(x_0, \lambda \text{PP}(x_0))\))

In 45.2, \(x_0\) is co-indexed with \(^j\) because the controller for 47 is \(^j\), and in the case in which \(x_0\) has such a feature as [+male], himself is co-indexed with John. The sentence with such a co-indexing is acceptable without any contradiction between the features. But in the case in which \(x_0\) has such a feature as [+female], the sentence is not acceptable because the feature that \(x_0\) has is inconsistent with the one that John has. With regard to the sentence of 46, \(x_0\) is co-indexed with Mary because the

In the case of verb ask, the above is reversed.

(iii) John asked Mary to go out.
(iv) John asked Mary to be allowed to go out.
(iii') Mary was asked to go out.
(iv') *Mary was asked to be allowed to go out.

Though in this paper a categorical difference such as (IV/NP)INF and (IV/INF)NP is mainly based on the acceptability of passive, it may be said from a point of view of semantics as follows: what the two verbs have in common is that in one interpretation they take an object as theme and that in the other they take a subject as theme. Each verb has two different interpretations in respect of theme; thus, it may well be said that it has two different categories: (IV/NP)INF and (IV/INF)NP.

From the above it may be generalized as follows: if a verb gives the theme to the object, the verb is categorized as (IV/NP)INF and if a verb gives the theme to the subject, the verb is categorized as (IV/INF)NP. For a relative discussion, see Williams 1980.
controller for the INF is Mary. In the case of \( x_0 = \text{himself} \), the feature that \( x_0 \) has is inconsistent with the one that Mary has; thus, the sentence with such a feature is not acceptable. The above observations show me that the assumption as in 18-III is right as to controlling relations.

Next consider how to co-index among NPs in the following sentences by means of local context and scope realm.

(48) John persuaded Mary to shave her/him.
(48.1) John'((\^persuaded'(^to-shave-her/him'))(^Mary'))
(48.2) persuaded'(^j, \^\lambda PP[^m], \^\lambda x_0 shave'(x_0, \^\lambda PP[y]))
(49) John promised Mary to shave her/him.
(49.1) John'((\^promised'(^Mary'))(^to-shave-her/him'))
(49.2) promised'(^j, \^\lambda x_0 shave'(x_0, \^\lambda PP[y]), \^\lambda PP[^m])

From the LS in 48.2, I can say that \( x_0 \) is controlled by \( \^\lambda PP[^m] \), which is just to the left of the variable in LS, and that \( \^\lambda PP[y] \) is in the same local context neither with \( ^j \) nor with \( \^\lambda PP[^m] \). From the SR in 48.1, it is also seen that her/him is not in the same scope realm with Mary though John, which has the widest scope, is in the same realm with her/him. I can briefly sum the above up as follows: (i) control(\( x_0 \), \( ^m \)), (ii) \( \sim \)local context(\( y \), \( ^j \)), (iii) \( \sim \)local context(\( y \), \( ^m \)), (iv) \( \sim \)scope realm (her/him, Mary), (v) scope realm (John>her/him). Thus, I can see from (iii) and (iv) a possibility that her might be co-indexed with Mary via 18-II-[II-2]. But her isn’t co-indexed with Mary because \( x_0 \) is controlled by \( ^m \) and \( x_0 \neq y \). Another possibility can also be seen from (ii) and (v) that him may be co-indexed with John via 18-II-[II-1-i]. In this case I have no trouble.

In 49, I can see from the LS in 49.2 that \( x_0 \) is controlled by \( ^j \) and that \( \^\lambda PP[y] \) is in the same local context neither with \( ^j \) nor with \( \^\lambda PP[^m] \) and that, from the SR in 49.1, John, which has the widest scope in the sentence, is in the same scope realm with her/him though Mary isn’t. I can, therefore, sum these up succinctly as follows: (vii) control(\( x_0 \), \( ^j \)), (viii) \( \sim \)local context(\( y \), \( ^j \)), (ix) \( \sim \)local context(\( y \), \( ^m \)), (x) scope realm (John>her/him), (xi) \( \sim \)scope realm (Mary, her/him). From (ix) and (xi) I can see a possibility that her may be co-indexed with Mary via 18-II-[II-2] and from (viii) and (x) another possibility that him may be co-indexed with John via 18-II-[II-1-i]. But the latter cannot be realized because \( x_0 \) is controlled by \( ^j \) and \( x_0 \neq y \). The former can be realized without any trouble. I have found that Co-IR is fixed on the basis of local context of LS and scope realm of SR.

