

*Indefinites; an extra-argument-slot analysis**

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Abstract

I propose an analysis of indefinites with a bound variable in the nominal restriction based on Schwarzschild's domain restriction theory, which avoids certain problems of Winter's skolem function analysis. In contrast to Schwarzschild, I argue that the domain restriction's dependency on a different quantifier is linguistically specified at LF.

1 Introduction

This paper discusses an indefinite noun phrase in the form of *a (certain) woman* in an argument position of a verb, especially an indefinite containing a bound variable in its nominal restriction.

The choice/skolem function analysis proposed by Winter (2001) requires an existential closure operation on the function variable, which makes a syntactic derivation more complex. In his logical form, an argument slot introduced by a bound pronoun is not directly bound by the quantifier, which goes against the spirit of semantic compositionality.

In order to avoid these problems, I take an alternative approach. While adopting the basic idea of the domain restriction analysis of the indefinite as in Schwarzschild (2002), I argue that an indefinite has an extra argument slot as its lexical information, which can be bound by a c-commanding quantifier in the sentence. The domain restriction is then dependent on this quantifier.

Based on this analysis of indefinites, I show how we can compositionally derive the required interface logical form in a Categorical Grammar derivation. I use **g** and **z** operators in Jacobson (1999) and show how we can percolate an extra argument slot of the indefinite into a later stage of a derivation and then have it get bound by a quantifier. Jacobson's theory enables us to derive an interface logical form without using a variable in an essential way.

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In Section 2, I explain the logical notations I use. In section 3, I explain the basic idea of a choice function as background knowledge. Section 4 introduces the main issue of this paper with Winter's solution. In section 5, I explain why I do not adopt his choice/skolem function analysis. In section 6, I explain the basic idea of domain restriction analyses, and argue that indefinites have an extra argument selection. Section 7 formalizes this idea in a Categorical Grammar derivation of an interface logical form. Section 8 gives some extensions and Section 9 gives a summary.

2 Semantic types of logical expressions

This section explains the basic notations. I use logical notations to represent the meanings that are paired with phonological strings. Logical forms are compositionally derived at LF through a syntactic derivation. They represent the encoded meanings of the strings, but some might be pragmatically derived meanings.

I use higher order logical expressions. Each logical expression has some semantic type. The basic semantic types are **e** for the expressions referring to individuals and **t** for propositions. Non-basic types are recursively defined as in (1b).

- (1) a. **e** and **t** are basic semantic types.
- b. If **a** and **b** are semantic types, (**a,b**) is also a semantic type.
(N.B. I omit the comma between **a** and **b** if they are made up of **e** and **t**.)

Later, I introduce another basic type **σ** for a tense variable. I also introduce an under-specified type **τ**, which covers the basic types other than **t**. I show the semantic type of a logical expression as subscript like **woman'**_{et} or **hate'**_{e(et)}, but for readability, I give the semantic types of some frequently used expressions beforehand, and keep on using these expressions with the same semantic types, unless otherwise specified. More logical expressions are introduced later; their semantic types are given when they are introduced. First, I give variables:

- (2) Variables.
 - a. type **e**: **x, y, z, m, n**
 - b. type (et): **A, B**
 - c. type (e(et)): **P**

I use English words as meta-language to represent logical expressions. I attach a prime mark to a logical expression to signify that it is a constant, rather than a variable. Here are some of the constants I use in the paper:

- (3) Constants:
- a. type (et): teacher', student', woman', man', boy', girl', smoke'
 - b. type (e(et)): hate', love', know', respect'
 - c. type (t(et)): say'

3 Choice function

In this section, I explain the basic idea of choice functions as background knowledge to understand the issue in this chapter.

The scope taking of an indefinite seems to be different from that of a universal quantifier.

- (4) a. Every teacher said that some/a student smoked at school.
 b. $\exists x$ [student'(x) & $\forall y$ [teacher'(y) \rightarrow say' ([smoke'(x)]_t)(y)]]
- (5) a. Some/ a teacher said that every student smoked at school.
 b.* $\forall x$ [student'(x) \rightarrow $\exists y$ [teacher'(y) & say'([smoke'(x)]_t)(y)]]

The sentence (4a) has a reading that says that there is a student x such that for all teachers y , y says that x smoked at school. Ignoring the tense, the wide scope logical form for the indefinite in (4b) represents this reading. However, if we change the positions of the indefinite and the universal quantifier, the corresponding wide scope reading for the universal is not available. (5a) does not have the reading (5b), which says that for all student x , there is a possibly different teacher y who said that x smoked at school.

