Scopal Independence

A Note on Branching and Wide Scope Readings of Indefinites and Disjunctions[*]

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Abstract: Hintikka claimed in the 1970s that indefinites and disjunctions give rise to 'branching readings' that can only be handled by a 'game-theoretic' semantics as expressive as a logic with (a limited form of) quantification over Skolem functions. Due to empirical and methodological difficulties, the issue was left unresolved in the linguistic literature. Independently, however, it was discovered in the 1980s that, contrary to other quantifiers, indefinites may scope out of syntactic islands. We claim that branching readings and the island-escaping behavior of indefinites are two sides of the same coin: when the latter problem is considered in full generality, a mechanism of 'functional quantification' (Winter 2004) must be postulated which is strictly more expressive than Hintikka's, and which predicts that his branching readings are indeed real, although his own solution was insufficiently general. Furthermore, we suggest that, as Hintikka had seen, disjunctions share the behavior of indefinites, both with respect to island-escaping behavior and (probably) branching readings. The functional analysis can thus naturally be extended to them.

0 Introduction

On two occasions in the recent history of semantics, indefinites were taken to pose a challenge to standard theories of scope. First, in the early1970s, the philosopher Jaakko Hintikka claimed that indefinites interact scopally with universal quantifiers so as to yield 'branching' readings which cannot be captured within the ordinary semantics of first-order logic (e.g. Hintikka 1974). By contrast, he claimed, these readings are naturally explained if a game-theoretic semantics is adopted. As it turns out, Hintikka's game-theoretic semantics can itself be translated into a fragment of (ordinary) second-order logic which comprises all formulas of the form $\exists f_1 \ldots \exists f_n \varphi$, where $\exists f_1 \ldots \exists f_n$ is a prefix of existential quantifiers over Skolem functions, and φ is an ordinary, first-order formula (a Skolem function f is simply a function that takes i individual arguments $x_1, \ldots, x_i$ and returns an individual $f(x_1, \ldots, x_i)$). In this way, Hintikka's plea for a game-theoretic semantics could be reinterpreted as an argument for analyzing indefinites in terms of a somewhat constrained form of existential quantification over Skolem functions. Hintikka further applied his device to the analysis of disjunction - to my knowledge, with some conceptual but no linguistic arguments. For empirical and methodological reasons, the matter was left unresolved and was somewhat forgotten in the linguistic literature of the 1980s and 1990s[1]. At the same time, however, another problem became the object of acute scrutiny: contrary to what was predicted by syntactic theories of Quantifier Raising, certain indefinites (sometimes called 'specific indefinites') appeared to scope out of syntactic islands[2]. This seemed remarkable because other quantifiers did not display such a behavior. Reinhart 1997, Kratzer 1998, Winter 1997, and Matthewson 1999 (among others) suggested that the problem should be solved by resorting to second-order quantification over *Choice functions*, a proposal that has been developed in various directions in recent research (a Choice function F is a function that takes as argument a -possibly complex- predicate-denotation P,

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[1] This is a slight simplification of the history. In fact, the problem of branching quantifiers was discussed in the literature on plurals (e.g. Barwise 1979, Sher 1991, Schein 1993, Beghelli et al. 1997), although Hintikka's original problem, which involved first-order quantifiers rather than plurals, was rarely discussed *per se*.

[2] We prefer the term 'island-escaping' to the adjective 'specific' because the latter has the disadvantage of pre-judging the issue of *how* these indefinites should be analyzed. By 'island-escaping indefinites', we will refer to expressions that *give the impression* of scoping out of syntactic islands (in our analysis, they don't literally do so), and we will use the term 'specific indefinites' with the same definition.

and returns an individual F(P) which satisfies P; special provisions must be made for the case in which the extension of P is empty).

In this note, we show that branching and island-escaping readings are two sides of the same coin: when the latter problem is considered in full generality, mechanisms must be postulated which predict that branching readings should indeed exist. The point is worth making for conceptual but also for empirical reasons. The *data* that served to motivate Hintikka's analysis were controversial. We will address some of the methodological objections that were raised against them, but our own examples will remain highly complex; on the other hand the connection between branching readings and the island-escaping behavior of indefinites will provide an *indirect* argument in favor of Hintikka's empirical claim. Specifically, we follow much existing research in analyzing island-escaping indefinites in terms of quantification over General Skolem Functions (Winter 2002, 2004, Schlenker 1998, Chierchia 2001, Kratzer 1998). These can be seen as Choice Functions which, in addition to their predicate argument, take any number of individual arguments[3] (thus a General Skolem Function G takes n individual arguments d_1, ..., d_n and a predicate-denotation P, and returns an individual G(d_1, ..., d_n, P) which satisfies P if P is non-empty; here too special provisions are needed when P is empty). But the availability of General Skolem Functions leads one to expect that branching readings should exist as well, which provides an indirect vindication of Hintikka. We will also suggest, somewhat cautiously, that the same analysis can be extended to disjunctions, which appear to display island-escaping readings and possibly branching readings as well. Despite this defense of Hintikka, however, we will see that his particular implementation of his insight within game-theoretic semantics was insufficiently expressive to account for all the possible readings, whereas full quantification over General Skolem Functions yields more adequate predictions.

The rest of this note is organized as follows. In Section 1, we lay out the problem of branching readings of indefinites and we seek to address some of the methodological objections raised against Hintikka. In Section 2, we show that when the problem of island-escaping indefinites is considered in full generality, it requires quantification over General Skolem Functions, which in turn predicts that branching readings should exist. Finally, we consider the case of disjunction in Section 3, where we give limited arguments in favor of Hintikka's empirical claims.

1 Indefinites I: Branching

1.1 Scope and Game-Theoretic Semantics

In the early 1970s, Jaakko Hintikka claimed that the standard ('Fregean') notion of scope should be replaced with a different one, which naturally falls out from a 'game-theoretic' semantics. To see what the issue is, it is easiest to start from the intuitive account of scopal interaction that one may give for (1): *for any x that you care to choose, I can associate a y so that P(x, y) will be true.*

(1) a. $\forall x \, \exists y \, P(x, y)$

b. $\exists f \, \forall x \, P(x, f(x))$

The underlying intuition is that of a game in which you (= the Falsifier) try to pick an x that makes the formula false. Then I (= the Verifier) try to pick a y that makes the formula P(x, y) true. Seen in this light, (1) is true just in case I, the Verifier, have a winning strategy for the game we are playing; this means that there exists a function f associating y's to x's in such a way that, no matter what your choice of x is, P(x, f(x)) will be true. The latter paraphrase, formalized in (1), is the 'Skolem Normal Form' of (1), arrived at through a game-theoretic metaphor (a Skolem Normal Form starts with a prefix of existential quantifiers over Skolem Functions, followed by a series of

[3] To my knowledge, the term 'General Skolem Functions' is due to Winter. Chierchia 2001 calls these 'Skolemized Choice Functions'.

universal quantifiers over individuals, followed by a quantifier-free formula). Of course the procedure may be repeated for more complex formulas, such as that in (2), whose Skolem Normal Form is given in (2), which can be further simplified to (2):

(2) a. $\forall x\ \exists y\ \forall z\ \exists t\ Q(x, y, z, t)$

b. $\exists f\ \exists g\ \forall x \forall z\ P(x, f(x), z, g(x, f(x), z))$

c. $\exists f\ \exists g\ \forall x \forall z\ P(x, f(x), z, g(x, z))$[4]

Intuitively, in (2) the choice of the witness y depends on the choice of x, and similarly the choice of the witness t depends both on the choice of x and the choice of z. This intuition is formally captured in the second-order translation given in (2), where the second argument of P (= f(x)) is a function of a single variable, x, while the fourth argument of P (= g(x, z)) is a function of two variables, x and z.

At this point it is natural to ask, with Hintikka, whether we could find a first-order formula whose translation was a Skolem form in which each of the functional arguments contains a *single* variable, as in the following:

(3) $\exists f\ \exists h\ \forall x \forall z\ P(x, f(x), z, h(z))$

The answer is that First-Order Logic contains no formula that is equivalent to (3). Why? Intuitively, sequences of two quantifiers $\forall x\ \exists y$ and $\forall z\ \exists t$ must be ordered somehow, and thus one of the existential quantifiers - say, $\exists t$ - must end up in the last position of the sequence, i.e. in the scope of the two universal quantifiers. It then follows from the traditional semantics of First-Order Logic that the 'choice' of the witness may depend both on x and on z, so to speak (see Hintikka 1996 for a proof that (3) is not equivalent to any first-order formula[5]).

