The Dynamics of Wh-Mo Interaction
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1 Introduction
The syntax and semantics of mo have posed several recalcitrant problems to formal linguistic analysis. The problems are of two broad types. The first is that of figuring out what sentences containing mo intuitively mean, and hence in what situations such sentences should be true. The second problem is that of providing a formal explanation of those intuitions. These problems are compounded by the fact that mo occurs in several different constructions, all of which bear a family resemblance to one another while also having their own unique properties. The following examples give a sampling of the range of uses of mo that one finds.

(1) a. Gakusei-ga hitori-mo inai
   b. Daremo-ga shukudai-o teishutsu shimashita
   c. John-ga kono hon-o yonde-mo naiyou-ga wakaranai
   d. Dare-ga kono hon-o yonde-mo naiyou-ga wakaranai
   e. John-ga yonda hon-mo omoshirokatta
   f. Dare-ga yonda hon-mo omoshirokatta
   g. John-mo Bill-mo paati-ni kita
   h. Taro-wa kita ronbun-o LI-ni okuri-mo shita

In (1a), mo functions as part of a negative polarity item. In (1b), it is a part of the universally quantified expression daremo. In (1c,d), mo occurs as a connective between a concessive clause and the main clause of a sentence. In (1d) it is further associated in some way with the wh-expression dare. The exact nature of the association is hard to pin down, though the association has a universal quantifier like flavor to it. In (1e,f), mo is attached to an NP with a relative clause. In the former example, mo signals addition. In the latter, however, there is once again a long distance association between mo and the wh-expression dare, similar to that seen in (1d). In (1g), the two occurrences of mo have the flavor of addition, as in (1e), though they also seem to signal a comparison. Finally, in (1h) once again we have an occurrence of mo which signals addition of some sort, though this time it is attached to an infinitival verb rather than to an NP or a clause.

The data shown in (1) can be naturally grouped into three intuitively coherent cases -- negative polarity cases, cases in which mo signals addition, and cases in which mo is associated with a wh-expression. To come to an adequate understanding of what unifies the various uses illustrated in (1), the natural approach is thus to look in detail first at each of these subcases. After understanding the special properties of each of the subcases of mo, the prospects of giving a unified analysis will hopefully become clearer. Our goal in this paper is to analyze one of the subcases as a first step toward reaching such a unified analysis.

The case that we will focus on is that in which mo is associated with one or more wh-expressions, as illustrated in (1d,f). This construction has attracted a lot of attention in the syntax literature, starting with Nishigauchi (1986) and continuing through Ohno (1989), Brocket (1994), Kawashima (1994), ... From a syntactician’s perspective, this construction has some puzzling properties. Like English wh-movement, the association of a wh-expression with mo is in principle unbounded, as indicated by (2) for a wh-expression embedded in a relative clause and by (3) for a wh-expression embedded in a concessive clause.

(2) [[[Dare-ga kita]-to John-ga itta]-to omotteiru] hito-mo machigaeteita
(3) [John-ga [dare-ga kita] to-itte]-mo, shinjinai hou-ga ii

Also like English wh-movement, the association is sensitive to a relativized minimality type effect (cf. Rizzi (1990?)) as illustrated in (4) and (5), where the blocking element in these cases is not another wh-expression, but rather one of the particles ka or mo.\footnote{Interestingly, the blocking effect that mo has on long distance association is independent of the type of interpretation intuitively assigned to mo. That is, it is impossible for a wh-expression to associate with one occurrence of mo across a second occurrence of mo regardless of which of the intuitive interpretations}
(4)  a. *[[Dare]-ga ronbun-o kaita]-ka kiita hito]-mo sono ronbun-o hihanshita
     b. *[[Dare]-ga kaita ronbun]-mo yonda hito]-mo sono ronbun-o hihanshita
(5)  a. *[[John-ni [dare]-ga kita]-ka kiita] ato-de atte]-mo1, kare-wa soitsu no warukuchi-o iwu
     b. *[[Dare]-ga kite]-mo komaru] hito ga John-ni atte]-mo1, kare-ni soitsu-no warukuchi-o iwanai.

In these examples, care must be taken in isolating the relevant interpretation. If dare is associated with the structurally closest occurrence of ka or mo in these sentences, they are all acceptable. What is impossible is for dare to be associated long distance with the occurrence of mo with which it is coindexed. Thus, in both (4a) and (5a) it is possible to interpret the most deeply embedded clause as an embedded wh-question, but it is not possible to interpret it as an embedded yes/no question. Similarly, (4b) and (5b) are acceptable if the highest occurrence of mo is interpreted as signalling addition and the lower occurrence is associated with dare. The opposite interpretations of the two occurrences of mo, however, is impossible.

Though similar in many respects as seen above, the association of a wh-expression with mo in Japanese differs from English wh-movement. As seen in (6) and (7) below, the association can felicitously cross complex NP islands.
(6)  Dare-ga kaita ronbun-o yonda hito-mo sono ronbun-o hihanshita
(7)  Dare-ga kaita ronbun-o yonda hito ni kiite-mo, sono ronbun-no naiyou-o setsumei shitekurenakatta.

It is also insensitive to adjunct islands, as seen in (8) and (9).
(8)  Dare-ga paati-o deta ato-de watashi-ga kiita uwasa-mo uso datta
(9)  [John-ni [proi darej-to hanashi-ta ato-de] atte-mo] karej-wa soituj-no warukuchi-o iwu

Furthermore, the association is sensitive to the strong/weak quantifier distinction, being blocked by an intervening strong quantifier but not by a weak one, as seen in (10) and (11).
(10) a. Darej-ga yonda futatsu-no ronbun-mo watashi-wa saki-ni yonda
      b. *Darej-ga yonda hotondo-no ronbun-mo watashi-wa saki-ni yonda
      c. *Darej-ga kaita futatsu-no ronbun-o hometemo, watashi-wa yorokobanai
(11) a. Darej-ga kaita futatsu-no ronbun-o hometemo, watashi--wa yorokobanai
     b. *Darej-ga kaita futatsu-no ronbun-o hometemo, soitsu-mo yonda.

Finally, a wh-expression associated with mo can appear to bind a pronoun outside of its own c-command domain provided that the pronoun is c-commanded by the expression immediately dominating mo.
(12) a. Darej-ga yonda ronbun-mo soitsu-ni homerareta
     b. *Darej-ga yonda ronbun-mo hihanshitaara, soitsu-ni homerareta
(13) a. Dono-honj-o katte-mo, Mary-wa kanarazu e/sorej-o yon-da
     b. *Dono-honj-o katte-mo ureshiku narito hito-wa kanarazu e/sorej-o yomu.

Though the basic properties of mo when associated with a wh-expression have been known for some time, there is still no analysis which accounts for all of these properties in a unified manner. Our aim is to rectify this situation. To do so, we will focus not on the syntax of the constructions but rather on their semantics. In particular, we will propose a semantic analysis of mo from which the distribution of blocking effects illustrated in (2) - (11) falls out as a consequence. One consequence of the analysis developed is that wh-expressions can be interpreted within the minimal clause that contains them even when the occurrence of mo that they are associated with occurs outside this clause. This makes it possible to account for the association between a wh-expression and mo without requiring a local syntactic agreement relation to obtain between them, and hence without requiring that the former expression raise to the position of the latter at some point in the syntax. Since

illustrated in (1) is assigned to the second occurrence. This is one fact that indicates the existence of an underlying similarity unifying the many uses.
syntactic agreement between a wh-expression and *mo* is unnecessary, Occam's razor dictates that the assumption that such a relation is required should be eliminated from the grammar.

The remainder of the paper is organized as follows. In section 2, we will review two previous analyses of the association between wh-expressions and *mo*, those of Nishigauchi (1986,90) and Brocket (1994). In section 3 we will show several shortcomings of these analyses. Section 4 contains the main analysis of this paper. There we will develop a dynamic analysis of the association in question, bringing together the frameworks of Chomsky's minimalist program and Groenendijk and Stokhoff's dynamic predicate logic. In section 5, we show how the analysis can be extended to account for wh-ka interactions. Finally, section 6 contains brief concluding remarks.

2 Previous analyses

2.1 Nishigauchi (1986, 90)

The best-known detailed analysis of the type of sentence discussed in the previous section is found in Nishigauchi (1986, 90). Based on his analysis of wh-questions in Japanese, Nishigauchi claims that the wh-phrases in relative clauses and concessive clauses are indefinite and unselectively bound by a Q-element (*mo* in the case of (1)).