Finally, let me consider the Co-IR in regard to NPs with a genitive
nominal (henceforth GN) and NPs without it. I will discuss it on the basis of SR and LS.

(50) He loves himself.
(51) his picture of himself

The surface structure of 51 looks like the one of 50 with regard to SR, as 50.1 and 51.1 show. I can assume from the similarity in SR that NPs with a GN constitute a similar local context as sentences do. Along the lines of this assumption, I assume that the LS for 51 is like 51.2 and that the local context is constituted between his and himself under $R$.

(50.1) he'("love"("himself"))
(51.1) his("picture-(of)-himself")
(51.2) (i) the("\lambda y\text{(picture}(y) \land R(u_0)(u_0)(y)))^{10}
\Rightarrow (ii) \exists x\forall y[[\text{picture}(y) \land R(u_0)(u_0)(y) \leftrightarrow x=y] \land P[x]]

($R$ is a variable determined by the context: $R$ could represent a possession-relation or an agent-relation.) What 51.2 means is that the set of properties of a thing such that $y$ is a unique one is a picture and stands in a $R$-relation between his and himself. Consider the sentences below along the lines of this consideration.

(52) Jack knows that he loves himself.
(53) Jack saw his picture of himself.

(52.2) know("j", "love"("x", "\lambda PP[x]"))
(53.2) (i) saw("j", the("\lambda y\text{(picture}(y) \land R(u_0)(u_0)(y))"))
\Rightarrow (ii) \exists x\forall y[[\text{picture}(y) \land R(u_0)(u_0)(y) \leftrightarrow x=y] \land saw("j", x)]

Just as with regard to the sentence of 52 he could be co-indexed with Jack and be interpreted as a bound variable via 18-I, so with regard to 53 his might be co-indexed with Jack via the like of 18-I. That is, in the case of 53.2i, the variable $u_0$ in the LS of 52.2 could be bound by Jack. (Roughly speaking, I assume here that $R(u_0)(u_0)$ corresponds to love'($x$, $x$)).

Next consider other cases of Co-IR about NPs without a GN as in the following 54–56.

(54) John told a story about himself to Bill.
(55) John told Bill a story about himself.

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9 There are prepositional phrases of which the prepositions only function as Case-Marker. It is possible that the proposition in point could be semantically treated as having no meaning. See Bach and Partee (1980: 13), Reinhart (1980: 631), and Bach (1980: 336).

10 For expository convenience, I used the similar notation used in Polland and Sag 1983.
(56) John told a story about Bill to himself.
Let me first examine the LSs for NPs without a GN.

(57) a story about himself
The LS for 57 would be assumed to be such an LS as in 57.2 along the
lines of the above assumption, because a reflexive must have a co-
indexed element in the local context via 17 and $R$ constitutes the local
context at 57.

(57.2) (i) $a'(^\lambda y(story'(y) \land R(u_0)(u_0)(y)))$
\[\Rightarrow (\text{ii}) \quad \lambda P \exists x[(story'(x) \land R(u_0)(u_0)(x)) \land P[x]]\]

Supposing that NPs with a GN constitute a similar local context as sub-
ordinate sentences do, I may assume that NPs without a GN constitute a
similar local context under $R$-relation as INFS do. That is, I assume that
just as the variable in INF is controlled (or co-indexed) by an NP, so the
variable in the translation of the NP without a GN would be co-indexed
by an NP first served up. Consider sentences in 54–56 on the basis of the
above consideration. Each LS and each analysis tree for 54–56 are repre-
sented roughly as follows:

(54.3) told a story about himself to Bill
\underline{told} to Bill \underline{a story about himself}

(55.3) told Bill a story about himself
\underline{told} Bill \underline{a story about himself}

(56.3) told a story about Bill to himself
\underline{told to himself} \underline{a story about Bill}

(54.2) (i) $told'(^j, a'(^\lambda y(story'(y) \land R(u_0)(u_0)(y))), ^\lambda PP[^b])$
\[\Rightarrow (\text{ii}) \quad \exists x[(story'(x) \land R(u_0)(u_0)(x)) \land told'(^j, x, ^b)]]\]

(55.2) (i) $told'(^j, ^\lambda PP[^b], a'(^\lambda y(story'(y) \land R(u_0)(u_0)(y))))$
\[\Rightarrow (\text{ii}) \quad \exists x[(story'(x) \land R(u_0)(u_0)(x)) \land told'(^j, ^b, x)]\]

