On Quantifier Raising and 'Move-F'

E.G. Ruys
U.i.L. OTS-Utrecht University

In Chomsky (1995) it is proposed that covert movement displaces only the formal features of a category, not the category as a whole. In this paper we shall attempt a preliminary exploration of some potential empirical consequences of this proposal. We shall argue in particular that the Move-F approach to Quantifier Raising, if it is to have any empirical content, requires an adjustment in the rules of semantic interpretation. One option is to view wide scope universal quantifiers as quantifiers over choice function variables. This will be seen to entail some useful empirical consequences with regard to the analysis of crossover. Also, we will find grounds for reconsidering the definition of the class of NPs subject to QR.

1. Introduction

Chomsky (1995: chapter 4) (henceforth Ch. 4) proposes that the movement operation 'Attract-α' attracts only the formal features of a category, not the category as a whole. Thus in (1) only the categorial features of the *wh*-phrase are attracted by the +*Wh* head of CP:

(1) which boy in this room did Susan like t best

The fact that movement in this example results in displacement of *which boy in this room*, not just its formal features, is a consequence of Pied Piping, necessary to fulfill the requirements of the phonological component which cannot process stray features. Movement which takes place after Spell-Out does not entail Pied Piping and moves only the formal features subject to Attract-α. We shall refer to this assumption as the "Move-F(eature)" hypothesis, and to the more traditional view of movement as the "Move-C(ategory)" hypothesis.

The motivation for the Move-F hypothesis derives primarily from conceptual considerations inherent to the Minimalist program. Since movement serves only to remove features that would cause a crash at the C-I interface, the optimally economical model of grammar will only show movement of these features. If an instance of movement shows displacement of a complete category, this must be attributed to some additional interface condition; in the case of (1), properties of the PF component.

Clearly, the Move-F approach, and the Minimalist view of grammar from which it derives, would be considerably strengthened if we could substantiate it with empirical evidence. Such evidence would show that post-Spell Out movement does not obey the Pied Piping convention, and that LF representations contain chains headed just by formal features. For instance, in the case of (2a):

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(2) a. Susan likes the boy in this room
b. which girl likes which boy in this room
c. some girl likes every boy in this room

we would need to show that covert movement as it applies to the Case features associated with *the boy in this room* displaces only these features, and leaves the remainder of the DP *in situ*. Similarly, we must present evidence that only the categorial (*wh*-) features associated with *which boy in this room* and the quantificational features associated with *every boy in this room* in (2b) and (2c) move at LF (if movement takes place at all), leaving the DPs *in situ*.

Conversely, to the extent that Minimalist considerations force us to assume feature movement in covert syntax, the Minimalist Program would be threatened if we were to find empirical evidence for covert *category* movement. We need to investigate whether such evidence exists.

Evidence on Move-F could in principle come either from semantic considerations or from observed properties of the computational system. A potential argument in favor of Move-F of the latter type is suggested by Chomsky's (1995:Ch. 4) discussion of Procrastinate. Chomsky suggests that, perhaps, Procrastinate need not be stipulated as an (axiomatic) condition, but may be derivable from other constraints. The idea is that, since no Pied Piping is necessary after Spell-Out has occurred, "more material" is moved during overt movement than during covert movement, so that it is natural to suppose that overt movement is more expensive than covert movement. Economy then prefers covert movement if possible. However, this account goes through only if we adopt an economy constraint which somehow "weighs" the amount of material displaced by a movement operation. In Ruys (1997) I have demonstrated that such a constraint, which is at least as stipulative as Procrastinate itself, must be both global and violable, hence does not fit well into the Ch. 4 framework.[1]

Since semantic considerations provide the most direct source of evidence available to us regarding the properties of LF representations, we expect evidence for or against Move-F to come primarily from semantics. Of course, we have no a priori knowledge as to how the C-I interface interprets stray moved features, or 'residual' constituents whose formal features have been moved, or the chains that connect them. It is possible in principle that constituents whose features have been moved are interpreted 'as if' they had been moved completely. In fact, Chomsky (1995:394, fn. 149) envisages this option:

> "Note that the syntactic forms produced differ from standard logical notations, though a simple algorithm Φ will convert them to these notations. To the

[1] A further, highly theory-internal syntactic reason to adopt Move-F is that, given the current definition of "Checking Domain" (see Chomsky 1993, 1995), Pied-piping (e.g. in the case of *wh*-movement) usually will not result in a checking configuration. Even in a simple case such as (1), *which* is not in the minimal domain of C, so if *which* is the locus of the *wh*-feature, the feature must move separately in order to be checked. The point is weakened by the Ch. 4 assumption that +*Wh* is "a variant of D" (Ch. 4:289) (as it must be categorial in order to be strong); if so, *which* presumably cannot be the locus of the *wh*-feature (but we still need Move-F to allow true Pied-piping).

extent that standard notations serve for semantic interpretation, so do the ones mapped into them by Φ."

But if we adopt this view, we essentially immunize the Move-F hypothesis against semantic counterevidence, while at the same time undermining any evidence we might find in favor of the Move-F hypothesis. If we take the Move-F hypothesis seriously, we should avoid this subterfuge as much as possible and assume that each constituent of an LF-representation is interpreted where it is found. Below we will attempt to establish whether this position is tenable. It is not, however, the purpose of this paper to take a definite stand on the existence or absence of semantic evidence for or against Move-F, but merely to conduct a preliminary exploration of the issues involved.