Syntactically, wh-phrases ([+wh] elements) have to be in a position which is governed by a Q-element at LF. To satisfy this requirement they move at LF to the Spec position of some CP. In the case where a wh-phrase is separated from the closest Q-element by an island, it only moves to the Spec of the highest CP contained within the island. The needed government relation is then obtained by moving a constituent containing the wh-phrase to the Spec of the CP headed by Q. Analyzing the wh-movement in this way makes it possible to have a syntactic connection between a wh-phrase and an associated Q across an island without producing a Subjacency violation. This is illustrated with (14), where the wh-pronoun **Dare** only moves within the relative clause to the Spec position of the first CP which dominates it, as shown in (15).

(14) a [pp[NP[CP DAre-ga kai-ta] tegami]-ni]-mo onaji-koto-ga kaite-atta
   (Nishigauchi (1990) p.126)

   b [AdvP[NP[CP DAre-ga kai-ta] hon]-o yonde-mo] boku-wa manzoku-deki-nai
   (Nishigauchi (1990) p. ??)

(15)

In order to allow wh-phrases in this configuration to satisfy the government requirement, Nishigauchi makes two modifications to the grammar. First, he assumes that features can percolate from a non-head YP to an XP dominating it just in case (i) the relevant feature is unspecified on the head X of XP, and (ii) YP occupies SpecXP. Second, he assumes that if an expression such as *mo* governs a YP in its Spec, it also governs all expressions from which a feature has percolated to YP. The two requirements in (i) and (ii) are taken to be
met in (15) with respect to the [+wh] feature of *dare*, allowing for percolation of this feature first to CP, and then from CP to NP, resulting in (16).

(16)

```
[+wh] NP
  /  
[+wh] CP  N tegami
  /  
[+wh] DAre₁ C'
    /  
      IP  C
    /  
   tᵢ
```

Movement of *dare* directly to the Spec of the projection headed by *mo* is impossible since such movement violates subjacency. However, movement of the NP to this Spec position does not violate subjacency, and furthermore is sufficient for *dare* to be governed by *mo*. The structure that results from this movement is illustrated in (17).

(17)

```
CP
  /  
[+wh] NP  C'
    /  
[+wh] CP  N tegami
      /  
[+wh] DAre₁ C'
        /  
          IP  C
        /  
       tᵢ
  /  
  PP  C mo
    /  
   tNP  P ni
```

In this structure, the wh-expression *dare* is governed by *mo* under the extended notion of government Nishigauchi assumes since the [+wh] feature of *dare* percolates to NP, and NP is directly governed by *mo*. This structure thus satisfies the LF requirement that all [+wh] elements be governed by an unselective binder.

In the case of (14b), too, the wh-pronoun *DAre* moves to the Spec of the relative clause, and after feature percolation, the entire NP moves to the Spec of the CP whose head is *mo*, as shown in (18).
(18) 

Once again this movement satisfies the government requirement of the wh-phrase. Since this is accomplished without having to move the wh-phrase outside an island, Nishigauchi's analysis directly accounts for the lack of subjacency violation in sentences such as (14a,b).

To account for the pronominal binding in cases such as (19), Nishigauchi adapts Haik's framework of indirect binding, under which an expression $Y$ can indirectly bind a pronoun $p$ if the index of $Y$ can percolate to a node c-commanding $p$.

(19) \[
[\text{AdjP} \, e_1 \, \text{DOno-hon}_i \,-\, \text{o} \, \text{kaw-te}]\,-\, \text{mo}, \, \text{Mary-wa} \, \text{kanarazu} \, e_i/\text{sore}_i \,-\, \text{o} \, \text{yon-da}
\]

To allow binding of a pronoun by a wh-expression in a wh-mo construction, Nishigauchi proposes the following index percolation mechanism for Japanese.

(20) CP $\rightarrow$ CP$^{(i)}$ iff C governs Y$_i$.

Under this analysis, the CP headed by mo can indirectly bind the pronoun in the matrix object position in a manner parallel to that in which the QP headed by every binds the pronominal expression it in (21). At LF, (19) is represented as in (22).

(21) \[\text{[Every man who owns a donkey]}_i^{(i)} \text{likes it}_i\]

(22)

CP in (22) bears index $(i)$ by (20) and thus **indirectly binds** the wh-phrase $\text{DOno-ronbun-o}$ 'which-paper-ACC'. Thus, the CP whose head is the Q-element mo can indirectly bind any expression which has the same index as the CP and which occurs in the c-command domain of the CP. This analysis correctly captures the generalization that a pronoun needs to be c-commanded by the minimal XP dominating mo in order to be bound by a wh-expression associated with mo from within that XP.

To give an interpretation to sentences with a wh-expression associated with mo, Nishigauchi (1986, 90) analyzes wh-pronouns as free variables bound by an unselective binder. Wh-pronouns are thus equivalent to indefinite expressions such as bare NPs.
Under this analysis, (14a,b) (repeated here as (23a,b)) are interpreted as in (24a,b) respectively.\textsuperscript{2}

\begin{equation}
\text{(23)} \quad \begin{aligned}
a & \quad \text{[\text{pp}[\text{NP[CP DAre-ga kai-ta] tegami]-ni]-mo onaji-koto-ga kaite-atta}} \\
b & \quad \text{[\text{Adv}[\text{NP[CP DAre-ga kai-ta] hon]-o yonde-mo] boku-wa manzoku-deki-nai}} \\
\end{aligned}
\end{equation}

(24) a. For all x, y, x a person, y a letter x wrote, the same thing was written in y

b. For all x, y, x a person, y a book x wrote, I cannot be satisfied by reading y

Relativized Minimality effects such as those witnessed in (4) and (5) are argued to fall out from the assumption that covert wh-movement is subject to subjacency. In a sentence such as (4) for example, repeated below as (25a), \textit{dare} can move to the Spec position of the CP headed by \textit{ka}, but is blocked by subjacency from moving from there to the CP headed by \textit{mo}. This results in the LF representation partially spelled out in (25b).

\begin{equation}
\text{(25)} \quad \begin{aligned}
a & \quad \text{\textbf{*[\text{[Dare]-ga ronbun-o kita]-ka kiita hito]-mo-1 sono ronbun-o hihanshita}}} \\
b & \quad \text{\textbf{[[\text{CP Dare]-ga [ t1 ronbun-o kita]-ka] kiita hito]-mo-1 sono ronbun-o hihanshita}}}
\end{aligned}
\end{equation}

The percolation mechanism that Nishigauchi assumes allows the index of \textit{dare} to percolate to the CP headed by \textit{ka}. However, since this CP is not in a specifier position, further percolation of the index is blocked. This makes it impossible for \textit{dare} to be governed by \textit{mo}, which presumably also makes it impossible for \textit{dare} to be bound by \textit{mo}.\textsuperscript{3}

Finally, though Nishigauchi does not note the blocking effect of strong quantifiers on the association of a wh-phrase with a Q-element, he does note a similar blocking effect that demonstratives and referential Ns such as names have on the association. This he analyzes as deriving from some (unanalyzed) incompatibility between the feature [+wh] and a feature [+def] which he takes to be inherent in demonstratives and names. Presumably, the same analysis could be extended to account for the blocking effect of strong quantifiers by analyzing these as having the feature [+def] as well. What the exact nature of the incompatibility is remains unclear, however, giving this part of the analysis a speculative flavor.

2.2 Ohno

As we have just seen, an important aspect of Nishigauchi’s analysis is that it treats wh-phrases and indefinite NPs on a par, with both analyzed as free variables that can be bound by an unselective binder such as an adverb of quantification. Ohno (1989) points out that this analysis fails to account for the existential reading of a DP in which a wh-phrase is contained\textsuperscript{4}. Example (26) has (27) as its interpretation in Nishigauchi’s analysis.

\begin{equation}
\text{(26)} \quad \text{[\text{DP[CP DAre-ga kai-ta] ronbun]-mo LI-ni not-ta}}
\end{equation}

\begin{equation}
\text{(27)} \quad \text{[\text{\forall x,y: person(x) \& paper(y) \& wrote(x, y)} (appeared(y, LI))}}
\end{equation}

Ohno (1989) argues that a Nishigauchi style unselective binding approach fails to account for one reading of examples like (26). Intuitively, the sentence in (26) can be true in a situation in which for each person in a relevant context there is some paper by that person which

\begin{itemize}
\item \textsuperscript{2} Nishigauchi claims that the universal quantifier associated with wh-phrases is “induced” by \textit{mo}, based on the interaction between \textit{mo} and adverbs of quantification. Since we will not be considering interaction with adverbs in this paper, we will ignore this aspect of his analysis and treat \textit{mo} directly as a universal quantifier. For a dynamic analysis of \textit{mo} which splits the domain-forming function of \textit{mo} from its quantificational force, see Yamashina (1999).