(56.2) (i) $told'(^j, a'(^\lambda y(story'(y) \land R(u_0)(^b)(y))), ^\lambda PP[z])$
\[\Rightarrow (\text{ii}) \quad \exists x[(story'(x) \land R(u_0)(^b)(x)) \land told'(^j, x, ^j)]\]

In the above cases, I assume that the variable $u_0$ in each LS ought to be
bound to an NP just as the variable in the translation of INF, $x_0$ in $\lambda x_0 \alpha$,
must be. $R(u_0)(u_0)(y)$ represents the following: $y$ is a story, which is such
that $u_0$ stands in $R$-relation to $u_0$, for example, $u_0$ talks about $u_0$. $R(u_0)$
($^b)(y)$ represents the following: a story is such that $u_0$ is in $R$-relation to
(for example, $u_0$ talks about) $Bill$. I also assume that the Co-IR is fixed at
54.2i rather than 54.2ii. The reason is that the similarity in argument
arrangements of LS between 54 and 45 can be shown only at a structure as in 54.2i: just as SR is needed to show a difference in scope relations, so an LS as in 54.2 is needed to show a similarity in argument arrangements.

(45.2)  promise’(j, λx₀ shave(x₀, PP{x₀}), λPP{m})

(46.2)  persuade’(j, λPP{m}, λx₀ shave(x₀, λPP{x₀}))

It can be seen that each LS in 54.2i and in 55.2i seems to correspond to the one of 45.2 and 46.2 with regard to the arrangement of arguments. Thus, the variable u₀ in 54.2 will be controlled by j which is just to the left of the NP, like the controller for INF, and u₀ in 55.2 by b and u₀ in 56.2 by j. And in 56.2i, z is co-indexed with John because the reflexive must be bound in the same local context under told. Consequently, each variable u₀ is co-indexed with the like of the controller just as variables in INF are done. To ensure this consequence, let me consider 58 and 59 below.

(58)  John saw a picture of him.

(59)  John saw a picture of himself.

(58.2)  (i)  saw’(j, a’(λx(picture’(x) & R(v)(u₀)(x))))

        ⇔  (ii)  ∃x[(picture’(x) & R(v)(u₀)(x)) & saw’(j, x)]

(59.2)  (i)  saw’(j, a’(λx(picture’(x) & R(u₀)(u₀)(x))))

        ⇔  (ii)  ∃x[(picture’(x) & R(u₀)(u₀)(x)) & saw’(j, x)]

(60)  John tried to beat him.

(60.2)  tried’(j, λx₀ beat(x₀, v)))

(58.3)  a’(λx(picture’(x) & R(v)(u₀)(x))))

The LS of NP in 58, namely 58.3, is such that R constitutes a local context between the variable u₀ and the pronoun him, and the variable u₀ is not co-indexed with him because the pronoun mustn’t be co-indexed with any element in the local context under R via 18. The argument arrangement in 58.2i (or 59.2i) is identical to the one in 60.2. (I assume here that R(v)(u₀) corresponds to beat(v)(u₀).) Assuming that the whole NP is controlled in the same way as INF is done, in the case of 58.2 the variable u₀ gets co-indexed with John, so that the Co-IR isn’t established between John and him which is translated into v, just as the variable v in 60.2 isn’t co-indexed with John. But in the case of 59 the Co-IR is established between John and himself because the variable u₀ can be co-indexed with John and u₀= himself. Thus, they are finally transformed into LSs as follows:

(58.0)  ∃x[(picture’(x) & R(x, j, v)) & saw’(j, x)]

(59.0)  ∃x[(picture’(x) & R(x, j, j)) & saw’(j, x)]

(60.0)  tried’(j, beat’(j, y))
4. Conclusion. It seems that Co-IRs are determined on the basis of both SR and LS, when judging from what was discussed above. I assume that the SR is what shows scope relations most relevant to Co-IR and is directly defined by compositional rules, and that the LS is what decides a local context under the same verb. (It is necessary to pay attention to the difference between the function/argument in SR and the one in LS.)

I have also found out that pronouns and reflexives can be defined on the basis of local context and scope relation as in 17 and 18. And the features of pronouns can be described as in 18-II. The meaning of a sentence as a whole can be determined on the basis of both SR and LS. These arguments lead me to the conclusion that the NPs with a GN have the same SR and bear the same Co-IR as subordinate sentences do. And the NPs without a GN are co-indexed just the same as INFs are controlled: the variables in the NPs are co-indexed with the like of the controller. These conclusions have been gotten from a semantic point of view by taking SR and LS into account. I believe that what is explained by Chomsky’s theory can be in part provided by this semantic account.

REFERENCES