2. Move-Spec

Although the framework of Chomsky (1993) did not yet contain the Move-F hypothesis, it did give rise to some observations that remain relevant. It was assumed that Quantifier Raising and *wh*-Raising affect at most the quantificational specifier and the *wh*-specifier in (3) (call this "Move-Spec"):

(3) a. * he_i liked [every picture that $John_i$ took$]_\alpha$
b. * who said he_i liked [how many pictures that $John_i$ took$]_\alpha$

If Pied Piping of α were to take place in (3), we would expect *John* to be moved out of the c-command domain of *he* at LF. The Move-Spec assumption that only *every* in (3a) and *how many* in (3b) are moved, and α remains *in situ*, explained the condition C effect observed in both examples. This account is retained under the Move-F approach, as it predicts that only the operator features associated with α are moved. Thus the facts in (3) provide semantic evidence for Move-F, as well.[2]

A potential piece of semantic counterevidence was presented by Reinhart (1992, 1993). She observed that the Move-Spec hypothesis leads to incorrect predictions in examples such as (4a). If *philosopher* remains *in situ* then on standard assumptions (4a) is interpreted as: 'for which x and y is it the case that x will be offended if y is a philosopher, and we invite y,' as indicated in (4b) (assuming Karttunen's (1977) treatment of questions).

(4) a. Who will be offended if we invite which philosopher?
b. $\{ P \mid \exists\langle x,y\rangle\ [\ P = {}^\wedge(\ (y \text{ is a philosopher } \wedge \text{ we invite } y) \rightarrow (x \text{ will be offended})) \wedge {}^\vee P\ ]\}$

The set in (4b) will, e.g., contain the proposition that Lucy will be offended if we invite Donald Duck (as Donald Duck is not a philosopher, the antecedent of the implication will be

[2] On minimalist assumptions, referential indices are not true constituents of syntactic representations. Consequently, condition C can not be a syntactic constraint, but must be taken to reflect a property of the C-I interface module(s). This implies that the observations in (3) provide semantic evidence as intended here.

false, hence P will be true). The incorrect prediction follows that “Lucy will be offended if we invite Donald Duck” is a true answer to (4a). Note, that this prediction does not follow if we assume that *which philosopher* is preposed as a whole.

In order to remedy the situation, Reinhart proposed that *wh*-in-situ are interpreted as follows. The question operator unselectively binds a variable that ranges, not over individuals, but over choice functions (which assign to each set in their domain a member of the set); the function is applied to the in-situ restriction on the *wh*-in-situ:

(5) $\{ P \mid \exists\langle x,f\rangle [P = {}^\wedge(\text{ we invite } f(\text{philosopher}) \rightarrow x \text{ will be offended}) \wedge {}^\vee P]\}$

(4a) now roughly paraphrases as: for which x and which choice function f is it the case that x will be offended if we invite the individual that f selects from the set of philosophers. The proposition that Lucy will be offended if we invite Donald Duck is not a member of the set of true answers (5), given that there can be no f which selects Donald Duck from the set of philosophers.

We have two options for the treatment of the *wh*-in-situ in (4a). Either it shows no movement at LF at all, in which case it provides no evidence on Move-F. Or it does show movement, and Move-F predicts that only the formal features of *which philosopher*, or *which*, are moved. Either way, Reinhart’s puzzle carries over to the present framework, since the lexical content of the restriction remains *in situ*. Therefore, we shall also adopt Reinhart’s solution to her puzzle. The choice function mechanism will be seen to provide a possible solution to some of the other puzzles we will present below.

In the remainder of this paper we shall consider some further semantic consequences of the Move-F approach. We shall see that there may be reasons to distinguish A-movement from $\bar{A}$-movement. Section 2 deals with A-movement in connection with Antecedent Contained Deletion; in later sections we will discuss Quantifier Raising.

3. Antecedent Contained Deletion

Antecedent Contained Deletion, first discussed by Bouton (1970), has been taken to provide evidence for Quantifier Raising (see esp. May 1985):

(6) John $[_{VP1}$ likes $[_{NP}$ every book Peter does $[_{VP2}$ e]]]

In a normal case of VP-deletion, we expect the content of the empty VP to be recovered, under identity, from its overt antecedent. In (6), this seems impossible, since copying the antecedent VP1 into VP2 also copies the empty VP, and the copying procedure leads to an infinite regress.

The QR theory proposed by May (1977) held the promise of resolving this conundrum. QR will move the quantified NP containing the deletion site out of the matrix VP. After QR, the matrix VP contains only the verb and a variable, which can safely be copied into the empty VP:

(7) [$_{NP}$ every book Peter does [$_{VP2}$ e]]$_i$ [$_{IP}$ John [$_{VP1}$ likes t$_i$]]

It is essential to this solution that QR move the complete quantified NP, including the relative clause. The Move-Spec hypothesis of Chomsky (1993) predicts that QR results in (8), in which the deletion site is still contained in its antecedent:

(8) every$_i$ [$_{IP}$ John [$_{VP1}$ likes [$_{NP}$ t$_i$ book Peter does [$_{VP2}$ e]]]]

Noting this problem for the Move-Spec hypothesis, Lasnik (1993) and Hornstein (1995) proposed an analysis of ACD that was more in line with the Minimalist framework. QR aside, the QNP in (6) must move at LF to check its Case in Spec,AgrO, which result in (9):

(9) [$_{IP}$ John [$_{AGRoP}$ [$_{NP}$ every book Peter does [$_{VP2}$ e]]$_i$[$_{VP1}$ likes t$_i$]]]

Although some technical problems remained (see esp. Hornstein (1995) for relevant discussion), this move again solved the regress problem, while preserving the Move-Spec hypothesis for QR. In particular, there is no conflict with the Move-Spec account of the condition C effect in (3a). Consider (10):

(10) a. [$_{IP}$ he$_j$ [$_{VP1}$ likes [$_{NP}$ every book John$_{*j}$'s mother does [$_{VP2}$ e]]]]
b. every$_k$ [$_{IP}$ he$_j$ [$_{AGRoP}$ [$_{NP}$ t$_k$ book John$_{*j}$'s mother does [$_{VP2}$ e]]$_i$ [$_{VP1}$ likes t$_i$]]]

ACD is allowed in (10a), indicating that the QNP moves out of VP, but coreference of *he* and *John* is disallowed, indicating that the QNP remains in the c-command domain of *he*. This is so, because Case movement targets Spec,AgrO, and QR, which targets IP, is a case of Move-Spec (see (10b)).