\item \textsuperscript{3} The relation that syntactic government of a wh-expression by \textit{mo} plays in deriving the interpretation of that wh-expression as bound by \textit{mo} is not made explicit by Nishigauchi. Nishigauchi appears to assume that government of a wh-expression by a particle \textit{x} is a prerequisite for binding of that expression by \textit{x}, though he gives no reason for adopting this assumption nor does he provide any way of deriving it.

\item \textsuperscript{4} Watanabe (1990) and Brockett (1994) also discuss this problem.
\end{itemize}
appeared in LI. Suppose for illustration that there are three people in the universe of discourse, John, Bill and Mary, and that John wrote papers 1, 2, 3, Bill wrote papers 4, 5, 6, and Mary wrote papers 7, 8, 9. Further suppose that papers 3, 6 and 9 appeared in LI, but the others did not, as schematized in (28).

(28)  

\[
\begin{align*}
&\text{J} \quad 1 \quad 2 \quad 3 \\
&\text{B} \quad 4 \quad 5 \quad 6 \\
&\text{M} \quad 7 \quad 8 \quad 9 \\
&\text{= appeared in LI}
\end{align*}
\]

Intuitively, sentence (26) can be taken as true in such a situation. However, interpretation (27) makes the sentence false in the same situation. Hence, Ohno claims that the interpretation of (26) which makes the sentence true in situation (28) is equivalent to (29), not to (27).

(29)  

\[\forall x: \text{person}(x) \left( \exists y: \text{paper}(y) \land \text{wrote}(x, y) \right) \left( \text{appeared}(y, \text{LI}) \right)\]

The fact that (26) can be true in situation (28) shows that (27), the interpretation that Nishigauchi claims for the sentence in (26), cannot be the only interpretation of the sentence. At the very least, an interpretation equivalent to (29) should be added,\(^5\) which leads to the conclusion that wh-phrases and indefinite NPs are not automatically both bound by the closest unselective binder. If unselective binding is taken to be automatic under Nishigauchi’s analysis, then the existence of a reading equivalent to (29) for the sentence in (26) constitutes an argument against the analysis. If not, it shows up the need to state the conditions under which unselective binding selects the expressions it binds. Either way, Nishigauchi’s analysis falls short of accounting for all of the readings available for sentences like (26).

3 Problems with Nishigauchi

3.1 Indefinites Can’t be Bound by \textit{mo}

Ohno and others argued that Nishigauchi’s analysis is not sufficient to account for all the readings that sentences such as (26) have, since \textit{mo} does not have to bind non-wh-indefinite DPs containing bound wh-phrases. This leaves open the question of whether (26) has the Nishigauchi style interpretation in (27) in addition to the Ohno style interpretation in (29). In other words, can \textit{mo} ever bind indefinite NPs other than wh-phrases? Based on the observation that (26) can also be interpreted in a way which makes it false in situation (28), one might suggest that such binding is possible, as Nishigauchi claimed, since the Nishigauchi interpretation in (27) that results from such binding makes the sentence false. Since we have already seen that the Ohno reading in (29) makes the sentence true in the same situation, some other interpretation for the sentence is necessary in addition to (29), and the Nishigauchi interpretation is a natural candidate. We will show below, however, that this suggestion is mistaken, and that \textit{mo} never unselectively binds indefinites. The intuition that (26) can be construed as false in situation (28) we show comes from the possibility of the subject DP in (26) being analyzed as definite.

The first indication that there is something wrong with a Nishigauchi-style interpretation comes from the observation that \textit{mo} never unselectively binds indefinite

\(^5\) Note that (27) entails (29) and hence the sentence in (26) could be claimed to have only the interpretation equivalent to (29).
expressions by themselves in sentences lacking a wh-phrase. This can be seen in the following examples.

(30) John-ga kaita ronbun-mo LI-ni notta

(31) John-ga kaita ronbun-wa itsumo LI-ni notta

If *mo* were interpreted as inducing an unselective universal adverb of quantification, then (30) should be synonymous with (31) in which such an adverb occurs overtly. In particular, it should minimally have both a normal reading according to which every paper John wrote appeared in LI, and also an absurd reading according to which one paper John wrote always appeared in LI, just as (31) does. The absurd reading of (31), however, is completely absent from (30). Similarly, if the universally quantified element induced by *mo* were a DP type quantifier, then (30) should be synonymous with (32). Here again, though (30) and (32) each have a reading which entails that every paper John wrote appeared in LI, (30) lacks a reading according to which one paper John wrote appeared in LI in its entirety. The argument is of course not decisive, since a mechanism which forces the quantifier induced by *mo* to bind the indefinite in (30) while allowing the indefinites in (31) and (32) to be interpreted ambiguously as existential quantifiers or as bound variables would explain these facts. In the absence of such a mechanism, however, it is far from clear what interpretation could be given to the quantifier induced by *mo* which would have the desired effects.

The second argument against a Nishigauchi style analysis of *mo* comes from comparison of cases like (26) with cases in which *mo* attaches to an NP headed by a wh-expression, such as the following.

(33) Dare-ga kaita dono-ronbun-mo LI-ni notta

Here once again Nishigauchi's analysis predicts a synonymy that does not exist. In (33), *mo* clearly is associated with both wh-expressions in its scope, giving as a meaning for the sentence something equivalent to the meaning Nishigauchi gives in (27) for sentence (26). There is no way of construing (33) in any other way. In particular, (33) does not have the Ohno interpretation of (26) given in (29). If *mo* unselectively binds both wh-expressions and indefinites alike, however, then we predict that (26) should have the same property as (33), having only a Nishigauchi interpretation and not an Ohno interpretation. We could overcome this problem by analyzing the indefinite in (26) as ambiguous, having both a restricted free variable interpretation and an existentially quantified interpretation and taking both to be compatible with *mo*. Wh-expressions on this assumption could be analyzed unambiguously as restricted free variables. Though this would solve the problem posed by (33), however, it would also make the problem posed by (30) - (32) appear intractable: the solution posed for that paradigm is incompatible with the solution posed for explaining the difference between (26) and (33). The former requires indefinites in the scope of *mo* to be obligatorily bound by *mo*, while the latter requires allowing such indefinites to not be so bound.

The above data can be taken to show that wh-expressions and NPs headed by a bare noun in Japanese behave differently with respect to their interaction with *mo*. The availability of an Ohno interpretation for sentences like (26) strongly suggests that such NPs can be interpreted as existentially quantified expressions. The impossibility of such NPs being independently bound by *mo* as seen in (30) further suggests that they are never interpreted as restricted variables. This leaves us in need of an explanation of the intuition which gave rise to Nishigauchi's analysis in the first place, that *mo* has the appearance of interacting simultaneously both with bare NPs and with the wh-expressions they contain. To find such an explanation, however, we needn't look far.

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6 The two readings in question are not equivalent, since *mo* in (30) contributes the meaning of addition. We will argue below that the relevant reading of (30) is in fact derived from interpretation of the NP as a (distributed) definite description, making it differ from (31) in its presupposition as well.
We noted above that (26) is at least two ways ambiguous. On one interpretation it is true in situation (28), and in another it is false. To obtain the former interpretation, we analyze the NP headed by ronbun as an indefinite description, following Ohno. The latter we obtain by analyzing that same NP as a definite description. Following Chierchia (1999), we assume that nouns in Japanese are inherently unspecified for number. We take the definite determiner in Japanese to pick out the maximal individual satisfying its NP argument without regard for whether this individual is atomic or not. Under these assumptions, the two interpretations of (26) can be informally represented as in (34).