It has been observed that the scope of a quantificational noun phrase (QNP) cannot cross a tensed clause boundary (See Fodor & Sag 1982: 367 – 370, Reinhart 1995: 3 – 4 and Winter 2001: 82 – 85 for typical boundaries to the wide scope taking of a genuine quantifier like the universal). (5b) suggests that a universal QNP is subject to this locality constraint but (4b) suggests that the scope of the indefinite is not. One possibility is that the scope-taking of the indefinite follows a fundamentally different mechanism from the one for a standard QNP like the universal. Reinhart (1997) and Winter (1997) claim that the mechanism the indefinite uses is a choice function.

A choice function applies to a set of entities denoted by the nominal restriction and picks a member out of this set, if the set is not empty.¹

¹ I ignore the empty set problem of choice functions in this paper. Because of this, I do not apply a further function of type (et)e \rightarrow (et)t to the function variable f here to derive a generalized

$$(6) \quad CH'_{((et)e)t} \stackrel{\text{def}}{=} \lambda f_{(et)e}. \forall A [A \neq \emptyset \rightarrow A(f(A))] \quad (\text{cf. Winter 2001: 89})$$

A represents a nominal restriction set of type (et) , like **student'**, and if this set is not empty, the choice function chooses an individual member out of it. The chosen individual plays the role of a type e argument. In (7b) and (7c) below, the choice function f picks an individual out of the student set, and this individual acts as the type e argument of the logical expression **smoke'**.

- (7) a. Every teacher said that some/a student smoked at school.
 b. $\exists f_{(et)e} [CH'(f) \ \& \ \forall x [\text{teacher}'(x) \rightarrow \text{say}'([\text{smoke}'(f(\mathbf{student}'))])_t(x)]]$
 Scope²: $\exists > \forall$
 c. $\forall x [\text{teacher}'(x) \rightarrow \text{say}'([\exists f_{(et)e} [CH'(f) \ \& \ \text{smoke}'(f(\mathbf{student}'))]])_t(x)]$
 Scope: $\forall > \exists$

(7b) means that there is a function f such that f is a choice function and for all teacher x , x said that the individual entity that f picks out of the student set smoked at school. Because the existential force associated with the function variable is outside the scope of the universal, f is one and the same function for all the teachers, and for all the teachers, it chooses the same individual out of the student set. This corresponds to the wide scope reading of the indefinite. The idea is to leave the nominal expression *student* and the function variable f in the base position of the indefinite noun phrase, while an existential closure is introduced at various positions in the structure that have the in-situ function variable within the scope.³ In (7c), the existential closure on the function variable is introduced within the scope of the universal quantifier. This means that for each teacher x , there is a possibly different choice function f that chooses a member of the student set. Because each f can pick out a different student, the identity of the student can co-vary with each teacher. This corresponds to the narrow scope reading of the indefinite.

In the next section, I introduce the main issue with Winter's solution.

quantifier type choice function as Winter does to solve the empty set problem. The difference is irrelevant in this paper.

² Scope $X > Y$ means that X takes wide scope over Y .

³ Winter (2001) does not specify at what level of representation an existential closure applies. In this paper, I assume that it is introduced at LF. Reinhart (1997) uses a choice function on top of the standard covert quantifier raising of indefinites that is clause bound. I do not discuss this mixed theory in this paper.

4 Issue: Indefinites with a bound variable and Winter's solution

Winter (1997, 2001) argues that the definition of a choice function in (6) cannot explain a certain reading of an indefinite with a bound variable in its nominal restriction.

- (8) a. Every boy₁ who hates [_{NP} a (*certain*) woman he₁ knows] will develop a serious complex. (cf. Winter 2001: 116)
 b. For each boy *x*, there is a (different) specific woman *y* among the women *x* knows such that if *x* hates *y*, *x* will develop a serious complex.

(8a) has the reading (8b).⁴ In this reading, the woman concerned can co-vary with each boy, but this is not the ordinary narrow scope reading. Which woman we choose for each boy is relevant to the truth condition. Each boy will develop a complex only if he hates a specific woman he knows, like his mother, not if he hates one woman or another whom he knows.

The idea of specificity is not clear as yet. We could define it in terms of a different specific woman for each boy, like Mary for Tom and Nancy for Sid. But Cormack (personal communication) argues that if she forces herself to get this reading, it has to be the case that a certain fixed relation holds for every pair of a boy and a woman, like the relation between a child and his mother. Winter (2003) assumes that the reading (8b) is defined in terms of a function that maps the set of woman each child knows to another function that maps each child to a member of that set. In some contexts, this second function can be understood as a fixed relation holding for every pair of a boy and a woman for him, like the motherhood relation. In section 6, I adopt this assumption in a different framework from Winter's. At the moment, I define this specificity rather informally: the woman is specific in that each boy has only one truth-conditionally relevant woman; it is not just some woman or other. But that relevant woman can co-vary with each boy.