This solution breaks down under the Move-F hypothesis, which holds that all covert movement, including Case movement in (6) and (10), displaces only the formal features being attracted. Case movement as it applies to the QNP in (6) will affect its formal features, i.e., its Case, φ-, and categorial features, adjoining them to AgrO.[3] If QR applies as well, it too moves only the formal features:

(11) FF(NP) [$_{IP}$ John [$_{AGRoP}$ [$_{AGRo'}$ [FF(NP)-AgrO] [$_{VP1}$ likes [$_{NP}$ every book Peter does [$_{VP2}$ e]]]]]]

3 Or to T, on the assumptions of Ch. 4:sec. 10; this does not affect the issue.

Whatever we take the extraction site of these formal features to be (DP, D, NP or N), the relative clause containing the empty VP remains *in situ*, and the deletion site is not removed from its antecedent.

Under the assumption that covert movement of the relative clause in (6) is the only way to account for the possibility of ACD, these observations are counterevidence to the Move-F hypothesis. Our observations regarding (10) furthermore suggest that Case-movement behaves like Move-C, whereas QR is Move-Spec or Move-F. There are several ways of implementing this distinction. We could postulate a distinction between A-movement and $\bar{A}$-movement and maintain that Move-F applies only to $\bar{A}$-movement, but it would be difficult to explain why this distinction should exist. A more principled way of distinguishing the two movements comes from the assumption that QR is triggered by properties of the quantificational specifier of DP, whereas the Case features that cause Case movement are arguably properties of (the head of) DP itself. We can assume that, when formal features are moved, LF is interpreted 'as if' the maximal projection whose label bears these features had moved.[4]

This is, of course, a significant retreat. Saying that the output of Move-F is interpreted as if Move-C had applied is tantamount to reinstating Move-C as far as semantic evidence is concerned. Possibly, there is a semantic principle that generalizes the effect of Move-F in this manner; but we may as well suppose that covert movement Pied-Pipes the smallest dominating XP, the distinction with overt movement being that overt Pied-Piping is not restricted to the smallest dominating XP.

We can still claim some headway, however. In the case of QR and *wh*-raising, the predicted semantic effect is that of Move-Spec. So we now predict what was previously a stipulation: that QR and *wh*-raising involve only Move-Spec. In the remainder of this paper, we will investigate the consequences of the move-F hypothesis for the treatment of quantifier scope.

4. Quantifier Raising

If QR is to have any effect on meaning under the Move-F hypothesis, it must imply that at least the quantificational specifier of a quantified DP is interpreted in the position of the moved features. If Move-F is to be distinguishable from move-C, it must imply that at most the

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[4] Fox (1995) argues that QR can move the deletion site out of VP because the grammar's economical preference for Move-Spec or Move-F is overruled by the need to resolve the ACD regress (see also references cited there). This does not obviate the Condition C violation in (10a) because QR moves the QNP no further than VP1 (in order to resolve ACD it is not necessary, hence impossible, to move further). This is confirmed by the fact that, when the pronoun that binds the R-expression is inside VP1, Condition C is not violated. See (ia):

(i) a. You bought him_i every picture that John_i thought you would
b. ?? You bought him_i every picture that John_i's mother would

However, the structure seems to deteriorate when we shorten the relative clause, as in (ib) (taking precautions to prevent a condition B violation inside the copy); this is suggestive of an effect of extraposition on both BT and ACD in (ia) (cf. Baltin 1987). Whatever the merits of Fox' proposal, subordinating the Move-F/Move-Spec hypothesis to interpretive requirements in this manner renders it all but immune to semantic couterevidence, so we shall not consider it in the present context.

specifier is so interpreted. If so, Move-F and Move-Spec make the same predictions for simple quantifiers. I will take this to be the case.

Consider (12):

(12) a. every boy sings
b. $[_{IP}\ [_{DP}\ [_{QP}$ every$]$ boy $]_i\ [_{IP}\ t_i$ sings $]]$
c. $[_{IP}\ [_{QP}$ every$]_i\ [_{IP}\ [t_i$ boy $]$ sings $]]$
d. $\forall x[boy(x) \rightarrow sing(x)]$

If the Logical Form of (12a) is anything like (12b), as Move-C predicts, familiar techniques will yield an interpretation equivalent to (12d). It is not so obvious how we can interpret the result of Move-F style QR, as in (12c), other than by mapping (12c) into (12b), as suggested by Chomsky in the footnote cited above.

Whether we treat *every* as quantifying over first-order variables, or as a relation over sets of individuals as in Generalized Quantifier theory, we face serious difficulties. Since strong quantifiers like *every* are not symmetrical, we must distinguish the restriction (*boy*) from the remaining predicate (*sing*); but in Move-F style LFs these form one constituent. We can recognize the restriction as the predicate in construction with the QP-trace, but in order to isolate the remaining predicate we must somehow “lift” the restriction out of it, in effect applying Chomsky’s Φ-algorithm in a non-obvious way. To illustrate, consider some of the things that go wrong if we fail to take such measures. Inverse linking (May 1977) provides an interesting case:

(13) a. exactly two people in every city were happy
b. $every_j$ [exactly two people in t_j city] were happy
c. $\forall x\ \exists 2!y\ [(\ person(y) \wedge (\ city(x) \rightarrow in(y,x)\ ))\wedge happy(y)]$

Move-F requires that we interpret the constituents of (13a) in the positions indicated in (13b). At best, this will get us (13c), which says that there are exactly two happy people in the world, who, furthermore, live in all cities.