What is remarkable, however, is that formulas such as (3) are in fact expressible when the game-theoretic metaphor is taken seriously. Let us first consider some simple examples. Hintikka suggests that the first-order formulas in (1) and (2) can be given a semantics in terms of games of perfect information, in which the Verifier (who is to pick 'witnesses' for the existential quantifiers) has at each point access to all the choices made in preceding rounds of the game by the Falsifier (who chooses values for the variables bound by the universal quantifiers). The truth of a formula is then defined by the existence of a winning strategy for the Verifier; such a winning strategy will comprise a set of functions $f_1 ... f_n$, such that for each round i of the game, f_i specifies which element the Verifier should pick *given the elements that the Falsifier picked in the preceding rounds*. Here are two simple examples of this analysis:

(4) A Game of perfect information

a. Formula: $\forall x\ \exists y\ P(x, y)$

b. Move 1a: Falsifier chooses an x (call it x_1).

c. Move 1b: Verifier chooses a y (call it y_1)

d. If $P(x_1, y_1)$ is true, Verifier wins; if $P(x_1, y_1)$ is false, Falsifier wins.

e. (a) is true iff the Verifier has a winning strategy, i.e. iff there is a function that pairs y's

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[4] Clearly, (2) entails (2). Conversely, if a pair of functions f, g satisfies $\forall x \forall z\ P(x, f(x), z, g(x, f(x), z))$, then by defining $g' = \lambda x \lambda z\ g(x, f(x), z)$, we obtain a pair of functions f, g' that satisfies $\forall x \forall z\ P(x, f(x), z, g'(x, z))$.

[5] One proof goes like this. We observe that when P is replaced by certain formulas, (3) singles out models that cannot be characterized by any First-Order sentence. For instance, the formula in (i) below asserts the existence of a function f and a function h such that (i) f is 1-1, (ii) h is constant, and (iii) the unique value of h has no antecedent by f.

(i) $\exists f\ \exists h\ \forall x \forall z\ ((f(x) = f(z) \Rightarrow x = z)\ \&\ h(x) = h(z)\ \&\ f(z) \neq h(z)))$

This condition is equivalent to: *there is an injection from the universe into a proper part of itself,* a statement that is true precisely in infinite models. But a well-known consequence of the compactness theorem for First-Order Logic is that there is no formula which is true if and only if the domain is infinite.

(= the Verifier's choices) with x's (= the Falsifier's choices) so as to make P(x, y) true, iff $\exists f_{<1>}\ \forall x\ P(x, f(x))$

(5) Another game of perfect information
a. Formula: $\forall x\ \exists y\ \forall z\ \exists t\ P(x, y, z, t)$
b. Move 1a: Falsifier chooses an x (call it x_1).
c. Move 1b: Verifier chooses a y (call it y_1)
d. Move 2a: Falsifier chooses a z (call it z_2)
e. Move 2b: Verifier **has access to the value of x_1, y_1, z_2, and** chooses a t (call it t_2)
f. If $P(x_1, y_1, z_2, t_2)$ is true, Verifier wins; otherwise Falsifier wins.
g. (a) is true iff the Verifier has a winning strategy, iff
$\exists f_{<1>}\ \exists g_{<2>}\ \forall x\ \forall z\ P(x, f_{<1>}(x), z, g_{<2>}(x, z)$

But here is now the salient point of Hintikka's analysis: without quantifying explicitly over Skolem functions, the truth conditions of (3) can be obtained by specifying that the game played is one of *imperfect* information, in which the Verifier has no access in the second round to the value picked by the Falsifier in the first round (for instance because in the two rounds the role of the Verifier is filled by two players that are on the same side but cannot communicate; or because the Verifier suffers from memory loss between the first and the second round). Thus without explicitly quantifying over Skolem functions, Hintikka manages to give truth conditions for a formula equivalent to (3), which he writes in a first-order syntax by indicating that the quantifier sequences $\forall x\ \exists y$ and $\forall z\ \exists t$ are unordered with respect to each other:

(6) A Game with *imperfect* information
a. Formula: $$\begin{matrix} \forall x\ \exists y \\ \forall z\ \exists t \end{matrix} \Big> P(x, y, z, t)$$
b. Move 1a: Falsifier chooses an x (call it x_1).
c. Move 1b: Verifier chooses a y (call it y_1) (with information about x_1)
d. Move 2a: Falsifier chooses a z (call it z_2)
e. Move 2b: Verifier choose a t (call it t_2) (with information about z_2 **but not x_1)**
f. If $P(x_1, y_1, z_2, t_2)$ is true, Verifier wins; otherwise Falsifier wins.
g. (a) is true iff the Verifier has a winning strategy, iff
$\exists f_{<1>}\ \exists g_{<1>}\ \forall x\ \forall z\ P(x, f_{<1>}(x), z, g_{<1>}(z))$[6]

1.2 Branching Readings

On the assumption that the truth conditions of (3) and (6) are indeed instantiated, Hintikka's semantics is definitely more adequate than a standard first-order analysis, which cannot derive these truth conditions at all. It is also arguably more elegant than a second-order analysis, which doesn't

[6] It should be observed that the Skolem translations of Hintikka's formulas always involve (i) a purely existential prefix of quantifiers over functions, followed by (ii) a first-order formula (in fact, a purely universal formula, i.e. a prefix of universal quantifiers followed by a quantifier-free formula). This is no accident - the existential quantifiers over functions assert the existence of a winning strategy for the entire game, and thus have scope over all other quantifiers, yielding what is called a *Σ^1_1 formula*. As is summarized in Hintikka & Sandu 1996, the following theorem follows from results due to Enderton, Hintikka and Sandu:

Theorem (Sandu 1991, Hintikka 1995, Enderton 1970)
Every first-order sentence of Hintikka's Independence-Friendly Logic is equivalent to a Σ^1_1 formula. Conversely, every Σ^1_1 formula is equivalent to a first-order sentence of Hintikka's Independence-Friendly Logic.

This result is important because, as we will see, the kind of quantification over Skolem functions that is needed to model indefinites (and, if we are right, disjunction as well) is less restricted than Hintikka thought, and takes us outside the class of Σ^1_1 formulas.

explain in a natural way *why* what seem to be first-order quantifiers (*some* and *every*) can interact scopally so as to yield branching readings. For the sake of argument, we will grant that *if* these readings exist, Hintikka's analysis is indeed adequate in the simple cases[7] (the qualification *in the simple cases* is added because, as we shall see shortly, Hintikka's analysis turns out to be insufficiently expressive for more complex examples). Still, the question remains whether branching readings are indeed instantiated in English. Hintikka claims that they are. Some of his examples are reproduced in (7). To illustrate, (7) has according to Hintikka the truth conditions represented in (8) (game-theoretic semantics, first-order quantification) or, equivalently, (8) (normal semantics, second-order quantification):

(7) a. Some relative of each villager and some relative of each townsman hate each other
b. Some book by every author is referred to in some essay by every critic
c. Some official of each company knows some aide of each senator

(8) a.
$$\begin{array}{l} \forall x\ \exists y \\ \\ \forall z\ \exists t \end{array} \Bigg> ((\text{author}(x)\ \&\ \text{critic}(z)) \Rightarrow (\text{book-by}(y, x)\ \&\ \text{essay-by}(t, z)\ \&\ \text{referred-to}(y, t)))$$

b. $\exists f_{<1>} \exists g_{<1>} \forall x\ \forall z\ ((\text{author}(x)\ \&\ \text{critic}(z))$
$\Rightarrow (\text{book-by}(f_{<1>}(x))\ \&\ \text{essay-by}(g_{<1>}(z))\ \&\ \text{referred-to}(f_{<1>}(x), g_{<1>}(z))))$

Since the innermost formulas in (8) are admittedly cumbersome to read, it may be helpful to introduce a restricted quantifier notation for Hintikka's system. We may then re-write (8) as (9):

(9) Branching Reading (Hintikka)
a.
$$\begin{array}{l} [\forall x: \text{author}(x)][\exists y: \text{book-by}(y, x)] \\ \\ [\forall z: \text{critic}(z)][\exists t: \text{essay-by}(t, z)] \end{array} \Bigg> \text{referred-to}(y, t)$$

b. $\exists F_{<1>} \exists G_{<1>} [\forall x: \text{author}(x)][\forall z: \text{critic}(z)]]\ \text{referred-to}(F_{<1>}(x, \lambda y\ \text{book-by}(y, x)),$
$G_{<1>}(z, \lambda y\ \text{essay-by}(y, z))$

The intended semantics for (9) is that of a game in which the Falsifier is constrained to pick x's that are authors and z's that are critics. The Verifier's task is then to find a y that is a book by x and a t that is an essay by z which satisfy the inner-most formula. In case there are no books by x or no essays by z, the Verifier has automatically lost. In (9), we introduce the device of n-ary General Skolem Functions (Winter 2002, 2004; Chierchia 2001):

(10) F is an n-ary General Skolem function for restricted quantification if for any n-tuple
$<d_1, ..., d_n>$ of objects and any set E,
$F(d_1, ..., d_n, E) \in E$ if $E \neq \emptyset$
$F(d_1, ..., d_n, \emptyset) = \#$ if $E = \emptyset$.

