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WH-IN-SITU: AN APPARENT PARADOX[1]

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Two approaches have been proposed, in the syntactic frameworks, regarding the assignment of wide scope to the wh-in-situ in multiple questions. (I will be concerned here only with the standard cases where the wh-in-situ is assigned wide scope, as in (1).) The one, most commonly assumed, is that they undergo movement at LF, to some clause-initial position, where their scope is correctly captured, as illustrated for the Surface- Structure (1) in (2a). The other, originating in Baker (1977), is that each question-sentence contains an abstract Q-morpheme, and wh-in-situ are bound directly to Q. Recently, this view has regained popularity with the work of Pesetsky (1987) and others, who argue that at least in certain cases, wh-in-situ are bound in situ by Q. This line makes use of the notion of unselective quantification developed in Heim (1982), following Lewis (1975): the Q operator unselectively binds all the variables in the wh-NPs which have not moved. The LF derived this way for (1) is (2b).[2]

1) Which lady$_2$ [e$_2$ read which book$_1$]?

2 a) [Which book$_1$ [which lady$_2$ [e$_2$ read e$_1$]]]
b) Q<$_1$,$_2$>[which lady$_2$ [e$_2$ read which book$_1$]]

3 a) {P| (**E** x) (**E** y) (lady (y) & book (x) & P=^(y read x) & true(P))}
b) {P| (**E** <x,y> (lady (y) & P=^(y read x & book (x)) & true(P)}

Although not much attention is given in the syntactic LF framework to the interpretations of these LFs, it seems unproblematic to translate them into standard representations. E.g., assuming Karttunen`s (1977) semantics for questions, their respective

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[2] Both of these proposed LFs are motivated not just by the problem of assigning scope and interpretation to wh-in-situ, but also by syntactic considerations restricting their occurrence, which I discuss in Reinhart (1992).

translations are given in (3)[3]. On this view, wh-NPs are, essentially, existential NPs; the question denotes the set of propositions which are true answers to it. Thus, (3a), which is the translation of (2a), denotes the set of true propositions P such that there is a lady y and a book x, about which P asserts that y read x. (3b), the translation of (2b), differs from (3a) only in where the book-restriction occurs in the representation. For brevity, I will omit the truth - clause (true (P)) in subsequent examples.

A problem which has received surprisingly little attention in the LF framework is that, in fact, given standard semantics, neither approach can capture correctly the (full range of the) interpretation of wh-in-situ.

1. An interpretation paradox.

1.1. Let us focus first on the case where the N-restriction of the wh stays in situ. Is it, in fact, true that the variable in this N-set can be unselectively bound in situ, as exemplified in (3b). Given standard semantics (assumed, e.g., in the LF framework), the answer appears to be no:

4 a) Who will be offended if we invite which philosopher?
b) $Q<_{1,2}>$ [who$_2$ [e$_2$ will be offended if we invite which philosopher$_1$]]
c) {P| (E <x,y> & P=^((we invite y & philosopher (y))---> (x will be offended))}
d) Lucie will be offended if we invite **Donald Duck**

5 a) [which philosopher$_1$ [who$_2$ [e$_2$ will be offended if we invite e$_1$]]]
b) {P| (**E** x) **(E** y) (y is a philosopher) & P=^((we invite y)--->
(x will be offended))}

6 a) Which linguist read every book by which philosopher?
b) {P| (**E** <x,y> & P=^(**A**z (z is a book by y & y is a philosopher)
--->(x reads z))}
c) All linguists read every book by **Nancy Reagan.**

If in (4a), we bind the index of which philosopher to Q, while leaving the N-restriction in-situ, as in the LF (4b), the final logical representation will be that in (4c). Now let us consider