A particularly relevant example is (14):

(14) a. some $musician_i$ will play every piece he_i likes
b. [every piece he_i likes$]_k$ [some $musician_j$ will play t_k]
c. * [every piece he_i likes$]_k$ [some $musician_i$ will play t_k]

Higginbotham (1980) made the following observations concerning such examples. *He* may be bound by *some musician*, as indicated in (14a). *Every piece he likes* may take scope over *some musician* by QR, as in (14b). But both may not happen at the same time, as shown in (14c). The simple explanation is that, when QR applies to the direct object, the pronoun is carried along out of the scope of the subject, and variable binding is ruled out.

The explanation will no longer be as simple if we adopt Move-F. When QR applies to the object, the pronoun remains in the scope of the subject. Variable binding is now possible in LF (15a), and we run the risk of predicting the meaning in (15b).

(15) a. $every_k$ [some $musician_i$ will play [t_k piece he_i likes]]
b. $\forall x\, \exists y\, [\, musician(y) \wedge ((\, piece(x) \wedge like(y,x)) \rightarrow play(y,x)\,)]$

It is implied by (15b) that for every piece there is a musician who, if he likes it, will play it; this is not implied by (14) on either of its readings.

Rather than giving up our attempt to provide substance to the Move-F hypothesis, let us consider the option that quantifiers such as *every* are not interpreted as quantifiers over individual variables or as GQ determiners. Instead, keeping in mind Reinhart's treatment of *wh*-in-situ, let us assume that *every* binds a variable of the Choice Function (CF) type. A Choice Function is a function which, for each set to which it is applied, has as its value a specific member of that set. That is, the set of Choice Functions can be (provisionally) defined as in (16):

(16) $[\![\, CF\,]\!] =_{df} \{f \mid \forall X\, (X \neq \varnothing \rightarrow f(X) \in X)\, \}$

For the moment, we will ignore the case where $X=\varnothing$, and we will omit the reference to CF in our formulas; we return to (16) in the final section.

Assume also that, since *every* binds CF variables, the trace it binds in Spec,DP is interpreted as such a variable. The function that is the value of this variable is applied to the D' denotation, which we therefore take to be a set of individuals.

With this mechanism in place, examples (12) and (13) come out as in (17).

(17) a. $\forall f\, [sing(f(boy))]$
b. $\forall f\, \exists 2!x\, [person(x) \wedge in(x,f(city)) \wedge happy(x)\,]$

Although in (17) we have left the restriction that f must be a CF implicit, we can already see that the CF approach is promising. Since a CF f applied to a set of individuals yields an individual, an expression such as f(boy) has type e, and can be interpreted in situ like any other term (alternatively, it can be lifted to a Generalized Quantifier, as in Winter (1996)). (17a) gives roughly the correct meaning for (12a): for every CF f the individual that f picks from the set of boys sings. Similarly, (17b) gives the meaning for (13a) with *city* interpreted in situ: for each CF f there are exactly two people who are in the city f chooses and who are happy.

Examples aside, we could be fairly confident that this approach will give the interpretations we expect, if it could be shown that a formula of the form (12d) is equivalent in general to a formula of the form (17a), i.e. that the following equivalence holds:

(18) $\forall x\, (\varphi \rightarrow \psi\,) \leftrightarrow \forall f\, [f(\lambda x \varphi)/x]\psi$

Assuming that: all variables free in φ are free for x in ψ (we can replace all free occurrences of x in ψ with f(λxφ) without any variables inside φ ending up bound by some operator in ψ); that ψ and φ do not already contain any occurrences of f; (and still ignoring the case where λxφ denotes the empty set and assuming the implicit restriction of f to *choice* functions), this equivalence indeed holds.[5,6]

The assumption that ψ and φ contain no occurrence of f is fairly innocuous; this should follow from a ban on accidental coindexing of QPs. The assumption that λxφ does not denote ∅ is far from innocuous; we discuss this in the final section. The case where not all variables free in φ are free for x in ψ is exemplified by Higginbotham's (14).

For (14), the Move-F hypothesis predicts that *every* can take wide scope, and *some musician* can bind *he* at the same time, as indicated in (15a). So we predict the interpretation in (19):

(19) $\forall f\, \exists x\, [\text{musician}(x) \wedge \text{play}(x, f(\lambda y(\text{piece}(y) \wedge \text{like}(x,y))))]$

This result is not as far off the mark as it seems, as the equivalence in (18) does not hold for (19). Despite its appearance, (19) almost gives the *narrow* scope reading for *every piece he likes*, i.e., the correct reading (14a).[7] The remaining problem is that there is a slight difference between (19) and (14a), stemming from the fact that the extension of *piece x likes* may happen to be the same for different musicians x. Among them, such a group of like-minded musicians may play each choice from their common favorites ((19) true), even if no musician plays every piece he likes ((14a) false). A related problem in connection with the CF treatment of wide scope indefinites has been noted by Winter (in prep), who suggests the problem may be resolved through an intensional treatment of CFs. The reader is referred to Winter (in prep) and references cited there for further discussion.

We shall return to some technical issues involving the definition of CF, and the possibility of extending the CF approach to non-universal strong quantifiers, in the final section. We

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5 In IL, additional assumptions would be required. We will not discuss intensional contexts here.

6 Under these assumptions, if $\llbracket f(\lambda x\varphi)\rrbracket_{M,g} = \mathbf{d}$, then $\llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g} = \llbracket\psi\rrbracket_{M,g[x/\mathbf{d}]}$. (This is so because, under these assumptions, $\llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g} = \llbracket \lambda x\psi(f(\lambda x\varphi)) \rrbracket_{M,g} = \llbracket\lambda x\psi\rrbracket_{M,g}(\llbracket f(\lambda x\varphi)\rrbracket_{M,g})$. Now if $\llbracket f(\lambda x\varphi)\rrbracket_{M,g} = \mathbf{d}$, $\llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g} = \llbracket\lambda x\psi\rrbracket_{M,g}(\mathbf{d}) = \llbracket\psi\rrbracket_{M,g[x/\mathbf{d}]}$.)