We may interpret # as triggering a presupposition failure. When we take this step, however, we run the risk of departing from Hintikka's original truth conditions. For instance, if # projects in a certain way, (9) will yield a presupposition failure where (8) simply produces a falsehood, e.g. in a situation where there are critics, and there are authors who didn't write any books (in this case (8) is false because no function $f_{<1>}$ exists that satisfies the consequent of the conditional; while (9) may yield a failure because under some assignments $F_{<1>}(x, \lambda y\ \text{book-by}(y, x))$ denotes #). For present purposes, a convenient alternative is to take # to be an object of which no atomic predicate is true. In this way, we get the desirable result that (9) comes out as false when some author has written no books (but only poems) or some critic has written no essays (but only reviews). (See Winter 1997

[7] See Janssen 2002 for arguments against this view.

for further considerations on what should be done with General Skolem Functions whose predicate argument is empty; we do not attempt to give a serious solution to this problem in the present note[8]).

Be that as it may, the problem of branching quantifiers as we have outlined it was left more or less unresolved at the end of the 1970s and at the beginning of the 1980s. There seem to have been at least two reasons for this. First, Hintikka's judgments were called into question by several researchers (e.g. Fauconnier 1975, Boolos 1984), and given the complexity of the crucial examples it proved difficult to reach a clear empirical verdict. Second, Fauconnier (1975) raised a methodological objection against Hintikka's argument. As Fauconnier noted, branching readings systematically entail non-branching ones. This appears most clearly when we look at the relevant Skolem translations:

(11) a. $\exists F_{<1>}\ \exists G_{<1>}\ \forall x\ \forall z\ R(x, F_{<1>}(x), z, G_{<1>}(z))$
b. $\exists F_{<1>}\ \exists G_{<2>}\ \forall x\ \forall z\ R(F_{<1>}(x), G_{<2>}(x, z))$

(11) is the Skolem translation of a branching reading, while (11) is the translation of a non-branching reading. Now it is clear that (11) implies (11) - if there is a *unary* Skolem function with the right properties in (11), then of course there is a *binary* Skolem function with the same properties (just make the dependency on the second argument vacuous). And this situation is quite general: Hintikka's branching readings are systematically *stronger* than some non-branching ones. For instance, (9) asymmetrically entails [∀x: author(x)][∃y: book-by(y, x)][∀z: critic(z)][∃t: essay-by(t, z)]referred-to(y, t). This is the source of the difficulty: whenever a situation satisfies the branching reading, it also satisfies a non-branching reading whose existence is uncontroversial (since Hintikka does not claim that some English sentences *must* have a branching reading, only that they *may*). Thus, on the basis of intuitions of truth alone, we cannot prove that branching readings exist, since any situation that makes the branching reading true will make a non-branching reading true as well. What about intuitions of falsity, then? The difficulty is that a charitable interpreter who has a choice between interpreting a sentence S as (11) or as (11) should be very reluctant to deem S false when (11) was false but (11) is true. Charity requires that the interpreter maximize the truth of the speaker's utterance, and thus assume that the speaker meant (11), not (11). As a result, it is *exceedingly* difficult to prove that the reading in (11) really does exist.

1.3 Improvement

However Fauconnier's methodological objection can be circumvented by embedding the relevant sentences in environments that reverse the order of entailments. Thus if a sentence *P* has two readings, a Strong Reading S and a Weak Reading W, where S entails W, it is clear that in *It is not the case that P* the reading corresponding to W will in fact entail the reading corresponding to S (because negation reverses the order of entailments). This example is still not ideal, because negation may be construed as meta-linguistic, which complicates further an already thorny issue. A

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[8]Two remarks should be made about the status of #.

(A) When # is seen as an object which is not in the extension of any atomic predicate, a Logical Form with General Skolem functions can systematically be translated back into a notation with simple Skolem functions. The key is to replace atomic formulas such as $admire(x, F_{0<1>}(x, \lambda y\ professor(y))$ (where $F_{0<1>}$ is a General Skolem Function) with conjunctions of the form $(professor(f_{0<1>}(x))\ \&\ admire(x, f_{0<1>}(x)))$ (where $f_{0<1>}$ is a simple Skolem Function). To give an example, (ib) below is translated as (ic):

(i) a. Every student admires some professor.
b. $\exists F_{0<1>}[\forall x: student(x)](admire(x, F_{0<1>}(x, \lambda y\ professor(y)))$
c. $\exists f_{0<1>}\forall x(student(x) \Rightarrow (professor(f_{0<1>}(x))\ \&\ admire(x, f_{0<1>}(x))))$

(B) Such a solution has a cost, however. In particular, we make counter-intuitive predictions about, say, 'I did not invite a certain Moldavian king', which should have a true reading with wide scope existential quantification over General Skolem functions ($\exists F_{0<0>}$ I did not invite $F_{0<0>}(\lambda y$ Moldavian-king(y))): since λy *Moldavian-king(y)* has an empty extension, $F_{0<0>}(\lambda y$ Moldavian-king(y)) denotes #, hence the result. (Similar problems are discussed in Geurts 2000).

better solution is to embed P in an *if*-clause or - to avoid issues that arise from the non-monotonicity of conditionals - in a *when*-clause. This attempt was carried out in Schlenker 1998, where it was suggested that there is an empirical difference between the following sentences, the first of which involves the indefinite 'a dissident' (or: 'a certain dissident'), and the second of which involves a modified indefinite 'at least one dissident'. The claim was that only the former allows for an embedded branching reading, i.e. a reading in which existential quantification over Skolem Functions has scope inside the antecedent of the conditional. My original example was improved by Eklund & Kolak 2002, and thus I shall cite their version of it (this is the example in (12). I add some controls to obtain minimal pairs):

(12) *Context:* We are fighting for human rights in China and as part of that campaign we are trying to get a representative from each country to fight for the release of one dissident from each (Chinese) prison. I make the following prediction:
a. If a (given / certain) representative from each country fights for the release of a (certain) dissident from each prison, our campaign will be a success. (Eklund & Kolak 2002, modified from Schlenker 1998)
b. If a (given / certain) representative from each country fights for the release of at least one dissident from each prison, our campaign will be a success.

(13) *Context:* We have been fighting for many years for human rights in China. I recount the story of our failures and successes, and say:
a. Whenever a (given / certain) representative from each country fought for the release of a (certain) dissident from each prison, our campaign was a success.
b. Whenever a (given / certain) representative from each country fought for the release of at least one dissident from each prison, our campaign was a success.

Suppose we are in the following situation: (i) every country did in fact select a representative who went to each prison to lobby for the liberation of a dissident, but (ii) for a given prison, different representatives lobbied for the liberation of different dissidents, i.e. *they did not coordinate their actions*. Suppose the campaign fails. Does this mean that I necessarily lied when I made the claims in (13)? There appears to be a difference between the sentences involving *at least one dissident* and those involving *a (certain) dissident*. If I asserted the former, it seems that I necessarily lied. If I asserted the latter, by contrast, there is a construal of what I said that makes it compatible with the facts.

Why should this be? Clearly, in all the relevant readings *a representative* is scopally dependent on *every country*, and similarly *a certain/at least one dissident* is dependent of *every prison*. Thus the Logical Form of the antecedent clause should be one of the following[9], where R(y, t) stands for: *y fights for the release of t*.