[3]. I chose Karttunen`s framework since it lends itself easily to the type of solution I propose for the problems below. I leave it open whether the same can be stated also in the framework of Groenendijk and Stokhof (1982)

the set of possible answers to the question under this representation. It turns out that the value for y can be anything in the world, since its restriction occurs in the antecedent clause of an implication. Suppose, e.g. we chose Donald Duck as a value for y in (4b). Since he is not a philosopher, the antecedent clause is false, and the implication is true for this value. So, if (4c) was the correct representation for (4a), (4d) should have been an appropriate answer.[4] Similarly, if we allow unselective Q-quantification in (6a), we obtain the representation (6b), under which it turns out that a necessarily true answer is e.g. (6c), since it is true for every linguist x that if Nancy Reagan is a philosopher, then x read every book by her.

The representation yielding the correct set of answers in such cases is that in which the restriction is pulled out of the implication. E.g. for (4a), if the wh-in-situ is raised, yielding the LF (5a), the derived representation (5b) correctly allows the values for y to be all and only those individuals who are philosophers and for whom the implication is true.

1.2. More generally, the mechanism of unselective binding, under its current formulations, is extremely powerful, and it is not clear that the full implications of allowing it in Universal Grammar have been sufficiently studied. It may seem, then, that our problem would be solved if we just give up unselective binding, and the idea of ever leaving wh-expressions in situ at LF. But is it really so that wh-in-situ must move at LF? The anaphora puzzle below, which was discovered by Engdahl (1986), suggests the opposite.

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[4]Technically speaking, it is not, in fact, fully clear that the representation (4c) should allow the relevant answer to be the proposition expressed in (4d). It allows Donald Duck as a value for y, but the proposition in the denotation set may have to be (i). If this is so, however, (4c) would also disallow (ii) as a possible answer, while equally allowing both (i) and (iii) as answers, which is sufficiently wrong.

i) Lucie will be offended if Donald Duck is a philosopher and we invite him.
ii) Lucie will be offended if we invite Kripke.
iii) Lucie will be offended if Kripke is a philosopher and we invite him.

7 a) Who remembers which patient$_1$ had what (type of) phantasies
about himself$_1$

b) Answer: **Dr Razi** remembers which patient had **war-hero phantasies about himself**, **Dr Zira** remembers which patient had **Don Juan phantasies about himself...**

c) *[what phantasies about himself$_1$]$_3$ [who$_2$ [e$_2$ remembers [which patient$_1$ e$_1$ had e$_3$]]]

d) {P| (**E** x) (**E** y) (phantasies about z (y) & P=^(x remembers {P`| (**E** z) patient (z) & P`=^z had y}))}

There are two ways to answer question (7a), one is to assign a value just to the top who (e.g. with the answer: 'Dr Razi'). On this construal, the lower wh-in-situ is not being questioned, i.e. its scope is that of the embedded clause. The other way is illustrated in (7b). This answer provides the values of two wh-expressions: The top who and the wh-in-situ what phantasy about himself. To obtain this answer, the wh-in-situ must have wide (matrix) scope, but which patient has scope only over the embedded clause, as witnessed by the fact that no value is provided for it by the answer. If wide scope must be captured by LF movement, the wh-in-situ must be raised to form the LF in (7c). Now, this LF is ill-formed, since the anaphor himself is not bound. The problem here is not just syntactic. Once the variables and operators are translated, as in (7d), it becomes clear that the pronoun is not in the scope of the operator which is supposed to bind it (which z). So, the curious property which such structures seem to display is that the antecedent must have a narrower scope than the pronoun it binds.

Of course, the problem can be solved if the wh-in-situ is reconstructed back to its original SS position. But this would be precisely the interpretation obtained with no LF movement and unselective binding, and we have just seen that this too is impossible.