Right-to-left: Suppose that $\llbracket \forall x\, (\varphi \rightarrow \psi) \rrbracket_{M,g} = 0$. Then for some $\mathbf{d}$, $\llbracket\varphi\rrbracket_{M,g[x/\mathbf{d}]} = 1$ and $\llbracket\psi\rrbracket_{M,g[x/\mathbf{d}]} = 0$. Since $\llbracket\varphi\rrbracket_{M,g[x/\mathbf{d}]} = 1$, $\llbracket \lambda x\varphi \rrbracket_{M,g}(\mathbf{d})=1$. Since neither φ nor ψ contain f, all this also holds for g'=g[f/**c**] for any CF **c**. Since $\llbracket \lambda x\varphi \rrbracket_{M,g}(\mathbf{d})=1$ there is some choice function **h** s.t. $\mathbf{h}(\llbracket \lambda x\varphi \rrbracket_{M,g})=\mathbf{d}$. Take g' to be g[f/**h**]. Then also $\mathbf{h}(\llbracket \lambda x\varphi \rrbracket_{M,g'})=\mathbf{d}$, so $\llbracket f(\lambda x\varphi) \rrbracket_{M,g'}=\mathbf{d}$. So, since $\llbracket\psi\rrbracket_{M,g'[x/\mathbf{d}]}=0$, $\llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g'} =0$. Therefore, $\llbracket \forall f\ [f(\lambda x\varphi) / x]\psi \rrbracket_{M,g} = 0$.

Left-to-right: Suppose that $\llbracket \forall f\ [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g} = 0$. Then there must be some **h** s.t. $\llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g[f/\mathbf{h}]} = 0$. Say that $\llbracket f(\lambda x\varphi) \rrbracket_{M,g[f/\mathbf{h}]} = \mathbf{d}$. Then $\llbracket\psi\rrbracket_{M,g[f/\mathbf{h}][x/\mathbf{d}]} = \llbracket [f(\lambda x\varphi)/x]\psi \rrbracket_{M,g[f/\mathbf{h}]} = 0$. Since ψ contains no f, also $\llbracket\psi\rrbracket_{M,g[x/\mathbf{d}]} = 0$. Furthermore, since $\llbracket f(\lambda x\varphi) \rrbracket_{M,g[f/\mathbf{h}]} = \mathbf{d}$, $\mathbf{h}(\llbracket \lambda x\varphi \rrbracket_{M,g[f/\mathbf{h}]}) = \mathbf{d}$, hence $\mathbf{h}(\llbracket \lambda x\varphi \rrbracket_{M,g}) = \mathbf{d}$. Since we assume **h** is a CF and $\llbracket \lambda x\varphi \rrbracket_{M,g} \neq \emptyset$, it follows that $\llbracket \lambda x\varphi \rrbracket_{M,g}(\mathbf{d}) = 1$, hence $\llbracket\varphi\rrbracket_{M,g[x/\mathbf{d}]} = 1$. Since $\llbracket\psi\rrbracket_{M,g[x/\mathbf{d}]} = 0$ and $\llbracket\varphi\rrbracket_{M,g[x/\mathbf{d}]} =1$, $\llbracket (\varphi \rightarrow \psi) \rrbracket_{M,g[x/\mathbf{d}]} = 0$ hence $\llbracket \forall x\, (\varphi \rightarrow \psi) \rrbracket_{M,g} = 0$.

7 When *every* takes wide scope but *some musician* does not bind *he*, we derive the correct wide scope reading (14b), by (18).

assume for the moment that the analysis of natural language universal quantifier determiners as quantifiers over CF variables is viable. If so, the Move-F hypothesis is not falsified by QR. But as yet we only have conceptual reasons to prefer the Move-F hypothesis over the Move-C hypothesis. In the next two sections we will present some empirical considerations which support the Move-F hypothesis.

5. Crossover

In this section we will argue that the analysis of wide scope universal quantifiers as quantifiers over choice function variables described above, allows us to explain the crossover phenomenon along the lines suggested by Ruys (in prep.). Consider (20):

(20) a. which boy_i t_i likes his_i mother
b. * which boy_i does he_i like t_i
c. ?? which boy_i does his_i mother like t_i

Ruys (in prep.) argues that crossover violations, as illustrated in (20b) and (20c), reflect a failure on the part of the operator to take scope over the pronoun, which prevents the pronoun from being interpreted as a bound variable. The suggested explanation is that the D'-restriction on the *wh*-operator undergoes reconstruction at LF, as proposed by Chomsky (1993). This results in the LF representations (21):

(21) a. $which_j$ [t_j boy $]_i$ likes his_i mother
b. * $which_j$ does he_i like [t_j boy $]_i$
c. ?? $which_j$ does his_i mother like [t_j boy $]_i$

As pointed out above, Reinhart (1992, 1993) has shown that interpreting the restriction on the *wh*-operator *in situ* in this manner will not give the correct truth conditions unless the *wh*-operator binds a choice function variable. If this is assumed the structures in (21) are interpreted as in (22):

(22) a. $\{P| \exists f [P = {}^\wedge(f(boy)_i \text{ likes } his_i \text{ mother}) \wedge {}^\vee P]\}$
b. $\{P| \exists f [P = {}^\wedge(he_i \text{ likes } f(boy)_i) \wedge {}^\vee P]\}$
c. $\{P| \exists f [P = {}^\wedge(his_i \text{ mother likes } f(boy)_i) \wedge {}^\vee P]\}$

In (22), the existential quantifier takes scope over the complete sentence, including the pronoun. However, it cannot bind the pronoun as a variable, since it is assumed that pronouns can only be interpreted as variables ranging over individuals, not as choice function variables. Hence, the pronoun can only be bound by the term f(boy). This is possible in (22a), where this term commands the pronoun, but not in (22b) and (22c), where the pronoun is higher in the structure than f(boy).