(34) a. [∀x: person(x)] ([∃y: paper/s(y) & wrote(x, y)] (appeared(y, LI))
   b. [∀x: person(x)] ([the y: paper/s(y) & wrote(x, y)] (appeared(y, LI))

(34a) is identical to Ohno's reading in (29) except in allowing for the possibility of y being a non-atomic individual. Since (34a) also allows for the possibility of y being atomic, it is true in situation (28) for the same reason that (29) is. (34b), in contrast, is false in this situation. Since each person in the situation wrote three papers, for each person x, the maximal individual which is either a paper or papers that x wrote consists of the three papers that x wrote, and no person in the situation had all three of their papers appear in LI.

3.2 Relativized Minimality Effects are not Explained

Though Nishigauchi repeatedly notes examples of a single wh-expression occurring in the scope of multiple Q-elements such as ka or mo as in the sentences in (4) and (5), and though he points out in several places that the wh-expression is obligatorily construed with the most local Q-element, his analysis does not actually predict this effect. To see why not, consider the sentence in (4a), repeated below as (35).

(35) *[Dare1-ga ronbun-o kita]-ka kiita hito]-mo1 sono ronbun-o hihanshita

By assumption, wh-movement is subject to Subjacency, which presumably blocks movement of dare out of the embedded question directly to the Spec of the CP headed by mo. However, such movement is not needed under Nishigauchi's analysis to establish an association between dare and mo. The alternative of raising dare to the Spec of the CP headed by ka, percolating the [+wh] feature of dare to the CP and then raising the lower CP to the Spec of the higher CP would result in dare being governed by mo (as well as by ka).

Nothing in Nishigauchi's analysis blocks this possibility, nor does anything determine what force dare should have in this case. This problem is not a difficult one to overcome, though it is not one whose solution comes for free as a consequence of the remainder of his analysis.

4 Formalizing the Analysis

4.1 Introduction

In the preceding sections, we have examined sentences like those in (36).

(36) a. [DP[CP Dare-ga kai-ta] ronbun]-mo LI-ni not-ta
   b. [DP[CP Dare-ga kite]-mo] John-wa soitu-ni awu

The main observations made regarding such sentences are summarized in (37).

(37)

(1) Syntactic Islands
   The association of an argument wh-phrase and the particle mo is not constrained by the complex NP constraint or by the adjunct clause constraint, but it does display relativized minimality effects.

(2) Strong quantifier blocking effect
   A wh-expression cannot associate with an occurrence of mo across an intervening strong quantifier (i.e. when the wh-expression occurs in the restrictive clause of the quantifier but the occurrence of mo does not), though association is possible across a weak quantifier.

(3) Indirect binding
   A wh-expression associated with an occurrence of mo can bind any pronoun in the semantic scope of mo.

(4) Selectiveness of mo
Mo does not associate with non-wh-phrases in the same sentence.

(5) Interpretation of a DP with a relative clause
A DP with a relative clause in which a wh-phrase occurs such as (36a) can be interpreted as either definite or indefinite. That is, example (38a) can be interpreted as in (38b) or (38c).

(38) a. DAre-ga kai-ta ronbun-mo LI-ni not-ta
   b. For every person x who wrote a paper, the paper(s) x wrote appeared in LI
   c. For every person who wrote a paper, (a) paper(s) x wrote appeared in LI

To account for these facts, we make the following assumptions.

(39) (i) Wh-movement is restricted by islands
   (ii) Mo is a quantifier which selectively binds wh-phrases
   (iii) Mo takes the maximal XP preceding it as its internal argument and the maximal XP following it as its external argument

The analysis we propose incorporates insights of Dynamic Predicate Logic (DPL) into the framework of the Minimalist Program (MP). To make the core insights of DPL accessible to the greatest number of people, we work these insights out in a Heim and Kratzer (1998) style semantics. We maintain the assumption from H&K that LF is directly interpreted, obviating the need for an intermediate language of translation such as DPL.

4.2 Dynamic LF Interpretation

4.2.1 Basics of Dynamic Interpretation
Dynamic Predicate Logic (DPL) (Groenendijk & Stokhof (1991)) was developed to account for anaphoric relations between a quantifier and a pronoun in cases like those illustrated in (40).

(40) a. A man_i came. He_i sat down.
    b. If a farmer owns a donkey, he beats it
    c. Every farmer who owns a donkey beats it

In DPL, these connections are derived by analyzing the relevant pronouns as simple variables. To get the pronouns to be bound by their antecedents, DPL changes the role that variable assignment functions play in interpretation. Rather than assuming that all sentences in a given context are interpreted with respect to a single static variable assignment function, DPL assumes that variable assignment functions can be changed in the course of interpretation. This is implemented by analyzing formulas of DPL as imposing restrictions on the input assignment/output assignment pairs <g,h> with respect to which the formula can be interpreted. Such a pair of assignments <g,h> is in the interpretation of a formula \( \phi \) iff when \( \phi \) is evaluated with respect to g, h is a possible outcome of the evaluation. Formulas come in two types. In one, changes to the input assignment made within the formula can be carried over as output, so that g may be distinct from h. Operators which create such formulas are called externally dynamic. In the other, such changes cannot be carried over and instead, the input variable assignment function is passed over unchanged as output, so that g=h. Operators which create this type of formula are called externally static.

The possibility of the pronouns in (40) acting as bound variables depends on the analysis of the existential quantifier and conjunction (implicit in connected discourse) as externally dynamic operators. Existentially quantified formulas in DPL introduce a change in the input variable assignment function (g above). They further allow this and other changes in assignment made within the formula to surface in the output variable assignment (h above). For the first sentence of (40a) above, the relevant change will be in the value assigned to the variable associated with the indefinite expression a man. Taking this variable to be x, the first sentence requires that x be assigned to a man who came. This restriction surfaces as a restriction on the output assignment function h. The second sentence is then interpreted with respect to h as input assignment. If the pronoun in this second sentence is interpreted as x, then the value of this occurrence of x will be determined by h, and hence will be the same as the value assigned to the occurrences of x in the first conjunct. This is how a variable that is free within its sentence can be indirectly bound by an operator from a preceding sentence.
4.2.2 A Dynamic Semantics for LF

The basic analysis of indirect binding outlined above is implemented by Groenendijk and Stokhof by modifying standard predicate logic. This implementation presupposes that natural language sentences are translated first into the language of predicate logic. However, this intermediate translation step is dispensable. Extending ideas from Kanazawa (1994) and Tancredi (1999), we implement dynamic binding by modifying the framework of compositional semantics developed in Heim and Kratzer (1998). In this framework, interpretation occurs at the interface between syntax and conceptual structure, with syntactic LF representations associated directly with semantic (i.e. conceptual) truth conditions.

The framework of Heim and Kratzer associates sentences with truth conditions by employing as basic operations function application and predicate abstraction, given below.

(41) Function Application (FA)
If \( \alpha \) is a branching node and \( \{ \beta, \gamma \} \) the set of its daughters, then, for any assignment \( a \), \( \alpha \) is in the domain of \( [[\text{p}]\alpha] \) if both \( \beta \) and \( \gamma \) are, and \( [[\beta]\beta] \) is a function whose domain contains \( [[\gamma]\gamma] \). In this case, \( [[\alpha]\alpha] = [[\beta]\beta]([[\gamma]\gamma]) \).

Predicate Abstraction (PA)
Let \( \alpha \) be a branching node with daughters \( \beta \) and \( \gamma \), where \( \beta \) dominates only a numerical index \( i \). Then, for any variable assignment \( a \), \( [[\alpha]\alpha] = \lambda x \in D. [[\gamma]\gamma]^{x/i} \).

Note that only PA produces a change in the variable assignment function. FA employs the assignment function of the mother for interpreting each of the daughters. Since dynamic interpretation requires the ability to change variable assignment functions, it follows that dynamic interpretation cannot be handled by the application of FA alone. However, as we noted above, not all expressions are equally able to induce a change in assignment functions -- indefinite determiners like \( a \) can, and so can the conjunction and, though strong quantifiers like every cannot. Since PA in H&K's semantics applies whenever an expression is raised, and since raising does not distinguish externally dynamic expressions from externally static ones, it follows that PA is not fit for generating dynamic interpretations either.

In order to modify this framework to allow for dynamic binding, we propose three changes. First, we assume a new interpretation function which contains two variable assignment functions -- an input function and an output function. Second, we analyze argument taking expressions as operating directly over syntactic expressions rather than over their interpretations, just as the numeral index in PA does in H&K's semantics. This allows us to distinguish externally dynamic operators from externally static ones according to the manner in which they manipulate the variable assignment functions with respect to which their arguments are interpreted. Finally, we modify the definition of FA to comport with the above changes.