Since in the specific examples above, an interpretation in-situ will, nevertheless, yield the correct truth conditions for the sentence, it might be worth it to stretch our patience to the mental exercise below, which combines the two contexts we have examined:

8 a) Who remembers which lady$_1$ will be offended if we invite which of her$_1$ philosophical rivals.

b) Answer: **I** remember which lady will be offended if we invite **her Deconstructionist Rival.**

9 a) {P| (**E** x) (**E** y) (P = ^(x remembers {P'| (**E** z) (lady (z) & P'=^((we invite y & (z's philosophical rivals) (y)) --> (z will be offended)))})}

b) Answer: **I** remember which lady will be offended if we invite **Donald Duck.**

10 a) {P| (**E** x) (**E** y) ((z's philosophical rivals)(y) & P = ^(x remembers {P'| (**E** z) (lady (z) & P'=^((we invite y) ---> (z will be offended)))})}

Although (8a) may not be the first question we would think about asking in any actual discourse, it is still not beyond our processing capacity, as witnessed by the fact that it can be straightforwardly answered, as, e.g. in (8b). But how could this answer be derived? So far we have precisely two options of analyzing the question with wide (matrix) scope to the wh-in-situ (which of her philosophical rivals): The one is to bind it unselectively in situ, as in (9a). Here all variables are appropriately bound, but we run into the Donald Duck problem we observed in (4): Since the restriction occurs inside an antecedent clause of an implication, there is no way to block (9b) as an appropriate answer to (8a). If, to avoid this problem, we choose to raise the wh-in-situ, obtaining (10a), we run into Engdahl's problem again. (10a) is nonsensical, since the variable z is outside the scope of its binding operator. So, neither approach to questions seems able, as stated, to explain why (8a) is, nevertheless, a well-formed question which can be answered.

In sum, then, if we change nothing in our standard semantics, we run into a contradiction: Wh-in-situ both cannot, and must, be interpreted in-situ.[5]

2. A solution: Existential quantification over choice functions.

2.1. The interpretive problem we encountered was how to assign wide scope to wh-expressions which, otherwise, show properties of remaining in situ. Now, suppose, for the sake of analogy, that we had some reason to desire to assign the existential some book in (11a) wide scope, without pulling its restriction out.

[5] Engdahl offers, of course, a solution to her paradox, but I will explore here a line which, I believe, is somewhat simpler and more strictly compositional. Another motivation for this alternative solution is that it can solve some syntactic problems of scope assignment, which I discuss in Reinhart (1992).

11 a) Every lady read some book
b) (**E** f) (**A** z) (lady (z) ---> z read f(book))

One way to do that is to allow existential quantification over choice functions, i.e. functions applying to a set and yielding an individual member of the set. In (11) such a function applies to the set of books. The function variable can be bound by an existential operator arbitrarily far away. Note that f(book) here is an argument (of read), which corresponds to the fact that its NP stayed in argument position, and it denotes the value of the function f (i.e. a given book)

It is more interesting to check how the same procedure applies when the N-restriction occurs in the antecedent clause of an implication, since these are the contexts which pose problems to unselective binding.

12 a) Max will be offended if we invite some philosopher
b) (**E** f) (we invite f(philosopher) ---> Max will be offended)
c) (**E** x) (philosopher (x) & (we invite x ---> Max will be offended))

13 a) Lucie read every book by some philosopher.
b) (**E** f) (**A** y) ((book by f(philosopher) (y))---> (Lucie read y))

Although the N-restriction (philosopher) in (12) has stayed in situ, inside the if clause, the representation in (12b) correctly captures its truth conditions, and it is equivalent to the standard representation of wide scope in (12c). Similarly, (13b) correctly captures the (wide existential scope) reading of (13a), the implication being that for all y, if y is a book by the philosopher selected by the given function, then Lucie read y.

Note that we are considering here only the interpretation of an existential with a wide scope (which is not, independently, a particularly interesting problem). Hence the functions used here are the relatively trivial choice functions, which lack the complexity of the more familiar Skolem functions, employed to capture narrow scope of existentials, where the value they yield varies with the value of some other variable.[6]

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[6] The more complex issue of capturing narrow wh scope in the functional reading of questions (e.g. Q: Who does every one love? A: His mother), may well lend itself to treatment with the equivalent of such Skolem functions, as in proposed in Chierchia (1991).