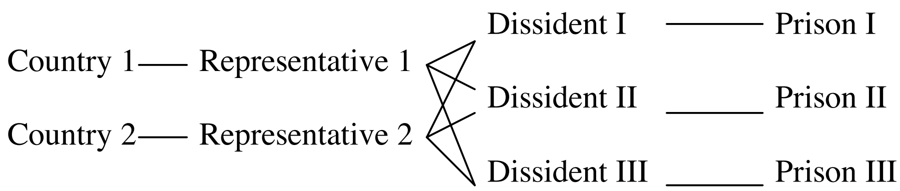
(14) a. [∀x: country(x)][∀z: prison(z)][∃y: rep.-from(y, x)] [∃t: dissident-from(t,z)] R(y,t)
b. [∀x: country(x)][∃y: rep.-from(y, x)][∀z: prison(z)][∃t: dissident-from(t,z)] R(y,t)
c. [∀z: prison(z)][∃t: dissident-from(t,z)] [∀x: country(x)][∃y: rep.-from(y, x)]R(y,t)
d. [∀x: country(x)][∃y: rep.-from(y, x)]
R(y,t)
[∀z: prison(z)][∃t: dissident-from(t,z)]
d'. $\exists F_{<1>} \exists G_{<1>}$ [∀z: prison(z)][∀x: country(x)] R($F_{<1>}$(x, λu representative-from(u, x)), $G_{<1>}$(z, λu dissident-from(u,z)))

As we just saw, there is a reading of the sentence that requires coordination between the representatives, so that, for each prison, the 'choice' of the dissident, so to speak, does not depend on the country. (14) is too weak to enforce this (because *[∃t: dissident-from(t,z)]* is in the scope of both universal quantifiers). Since (14) is weaker than (= asymmetrically entailed by) (14), it too is

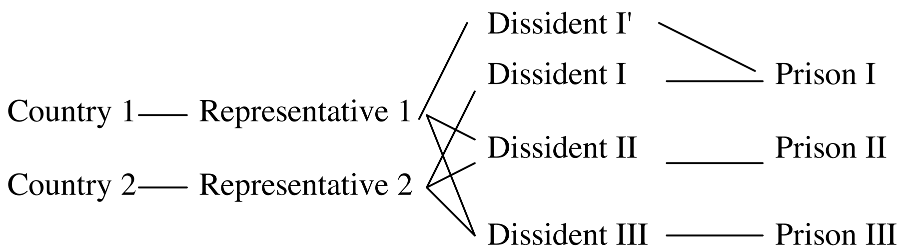
[9] For reasons that are discussed in Section 1.4, Hintikka's particular implementation is in fact not adequate to represent *embedded* branching readings. We disregard this point in the present section.

too weak to represent the reading in question. By contrast, the branching reading in (14) specifies that the condition for success is that the representatives *coordinate* their actions, as is the case in (15) but not in (15):

(15) a. A situation that satisfies the Branching Reading (14)d (and thus also each Non-Branching Reading)



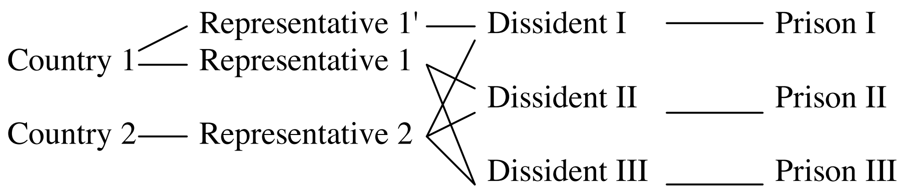
b. A situation that satisfies the Non-Branching readings (14) but not the Branching Reading (14)d



The kind of situation illustrated in (15) is the hallmark of branching readings. There must be a group S of representatives (those that are assigned by one of the functions to the countries) and a group D of dissidents (assigned by the other function to the prisons) such that each of the representatives in S stands in the designated relation to each of the dissidents in D (this is what Sher 1991 calls a 'massive nucleus'). Why? Because by virtue of the existence of the functions whose existence is asserted by the initial prefix of the Skolem translation, the universal quantifiers over countries and representatives quantify also, indirectly, over the representatives associated to countries and the dissidents associated to those prisons; and thus each of these representatives must stand in the relevant relation to each of these dissidents, and vice versa. In particular, for each of these dissidents it must be the case that each representative lobbies for him; there must thus be a *coordination* so as to apply maximum pressure on the Chinese authorities.

The conclusion at this point is that the branching analysis correctly handles the 'coordination' reading; the logical forms in (14) and (14) do not. But what about the logical form in (14)? It correctly imposes that for each prison one of its dissidents receive the support of every country. But this logical form suffers from a different problem: it makes *[∃y: representative-from(y, x)]* scopally dependent on *[∀z: prison(z)]*. However with the modifiers *given* or *certain* in *a given / certain representative*, this reading is very difficult to obtain. If two representatives of Country 1 have divided the job among themselves, so to speak, and if the campaign is a failure, I could plausibly maintain that I did not lie because each prison was to be pressured by the same representative from each country - a condition which is not met in (16):

(16)



I conclude that the branching reading in (14)d-d' is the only plausible contender to analyze the 'coordination' reading we started out with.

1.4 Beyond Hintikka

There is something ironic about the preceding discussion. In essence, we have claimed that Hintikka's initial observation about branching readings was correct, but hard to prove on his own examples because a formula of the form $\exists f_{<1>}\ \exists g_{<1>}\ \forall x\ \forall z\ R(x,\ f_{<1>}(x),\ z,\ g_{<1>}(z))$ is logically stronger than the formula $\exists f_{<1>}\ \exists g_{<2>}\ \forall x\ \forall z\ R(f_{<1>}(x),\ g_{<2>}(x,\ z))$, which represents an uncontroversial reading of the sentences of under study. In order to circumvent this difficulty, we had to embed the test sentences within a downward-monotonic environment, which had the effect of reversing the order of entailments. In so doing, however, we produced readings that are indeed branching, but *which Hintikka's system cannot account for*[10]. To see this, observe that the sentences we used were of the form *If P, Q,* where P had a branching reading and was thus equivalent to $\exists f_{<1>}\ \exists g_{<1>}\ \forall x\ \forall z\ R(x,\ f_{<1>}(x),\ z,\ g_{<1>}(z))$. For simplicity, let us analyze conditionals as material implications, and assume that Q is a contradiction. The result is then equivalent to $\neg\exists f_{<1>}\ \exists g_{<1>}\ \forall x\ \forall z\ R(x,\ f_{<1>}(x),\ z,\ g_{<1>}(z))$ (we could have obtained this result more directly by embedding P under negation, but as was mentioned earlier negation introduces problems of its own). However the logic that corresponds to Hintikka's game-theoretic semantics, 'Independence-Friendly Logic', is *not* closed under ordinary (contradictory) negation. This is because, as was mentioned earlier, this logic is equivalent to a fragment of Second-Order Logic (call it F_{IF}) which includes all the formulas that contain (i) a prefix of existential quantifiers over Skolem functions, followed by (ii) a first-order formula. But in general $\neg\exists f_{<1>}\ \exists g_{<1>}\ \forall x\ \forall z\ R(x,\ f_{<1>}(x),\ z,\ g_{<1>}(z))$, which is equivalent to $\forall f_{<1>}\ \forall g_{<1>}\neg\forall x\ \forall z\ R(x,\ f_{<1>}(x),\ z,\ g_{<1>}(z))$, is not equivalent to any formula of this form. In fact, Barwise 1979 proves that the negation of a formula P of F_{IF} is itself expressible in F_{IF} just in case P is expressible in First-Order Logic. But in general the formula $\exists F_{<1>}\ \exists G_{<1>}\ \forall x\ \forall z\ \varphi$ is not expressible in first-order logic, from which it follows that its negation is not expressible in F_{IF}.

Now Hintikka does give game-theoretic rules for a negation, but as he points out this is *not* ordinary, contradictory negation. The rule is that *$\neg_{IF}S$ is true iff S is true when the roles of the Verifier and of the Falsifier are reversed*, whereby we do obtain the result that the negation Hintikka defines for IF does not take us out of IF, since $\neg_{IF}S$ also asserts the existence of a strategy for one of the players (in the second-order translation, this will indeed yield a formula of F_{IF}). But there are cases in which neither the Verifier nor the Falsifier has a winning strategy. Consider the following formula, where $\forall x$ and $\exists y$ are scopally independent:

(17) $\begin{array}{l}\forall x \\ \exists y\end{array}\Big> \ x \neq y$

The Verifier has a winning strategy for this formula just in case for some y *whose choice does* not *depend on the Falsifier's choice of x,* $x \neq y$. Clearly no y can satisfy this requirement. For his part, the Falsifier has a winning strategy just in case he can choose an element x such that, no matter what element y the Verifier chooses, $x = y$. Again no element x has this property when the domain contains at least two individuals. Thus Hintikka's definition of negation does not give us contradictory negation, since the contradictory negation of P should be true whenever it is not the case that P is true, and this fails to be the case in this example. Now Hintikka does discuss the possibility of introducing contradictory negation in his logic to obtain what he calls an 'extended IF first-order language'. The rule is simply: *$\neg S$ is true iff S is not true, otherwise false.* As he points out, 'no game rules can be used to define contradictory negation' (Hintikka 1996 p. 148); and furthermore, 'contradictory negation can syntactically speaking occur only in front of an entire sentence (closed formula)', for if it were prefixed to an open formula, 'you would need a game rule to handle a substitution-instance of that open formula when you reach it in a semantical game'.

[10] Schlenker 1998 failed to see this point, as did Eklund & Kolak 2002.