In modifying FA to accommodate dynamic interpretation, it is necessary to change the way in which variable assignment functions are passed down the tree. In particular, not all of the daughters of an expression can directly inherit the variable assignment functions of the expression as a whole. We propose that only the semantic head of an expression inherits the assignment functions of its mother node, resulting in the following modification of FA.

(42) Dynamic Function Application (DFA)
If \( \alpha \) is a branching node and \( \{ \beta, \gamma \} \) the set of its daughters, then, for any pairs of assignments \( \langle g, h \rangle \), \( \alpha \) is in the domain of \( [[\text{p}]\alpha] \) if \( \beta \) is, and \( [[\beta]\beta]^{g,h} \) is a function whose domain contains \( \gamma \). In this case, \( [[\alpha]\alpha]^{g,h} = [[\beta]\beta]^{g,h}([\gamma]) \).

The interpretation of simple predicates and non-variable referring expressions given by \( [[\text{p}]\alpha] \) is given in the lexicon and is similar to that given by H&K's interpretation function \( [[\text{p}]\alpha] \). However, \( \lambda \)-expressions in the former case apply to syntactic expressions rather than semantic interpretations. The changes that this difference requires can be seen by comparing a Heim and Kratzer style interpretation of the verb come with the new style below.
In the H&K style of interpretation, FA guarantees that the expression combined with will have already been interpreted, and hence this expression need not (and in fact must not) be interpreted again. In the new style in contrast, the expression combined with is taken to be a syntactic expression, and hence in need of interpretation. This makes it necessary to specify what variable assignment functions the argument of the verb is interpreted with respect to. In the case of a simple predicate, the relevant variable assignment functions are just those with respect to which the predicate itself is interpreted. Thus, inheritance of variable assignment functions, which for H&K was a general property of all semantic composition, becomes a property specified in the lexical entry for individual lexical items.

As in H&K, the interpretation of a variable denoting expression such as a syntactic trace or a pronoun is sensitive to the local variable assignment function(s). The two styles of interpreting an indexed trace are illustrated below for comparison.

\[
\llbracket \text{index} \rrbracket_{\llbracket g,h \rrbracket} = \lambda \text{index} . \llbracket \text{index} \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) \quad (\text{H&K})
\]

\[
\llbracket \text{index} \rrbracket_{\llbracket g,h \rrbracket} = \lambda \text{index} . \llbracket \text{index} \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) \quad (\text{here})
\]

In both cases, the value assigned to the trace is determined by the \textit{index} borne by the trace and the local variable assignment function. The equality to the right of the colon in the second case, \( g=h \), is a restriction arising from interpretation which is not itself part of the semantic value of what is interpreted. The particular restriction given here identifies traces as externally static expressions.

One consequence of adopting DFA over FA is that it becomes possible to dispense with a separate rule of predicate abstraction. Since DFA allows any expression to manipulate variable assignment functions, predicate abstraction becomes only a special case of DFA. The Rule of \( \text{PA} \) can be subsumed by assignment of the following lexical content to a bare index.

\[
\llbracket i \rrbracket_{\llbracket g,h \rrbracket} = \lambda x. \llbracket \text{index} \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (x)
\]

The most important change allowed by DFA as opposed to FA is in making possible a direct dynamic interpretation of quantifiers and conjunction.

\[
\llbracket [a] \rrbracket_{\llbracket g,h \rrbracket} = \lambda P. \lambda Q. \llbracket [P] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (P) = \llbracket [Q] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (Q)
\]

If we assume that separate sentences in a discourse are implicitly conjoined, then we can use the interpretation of \textit{and} given above in interpreting multiple sentence discourses as well. Given these assumptions together with other obvious assumptions regarding the interpretations of lexical expressions, the anaphoric connection between the pronoun \textit{he} in the second sentence of (40a) and the indefinite in the first sentence can be analyzed formally as follows. (\textit{D} is taken to be a syntactic projection of a discourse, headed here by an implicit \textit{and}.)

\[
\begin{align*}
\text{(43) a. } & \llbracket \text{ID} [\text{IP} [\text{man}, \text{IP} [\text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] (\text{and} ) [\text{IP} \text{he}_1 \text{ sat down}]] \rrbracket_{\llbracket g,h \rrbracket} \\
& = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] (\text{and} ) [\text{IP} \text{he}_1 \text{ sat down}]] \llbracket_{\llbracket g,h \rrbracket} \\
\text{b. } & = \llbracket [a] \llbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]] (\text{and} ) [\text{IP} \text{he}_1 \text{ sat down}]] \rrbracket_{\llbracket g,h \rrbracket} \\
\text{c. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \llbracket_{\llbracket g,h \rrbracket} \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = 1 \\
\text{i. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \llbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} \\
\text{c. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = 1 \\
\text{c. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = 1 \\
\text{j. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = 1 \\
\text{c. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = 1 \\
\text{j. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = 1 \\
\text{c. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} = 1 \\
\text{j. } & = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = \llbracket [\text{IP} [\text{man}, \text{IP} [\text{IP} \text{he}_1 \text{ sat down}]]] \rrbracket_{\llbracket g,h \rrbracket} (\text{index}) (\text{index}) = 1 
\end{align*}
\]

\[7\text{ I.e. for some variable assignment function } g \text{ which differs from the variable assignment function } h \text{ at most in the value it assigns to the } i^{th} \text{ position.}\]
The interpretation of (44) will then proceed as follows.

(45) a. \([\text{[[IP [every man]]_i [IP i [IP e_i came]]] (and) [IP he_i sat down]]]]^{g,h}\)

b. \([\text{[[IP [every man]]_i [IP i [IP e_i came]]] (and) [IP he_i sat down]]]]^{g,h}\)

c. \([\text{[IP [every man]]_i [IP i [IP e_i came]]]^{g,h} = [\text{IP he_i sat down]]}]]^{g,h}\)

\[= \lambda P. \lambda Q. l(x: \text{for some j,k: } k = i \text{ g} \& k(i) = x, [[P]]^{k,j>}(e_i) = 1)] =
\[l(x: \text{for some j,k: } k = i \text{ g} \& k(i) = x, [[P]]^{k,j>}(e_i) = 1)] =
\[= \lambda P. \lambda Q. l(x: \text{for some j,k: } k = i \text{ g} \& k(i) = x, [[P]]^{k,j>}(e_i) = 1)] =
\[l(x: \text{for some j,k,m: } k = i \text{ g} \& k(i) = x, [[P]]^{k,j>}(e_i) = 1)] =
\[l(x: \text{for some j,k: } k = i \text{ g} \& k(i) = x, [[P]]^{k,j>}(e_i) = 1)] =

Here, the same individual, \(h(i)\), that has to satisfy the predicates in the restrictive clause and nuclear scope of \(a\), namely \(\text{man}\) and \(\text{came}\), must as the interpretation of the pronoun also satisfy the predicate \(\text{sat-down}\) from the second sentence. This explains the observation that the pronoun \(he\) can be anaphoric on the quantifier \(a\ \text{man}\). Note that \(h\) is restricted but not determined by the choice of input function \(g\) together with the interpretation of the two sentences.

While pronouns can be indirectly bound by weak quantifiers across sentence boundaries, they cannot similarly be indirectly bound by strong quantifiers, as seen in (44).
from Heim and Kratzer (1998). An illustration of these syntactic assumptions is given below:

The interpretation given for \[ \exists g,k,m: k =_i g \land k(i) = x, \] 
\[ [[\text{man}]]^{g,k,m}(e_i) = [[[\text{IP}} \land [\text{IP} \; e_i \; \text{came}]]]^{g,k,m}(e_i) = 1]: g=h \]

... 

\[ = \{x: \text{for some } j,k: k =_i g \land k(i) = x, \text{man}(k(i)): k=j = 1\}\]

... 

\[ i: [[\text{IP} \; h_e \; \text{sat down}]]^{g,h} \]

... 

\[ = \text{sat-down}((l(i): l=h)) = 1 \]

d. For some \( l \), \( \{x: \text{man}(x) = 1\} = \{x: \text{man}(x) = \text{came}(x) = 1\} = \text{sat-down}(h(i)): l=h = 1 \)

e. For some \( l \), \( \{x: \text{man}(x) = 1\} = \{x: \text{man}(x) = \text{came}(x) = 1\} = \text{sat-down}(h(i)): l=h = 1 \)

The value assigned to the pronoun in the second sentence, namely \( h(i) \), is independent of the variable \( x \) associated with the universal quantifier. There is thus no indirect binding of the pronoun in this example: every is externally static. Note that the interpretation of every given above is internally dynamic. That is, changes to the variable assignment function made internal to the restrictive clause of the quantifier (= P above) affect the interpretation of the nuclear scope of the quantifier (= Q), just as with the dynamic interpretation of and. This is what makes it possible for an indefinite to bind a pronoun in donkey anaphora environments like (40c). (See Groenendijk and Stokhoff (1991) and especially Kanazawa (1994) for detailed analyses of donkey anaphora.)