As far as I know, existential quantification over choice functions, to capture wide scope, was not used in linguistic semantics before. This is mainly because to capture just the fact

2.2. While in the case of the standard existentials above, quantifying over choice-functions may be viewed as nothing more than a logical game, in the case of which-N, we have, as we saw, substantial reasons to allow them to stay in-situ sometimes. Crucially, in Karttunen`s approach, which I have assumed here, wh-NPs are always translated into existential quantifiers. Hence, if desired, we can apply straightforwardly the same mechanism of quantifying over choice functions:

In (14), which book moved at SS, so it is no longer in argument position. Hence it cannot serve as an argument (of the form f(book)), and it is interpreted as the restriction of the existential operator, just as before.[7]

14 a) Which book$_1$ did Lucie read e_1?
b) {P | (**E** x) (book (x) and P = ^Lucie read x)}

15 Which book$_1$ did which lady read e_1?

16 a) LF: which lady$_2$ [which book$_1$ [e_1 read e_1]]
b) {P| (**E** x) (**E** y) (lady (y) and book (x) and P=^y read x)}

17 {P| (**E** x) (**E** f) (book (x) and P = ^f(lady) read x)}

However, in (15), one wh-NP (which lady) stayed in situ at SS. So we have now two options. If it moves at LF, as in (16a), we would obtain the standard Karttunen representation in (16). If it stays in-situ, it can be interpreted as (17), which is the set of propositions each stating for some book x and for some function f that x read the book selected by f. This is precisely equivalent to the set defined in (16b).

Let us see now how this analysis handles the problems we observed in section 1.2. for binding wh-in-situ unselectively. In (4), repeated in (18), the problem was that if we leave the philosopher restriction in-situ,as in (18b) we would allow any non-philosopher to be a possible value for the question variable. However, under

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that existentials can have freely wide scope, as in contexts above, constant Skolem functions are sufficient. The same will not be true when I apply this analysis to wh in situ. Since this use of choice functions is new, more attention must be given to their precise formal properties. I return directly to further specification of their domains, relevant for intensional contexts.

[7] Of course, which book can be reinterpreted as an argument, if we create a Lambda predicate for that purpose, as in (ia), translated as in (ib). But since I am not aware of any reason to want to do that, this option need not be dwelled on.

i a) Which book (\x (Lucie read x)
b) {P | (**E** f) (P = ^f(book) (\x (Lucie read x)))}

the present analysis, if the wh stays in situ, the representation will be (19) where the values permitted are, correctly, only those selected from the philosophers set, as we saw already in the parallel (12), with the existential some philosopher.

18 a) Who will be offended if we invite which philosopher?
b) {P| (**E** <x,y> & P=^((we invite y & philosopher (y))--->
(x will be offended))}

19 {P| (**E** x) (**E** f) (P = ^((we invite f(philosopher)) --->
(x will be offended)))}

Similarly, (6a), repeated in (20a), is analogous to (13). Using a choice function, as in (20b), rather than unselective binding of an individual variable, does not allow Nancy Reagan as one of the values of the answer, since the set selected from must be that of philosophers.

20 a) Which linguist read every book by which philosopher?
b) {P| (**E** x) (**E** f) (linguist (x) & P = ^(**(A** y) (y is a book
by f(philosopher)---> x reads y)))}

For both (18a) and (20a) a derivation with LF-movement of the wh-in-situ is equally possible. (This was illustrated for (18a) in (5).) But the anaphora problem of section 1.2. was that the N-restriction of the wh-in situ contained a variable bound by a wh antecedent with narrower scope, as in (7), repeated in (21a) (where what we are considering is the wide scope of what phantasies about himself). So the only way to get a well formed interpretation was to leave the wh in situ.