As Winter claims, neither the wide scope nor the narrow scope choice function logical form represents this reading with a type ((et)e) choice function.

- (9) a. $\exists f_{(et)e} [CH'(f) \ \& \ \forall x [[boy'(x) \ \& \ hate'(f \ (\lambda y.[woman'(y) \ \& \ know'(y)(x)])(x))] \rightarrow develop_a_complex'_{et}(x)]]$

⁴ Cormack (p.c.) does not get this reading. But some other speakers do. In this paper, I simply follow the judgments of Winter (2001) and Geurts (2000) and assume that the reading (8b) is truth conditionally different from both the wide scope reading and the ordinary narrow scope reading of the indefinite at the level of linguistic meaning or at explicature.

- b. $\forall x [[\text{boy}'(x) \ \& \ \exists f_{(\text{et})e} [\text{CH}'(f) \ \& \ \text{hate}'(f \ (\lambda y. [\text{woman}'(y) \ \& \ \text{know}'(y)(x)])](x))] \rightarrow \text{develop_a_complex}'_{\text{et}}(x)]$
- (10) a. $\exists y [\text{woman}'(y) \ \& \ \forall x [[\text{boy}'(x) \ \wedge \ \text{know}'(y)(x) \ \wedge \ \text{hate}'(y)(x)] \rightarrow \text{develop_a_complex}'_{\text{et}}(x)]]$
- b. $\forall x_e [[\text{boy}'(x) \ \& \ \exists y [\text{woman}'(y) \ \& \ \text{hate}'(y)(x) \ \& \ \text{know}'(y)(x)]] \rightarrow \text{develop_a_complex}'_{\text{et}}(x)]$ (cf. Winter 2001: 116)

The indefinite wide-scope logical form in (9a) or the corresponding classical indefinite-wide-scope logical form in (10a) does not represent the required interpretation. (9a) says that there is a choice function f such that for all boy x , if x hates the individual y that is picked by f out of the set of women x knows, x develops a complex. Consider a context in which all the boys happen to know exactly the same set of women. In this context, the logical form in (9a) means that the function f chooses one and the same woman for all boys, and that if each boy x hates that woman, x develops a complex. Note that there is only one function f involved for all the boys in (9a) because the existential quantifier binding f takes wide scope over the universal quantifier. If the function is one and the same, and the set out of which f chooses an individual is one and the same, it picks out one and the same individual for all the boys. But (8b) implies that even if all the boys know exactly the same set of women, we should still be able to pick out a different specific woman for each boy. For example, for each boy, we can choose his mother.

The indefinite narrow-scope logical form of the choice function analysis, given in (9b), or its truth conditional equivalent in the classical notation, given in (10b), does not represent the reading in (8b) either. These narrow-scope logical forms say that for all boy x , if x hates a woman x knows, whichever woman it is, x develops a complex. This is the **exhaustive reading** of the indefinite. But (8b) says that each boy x develops a complex only if x hates a specially chosen woman among the women x knows.

As the classical logical forms in (10) do not represent the reading (8b), the problem is not only for a choice function analysis. It is a problem for any analysis explaining the meaning of indefinites solely in terms of the scope relation of the existential quantifier of the indefinite relative to another quantifier.

Winter solves this problem by re-defining choice functions as skolem functions with flexible arities. For simplicity, I discuss a case in which the nominal restriction of the indefinite contains only one bound variable. Then the arity of the skolem function is just one (the super script on SK^1 indicates the arity):

(11) $\exists f_{(e(et))(ee)} [\text{SK}^1(f) \ \& \ \forall x [[\text{boy}'(x) \ \& \ \text{hate}'(f(\lambda m.\lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(m)])(x)) (x)] \rightarrow \text{develop_a_complex}'(x)]]$ (Winter 2001, p.118)

(12) $\text{SK}^1_{((e(et))(ee))t} \stackrel{\text{def}}{=} \lambda f_{((e(et))(ee))}. \forall g_{(e(et))} \forall x_e [g(x) \neq \emptyset \rightarrow g(x)(f(g)(x))]$

Winter argues that (11) correctly represents the reading (8b). The idea is that when a bound pronoun appears in the nominal restriction, the type of the nominal set denoted by the expression *woman he knows* is of type $(e(et))$:

(13) $\lambda m.\lambda n. [\text{woman}'(n) \ \& \ \text{know}'(n)(m)]$

In (11), the function g in (12) corresponds to the logical expression (13), which denotes a function that maps each individual m to a possibly different set of women m knows. If this g is applied to each boy x , we get a possibly different set of women for each x . The skolem function f defined in (12) denotes a function that maps each $(e(et))$ function g to another function $f(g)$, which maps each individual x to a member of the set denoted by $g(x)$ ⁵. If x is a boy, $g(x)$ denotes a set of women for the boy x . Now, what happens if $g(x)$ denotes one and the same woman-set for every boy x . $f(g)$ in (12) can still map each boy x to a different member of the woman-set denoted by $g(x)$. In other words, even if $g(x)$ denotes one and the same set of individuals, $f(g)$ can map each individual x to a different member of that same set. In this way, the function $f(\lambda m.\lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(m)])$ in (11) can still map each boy x to a different member of the set of women he knows, even if every boy happens to know exactly the same set of women. Notice that (11) still says that we pick out a specific kind of woman for each boy, rather than whichever woman it is. The existential quantifier $\exists f$ takes wide scope over the universal quantifier and there is only one function f involved for every boy x . The logical form does not lead to the exhaustive narrow scope reading as in (9b) or (10b).

In summary, specificity in (8b) is explained in terms of the widest scope of the existential quantifier binding the function variable, which leads to the use of one and the same skolem function for all the boys, but we can still pick out a different woman for each boy, because this skolem function applied to the same set of women can still pick out a different woman for each boy out of that same set. In the next section, I explain two problems of Winter's analysis.

⁵ For readability, I sometimes write as if the expressions like f and g themselves were functions, rather than using a complex way of saying things like *a function denoted by f* (or g).

5 Problems

5.1 Unconstrained existential closure

In Winter's analysis, the type e argument slot of the choice/skolem function f is assumed only when there is a bound variable in the nominal restriction of the indefinite, and because of this, we need to apply an existential closure in different places in the structural representation in order to explain different scope readings of the indefinite. If the nominal restriction of the indefinite does not have any bound variable, the type of the choice function is just $((et)e)$. The function f then does not have any type e argument slot and if an existential quantifier binding f takes widest scope in the logical form, f picks out the same member out of the set all the time. In (14b), there is only one function f involved for all the boys, and this f picks out the same girl for every boy. But (14a) has a reading in which we pick out a possibly different girl for each boy. In order to represent this reading, Winter needs to apply an existential closure within the scope of the universal quantifier, as in (14c).

- (14) a. Every boy loves a girl. Scope: $\forall > \exists$ or $\exists > \forall$
 b. $\exists f_{(et)e} [\mathbf{CH}'(\mathbf{f}) \ \& \ \forall x [\text{boy}'(x) \rightarrow \text{love}'(\mathbf{f}(\text{girl}'))(x)]]$
 c. $\forall x [\text{boy}'(x) \rightarrow \exists f_{(et)e} [\mathbf{CH}'(\mathbf{f}) \ \& \ \text{love}'(\mathbf{f}(\text{girl}'))(x)]]$

In (4), we saw that the scope of an indefinite is unconstrained by a tensed clause. In (15), the indefinite within the complex NP can take scope over the universal in the matrix clause, as is shown in the reading (15b).

- (15) a. Every teacher over-heard the rumour that some student smoked at school.
 b. *There is one student x such that every teacher over-heard the rumour that x smoked at school.*

The choice function logical form in (16a) is claimed to represent this reading in a better way than the LF representation in (16b), which covertly moves the indefinite out of the complex NP island at LF. But it is questionable whether introducing an unconstrained existential closure operation just to explain the scope of indefinites is any better than assuming an unconstrained covert movement just for indefinites.

- (16) a. $\exists \mathbf{f} [\mathbf{CH}'(\mathbf{f}) \ \& \ [\text{every teacher over-heard } [_{NP} \text{the rumour } [\text{that } \mathbf{f}(\text{student}) \text{ smoked at school}]]]]$

b.[**some student**_{t₁} [every teacher over-heard [_{NP} the rumour [that **t₁** smoked at school]]]]]

Also, if we adopt the idea of inclusiveness as in Chomsky (1995) and assume that all the information comes from lexicon, we need to assume that the function variable f and the existential closure operator come from some lexical information as well. Notice that a mere existential closure over f is not enough; f has to have the choice function property denoted by \mathbf{CH}' . We need an operation as in (17).