One problem with this approach to crossover in Ruys (in prep) was that it accounted only for crossover with *wh*-operators. However, in view of the analysis of universal quantifiers proposed above, we can now extend this explanation to crossover with quantified NPs. Consider (23):

(23) a. * he_i likes every boy_i
b. ?? his_i mother likes every boy_i

Traditionally, it has been assumed that *every boy* in these structures undergoes Quantifier Raising to a position where it c-commands, hence takes scope over the pronoun. The question then was why it is nevertheless unable to bind the pronoun as a variable. We can now understand why this is the case. Only the formal features of *every* undergo QR, and *every* quantifies over CF-variables:

(24) a. every f [he_i likes $f(boy)_i$]
b. every f [his_i mother likes $f(boy)_i$]

Again, the bound variable reading for the pronoun is unavailable because the pronoun is not in the scope of a quantifier binding a variable that ranges over individuals.

If this analysis is correct, then how can a bound variable reading ever become available? Although the universal quantifier cannot bind a pronoun, the DP interpreted as f(boy) in (24) can. This expression is a term; i.e., it has the semantic type of referential expressions such as *John* or *this man*. And such expressions are capable of variable-binding pronouns under certain conditions, as exemplified in (25).

(25) a. John likes his mother, and Peter does too [$_{VP}$ e]
b. John λx(x likes x' mother), and Peter λx(x likes x' mother)

On its "sloppy" reading (Peter likes Peter's mother) the pronoun in (25a) is interpreted as a bound variable. According to the usual analysis (Lasnik (1976), Reinhart (1983)), this variable is bound, not by *John*, but by the lambda operator which constructs the predicate that is applied to *John*. Copying the lambda expression into the elided VP, as in (25b), yields the sloppy reading.

We equally expect the remnant DP of a QR'ed universal QP to be able to variable bind a pronoun in this manner:

(26) a. every boy_i likes his_i mother
b. $every_j$ [$_{IP}$ [$_{DP}$ t_j boy]$_i$ likes his_i mother
c. ∀f [f(boy) λx(x likes x' mother)]
d. ∀x [boy(x) → like(x, x' mother)]

(27) a. $[_{CP}$ which boy_i $[_{IP}$ t_i likes his_i mother]]

b. $[_{CP}$ which $[_{IP}$ $[t_k$ boy$]_i$ likes his_i mother]]

c. $\{P| \exists f [\ P = \hat{}(f(boy)\ \lambda x(x \text{ likes } x\text{' mother})) \wedge {}^{\vee}P]\}$

The Move-F/CF hypothesis predicts that the LF (26b) of (26a) is interpreted as indicated in (26c), which is equivalent to the more familiar (26d). The bound variable reading for (27a) is obtained in the same way.

More generally, the Move-F/CF hypothesis exactly predicts the A/$\bar{A}$-bifurcation stipulated by many accounts of the crossover effect. It predicts that QR and *wh*-movement do not affect the variable binding options of quantified and *wh*-expressions. Rather, these expressions behave as if they remain in A-position, where they have the same binding options as any other term in A-position. This in effect derives Reinhart's (1983) stipulation that only expressions in A-position can bind pronouns as variables.

Our account of the crossover effects in (23) may in itself be independent of the CF-hypothesis: it can presumably be derived from Move-F alone. By Move-F, only *every* moves at LF and c-commands the pronoun; assuming that a DP may not be coindexed with a QP then prevents a bound reading on syntactic grounds alone. But the combined Move-F/CF explanation of the crossover effect fits better with the Minimalist framework. Although Weak Crossover is usually explained by means of a syntactic rule which crucially refers to referential indices, minimalist considerations suggest that such indices should preferably not be considered part of syntactic representations. Our account attributes the phenomenon to a semantic mismatch (pronouns denote individual variables at best, which cannot be bound by CF quantifiers), so that WCO is seen to reflect a property of the C-I interface.

In addition, by moving the explanation to semantics, the Move-F/CF hypothesis predicts a range of crossover phenomena left unexplained by previous accounts. In Ruys (in prep.), it is observed that a crossover effect is found even when the intended bound variable is not present in syntactic structure. Consider (28) and (29):

(28) a. every student kissed another student

b. every linguist contradicted a taller linguist

c. every boy under ten loves his cousin, but every boy over ten hates her

(29) a. ?? another student kissed every student

b. ?? a taller linguist contradicted every linguist

c. ?? every boy under ten loves his cousin, but her husband hates every boy over ten

In (28) we find dependent readings: the interpretation of *another* in (28a) and *taller* in (28b) depends on the value of the quantified subject (see a.o. Barwise 1987); the same holds of the pronoun of laziness *her* in (28c). The dependent readings do not obtain in (29), apparently a crossover effect. But since the dependent elements do not contain pronouns in syntax (see esp. Partee 1989), existing analyses of crossover cannot account for these observations. Those analyses which, like Koopman & Sportiche's (1982) Bijection Principle, attribute the crossover effect to a proscribed $\bar{A}$-bound pronoun, fail to exclude the ill-formed examples in (29). And those analyses which, like Reinhart's, require a relation of syntactic A-binding to license a bound variable reading cannot rule out the ill-formed examples without ruling out the well-formed examples as well.

Although the dependent elements in (28) and (29) do not contain a bound pronoun, their denotations must contain a variable bound by the quantified NP on which they depend: they are interpreted roughly as *other than x*, *taller than x*, *x's cousin*. Assuming this much, we can derive the observed contrasts from the Move-F/CF hypothesis. For instance, (29a) is interpreted as in (30):

(30) ?? $\forall f\, \exists y\, [\, student(y) \wedge other(y,x) \wedge kissed(y,f(student))]$

In (30), as in the other cases of weak crossover discussed above, the variable *x* cannot be bound by the universal quantifier and the bound variable reading is ruled out. For further discussion of these exceptional cases of crossover, see Ruys (in prep.) and references cited there.