Clearly this is not what happens in natural language, and I conjecture that the problem is in fact completely general: *to the extent that there are branching readings to begin with, it would appear those can be obtained within the scope of any operators that one cares to choose*. If so, the challenge for supporters of IF who take linguistic data seriously is to *show how embedded branching readings can be obtained*. Of course the problem does not arise if instead of a game-theoretic semantics one adopts an analysis with existential quantifiers over Skolem functions that are not constrained to have widest scope. This is what we shall do in what follows. (This analysis has the additional advantage of being immediately compatible with the theory of generalized quantifiers, which Hintikka did not consider in his analysis; see, however, Robin Clark's 'Quantifier Games and Reference Tracking' for an analysis of generalized quantifiers within game-theoretic semantics).

2 Indefinites II: Island-escaping behavior

It must be granted that the semantic judgments on which the argument of the previous section is based are rather subtle. Much more robust, on the other hand, are some data that have given headaches to syntacticians working on theories of 'Quantifier Raising'. As we will see, these data provide strong indirect evidence for Hintikka's claim that branching readings exist. Furthermore, the problem raised for Hintikka by embedded branching readings has a direct counterpart with island-escaping indefinites that take embedded scope. If the present approach is on the right track, this is unsurprising, since island-escaping indefinites and branching readings are two sides of the same coin.

2.1 The original discussion

As is well known, indefinites give the appearance of scoping out of syntactic islands, as in the following examples, cited in Reinhart 1997 (see also Farkas 1981, Abusch 1994, Kratzer 1998, Jäger 2006):

(18) a. If some relative of mine dies, I will inherit a house
a'. [some relative of mine]$_i$ [if x_i dies, I will inherit a house]
b. If we invite some philosopher, the party will be a disaster (Reinhart 1997, slightly modified)
b'. [some philosopher]$_i$ [if we invite x_i, the party will be a disaster]
c. Most linguists have looked at every analysis that solves some problem
c'. [Most linguists]$_i$ [some problem$_j$ x_i have looked at every analysis that solves x_j

We will follow the literature (especially Reinhart 1997) in assuming that (a) the behavior illustrated in (18) is shared by indefinites headed by 'a' as well by numerals ('one problem', 'two problems', 'three problems', etc.), and that (b) modified numerals ('at least one problem', 'more than two problems', etc.) generally do *not* display an island-escaping behavior, for reasons that we do not investigate in the present note. Finally, (c) unless otherwise noted, we take the adjective 'certain' (or 'specific') to help bring out readings that are available but sometimes difficult to obtain in its absence.

If the indefinites in (18) give the appearance of escaping syntactic islands, why not assume that they literally do so at Logical Form? Granted, this would require a stipulation, since other quantifiers do not escape syntactic islands; but after all every analysis ends up having to stipulate *something* about indefinites, so this might not be such a bad thing in the end. However this theoretical line raises two additional problems:

(i) Unlike indefinites that overtly have wide scope, plural specific indefinites are claimed by Reinhart 1997 *not* to give rise to distributive readings (see Winter 1997, Ruys 1992; the version below is from Geurts 1999b). Thus (19) can be read as (19) but not as (19):

(19) a. If three relatives of mine die, I will inherit a house.
b. There are three relatives of mine such that, if they all die, I will inherit a house.
c. There are three relatives of mine such that, if any of them dies, I will inherit a house.

(The generality of these judgments has sometimes been called into question, e.g. by Matthewson 1999 and Geurts 1999b.)
(ii) In addition, there is a much stronger argument against a solution based on unrestricted Quantifier Raising for indefinites. The crucial point is that there are indefinites whose restrictor contains a bound variable, and yet which in some sense appear to have wider scope than the binder of this variable:

(20) a. If each of my guests comes with a certain friend of his, the party will be disaster
b. If [each of my guests]$_i$ [a certain friend of his$_i$]$_k$ x_i comes with x_k, the party will be a disaster
c. [a certain friend of his$_i$]$_k$ If [each of my guests]$_i$ x_i comes with x_k, the party will be a disaster

Intuitively, (20) means something like this: *there is a way to associate each of my guests to a friend of his such that, if each guest comes with the friend associated to him, the party will be a disaster*[11]. But all the unrestricted QR analysis can deliver is (20) or (20). In (20) I am committed to the claim that the party will be a disaster if each of my guests comes with *any* friend of his - which is much stronger than the intended reading of (20). By contrast, (20) commits me to the much weaker claim that individual i has a friend such that, if each of my guests invite him, the party will be a disaster - which is clearly not the intended meaning of (20) (where 'a certain friend' covaries with 'each of my guests').

2.2 General Skolem Functions vs. Choice Functions

As it turns out, however, we already have a mechanism at our disposal to formalize the intended reading of (20). Using General Skolem Functions, (20) may be given the Logical Form in (21) (to be refined below):

(21) $\exists F_{<0>}$ [if [each of my guests]$_i$ x_i comes with $F_{<0>}$ (λx x a friend of his$_i$), the party will be a disaster[12]

Using the same device, we may also account for the other cases of island-escaping indefinites that were discussed earlier. (18) can be analyzed as in (22), and (18) as in (22) or(22) (which yield the same truth-conditions):

(22) a. $\exists F_{<0>}$ [if $F_{<0>}$(λx x a relative of mine) dies, I'll inherit a house]
b. [most linguists]$_i$ $\exists F_{<0>}$ x_i has looked at every analysis that solves $F_{<0>}$(λx x a problem)
b'. $\exists F_{<1>}$ [most linguists]$_i$ x_i has looked at every analysis that solves $F_{<1>}$(x_i, λx x a problem)

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[11] B. Geurts (p.c.) notes that the relevant reading is unavailable when 'certain' is deleted from (20). To my (non-native) ear, this observation is correct, but it does not extend to minimal variants of (20) in which 'a certain friend of his' is replaced with 'some friend of his' or with 'one of his friends'.

[12] Note that in this example the General Skolem Function need not take any individual argument, because in any event the restrictor *friend of his* contains a bound variable, which allows variation between the friends and the guests (since different guests may have different sets of friends, the function $F_{<0>}$ may select different individuals from these sets). Still, as has been observed repeatedly in the Choice Function literature, this analysis is still wanting (see for instance Geurts 2000). Suppose that two of my guests G_1 and G_2 have exactly the same friends. Does it follow that the functions quantified over in select the same friend for G_1 and G_2? The Logical Form in (21) predicts that this is indeed the case. If this is incorrect, as has been claimed in the literature, we need to replace $F_{<0>}$(friend of his$_i$) with the expression $F_{<1>}$(i, friend of his$_i$), which may associate to different individuals i and i' different friends f and f', even if i and i' happen to have exactly the same friends:

(i) $\exists F_{<1>}$ [if [each of my guests]$_i$ x_i comes with $F_{<1>}$ (i, friend of his$_i$), the party will be a disaster

General 0-ary Skolem Functions are called *Choice functions*. So far the latter are sufficient to handle our examples. Several versions of the Choice Function analysis have been offered in the literature:
(i) Reinhart 1997 suggested that existential closure over Choice Functions could be performed at any (propositional) level of a syntactic derivation.
(ii) By contrast, Kratzer 1998 suggested that Choice Functions variables are not existentially quantified, but that their value is provided by the context. She further suggested that these functions may take additional individual arguments, and thus that they should be General Skolem Functions rather than simple Choice functions.
(iii) Matthewson 1999 suggested against Kratzer that Choice Functions should be existentially quantified. However against Reinhart she claimed that the existential closure need only occur at the highest level.

By contrast, we will suggest that (i) quantification over General Skolem Functions is needed, and that (ii) the existential quantifiers over functions sometimes need to have scope under other operators. Importantly, these are exactly the conclusions we reached on the basis of branching readings in Section 1[13].

2.3 Functional readings

Reinhart's Choice Functions cannot handle the following examples (Schlenker 1998; Dekker 2002; Winter 2004):

(23) [<u>Context:</u> Every student in my syntax class has one weak point - John doesn't understand Case Theory, Mary has problems with Binding Theory, etc. Before the final, I say:]
a. If each student makes progress in some / a<n> (certain) area , nobody will flunk the exam.
Intended Reading: There is a certain distribution of fields per student such that if each student makes progress in the field assigned to him/her, nobody will flunk the exam.
b. ≠ If each student makes progress in at least one area, nobody will flunk the exam
c. $\exists F_{<1>}$ if [$\forall x$: student x] x makes progress in $F_{<1>}(x, \lambda y$ area y), nobody will flunk the exam.