(17) $\text{ECC}(\lambda f. \forall x [\text{boy}'(x) \rightarrow \text{love}'(f(\text{girl}'))(x)]) =$
 $\exists f_{((\text{et})\text{e})} [\mathbf{CH}'(f) \ \& \ \forall x [\text{boy}'(x) \rightarrow \text{love}'(f(\text{girl}'))(x)]]$, where
 $\text{ECC}_{(((\text{et})\text{e})\text{t})} \stackrel{\text{def}}{=} \lambda Q_{((\text{et})\text{e})\text{t}}. Q \cap \mathbf{CH}' \neq \emptyset$, with an additional mechanism to make sure this leads to various scopes of $\exists f$. (cf. Winter 2001: 131)

The details in (17) are not essential in this paper, but an operation, \mathbf{ECC} , defined as in Winter 2001, has to introduce not only an existential quantifier binding the variable f , but the choice function property \mathbf{CH}' of the function f . If an analysis that does not use choice functions can explain the exceptional scope taking of indefinites, that analysis is preferable in that we do not need these extra mechanisms in the syntactic derivation of an interface logical form.

5.2 Compositionality problem

Another problem of Winter's analysis is that his skolem function logical form can not directly mark the binding relation between the universal quantifier and the pronoun bound by it. In a classical logical form, a bound pronoun is represented by a variable bound by the quantifier, as in (18b).

(18) a. Every boy_{t₁} said that he_{t₁} smokes.
 b. $\forall \mathbf{x}[\text{boy}'(x) \rightarrow \text{say}'([\text{smoke}'(\mathbf{x})]_i)(x)]$

But the external argument slot of the verb *know* in Winter's skolem function logical form cannot be directly bound by the universal quantifier.

- (19) $*\exists f_{(e(et))(ee)} [\mathbf{SK}^1(f) \ \& \ \forall \mathbf{x} [[\text{boy}'(x) \ \& \ \text{hate}'(f(\lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(\mathbf{x}))](x)) (x)] \rightarrow \text{develop_a_complex}'(x)]]]$

The logical form in (19) is illicit because the first argument of f does not have the required type $(e(et))$; its type is (et) . This means that we cannot let the universal quantifier bind the highlighted external argument slot x of the verb *know*, even though this argument slot corresponds to the bound pronoun *he*⁶. In Winter's logical form in (11) repeated here as (20a), the argument slot m for the bound pronoun *he* and the extra argument slot x of the skolemized function f are set to denote the same individual only indirectly, through the definition of the skolem function as in (12), repeated here as (20b).

- (20) a. $\exists f_{(e(et))(ee)} [\mathbf{SK}^1(f) \ \& \ \forall x [[\text{boy}'(x) \ \& \ \text{hate}'(f(\lambda m.\lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(\mathbf{m}))](x)) (x)] \rightarrow \text{develop_a_complex}'(x)]]]$
 b. $\mathbf{SK}^1_{((e(et))(ee))t} \stackrel{\text{def}}{=} \lambda f_{(e(et))(ee)}. \forall g_{(e(et))} \forall x_e [g(x) \neq \emptyset \rightarrow g(x)(f(g)(x))]$

As we already saw, $f(g)$ denotes a function that maps each boy x to a member of the woman set denoted by $g(x)$. Technically, we could define the property \mathbf{SK}^1 in a different way such that $f(g)$ maps each individual x to a member of the set denoted by $g(y)$, where $x \neq y$. If we applied this alternative definition to (20a), then, m and x would denote different individuals, contrary to the interpretation required by the bound pronoun *he*. In this sense, the interpretation of the bound pronoun *he* necessitates the definition of \mathbf{SK}^1 as in (20b). But in (17), it is the existential closure operator \mathbf{ECC} that introduces the choice function property \mathbf{CH}' . \mathbf{ECC} would presumably be associated with the indefinite NP, with or without the existence of a bound pronoun. Modifying the definition of \mathbf{ECC} in a way such that the definition of the skolem function property in (20b) is triggered by the lexical information of the bound pronoun in the nominal restriction of the indefinite is not a trivial task. Even if we could come up with a rule like that without violating the idea of Inclusiveness, the interpretational contribution of the bound pronoun *he* would still be different in the standard binding case as in (18) and in a case as in (20). Winter's logical form at least goes against the spirit of semantic compositionality, which predicts that the contribution of the bound pronoun to

⁶ The following β reduction is also illicit in (20) as it collapses the two arguments of f into one (i.e., replacing x for m while deleting λm is illicit). We cannot bind the m slot in this way either:
 $(\lambda m.\lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(\mathbf{m}))](x) \Rightarrow_{\beta \text{ red.}} \lambda n.[\text{woman}'(n) \ \& \ \text{know}'(n)(x)]$

deriving the binding relation should be the same both for (18) and (20) (which is for the issue sentence in (8)).

Admittedly, the two points I have given are problematic only if we assume that the logical form is compositionally derived through a syntactic derivation following the Chomskian idea of Inclusiveness, and if our primary concern is to explain the available readings of indefinites in an empirically adequate way, these might be less of a problem. But in this paper, I assume that a compositional derivation of an interface logical form is an essential factor.