4.3 An alternative analysis of wh-mo interaction

We now turn to an analysis of the interaction between wh-expressions and mo in sentences like (36), repeated below:

\[ (36) \]

a. \[ [[\text{DP} \; [\text{CP} \; \text{Dare-ga kai-ta}] \; \text{ronbun} \; \text{mo}] \; \text{LI-ni not-ta} \]

b. \[ [[\text{DP} \; [\text{CP} \; \text{Dare-ga kite]-mo}] \; \text{John-wa soitu-ni awu} \]

to account for the fact that \( mo \) selectively quantifies over wh-expressions, we analyze \( \text{wh-expressions as contributing variables to a special variable store} (= \text{an n-tuple of variables}) \), with the operators \( mo \) and \( ka \) operating over all and only variables in this store. Formally, this constitutes a further extension of the dynamic framework of interpretation. To incorporate this variable storage device, we reanalyze \( g \) and \( h \) in the interpretation function \([[[g,h]]]^{g,h}\) as containing not only variable assignment functions \( A(g) \) and \( A(h) \), but also variable stores \( S(g) \) and \( S(h) \). So as to be able to leave the definitions from the previous section unchanged, we make the following reinterpretations of the notations used there: For any \( g,k, k =_i g \) is reinterpreted as equivalent to \( A(k) =_i A(g) \) and \( S(k) = S(g); k(i) \) is reinterpreted as equivalent to \( A(k)(i) \); and \( k=g \) iff \( A(k) = A(g) \) and \( S(k) = S(g) \).

We can now give the following definitions for \( \text{dare} \).

\[ [[\text{dare}_i]]^{g,h} = \lambda P. \text{for some } j, \text{person}([[e_i]^{g,d})(e_i) = [P]^{g,h}(e_i) = 1: A(j) = A(g) \land S(j) = S(g) \]

The interpretation given for \( \text{dare} \) presupposes that this expression raises by a process akin to QR. For illustrative purposes, we will assume uniformly that \( \text{dare} \) adjoining to IP. Note that \( \text{dare} \) introduces an indexed trace in its interpretation without quantifying over that trace. The value assigned to the trace is determined entirely by the input assignment function \( g \). To mark the fact that this trace arose from a wh-expression, the index of the trace is added to the variable store for interpretation of the argument of \( \text{dare} \), ultimately surfacing in the output of \( \text{dare} \) as well. This way of marking traces as having arisen from wh-expressions

---

8 Here and throughout, we assume that the expression that raises is indexed, and that this index is shared by the head and the projection of the head that moves. Movement leaves behind a trace bearing that same index, and an occurrence of the index as abstractor over the expression adjoined to. This last assumption is adopted from Heim and Kratzer (1998). An illustration of these syntactic assumptions is given below:

\[ ... [Y ... [XP ... X_i ... i] ... ] ... ] \rightarrow ... [Y ... [XP ... X_i ... i] [Y i [Y ... e_i ... i]]] ... \]
makes it possible for \textit{mo} to quantify over \textit{dare} by analyzing \textit{mo} as manipulating the variable assignment functions of its arguments. The interpretation of \textit{mo} we propose is given below.

\[ [[\text{mo}]^{g,h}] = \lambda \varphi \lambda Q. l\{x: \text{for some } j,k: k =_{S(j)} g \text{ and } k(S(j)) = x \text{ and } S(k) = \langle \rangle, \]
\[ \{x: \text{for some } j,k,l: k =_{S(j)} g \text{ and } k(S(j)) = x \text{ and } S(k) = \langle \rangle, \]
\[ \lambda \varphi \lambda Q. l\{x: \text{for some } j,k,l: k =_{S(j)} g \text{ and } k(S(j)) = x \text{ and } S(k) = \langle \rangle, \]

This interpretation can be unpacked as follows. The overall function of \textit{mo} is similar to that of a universal quantifier. \textit{Mo} takes two arguments, \varphi and Q. It compares the number of individuals who satisfy application of \varphi to T, a predicate defined to be true of all individuals, with the number of individuals who satisfy application of \varphi to Q. If the numbers are identical, then the sentence headed by \textit{mo} is true.\footnote{This is parallel to a generalized quantifier analysis of \textit{every}, with changes made to accommodate the differences in semantic types of the arguments.} In evaluating the application of \varphi to T, \textit{mo} first changes the input assignment and variable store with respect to which the evaluation is made from g to k, with the output assignment and variable store being j. The variable store of k, S(k), is reset to the 0-tuple \langle \rangle. Since wh-expressions augment the variable store, the output variable store S(j) will contain the indices of all the wh-expressions free in \varphi and nothing else. \textit{Mo} then analyzes the assignment A(k) as differing from the original input assignment A(g) at most in the values of the variables that are in the output storage S(j). An n-tuple of individuals \(x\) which can be assigned to the variables in S(j) by k so as to satisfy the application of \varphi to T made with respect to k is then an n-tuple of individuals which could be substituted for their respective wh-expressions in \varphi to satisfy the restrictions placed on the wh-expressions by \varphi. Collecting together all such n-tuples which can be gotten from different choices of k then gives the first set of n-tuples of individuals that \textit{mo} compares.

Subtask 1
\[ [[[DP[Dare-ga kai-ta ronbun]] D]]^{k,j}(T) \]
Subtask 1 (continued)

= \([D]^{k,i}_{<g,h>} ([Dare-ga kai-ta ronbun]) \) (T)
= \([\lambda P. \lambda Q. \text{For some } l,m: m \equiv k, ([P]^{m,l}_{<g,h>}(e_i) = ([Q]^{l,i}_{<g,h>}(e_i) = 1) ([NP \text{ Dare-ga kai-ta ronbun}] \)) (T)
= \([\lambda P. \lambda Q. \text{For some } l,m: m \equiv k, ([NP \text{ Dare-ga kai-ta ronbun}]^{k,m,i}_{<g,h>}(e_i) = ([T]^{l,i}_{<g,h>}(e_i) = 1)
= \([\lambda P. \text{For some } l,m: m \equiv k, ([NP \text{ Dare-ga kai-ta ronbun}]^{k,m,i}_{<g,h>}(e_i) = 1 : l=j)
= \([\lambda P. \text{For some } l,m: m \equiv k, ([NP \text{ Dare-ga kai-ta ronbun}]^{k,m,n}_{<g,h>}(x) = \text{[ronbun]}^{n,i}_{<g,h>}(x) = 1) (e_i) = 1
= \([\lambda P. \text{For some } l,m: m \equiv k, ([NP \text{ Dare-ga kai-ta ronbun}]^{k,m,n}_{<g,h>}(e_i) = \text{[ronbun]}^{n,i}_{<g,h>}(e_i) = 1)

Subtask 1.1

\([[[CP 1 \text{ Dare-ga [ 2 e2 e1 kai-ta]]}]_{<g,h>}(e_i)
= \([\lambda P. \lambda x. ([P]^{[m,i]}_{<g,h>})(\text{Dare-ga [ 2 e2 e1 kai-ta]}) (e_i)
= \([[[\text{Dare-ga [ 2 e2 e1 kai-ta]]}]_{<g,h>}(e_i) = \text{[Dare-ga]}^{m(i)/1}_{<g,h>}(e_i)
= \([\lambda P. \text{For some } o, \text{person}(e_2)^{<m(i)/1,m(i)/1>,}(o,n,e_2) = 1: A(o) = A(m(i)/1) & S(n)=S(m(i)/1)+2) ([ 2 e2 e1 kai-ta])
= \([\lambda P. \text{For some } o, \text{person}(m(i)/1)(2)) = \text{[2 e2 e1 kai-ta]}^{o,n,e_2}(e_2) = 1: A(o) = A(m(i)/1) & S(o)=S(m(i)/1)+2
= \([\lambda P. \text{For some } o, \text{person}(m(2)) = \text{kaita}(o(2),o(1): o=n) = 1: A(o) = A(m(i)/1) & S(o)=S(m(i)/1)+2
= \text{person}(m(2)) = \text{kaita}(m(2),m(2)) = 1: A(n) = A(m(i)/1) & S(n)=S(m(i)/1)+2