Consider (23), and assume the following situation: (i) every student made progress in some area he was already good at, but (ii) I still flunked some of the students. It seems that in such a situation I could have uttered (23) without lying; but had I asserted (23), my utterance could not have been construed as true. In other words, (23) has the reading given in (23), which can be paraphrased as: *There is a distribution of areas per student such that if every student makes progress in the area that is assigned to him (say, the one that he is weakest in), then nobody will flunk the exam.* (23) lacks such a reading. On the relevant reading of (23), the choice of the area is clearly dependent on the choice of the student. As observed by R. Schwarzschild (p.c.), the functional reading can be brought out by continuing the discourse with: 'John must make progress in Binding Theory, Mary must make progress in Case Theory, ...' . This continuation is much more difficult with 'at least one area' than with 'some / a certain area'.

To analyze (23), Reinhart has no choice but to insert an existential quantifier over Choice functions *under* the universal quantifier, which is itself in the scope of the *if*-clause - as in (24):

(24) If ([each student]$_i$ $\exists F_{<0>}$ [x_i improves in $F_{<0>}$ (area)]), nobody will flunk the exam

But this now yields the wrong truth conditions, for (24) predicts that in case each student makes progress in *any* area, I am not allowed to flunk anybody. This is clearly not the reading we are after. By contrast, the additional dependency offered by 1-ary Skolem functions in (23) suffices to

[13] See Jäger 2006 for an entirely different solution, in which indefinites are analyzed as variables with certain definedness conditions imposed by their restrictor.

solve the problem[14]. Exactly the same argument can be extended to unmodified numerals, which can be analyzed in terms of General Skolem Functions that take as predicate argument a property of pluralities (*[λy (two y & areas y]* denotes the set of groups of (at least) two areas):

(25) [<u>Context:</u> Every student in my syntax class has two weak points - John doesn't understand Case Theory and LF, Mary has problems with Binding and Theta theory, etc. Before the final, I say:]
a. If each student makes progress in two (specific) areas, nobody will flunk the exam
b. If each student makes progress in at least two areas, nobody will flunk the exam
c. $\exists F_{<1>}$ if [$\forall$x: student x] x makes progress in $F_{<1>}$(x, λy two(y) & areas(y)), nobody will flunk the exam.

Once we have at our disposal all the expressive power afforded by General Skolem Functions, we may try to constrain the system by requiring that the existential closure always have maximal scope - a position which would mesh nicely with Hintikka's original analysis, and also with Matthewson 1999. But this won't work. Whatever readings are obtained in (23) can be replicated in the scope of a variety of operators, including non-monotonic ones. This point was made forcefully by Chierchia 2001, 2003 with respect to quantification over Choice Functions. Starting with (26), which exhibits a specific indefinite, Chierchia observes that (26) can be used to deny (26), and that similarly (26) may attribute to Lee the denial of (26).

(26) a. Every linguist studied every solution that some problem might have
b. Not every linguist studied every solution that some problem might have
c. Lee said that not every linguist studied every solution that some problem might have[15]

It would appear, then, that existential quantification over General Skolem Functions must be allowed to occur at any propositional level in a sentence. This is also the conclusion reached independently by Winter (2002, 2004). Winter emphasizes the analogies between the use of Skolem Functions in (a) the analysis of indefinites, (b) functional readings of definite descriptions, as analyzed in particular by Jacobson 1994 and Sharvit 1999, and (c) the theory of functional and pair-

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[14] One could try to save Reinhart's system by postulating that the examples in (23) contain concealed pronouns, along the lines of (i):

(i) If each student makes progress in some / a<n> (certain) area **<that he must make progress in>**, nobody will flunk the exam.

Apart from the fact that such a mechanism is *ad hoc*, it also makes incorrect predictions. For if it is generally available, there is no reason it could not be used in (23) as well. But this generates a reading that this sentence does not normally have:

(ii) If each student makes progress in at least one area **<that he must make progress in>**, nobody will flunk the exam

If such a reading were available, I could assert (23) truthfully and still flunk students who did make progress in (any) one area. This does not seem to be the case.

[15] While the operators in (26) are all monotonic, the same point applies to non-monotonic environments as well, as in (i):

(i) Exactly two linguists studied every solution that some problem might have.

And lest the reader think that this applies only to those non-monotonic quantifiers that can be analyzed as a conjunction of monotonic quantifiers (e.g. *exactly two students = at least two students and no more than two students*), I give in (ii) an example in which this strategy won't work (because *an odd number of students* can not be obtained as a conjunction of monotonic quantifiers - see Gamut 1991, Vol. 2, p. 329)

(ii) An odd number of linguists studied every solution that some problem might have.

See also the discussion in Chierchia 2001 for further relevant observations.

list readings of interrogatives. This is an important theoretical step because these readings provide independent evidence for a formal device (quantification over functions) which, up to this point in our discussion, has been a pure stipulation. Consider first functional readings of definite descriptions. Jacobson argues that (a variant of) (27) involves quantification over functions as in (27) rather than quantification over individuals as in (27):

(27) a. The only woman that no man loves is his mother-in-law[16].
b. [no x: man x] [[the only y: woman y & x loves y] = x' s mother-in-law.]
c. [ιf: f is a natural function & f maps men to women & [no x: man x] x loves f(x)] = [λx: man x. x's mother-in-law]

Jacobson (who attributes this point to Dahl 1981 and Hornstein 1984) observes that (27) does not yield the right truth conditions. As summarized by Winter 2004, we may 'consider a situation in which John is a man who loves both his wife and his mother-in-law. In this situation (27) is false. However, [(27)] [and (27) -PS] may still be true, as long as also other men do not love *only* their mother-in-law'. (Other arguments against (27) are offered in Jacobson 1994 and Sharvit 1999)

Next, consider questions:

(28) Which dish did every guest make?
a. (Every guest made) his favorite dish.
b. Al (made) the pasta; Bill, the salad; and Carl, the pudding.

(29) Which dish did most/several/a few/no guests make?
a. Their favorite dish.
b. #Al the pasta, and Bill the salad.

(28) allows both for a pair-list and for a functional reading of the question, in the sense that it allows for a list of pairs of guests and dishes that they made, and also for a single answer that defines in a natural way a function from guests to dishes they made. By contrast, (29) only allows for a functional reading, and thus the pair-list answer in (29) is simply impossible. For later reference we note (i) that the contrast between these two examples stems from the nature of the quantifier that has scope over the interrogative word ('every guest' in (28), 'most'/'several'/'a few'/'no guests' in (29), and (ii) that in (29) the functional readings do not allow for unrestricted quantification over all the functions there are, but only over those which are presented as being, in some sense, 'natural' (this presumably accounts for the deviance of (29): what is called for in the answer is the description of a natural function rather than an arbitrary pairing between individuals and dishes). In particular, *all* the non-upward monotonic quantifiers allow only for a functional reading, and never for a pair-list reading (see Winter 2004 for further discussion).

2.4 A Problem of Overgeneration?

Schwarz 2002 argues that an analysis of specific indefinites based on Skolem Functions is bound to overgenerate miserably (see also Bende-Farkas & Kamp 2001). The problem arises in configurations such as [...$\exists F_{<n>}$... O ... $F_{<n>}$...], where the existential quantifier over Skolem Functions binds 'across' an operator O which is not upward-monotonic. This is the case in (30), which -if we are right- should be a possible logical form for (30). The difficulty is that (30) predicts truth conditions that are not attested.

(30) a. No student read a book I had recommended.
b. $\exists F_{<1>}$ [[no x: student x] x read $F_{<1>}$ (x, λy [book y & I had recommended y])]
c. No student read every book I had recommended.

[16] Examples of this sort are originally due to Dahl 1981. Jacobson 1994 discusses (i):

(i) The only woman that no Englishman will invite for dinner is his mother.

d. Suppose that none of the restrictors are empty, and call B the set of books I had recommended. Then:

b ⇒ c: let f be a function that witnesses the truth of b; then f(_, B) associates to each student a book I recommended which he didn't read. The existence of such a function shows that c. is true.

c ⇒ b: Construct f(_, B) so that for each student x, f(x, B) is a book I had recommended and that x did not read. f witnesses the truth of b.

Assuming that there are indeed books that I recommended (so as to avoid the ‘empty restrictor’ problem), (30) is true if and only there is at least one pairing f of students and books such that no student read the book assigned to him by f; and in turn this is true just in case no student read every book that I had recommended, as is laid out in (30).

How serious is this problem? As Schwarz himself points out, the natural solution is to claim that the existential quantifier does not range over all the functions there are, but only over the ‘natural’ ones. Furthermore, we already saw that in the case of questions the non-upward-monotonic quantifiers only allow for functional readings, where quantification is restricted to ‘natural’ functions. If the same constraint is at work for indefinites, we would in fact expect that (30) should not have the reading in (30), because it requires quantification over all the functions there are rather than only the ‘natural’ ones. Pending further investigation, then, I conclude that Schwarz's objection can be circumvented.