21 a) Who_2 [e_2 remembers [which $patient_1$ [e_1 had what (type of) phantasies about $himself_1$]]
b) {P| (**E** x) (**E** f) (P=^(x remembers
{P`| (**E** z) patient (z) & P`=^z had f(phantasies about z)}))}

This can be easily done, with the mechanism proposed here, as in (21b). The variable z is appropriately bound by the existential corresponding to which patient, in the embedded clause. The N set left in situ is now (that denoted by) phantasies about z, and the function bound by the wide scope existential selects an individual from that set.

Finally, we may turn to the anaphora paradox in (8), repeated in (22).

22 a) Who_2 [e_2 remembers which $lady_1$ will be offended if we invite
which of her_1 philosophical rivals.
b) {P| (**E** x) (**E** f) (P = ^(x remembers {P'| (**E** z) (lady (z)

& P'=^((we invite f(z's philosophical rivals)) ---> (z will be
offended))}))}

Crucially, which of her philosophical rivals must be assigned wide scope here, which gives rise to the anaphora problem. As we saw, the anaphora requires leaving it in situ, but doing this with unselective binding gives the wrong interpretation, enabling Donald Duck to be a possible value for this wh. In (22b) none of these problems arise. The interpretation is captured by quantifying over functions which select a value out of the set of z's philosophical rivals. The variable z in this set is appropriately within the scope of the binding existential operator, so the representation is both well formed, and gives the correct interpretation.

2.3. I have not been fully explicit yet on the formal characterization of the quantification I assume. It is intended to capture strictly the wide scope of existentials. To guarantee that it is equivalent to their standard wide-scope interpretation we must make sure that the given functions select always only from the extension of the N-set in the actual world (even when the N-restriction originates in an intensional context). This can be captured by defining the range of quantification for f, as in (23). This means that the precise representation of e.g. the wh-in-situ of (18a), repeated in (24a), should be (24b), rather than the simpler version I used so far. (f is defined to belong to the set in (23), and its argument is an intension.)

23) G = {f| **A** P (f(P) P)}
P of type <s,<e,t>>

24 a) Who will be offended if we invite which philosopher?
b) {P| (**E** x) (**E** f G) (P = ^((we invite f(^philosopher)) --->
(x will be offended))}

All instances of quantific
ation over function variables above, should be read in the same way.

3. How is the interpretation derived.

What we saw so far, is that using existential quantification over choice functions solves the interpretation problem we encountered: It allows wh expressions to be interpreted in situ, without running into the problems of unselective binding of individual variables. But for this to be a feasible solution, rather than an exercise in logic, we need to know how it relates to the syntax of natural language. There are, in fact, two questions here: First, can this interpretation be compositionally derived for the given syntactic structures (in a way consistent with what we know about UG)? Next, can we make sure that whatever mechanism we use in the derivation will not allow also the wrong interpretations we wanted to exclude?.

25 a) N''

Det N

some/wh woman (i)

b) (E x) (woman (x))

c) f {x|woman (x)}

Starting with the first question, let us look at a standard existential NP such as some woman, whose structure is given in (25a). Following Higginbotham (1983), N is generated with an index-argument, which must be bound (`discharged` in his terms, though for what we are concerned with here, nothing hinges on the specific formulation of the NP-structure). One way the variable can be bound is if the determiner some is translated, itself, as an existential operator, as in (25b). However, one of the basic insights emphasized in the DRT framework is that indefinite determiners, or more generally weak determiners, do not necessarily correspond to an operator (unlike the strong determiners)[8]. An available alternative, then, is to bind the variable by forming a set as the translation of N, as in (25c). Now, the determiner is, in any case, a function, so an option (in the case of weak NPs) is to let it serve as a (choice-) function variable, applying to the given set. This is how f(woman), used in our formulae before, is derived.