Subtask 1.2

\([\text{ronbun]}^{n,i}_{<g,h>}(e_i)
= \text{ronbun}(n(i): n=j)

Subtask 1 (continued)

\([[[DP[Dare-ga kai-ta ronbun] D]]^{k,i}_{<g,h>}(T)
= \text{For some } m: m \equiv k, \text{for some } n, [\text{person}(m(2)) = \text{kaita}(m(2),m(2)) = 1: A(n) = A(m(i)/1) & S(n)=S(m(i)/1)+2) = \text{ronbun}(n(i): n=j) = 1
= \text{For some } m: m \equiv k, [\text{person}(k(2)) = \text{kaita}(k(2),m(2)) = 1: A(j) = A(m(i)/1) & S(j)=S(m(i)/1)+2) = \text{ronbun}(j(i)) = 1

Subtask 2

\([[[DP[CP Dare-ga kai-ta] ronbun]]^{k,i}_{<g,h>}(LI-ni not-ta)
= \text{For some } m: m \equiv k, [\text{person}(k(2)) = \text{kaita}(k(2),m(2)) = 1: A(j) = A(m(i)/1) & S(j)=S(m(i)/1)+2) = \text{ronbun}(j(i)) = 1)
= \text{notta}(j(i),LI) = 1

Main Derivation (continued)

\([[[DP[CP Dare-ga kai-ta] ronbun]-mo LI-ni not-ta]^{g,b}_{<g,h>}
= \{x: \text{for some } j,k: k = S(j) \text{ g & k(S(j)) = x} \& S(k) = \emptyset, \text{for some } m: m \equiv k, [\text{person}(k(2)) = \text{kaita}(k(2),m(2)) = 1: A(j) = A(m(i)/1) & S(j)=S(m(i)/1)+2) = \text{ronbun}(j(i)) = 1 \} \} =
\{x: \text{for some } j,k,l: k = S(j) \land k(S(j)) = x \land S(k) = \langle \rangle, \\
For \text{some } m: m = i \land \{\text{person}(k(2)) = \text{kaita}(k(2),m(i)) = 1: A(j) = A(m(i)/1) \land \\
S(j) = S(m(i)/1)+2 \} = \text{ronbun}(j(i)) = 1\}\} : g=h

\{x: \text{for some } k: k = S(j) \land k(S(j)) = x \land S(k) = \langle \rangle, \\
For \text{some } m: m = i \land \{\text{person}(k(2)) = \text{kaita}(k(2),m(i)) = 1: S(j) = S(k)+2 = \langle 2 \rangle \} = \\
\text{ronbun}(m(i)) = 1\}\} : g=h

\{x: \text{for some } k: k = S(j) \land k(S(j)) = x \land S(k) = \langle \rangle, \\
For \text{some } m: m = i \land \{\text{person}(x) = \text{kaita}(x,m(i)) = \text{ronbun}(m(i)) = 1\}\} : g=h

This final stage of the derivation is equivalent to the following more conventional formula.
\{x: \text{for some } y, \text{person}(x) = \text{kaita}(x,y) = \text{ronbun}(y) = 1\}\} = \\
\{x: \text{for some } y, \text{person}(x) = \text{kaita}(x,y) = \text{ronbun}(y) = \text{notta}(y,LI) = 1\}\} : g=h

According to the semantics given, then, the sentence in (36) is predicted to be true if and only if the set of people who wrote a paper is equal to the set of people who wrote a paper which appeared in LI. The instruction g=h shows that the sentence as a whole is externally static, meaning that none of the expressions contained within can bind an expression outside of the sentence.

4.3 Properties of wh-mo Associations Explained

Having set out the proposed analysis, it remains now to show how the analysis accounts for the four properties of wh-mo interaction summarized in section 4.1. The first of these -- that wh-mo interaction is not blocked by complex NP islands and adjunct islands -- follows since the analysis does not rely on movement to establish the semantic connection between wh-expressions and mo. Wh-expressions are taken to raise, but their movement is equivalent to Quantifier Raising and is only done to satisfy semantic interpretation requirements. There is no syntactic interaction between the wh-expression and mo.

The analysis also accounts for the blocking effect of strong quantifiers intervening between a wh-expression and mo. This blocking effect derives from the fact that strong quantifiers are externally static. As an externally static operator, a strong quantifier passes its input variable assignment functions and variable stores on unchanged as its output. That means that any changes made within either of the arguments of the quantifier are invisible from outside, including in particular additions made to the variable store by processing wh-expressions. Since variables added to the variable store within an argument of a strong quantifier are invisible outside these arguments, and since mo quantifies over variables in the store, it follows that mo will be unable to quantify over the variables introduced by wh-expressions within an argument of a strong quantifier. The same does not hold for weak quantifiers, however. As externally dynamic operators, changes made to the variable assignment function and variable store within either of the arguments of a weak quantifier are passed on to the output of the quantified sentence headed by that quantifier. Variables added to the variable store by a wh-expression contained in one of the arguments of a weak
quantifier will thus remain in the output variable store of the quantified sentence headed by that weak quantifier, becoming available for quantification by an occurrence of *mo* outside the scope of the quantifier. Importantly, the blocking behavior of quantifiers falls out as a direct consequence of their semantics, making it unnecessary to posit an otherwise unmotivated syntactic feature giving rise to an unanalyzed incompatibility with the [+wh] feature of a wh-expression.

The Relativized Minimality effects observed with wh-*mo* association, i.e. the blocking effect that an intervening occurrence of *mo* or *ka* has on association with a higher such occurrence, is under the analysis sketched above identical in nature to the blocking effect of a strong quantifier. This is because *mo* and (as we will show below) *ka* are both externally static operators. Though they operate over variables in the variable store contributed by wh-expressions in their first argument, they do not allow these variables to remain in the store outside their scope, making them unavailable for quantification over by higher operators. Once again, syntactic mechanisms are not needed to explain the blocking effects since they fall out entirely by the semantics alone.

The indirect binding of pronouns witnessed in examples such as (36b) also falls out from the semantics of the wh-*mo* interaction. *Mo*, like strong quantifiers, is internally dynamic, meaning that changes made to the variable assignment function within its first argument affect the interpretation of expressions in its second argument. Since *mo* quantifies over the variables introduced by wh-expressions in its first argument, it can bind occurrences of these variables in its second argument, such as those contributed by pronouns. Pronouns occurring outside the scope of *mo* will not be able to be bound in this manner, accounting for the distribution of pronominal binding observed.

We argued in section 3 that *mo* selectively binds wh-expressions, and never binds indefinites. This too follows directly from the semantics proposed, since only wh-expressions, and not indefinites, contribute variables to the variable store over which *mo* operates. The binding of wh-expressions is unselective in that all free occurrences of wh-expressions in the first argument of *mo* will be bound by that occurrence, though it is selective in that only wh-expressions ever get bound.