3 Disjunction

As is well-known, disjunctions and existential quantifiers share the same algebraic properties (both are 'joins' in a Boolean algebra). In fact, a disjunction *p or q* can be seen as an existential statement *there is a proposition in {p, q} which is true*. It was even proposed by Rooth and Partee 1982 that disjunction should literally be analyzed as an indefinite because it gives rise to 'donkey'-style readings:

(31) If John lost a watch or a compass, Mary found it (Rooth and Partee 1982)

Rooth and Partee observe that the consequent means something like *Mary found what John lost*, a reading that they analyze by treating the disjunction as a DRT-style indefinite bound by an unselective universal quantifier:

(32) $\forall_i$[(watch x_i or compass x_i) & John lost x_i] Mary found x_i

(see Stone 1992 for some difficulties with this approach).

Hintikka's 'Independence Friendly' Logic treats disjunctions on a par with existential quantifiers, in terms of a game-theoretic semantics whose second-order translation involves quantification over Skolem functions. In particular, like existential quantifiers disjunctions allow for branching readings such as the one represented in (33), whose second-order translation is (33) (where it must be assumed that g ranges, among others, over the functions that have {0, 1} as their range). It should be noted that the disjunction in (33) plays the role of the existential quantifier ∃t in our earlier example (6)[17]. For comparison, I include in (33) a standard first-order formula in which a disjunction has scope under two universal quantifiers:

(33)

a. First-Order Notation:

$$\begin{matrix} \forall x\ \exists y \\ \forall z\ \ v \end{matrix} \Big> (P(x, y, z), Q(x, y, z))$$

[17]In more complex cases, an enriched syntax must be used for branching readings involving disjunctions, in order to indicate which formulas the disjunction *v* is supposed to apply to (the notation in (33) would lead to ambiguities if there were more than two formulas). Such a syntax is developed for instance in Sandu and Väänänen 1992 and Hintikka 1996. I will stick to the simpler notation in what follows.

b. Second-Order Translation:
$\exists f_{<1>} \exists g_{<1>} \forall x \forall z ((P(x, f_{<1>}(x), z) \& g_{<1>}(z) = 0) \vee (Q(x, f_{<1>}(x), z) \& g_{<1>}(z) = 1)$

a'. First-Order Notation: $\forall x \exists y \forall z (P(x, y, z) \vee Q(x, y, z))$
b'. Second-Order Translation:
$\exists f_{<1>} \exists g_{<2>} \forall x \forall z ((P(x, f_{<1>}(x), z) \& g_{<2>}(x, z) = 0) \vee (Q(x, f_{<1>}(x), z) \& g_{<2>}(x, z) = 1)$

It is useful to think of the functions $g_{<1>}$ and $g_{<2>}$ in (33) as making a 'choice' between the two disjuncts. Consider for example (33). If $g_{<1>}(z) = 0$, the only way the innermost formula can be true is if the first disjunct (and hence $P(x, f_{<1>}(x), z)$) is true; while if $g_{<1>}(z) = 1$, the innermost formula can be true only if the second disjunct (and hence $Q(x, f_{<1>}(x), z)$) is true. Of course the choice of the values 0 and 1 is entirely arbitrary; all that matters is that the domains of the quantifiers $\exists g_{<1>}$ and $\exists g_{<2>}$ include functions with at least two elements in their range, so as to enforce a 'choice' between the two disjuncts. As the Skolem translations given in (33) make clear, the branching reading *entails* the corresponding non-branching logical form (though the converse need not be the case): if some pair of functions $<f_{<1>}, g_{<1>}>$ witnesses the truth of (33), then $<f_{<1>}, g'_{<2>}>$ witnesses the truth of (33), where for all x, z, $g'_{<2>}(x, z) = g_{<1>}(z)$. This is exactly the pattern we saw earlier when we discussed the branching readings of indefinites.

To my knowledge, Hintikka did not provide arguments to establish that English disjunctions must indeed be analyzed in this way. In the following sections, we try to fill this gap. The rough generalization appears to be that *disjunctions generally share the behavior of indefinites in that they too escape syntactic islands, and give rise to functional readings* - and probably also to branching readings. But the readings in question tend to be harder to obtain than in the case of indefinites - a fact that should ultimately be derived. As a result, the data about branching readings, which were already quite difficult with indefinites, are outright unclear when it comes to disjunctions. I shall thus start the discussion with island-escaping readings, where the judgments are somewhat easier.

3.1 Island-escaping behavior

Larson 1985 suggested that disjunction can have scope only as far as the word 'either' in the construction 'either... or...' can go. In other words, 'either' may optionally mark the site of the covert scopal movement of 'or'. This conclusion is suggested by the following paradigm:

(34) Mary is looking for a maid or a cook (... but I don't know whether it's a maid or a cook that Mary is looking for) (Rooth & Partee 1982, also cited in Winter 1998)

(35) a. Mary is looking for either a maid or a cook.
b. Either Mary is looking for a maid or a cook.
c. Mary is either looking for a maid or a cook.
d. ??Either Mary isn't looking for a maid or a cook.
e. ?? Mary either isn't looking for a maid or a cook
f. Mary isn't looking for (either) a maid or a cook
can't be interpreted as:
'Mary isn't looking for a maid or isn't looking for a cook'

Larson's precise generalization is stated in (36):

(36) Larson's Generalization (cited in Winter 2001)
a. In *or* coordinations without *either*, as well as in *either* coordinations with *either* undisplaced, the scope of *or* is confined to positions where *either* can potentially appear.
b. When *either* is displaced, it specifies the scope of *or* to be at that displaced position.

As is suggested by Larson, 'either' certainly cannot move out of syntactic islands - for instance the following is ungrammatical:

(37) *Either not a single student who picked Greek or Latin passed the exam
(cannot mean: Not a single student who picked Greek passed the exam or not a single student who picked Latin passed the exam).

However, contrary to what Part (a) of Larson's generalization predicts, I believe that there are cases in which a disjunction can give the appearance of scoping out of a syntactic island.

Let us first consider the clearest data, which involve parentheticals:

(38) Students taking the exam have a choice of two options: Greek or Latin
a. Not a single student who picked some / a certain option (I don't remember which) passed the exam.
b. #Not a single student who picked at least one option (I don't remember which) passed the exam.
c. Not a single student who picked Greek or Latin (I don't remember which) passed the exam.
d. Not a single student who picked Greek or picked Latin (I don't remember which) passed the exam
Reading: For some x∈{Greek, Latin}, not a single student who picked x passed the exam.

I use the behavior of indefinites as a baseline, and note that (i) the parenthetical in (38) help bring out the relevant island-escaping readings, while (ii) the same parenthetical in (38) is incompatible with modified indefinites, which are independently known *not* to escape islands. I then use the same parenthetical strategy in (38) to force wide scope readings of disjunctions. The result is similar to (38) rather than (38), which suggests that the parenthetical helps bring out an island-escaping reading of disjunction.

Without parentheticals, a special intonation is sometimes needed to obtain an island-escaping reading (it has been noted that intonation can also help indefinites take scope outside of islands; it is too early to tell whether it is the same intonational pattern that does the trick in both cases):

(39) Not a single student who picked Greek OR Latin passed the exam[18].

The phenomenon appears to be quite general. Although there are three ways to form disjunction in French, all of them yield island-escaping readings with a parenthetical or a special intonation (or both)[19]:

(40) a. Pas un seul étudiant qui a choisi le grec OU le latin (je ne rappelle plus) (n') a réussi l'examen.
Not a single student who has picked the Greek OR the Latin (I don't remember) NE has passed the exam
b. Pas un seul étudiant qui a choisi le grec OU BIEN le latin (je ne me rappelle plus), ...
Not a single student who has picked the Greek OR-WELL the Latin (I don't remember)
c. Pas un seul étudiant qui a choisir SOIT le grec, SOIT le latin (je ne me rappelle plus), ...
Not a single student who has picked BE-IT the Greek OR-WELL the Latin (I don't remember)

As was the case with indefinites, it appears that island-escaping disjunctions can take scope under other operators, including non-upward monotonic ones. Again I use examples involving indefinites as a baseline, and observe that with the right intonation the disjunction, like the

[18] Emphasis of 'or' can also give rise in this example to an exclusive reading of the disjunction, a reading which is irrelevant for our purposes.
[19] Example (40) shows that the wide scope reading is not obtained through a kind of meta-linguistic afterthought ('I said *Greek*, but maybe I should have said *Latin* instead'). This line wouldn't work for the *soit ... soit...* construction, since one half of the construction only (*soit* ...) wouldn't yield a grammatical sentence.

indefinite, can take scope outside of the island but in the scope of subject quantifier (and in (41) it can be checked that prefixing the sentence with *not* can indeed yield the contradictory negation of the initial sentence, as was pointed out for indefinites by Chierchia 2001).