[8] In slight variance from DRT I am assuming here that the determiner can also be directly interpreted as an existential operator, though it does not have to.

The next procedure is the binding of the function variable. For this, existential closure applies, introducing an existential operator, along the lines proposed in Heim (1982) (except that this operator binds here a function variable).[9]

In the case of wh expressions, such as which woman, under the semantics we assumed for them all along, they are viewed just as standard existentials, hence at the local NP-level they can be analyzed just as in (25c). However, they differ from the other existentials in that their binding existential operator must be inserted in a predetermined position in the scope of the question-formation operator (which forms the set of propositions denoted by the question).

When applying existential closure, there are, in principle, two options. One is to introduce an existential operator for each free f-variable (which is what I have done in the formulae I used here), and the other is to let them all be bound by one operator, along the lines of unselective binding. In the cases under consideration here, the two ways are equivalent, and which one we chose depends on whether unselective binding is, independently, assumed to be an operation available in UG, a question which I will not get into here.[10]

So the interpretations I assumed here can be derived, and we may turn to the next question of whether we are not allowing too much. Specifically, I assumed, following the insights of DRT, that indefinite (weak) NPs are not necessarily closed. However, in that framework (e.g. Heim (1982)), this is taken to mean that an

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[9] Technically, Heim uses the term `existential closure` only for the introduction of an existential operator in the nuclear scope of another operator. I use it here in the broader sense of introducing this operator anywhere (arbitrarily far away). However, the restrictions on this operation are precisely the same as stated by Heim. Specifically, this cannot be done in the restrictive term of another operator.

[10] We may note, though, that allowing just unselective existential closure is a much more restrictive assumption than that currently assumed, which, as far as I can see, would not run into the potential problems of the current liberal application of this procedure (though it would not, of course, handle everything attempted by the current application). In the specific case of wh-in-situ, this is an attractive option, since the location of the existential operator must be syntactically marked. We could assume that the existential operator is introduced by the one wh-NP which must move to COMP (visibly in English, invisibly at the LF of Chinese). It is, then, this same operator which bind all the function-variables marked syntactically with a wh.

NP like (25a) can be treated as an open formula (woman (x)), whose variable is, then, existentially bound outside the NP. I.e. existential closure is allowed to bind directly the N-variable. If we allow that, and also allow wh to stay in situ, then we are back precisely where we started. In a sentence like (4) (Who will be offended if we invite which philosopher?), if we leave which philosopher in situ, and introduce an existential at the top-level to bind it, we obtain an interpretation identical to (4b), which allows Donald Duck to serve as a value for the answer. For the solution of the wh -paradox to work, it is essential that existential closure can bind only function variables.

The relevant restriction can be drawn from Higginbotham (1985). He argues, essentially, that the N-variable must be discharged inside the NP. This constraint could not, of course, follow from principles of logic, but it is, most likely, a universal constraint of natural language. If true, this entails that the options illustrated in (25) are the only ones available: either the variable is bound by the NP`s determiner or by a set formation operator. This result does not effect the major insight in DRT, that weak NPs are not necessarily closed (since they may still contain a free function variable), but it entails a restriction on the type of existential closure allowed. E.g. variables bound by a discourse existential must be function variables. If this is so, this means that quantification over choice-functions is a crucial linguistic device and its precise formal properties should be studied in much greater depth than what I was able to do here.[11]

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[11] Assuming this restriction would also have direct implications for the issues of unselective binding. E.g. The interpretation of (i) in (ib) is not allowed.

i a) An old fashioned critic always hates a modern piece.
b) **(A** <x,y>) ((old fashioned critic (x) & modern piece (y)) -->
(x hates y))

ii) (**A** <f,g>) (f(old fashioned critic) hates g(modern piece))

Rather, the only interpretation of unselective binding allowed here would be (ii). At present, it is not even obvious how to determine whether the two representations may be equivalent, since much work is still needed on what the value of f or g is if the N set is empty.

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