The variable interpretation of a DP containing a wh-expression in its relative clause associated with an occurrence of *mo* outside the DP is analyzed as deriving from a definite/indefinite ambiguity in the DP. On its indefinite interpretation, we take the DP to be headed by a covert occurrence of the indefinite determiner *a*. On its definite interpretation we take it to be headed by a covert *the*. We take both determiners to be externally dynamic. For *a*, the required semantics has already been given. For *the*, we adopt the following semantics.

\[
\text{[[the, ![g,h]]} = \lambda P \lambda Q. \text{MAX}\{y: \text{For some } j,k: k = g \& k(i) = y, [[P]^{<k,j>}](e_i) = 1\}
\]

\[
\in \{y: \text{For some } j,k: k = g \& k(i) = y, [[P]^{<k,j>}](e_i) = [[Q]^{<j,h>}(e_i) = 1\}
\]

MAX is an operator which takes a set as its argument and returns as its value the (possibly atomic) plural individual from that set of which every other individual in the set is a proper part. If no such individual exists in the set, then MAX applied to that set is undefined. In the Appendix, we give a full derivation of (26) under the assumption that the DP *Dare-ga kaita ronbun* is headed by a cover occurrence of *the*. The truth conditions associated with (26) under this interpretation are given informally in (48) below.

\[
(48) \text{[[Dare-ga kai-ta ronbun-mo LI-ni not-ta]]}^{[g,h]} =
\]

\[
\{x: \text{MAX}\{y: \text{person}(x) \& \text{kaita}(x,y) \& \text{ronbun}(y)\}\}
\]

\[
\in \{y: \text{person}(x) \& \text{kaita}(x,y) \& \text{ronbun}(y)\}\}
\]

\[
\{x: \text{MAX}\{y: \text{person}(x) \& \text{kaita}(x,y) \& \text{ronbun}(y)\}\}
\]

\[
\in \{y: \text{person}(x) \& \text{kaita}(x,y) \& \text{ronbun}(y) \& \text{notta}(y,LI)\}\}
\]

This says that the set of individuals such that the papers they wrote are papers they wrote is equal in size to the set of individuals such that the papers they wrote are papers they wrote which appeared in LI.

---

10 This includes the case in which the set is empty.
Appendix
Derivation for *Dare-ga kaita ronbun-mo LI-ni notta* (= (26)) under the assumption that *Dare-ga kaita ronbun* is definite.

\[
[[[[Dare-ga kai-ta ronbun-mo LI-ni not-ta ]]^{g,h>}} = \]
\[
l\{x: \text{for some } j,k: k = S(j) \text{ and } S(j) = x \land S(k) = \leftrightarrow,\]
\[
[[[[Dare-ga kai-ta ronbun]]^{k,i>}(T) = 1\} \}
\[
l\{x: \text{for some } j,k: k = S(j) \text{ and } S(j) = x \land S(k) = \leftrightarrow,\]
\[
[[[[Dare-ga kai-ta ronbun]]^{k,i>}(T) = \]
\[
[[[[Dare-ga kai-ta ronbun]]^{k,i>}(LI-ni not-ta) = 1\} : g = h
\]

Subtask 1
\[
[[[D_p[Dare-ga kai-ta ronbun] D]]^{k,i>}(T)
\]
\[
= [D_p[Dare-ga kai-ta ronbun]) (T)
\]
\[
= [\lambda P \lambda Q . \text{MAX}(\{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, [[P]]^{m,l>}(e_l) = 1\})
\]
\[
\quad \in \{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, [[P]]^{m,l>}(e_l) = [[Q]]^{n,l>}(e_l) = 1\}
\]
\[
= \text{MAX}(\{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, [[\text{NP Dare-ga kai-ta ronbun}]]^{m,l>}(e_l) = 1\})
\]
\[
\quad \in \{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, [[\text{NP Dare-ga kai-ta ronbun}]]^{m,l>}(e_l)
\]
\[
\quad = [T]^{k,i>}(e_l) = 1\}
\]
\[
= \text{MAX}(\{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, \text{for some } n, [[\text{CP 1 Dare-ga [2 e2 e1 kai-ta]}}]^{m,n>}(e_l) = [[\text{ronbun}]]^{n,l>}(e_l) = 1\})
\]
\[
\quad \in \{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, \text{for some } n, [[\text{CP 1 Dare-ga [2 e2 e1 kai-ta]}}]^{m,n>}(e_l) = [[\text{ronbun}]]^{n,l>}(e_l) = 1 : l = j\}
\]

Subtask 1.1
\[
[[[\text{CP 1 Dare-ga [2 e2 e1 kai-ta]}}]^{m,n>}(e_l)
\]
\[
= \text{person}(m(2)) = \text{kaita}(m(2), m(i)) = 1: A(n) = A(m^{n(i)/1}) \land S(n) = S(m^{n(i)/1})+2
\]

Subtask 1.2
\[
[[\text{ronbun}]]^{n,l>}(e_l)
\]
\[
= \text{ronbun}(n(i): n=j)
\]

Subtask 1 (continued)
\[
[[[D_p[Dare-ga kai-ta ronbun] D]]^{k,i>}(T)
\]
\[
= \text{MAX}(\{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y, \text{for some } n,
\]
\[
\quad [\text{person}(m(2)) = \text{kaita}(m(2), m(i)) = 1: A(n) = A(m^{n(i)/1}) \land S(n) = S(m^{n(i)/1})+2]\]
\[
\quad = \text{ronbun}(n(i): n=j) = 1: l=j\}
\]
\[
= \text{MAX}(\{y: \text{For some } l,m: m =_l k \text{ and } m(i) = y,
\]
\[
\quad [\text{person}(m(2)) = \text{kaita}(m(2), m(i)) = 1: A(j) = A(m^{n(i)/1}) \land S(j) = S(m^{n(i)/1})+2]\]
\[
\quad = \text{ronbun}(j(i)) = 1\})
\]
\[
\in \{y: \text{For some } m: m =_l k \text{ and } m(i) = y,
\]
[person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]
ronbun(j(i)) = notta(j(i),LI) = 1\}

Subtask 2
\\ll [DP_{CP}Dare-ga kai-ta] ronbun]^{k,j}\rr (LI-ni not-ta)
= \max\{\{y:\text{For some }l,m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]=
\text{ronbun(j(i)) = 1}\}\}
\in \{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]}
\text{ronbun(j(i)) = notta(j(i),LI) = 1}\}\}

Main Derivation (continued)
\\ll [DP_{CP}Dare-ga kai-ta] ronbun]^{-}\text{mo LI-ni not-ta}]^{g,h}\rr
= l\{x:\text{for some }j,k:\ l =_S(j) g & k(S(j)) = x & S(k) = \langle\rangle,\
\max\{\{y:\text{For some }l,m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]=
\text{ronbun(j(i)) = 1}\}\}
\in \{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]}
\text{ronbun(j(i)) = notta(j(i),LI) = 1}\}\}
= \max\{\{y:\text{For some }l,m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]=
\text{ronbun(j(i)) = 1}\}\}
\in \{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]}
\text{ronbun(j(i)) = notta(j(i),LI) = 1}\}\}
= \max\{\{y:\text{For some }l,m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]=
\text{ronbun(j(i)) = notta(j(i),LI) = 1}\}\}
= \max\{\{y:\text{For some }l,m:\ m =_1 k & m(i) = y,\
\[\text{person(m(2)) = kaita(m(2),m(i)) = 1: A(j) = A(m^{m(i)/1} & S(j)=S(m^{m(i)/1}+2]}
\text{ronbun(j(i)) = notta(j(i),LI) = 1}\}\}
= 1\}\}}: g=h
= l\{x:\text{for some }k:\ l =_S<2> g & k(<2>) = x & S(k) = \langle\rangle,\
\max\{\{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\text{person(m(2)) = kaita(m(2),m(i)) = ronbun(m(i)) = 1}\}
\in \{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\text{person(m(2)) = kaita(m(2),m(i)) = ronbun(m(i)) = 1}\}\}
= \max\{\{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\text{person(m(2)) = kaita(m(2),m(i)) = ronbun(m(i)) = 1}\}\}

= \max\{\{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\text{person(m(2)) = kaita(m(2),m(i)) = ronbun(m(i)) = 1}\}\}
= \max\{\{y:\text{For some }m:\ m =_1 k & m(i) = y,\
\text{person(m(2)) = kaita(m(2),m(i)) = ronbun(m(i)) = 1}\}\}


\[
\text{person}(m(2)) = \text{kaita}(m(2), m(i)) = \text{ronbun}(m(i)) = 1
\]
\[
\in \{y: \text{For some } m: m =_i k & m(i) = y, \text{person}(m(2)) = \text{kaita}(m(2), m(i)) = \text{ronbun}(m(i)) = \text{notta}(m(i), LI) = 1\}
\]
\[= 1\} : g = h
\]
\[
= \{x: \text{MAX} (\{y: \text{person}(x) = \text{kaita}(x, y) = \text{ronbun}(y) = 1\})
\]
\[
\in \{y: \text{person}(x) = \text{kaita}(x, y) = \text{ronbun}(y) = 1\} = 1\} : g = h
\]

References

Ohno, Y (1989) "Mo," in ...

5 Extention to ka

6 Conclusion