6. Strong and weak quantifiers

Since May (1977) it has generally been assumed (with the notable exception of Reinhart 1991) that only quantified NPs undergo Quantifier Raising; other NPs (definite descriptions, proper names, pronouns) do not. The distinction has always been problematic, since it describes a syntactic phenomenon in semantic terms. Furthermore, quantified NPs do not behave uniformly with respect to QR. Ioup (1975) reports that whether an NP has the tendency to take wide or narrow scope depends on the lexical choice of its quantificational specifier. Specifiers at one end of the scale (e.g. *each*) display a high wide scope propensity; specifiers at the other end of the scale (e.g. *few*) show little evidence of QR in an experimental setting. Observing that all weak quantifiers are at the low end of the Ioup scale, Ruys (1992) proposed to redraw the dividing line between NPs that undergo QR and those that do not: only strong quantified NPs are subject to QR. Consider some of the evidence. The examples in (31) are from Ioup (1975:75):

(31) a. Joan gave a few handouts to some pedestrians
b. Joan gave a few handouts to every pedestrian

(31a) cannot be interpreted with wide scope for *some pedestrians*, but this reading is available for *every pedestrian* in (31b). Data from Dutch show the same contrast:[8]

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8 For further evidence of the effect of the weak/strong distinction on QR, see Ruys (1992).

(32) a. er zat een jongen op enkele ezels
'there sat a boy on some donkeys'
b. er zat een jongen op iedere ezel
'there sat a boy on every donkey'

These distinctions are difficult to explain in semantic terms. It is certainly possible to devise a semantics for non-QR NPs which allows them to remain in situ (e.g., Reinhart (1996) assumes that weak NPs are mapped onto an individual by a CF variable, the variable being bound through default existential closure). But such a semantics will not in itself predict that weak NPs *must* remain in situ. On the other hand, it is possible to devise a semantics for QR NPs which require that they move to an operator position, but it is equally possible to interpret them in such a way that they can remain in situ as well (Montague 1973). It is not to be ruled out that an explanation for the relevant distinctions can be constructed along these lines. Indeed, if it could be shown that QR NPs are only interpretable after QR, and non-QR NPs are interpretable in situ, then the observed distinctions and the QR phenomenon itself could be explained in terms of interface requirements, in keeping with the tenets of the Minimalist Program. But this remains to be established.

On the other hand, it has so far seemed impossible to describe the QR/non-QR distinction in syntactic terms, because since May (1977) QR has always been considered a rule applying to NPs/DPs. And at the DP level, QR DPs are syntactically indistinguishable from non-QR DPs; it is only their internal structure, and possibly their semantics, which sets them apart. The problem is exacerbated in the Ch. 4 framework, since it does not allow semantic considerations to influence syntactic derivations at all: movement is driven by feature checking requirements alone.

The Attract-F hypothesis sheds new light on these questions. It allows us to describe the distinction in syntactic terms, even though the relevant distinction cannot be made at the DP-level. QR must involve checking of a [QUANT]-feature (Chomsky 1995:377), which may in principle be contained anywhere inside DP. The Move-Spec/Move-F hypothesis narrows down the search for the locus of the [QUANT]-feature: it must be located in the quantificational specifier.[9] A syntactic subclassification of DP specifiers should therefore give us the QR/non-QR distinction. The relevant subclassification of quantifiers can be given an independent syntactic motivation. Determiners and pronouns are presumably D-heads, not specifiers; weak determiners have a different syntactic distribution than strong determiners and are located at a more deeply embedded position inside DP. Therefore, strong specifiers seem to constitute a natural syntactic class, and we may safely assume that only they can check the [QUANT]-feature. This accounts for the QR/non-QR distinctions outlined above.

Having reached this position, we can return briefly to our discussion of A-movement in section 3. Lasnik (1993) discusses contrasts of the following type:

[9] It does not allow us to assume that the QR/non-QR distinction reflects a property of the D head of DP; that would imply that the DP as a whole is interpreted as if it were moved by QR (see section 3).

(33) a. ? the DA proved very few defendants to be guilty during any of the trials
b. * the DA proved that very few defendants were guilty during any of the trials

In (33a), the NPI *any* is (marginally) licensed by the ECM subject. The nominative subject in (33b) cannot license *any*. This is taken as an argument for a movement analysis of ECM. Note that the downward monotonicity required to license the NPI is not a property of D, but of the specifier *very few*. Since *very few* is a weak specifier and does not undergo QR, Move-F leads us to expect that Case-driven movement of the formal features of the subject to the matrix clause will not be sufficient to license the NPI. Thus, the well-formedness of (33a) provides additional evidence that covert Case-movement has the effect that the DP is interpreted as if it had moved as a whole.

7. Remaining issues

This section discusses some problems for the CF hypothesis outlined above, and suggests some topic for further research.

So far, we have only provided a possible semantics for wide scope universal quantifiers (*each*, *every*). How about other strong quantifiers, such as *most*, *both*, *all but one*? For *most*, it appears that the CF approach may work as well as for *every*. A sentence such as (34):

(34) most boys sing

is judged true, if a certain proportion (say, more than half) of the set of boys is included in the set of singers. The CF approach is feasible, if this proportion equals the proportion of choice functions that choose a singer from the set of boys. If that is the case, (35) will give the correct meaning for (34) (we still leave the CF restriction implicit):

(35) most f [sing(f(boy))]

This is indeed the case in a finite, non-empty domain D with cardinality d.[10] In such a domain, a CF will choose an element from each of the $2^d - 1$ non-empty subsets of D (we still ignore the empty set case; this does not affect the issue at hand). This means that the total number of choice functions in the domain, CF_D, can be written as:[11]

(36) $CF_D = |X_1| \times |X_2| \times \cdots \times |X_{2^d-1}|$ for $X_i \subseteq D$

10 Non-finite domains will in any case require an adjustment in the usual semantics for *most*.

11 More succinctly, the number of CFs in a domain with cardinality n is:

(i) $$\prod_{1 \le i \le n} i^{\binom{n}{i}}$$

(That is, with one set of n objects, we have n CFs; adding another set with m objects gives us n × m different CFs, etc.) Now the number of different CFs that pick a particular element a_i from an n-sized set A = $\{a_1,a_2,\ldots a_n\}$, where A is the *j*-th subset of D, is:

(37) $$|X_1|\times\cdots\times|X_{j-1}|\times 1\times|X_{j+1}|\times\cdots\times|X_{2^d-1}| = \frac{\mathrm{CF_D}}{n}$$

So, if the proportion of singing boys to boys is $\frac{m}{n}$, the proportion of CFs that pick a singer from the boys to CFs is the same: $\dfrac{m\frac{\mathrm{CF_D}}{n}}{\mathrm{CF_D}}$.