In conclusion, Winter's analysis requires the use of an existential closure applied to function variables in a syntactic derivation of logical forms while introducing the choice/skolem function property, while the operation is not syntactically well-motivated. Winter's logical form cannot directly represent the binding relation holding between the quantifier and the pronoun bound by it.

6 Domain restriction

In this section, I informally motivate a domain restriction analysis with an inherent argument slot for the indefinite, which can solve the problems I mentioned in the prior section. The formal analysis is given in section 7.

First, I introduce the pragmatic domain restriction analysis proposed by Schwarzschild (2002) with one of its main motivations. Consider the example (21).

- (21) a. Every boy who hates a (certain) woman develops a complex
 b. $\exists x [\text{woman}'_{\text{et}}(x) \ \& \ \forall y [[\text{boy}'(y) \ \& \ \text{hate}'(x)(y)] \rightarrow \text{develop_a_c}'_{\text{et}}(y)]]$
 c. $\forall y [[\text{boy}'(y) \ \& \ \exists x [\text{woman}'(x) \ \& \ \text{hate}'(x)(y)]] \rightarrow \text{develop_a_c}'_{\text{et}}(y)]$

In (21a), when the domain of the set of women is pragmatically restricted to a singleton set, the assertion is made only about that singleton member of the set. This means that we can get the wide scope reading equivalent while assuming only the narrow scope linguistic meaning for the string, given in (21c).

Schwarzschild claims that the so-called wide scope reading is not a matter of the existential having wide scope (2002: 298). Analyses that give exceptional quantificational scope-taking possibilities to indefinites assume that the indefinite *a (certain) woman* in (21a) can take scope over the matrix universal, but it is not obvious whether the so-called wide scope reading some native speakers get with this string can be captured by the wide scope logical form of the indefinite, given in (21b). (21b) is trivially true when there is some individual *x* such that *x* is a woman and no boy hates *x*, even if there is another woman *y* such that the speaker has *y* in

mind with the use of *a certain woman* and some boy who hates *y* does not develop a complex. This wide scope logical form does not correctly represent the specific reading of (21a). What we want to capture is the non-arbitrariness of the choice of the woman. Each boy develops a complex only when he hates a specific woman, say, Mary; not when he hates some woman or other.⁷

This is explained in the domain restriction theory. If the domain is restricted into a singleton, the other members of the original set excluded from this domain are irrelevant. If the sentence is understood as an assertion about women in general, the domain is not restricted into a singleton set and we do not get the specific reading.

What happens if the domain is restricted to a singleton set that contains a woman that no boy hates? In that case, the sentence (21a) is simply true. Note that in this analysis, the woman no boy hates and the specific woman that is picked out by the indefinite *a (certain) woman* in this context have to be the same woman, because the domain-restricted set has only one member. So the above problem for the logical form (21b) does not arise. In an actual interpretation, it will be difficult to restrict the domain in this way. It is a pragmatic inference that decides to which member the domain is restricted and I assume the pragmatic domain restriction is done with the linguistic meaning of the sentence and relevant contextual information. This explains why in a normal context, it is difficult to restrict the domain in a way such that the main clause meaning *Every boy...develops a complex* becomes irrelevant to the truth condition of the whole sentence.

Unlike the choice/skolem function analysis, the domain restriction theory does not require an existential closure operation or a function variable in a syntactic derivation of a logical form. This makes the syntactic derivation simpler. The existential quantifier is generated in-situ with the indefinite noun phrase, which does not take an exceptional wide scope. Because we interpret the indefinite quantificationally, we do not need a choice function variable either.

On the other hand, a challenge for the domain restriction analysis is the intermediate scope reading as in (22). Ruys (1992:101-102) and Abusch (1994: 84 – 88) argue that an analysis that predicts that the exceptional wide scope taking of an indefinite always leads to the widest scope is wrong, based on sentences like (22).⁸ Their arguments are against the lexical ambiguity analysis of indefinites in Fodor and Sag (1982), which gives the widest scope to the referential indefinite, but if the domain restriction analysis always gives the widest scope when the domain is restricted to a singleton, the analysis is subject to the same criticism.

⁷ This does not mean that the individual Mary appears in the linguistic meaning or in the proposition expressed. See the end of the section 6.

⁸ Cormack and Kempson (1991) also mentions the existence of the inter-mediate reading, though unlike Ruys and Abusch, they take a pragmatic approach to explain this reading.