(41) a. (Not) Every logician presented every proof that some theorem has (modified from Chierchia 2001)
b. Exactly four logicians presented every proof that some theorem has.
c. (Not) Every logician presented every proof that the Completeness Theorem OR the Incompleteness Theorem has.
d. Exactly four logicians presented every proof that the Completeness Theorem OR the Incompleteness Theorem has. (Two French logicians focused on the Completeness Theorem and two German logicians focused on the Incompleteness Theorem).

Given the mechanisms that we have already used for indefinites, a simple analysis suggests itself, in which a General Skolem Function takes as argument the set of the disjuncts, in addition to n individual arguments (in the next two examples, n = 0; we discuss below examples for which n = 1).

(42) a. Exactly four logicians studied every conceivable proof that the Completeness Theorem or the Incompleteness Theorem might have.
b. [=4x: logician x] $\exists F_{<0>}$ [every y: y proves $F_{<0>}$({the Completeness Theory, the Incompleteness Theorem}] (x studied y)

(43) a. Not a single student who picked Greek or Latin passed the exam.
b. $\exists F_{<0>}$[no x: student x & x picked $F_{<0>}$({Greek, Latin}] (x passed the exam)[20]

Our conclusion accords with the theory of Winter 2004, who suggested (pp. 157-159) that his Choice/Skolem Function mechanism should be applied to disjunctions (be they propositional or not). We leave it for future research to determine in greater detail how the syntax/semantics interface works in these cases[21].

3.2 Functional Readings

To go one step further, I will now suggest that disjunctions can also, somewhat marginally, allow for functional readings. As with other island-escaping readings, a special intonation on ‘or’ can be helpful. In addition, we can once again use Schwarzschild's suggestion about possible continuations of the discourse to bring out the functional reading.

(44) *Context:* Every student in my linguistics class in syntax or in semantics. Before the final, I say:
a. If each student makes progress in syntax OR in semantics, nobody will flunk the exam. (John must make progress in syntax, Mary must make progress in semantics, ...)

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[20] As noted by an anonymous reviewer, this mechanism should presumably be extended to cases of predicate and propositional disjunction, where the data appear to be somewhat similar:

(i) a. Not a single student who picked Greek or picked Latin (I don't remember which) passed the exam.
b. Not a single student who picked Greek or who picked Latin (I don't remember which) passed the exam.

[21] One problem is to determine how a General Skolem Function can come to take as one of its arguments the *set* of the disjuncts. In Winter's framework, the solution is to take disjunction to have its normal Boolean meaning (= join), and to take a Choice/Skolem function to select one of the *minimal* elements of the denotation of the disjunction. Thus Winter 2004 analyzes (ia) [with a wide scope disjunction] as in (ib):

(i) a. If Bill praises Mary or Sue then John will be happy.
b. $\exists f\, [CH(f)\ \&\ [\langle f\rangle^{d}(min(M\cup S))\ (\lambda x.\ praise'(x)(b')) \rightarrow happy'(j')]]$
where min(M∪S) is the set of the minimal sets of which the generalized quantifier M∪S is true - i.e. min(M∪S) = {{m'}, {s'}}.

Intended Reading: There is a certain distribution of fields (syntax or semantics) per student such that if each student makes progress in the field assigned to him/her, nobody will flunk the exam.

b. If each student makes progress in some area, nobody will flunk the exam. (John must make progress in syntax, Mary must make progress in semantics, ...)
Intended Reading: There is a certain distribution of fields (syntax or semantics) per student such that if each student makes progress in the field assigned to him/her, nobody will flunk the exam.

c. ≠ If each student makes progress in at least one area, nobody will flunk the exam. (<#>John must make progress in syntax, Mary must make progress in semantics ...)

The functional reading in (44) can be analyzed with 1-ary General Skolem Functions, as is shown in (45):

(45) $\exists F_{<1>}$ if [$\forall$x: student x] x makes progress in $F_{<1>}$(x, {syntax, semantics}), nobody will flunk the exam[22].

3.3 Branching?

Do disjunctions give rise to branching readings? If the previous observations are correct, they should, since the expressive power of quantification over Skolem functions is necessary to handle functional readings of (stressed) disjunctions. As was the case for indefinites, this predicts that branching readings of disjunctions should indeed be available, as is expected in Hintikka's system. The judgments are, if anything, more difficult than in the case of branching readings of indefinites. My impression is that the semantic judgments for (46) are closer to those we obtain in (46) than in (46) (in order to avoid difficulties that may arise from the non-monotonic nature of conditionals, the examples can be refined so as to replace the *if*-clause with a past tense *when*-clause):

(46) *Context:* We are fighting for human rights in China and as part of that campaign we are trying to get a representative from each country to fight for the release of one dissident from each (Chinese) prison. I make the following prediction:

a. If a given representative from each country fought fights for the release of the youngest inmate OR the oldest inmate from each prison, our campaign will be was a success.

b. If a given representative from each country fights for the release of a certain inmate from each prison, our campaign will be a success.

c. If a given representative from each country fights for the release of at least one inmate from each prison, our campaign will be a success.

On the assumption that *a given representative* has scope over *each prison*, the crucial question is what happens if the campaign fails because representatives from different countries sent conflicting signals to a given prison - some of them asking for the release of the youngest inmate, while others asked for the release of the oldest inmate. Does this entail that I lied when I asserted (46), (46) or (46)? It seems to me that I could more easily claim that I did not lie if my utterance was (46) or (46) than if it was (46), but of course the data are difficult to assess. If this empirical claim is correct, it can be explained by positing the logical form in (47), which involves existential quantification over Skolem Functions which each take a single individual argument and a single set argument:

(47) $\exists F_{<1>} \exists G_{<1>}$ [$\forall$z: prison(z)][$\forall$x: country(x)] R($F_{<1>}$(x, λu representative-from(u, x)), $G_{<1>}$(z, {the u: youngest-inmate-from(u,z)), the u: oldest-inmate-from(u,z))})

[22] Using the notation of (33), we may also analyze this reading as follows:

(i) $\exists f_{<1>}$ if [$\forall$x: student x] (x makes progress in syntax & $f_{<1>}$(x) = 0 or x makes progress in semantics & $f_{<1>}$(x) = 1), nobody will flunk the exam.

Importantly, the availability of such a logical form is exactly what is expected on the basis of our earlier observations about the existence of island-escaping and functional readings of disjunctions[23]. As in our discussion of indefinites, then, the surest way to vindicate Hintikka's original insight is thus to make a detour through island-escaping and functional readings of disjunctions: the existence of functional readings suggests that existential quantification over Skolem functions is available, which in turn leads one to expect that branching readings should be real as well.

4 Conclusion

Although several aspects of the analysis remain tentative, this note has sought to establish the following points:
(i) When the full array of data is taken into account, Hintikka's problem of branching readings and the syntactic problem of island-escaping readings turn out to be two sides of the same coin. In particular, data from functional readings of island-escaping indefinites motivate a semantic mechanism of quantification over Skolem functions, which in turn predicts that branching readings should be real.
(ii) It is likely that disjunction shares the behavior of indefinites with respect to island-escaping readings and possibly with respect to branching as well. This is natural both given Hintikka's theory and given other observations that suggest that the analogies between disjunction and indefinites are quite systematic.
(iii) Hintikka's particular analysis suffered from the same drawback as analyses of island-escaping indefinites based on wide scope existential closure. Theses analyses are too restrictive and should allow for intermediate existential quantification over General Skolem Functions.
On the other hand we leave it for future research to determine *why* indefinites can have Skolem Function readings in the first place (and why modified indefinites generally cannot).

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[23] This conclusion could be avoided, but only at the cost of a rather unnatural stipulation. One would have to posit that if a General Skolem Function G(R, _, ..., _) appears in the scope of a quantifier Qx, then x *must* be an argument of G. This would rule out branching readings, since the latter involve Skolem Functions that *fail* to encode a dependency with some quantifiers they are in the scope of. Thus in (i), $F_{<1>}(R, x)$ and $G_{<1>}(S, y)$ are in the scope of two individual quantifiers, but they take only one individual argument (x and y respectively, since R and S are the predicate arguments):

(i) $\exists F_{<1>}\ \exists G_{<1>}\ [\forall x: \_\_\_]\ [\forall y: \_\_\_]\ ...\ F_{<1>}(R, x)\ ...\ G_{<1>}(S, y)...$

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