But the CF approach will definitely not work for definite determiners, such as *both* or *neither*, or complex QPs such as *all but one*. It is certainly reasonable to suppose that these differ syntactically from *every*, *each*, and *most*, either in the position they occupy in the DP, or in their internal structure (if complex QPs such as *all but one* have constituenthood at all). Our failure to describe them as CF quantifiers suggests that they may differ semantically, as well. Together, these observations lead us to expect that they are not subject to QR, and are interpretable only in situ as GQ determiners. Whether this is so remains to be seen; if not, we seem to be left with very little semantic support for the Move-F hypothesis.

Finally, we turn to the correct definition of *choice function*. We repeat our provisional definition (16):

(16) $$[\![\text{CF}]\!] =_{df} \{f \mid \forall X\ (X \neq \emptyset \rightarrow f(X) \in X)\ \}$$

Given such a definition, the meaning of *every boy sings* and *most boys sing* can be stated, without our previous abridgments, as in (38):

(38) a. every′ (CF) (λf sing′(f(boy′))) or ∀f [CF(f) → sing′(f(boy′))]
b. most′ (CF) (λf sing′(f(boy′)))

This worked fine for the cases considered above, but not when the D’ to which the function is applied denotes the empty set. When the set of boys is empty, *every boy sings* is judged either true, or undefined. But according to (16), a CF applied to the empty set may map it onto any individual at all; so when there are no boys, (38a) is true just in case every individual in the domain sings. So we predict that *every boy sings* would usually be false.

Exactly the reverse problem is discussed extensively in Winter (1996). Following Reinhart (1996), Winter argues that exceptionally non-narrow scope (“specific”) indefinites should be analyzed by means of wide scope existential quantification over CFs. This means that (39a) may be interpreted as in (39b):

(39) a. some boy sings

b. $\exists f\,[\,CF(f) \wedge sing'(f(boy'))\,]$

Again, this works fine, but not when the set of boys is empty; then, (39b) is true just in case *any* individual in the domain sings (i.e., usually true, instead of simply false, as intuitions on (39a) would have it). Winter's solution to this problem is to redefine CFs in such a way that they map a set, not onto a member of the set, but onto the Generalized Quantifier corresponding to a member of the set. A CF applied to the empty set yields the empty GQ, i.e., the GQ which is false of every predicate; (39b) then comes out as false. Following Winter's lead, we could solve our own problem as follows. A CF applied to a non-empty set yields the GQ corresponding to a member of the set; applied to the empty set it yields the all-inclusive GQ, which is true of every predicate. These two options are given in (40a) and (40b), respectively:

(40) a. $[\![\,CF\,]\!] =_{df} \{f \mid f(\varnothing)=\varnothing \wedge \forall X(X\neq\varnothing \rightarrow \exists x\in X[f(X)=\{Y \mid x\in Y\}])\}$

b. $[\![\,CF\,]\!] =_{df} \{f \mid f(\varnothing)=Pow(D) \wedge \forall X(X\neq\varnothing \rightarrow \exists x\in X[f(X)=\{Y \mid x\in Y\}])\}$

For our purposes, (40b) is reasonably acceptable: *every boy sings* now comes out true if there are no boys. In fact, we now have full equivalence with first-order universal quantification.

Winter's redefinition of CF will not work for universal quantification over CFs; our redefinition in (40b) will not work for existential quantification. This may be a stale-mate, but it need not be. One option is to allow two different types of CFs; which type is used by the interface systems apparently depends on the type of quantification involved. Another, less stipulative approach is to change tacks and say that *every boy sings* is not true when there are no boys, but undefined due to a presupposition failure.

The presupposition approach is reasonable for *most* and *every* (see De Jong & Verkuyl 1984) but seems obviously wrong for *some*: (39a) is solidly judged false (not undefined) when there are no boys. However, we have no direct evidence that *some boy* in (39a) is specific, and must be interpreted by means of CF quantification. We can allow the option that indefinites may also be interpreted as ordinary (Generalized) quantifiers. We predict then that (39a) is ambiguous, and may either be false, or undefined when the set of boys is empty. And we expect that such an ambiguity will not easily be discerned; in the presence of an alternative reading, the reading whose presuppositions fail will not be salient, and (39a) will be judged false. It seems that subtle intuitions on complex examples will be required in order to determine whether this approach is tenable: we need to construct examples where an indefinite can only be specific, and then judge whether the sentence is false or undefined when the D' denotation is empty. The example in (41) may be a case in point:

(41) John didn't manage to solve some serious problems

In (41) the specific reading is strongly preferred; a narrow scope reading for the indefinite would require replacing *some* with *any*. If the set of serious problems is empty, (40a) predicts that the embedded sentence is false, and (41) true. However, we feel that in such a case (41) may only be judged undefined or false at best.[12]

Finally, we predict that *wh*-in-situ (or even all *wh*-operators) are presuppositional, and this may be easier to verify. We will leave these matters for further research.

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[12] Implementation of the presupposition approach is another matter, which we will also not attempt to address here. Several options come to mind, one being that we take the intuitive notion “choice” seriously and define CF in such a way that the empty set is not in the domain of a choice function; when we are asked to choose from the empty set, computation crashes.

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