- (22) Every student discussed every analysis that solved a (certain) problem in Chomsky 1995. (cf. Reinhart 1997: 346)

(22) has a reading that says that for each student x , there is a possibly different problem y in Chomsky 1995, and x discussed all the analyses that solved y . If the domain restriction to a singleton set is insensitive to other elements in the sentence, we make a wrong predication such that whenever the domain is restricted to a singleton, *a certain problem* has to denote one and the same problem for all the students.

One way to solve this problem is to assume that an indefinite has an inherent argument slot on which the domain restriction is dependent. When this inherent argument slot is bound by the universal quantifier in *every student* in (22), the domain restriction can be done differently for each student, and so we can pick out a different problem for each student.

The sentences like those in (23) (cf. Winter 2003: 1) intuitively fall under the same sort of explanation.

- (23) a. Every student₁ admired a (certain) teacher – his₁ homeroom teacher.
b. A woman that every man₁ loves is his₁ mother.

(23a) suggests that the specificity of the teacher can be relativized to each student; each student can admire a possibly different specific teacher, and if this specificity is the result of a domain restriction into a singleton set, that domain restriction has to be done in a possibly different way for each student.

The so-called functional reading gives another argument for this inherent argument slot of indefinites. The co-indexed pronouns in (23a) and (23b) give a problem to a structural analysis of pronoun binding, because these pronouns are not within the surface c-command domain of the universal quantifiers. But if we assume that an indefinite has an inherent argument slot, which can be formally linked to the universal quantifier, then we can claim that the equality of the functional relation holding between the universal quantifier and the indefinite on the one hand and the functional relation between the universal quantifier and the noun phrase containing the pronoun on the other justifies the use of the pronoun in this way.⁹ In (23a), the sentence means that the function mapping each student to a singleton teacher-set for him is the same as the function mapping each student to a

⁹ Winter (2003: 4-13) uses a similar argument to support his Skolem function analysis of indefinites. Jacobson's examples suggest that this identity of functional relations justifies a binding relation across a question – answer pair as well. E.g.:

i) Who does every Englishman₁ admire? — His₁ mother. (1999: 156)

singleton homeroom-teacher-set for him. (23b) means that the function mapping each man to a singleton woman-set for him is the function mapping each man to the singleton set containing his mother as its unique member.¹⁰

From these considerations, I propose that indefinites have an inherent argument slot, which can be bound by another quantifier in the sentence, and which can make the domain restriction dependent on this quantifier.¹¹ Schwarzschild assumes that the dependency of the domain restriction is pragmatically derived without a linguistic encoding, but I assume that the indefinite noun phrase is equipped with this extra argument slot as lexical information, in order to derive the required dependency relations compositionally in a syntactic derivation of a logical form.

(24) a. Every boy₁ respects a (certain) man (– his₁ father).

b. $\forall x[\text{boy}'(x) \rightarrow \exists y[\text{sg}'(\text{man}')(x)(y) \wedge \text{respect}'(y)(x)]]$

In (24b), sg' is of type $((\text{et})(\text{e}(\text{et})))$ and it has three arguments: **man'**; **x** ; **y** in this order. sg' denotes a function that maps a set of men to another function which then maps each boy **x** to a singleton *man*-set.¹² That is, the function denoted by sg' maps the set of men to a possibly different singleton set for *each boy x*. In other words, sg' enables us to restrict the domain of the *man*-set to a singleton set differently for each **x**.

If the nominal restriction of the indefinite has a pronoun in it, the semantic type of the logical expression for the nominal restriction changes from (et) to (e(et))¹³. In Winter's sentence (8a), repeated here as (25a), the nominal restriction *woman he knows* is paired with the logical expression: $\lambda x.\lambda y.[\text{woman}'(y) \ \& \ \text{know}'(y)(x)]$ of type (e(et)), where the pronoun *he* introduces an extra argument slot **x**.¹⁴ Because the type of sg' is of $((\text{et})(\text{e}(\text{et})))$, we cannot use a simple function application to merge the two expressions; we need to use a Combinator to merge sg' with the

¹⁰ For a more rigorous formulation of this function equivalence analysis, see Winter (2003), though the functional type is different in his choice/skolem function analysis.

¹¹ I do not think about either a generic indefinite or an indefinite in a non-argument position, though I give some preliminary suggestion about the latter in terms of my proposal.

¹² In section 7, I slightly change the type of the extra argument slot of an indefinite. See (28e) and the following text.

¹³ Following Jacobson (1999), I do not lexically distinguish a bound pronoun and an un-bound pronoun. The difference comes as a result of a syntactic derivation.

¹⁴ This logical expression is the same as in Winter's skolem function analysis. See (13) and the following text for the interpretation of the expression. Unlike Winter's skolem function, however, sg' has an inherent argument slot, independent of the argument slot introduced by the bound pronoun.

nominal restriction. For lack of space, I do not define this combinator here,¹⁵ but the idea is that the extra argument slot introduced by the pronoun can be percolated into a later stage of derivation separately from the inherent argument slot encoded with *a certain*. If these two extra argument slots are bound by the same quantifier, we get the reading at issue: (8b). The normalized interface logical form is given in (25b).

- (25) a. Every boy₁ who hates [_{NP} *a (certain) woman* he₁ knows] will develop a serious complex.
- b. $\forall x[[\text{boy}'(x) \ \& \ \exists y[\text{sg}'(\lambda z. [\text{woman}'(z) \ \& \ \text{know}'(z)(x)])(x)(y) \ \& \ \text{hates}'(y)(x)]]$
 $\rightarrow \text{develop_a_complex}'(x)]$

The logical form in (25b) means that, given a set of men each boy x knows, we can map it to a different singleton set for each x , even if every boy happens to know exactly the same set of men. In (25b), the highlighted second argument x of sg' marks the dependency of the domain restriction to x .

The external argument x in the formula $\text{know}'(z)(x)$ corresponds to the bound pronoun *he*. In (25b), this x is also bound by the same quantifier that binds the highlighted x , which is the second argument of sg' , but this does not have to be the case. These two argument slots can be bound by different operators. See the example (45) for a motivation of this formulation. Notice that, unlike in Winter's logical form (11), the binding relation between the universal quantifier and the bound pronoun *he* is directly represented in (25b).

As in Schwarzschild's analysis, the phrase *a certain* changes the set into a singleton set. This forces a specific reading, but this specificity can be relativized because of the inherent argument slot of the indefinite. An indefinite *a boy* without the word *certain* still has this inherent argument slot, but there is no linguistic singleton set requirement. We can still optionally restrict the domain into a singleton using pragmatics. Then the identity of this singleton set can be dependent on the inherent argument slot. But normally, the domain restriction relativization is not quite noticeable with an indefinite without *a certain* because the domain is normally not restricted into a singleton set with this indefinite. This is why we can get the exhaustive reading when this indefinite appears in the nominal restriction of a universal noun phrase. An exceptional wide scope reading¹⁶ is available only when the domain is restricted into a singleton. Because of the existence of the more specific expression *a certain girl*, some native speakers have difficulty

¹⁵ This would be just a normal Geach combinator. See (32) for a general definition.

¹⁶ For convenience, I keep on using this expression, even though I follow Schwarzschild in that this reading is not a matter of quantificational scope.

pragmatically restricting the domain into a singleton set and getting an exceptional wide scope reading with the ordinary indefinite *a girl*.

While being constrained by the linguistic information given above, how the domain is restricted in the actual use of a sentence is a matter of pragmatics. I will not discuss the pragmatic process in detail. But roughly, when a noun phrase with *a certain* is used or when an indefinite *a woman* is interpreted specifically, the hearer assumes that the speaker must have some evidence in mind which supports the set being restricted into a singleton set. If the speaker knows who the singleton member of the set is, it counts as good evidence, and so the hearer often has the impression that the speaker must know who the singleton member is. The linguistic meaning implies that there is a certain relation holding between an element binding the inherent argument slot of an indefinite and the resultant singleton member of the indefinite. A particular relation the speaker has in mind can count as a ground supporting the singleton domain restriction. It might be the son-mother relation as in (23b).

In this section, I argued that an indefinite is lexically equipped with an inherent argument slot on which the domain restriction is dependent. Unlike Winter's analysis, this theory does not require an existential closure in syntax. And the logical form directly represents the binding relation between the quantifier and the pronoun bound by it.

In the next section, I show a derivation of a logical form of a simple English sentence that has an indefinite NP in order to show how an inherent argument slot with the indefinite can be compositionally percolated until a later stage of derivation and then get bound by a c-commanding operator.

7 Formal analysis

7.1 Categorical Grammar and derivation of logical forms

Following Categorical Grammar theories as in Jacobson (1999) or Steedman (2000), I assume a Grammar derivation pairs a phonological string with a logical form. More specifically, each lexical item has three entries:

(26) <phonological form; syntactic category; logical expression>

Phonological entries are given as English expressions in italics. For example, the lexical item *boy* is: <*boy* ; N ; boy'_{et}>.

I follow Jacobson (1999) for her notation of syntactic categories. The category X/R Y selects the category Y to the right and the result category after the merge is

X. The category $X/_L Y$ is merged with the category Y to the left, and the result is the category X .

The semantic type of a logical entry corresponds to the syntactic category. But the mapping is not necessarily one to one. Both $S/_R NP$ and $S/_L NP$ correspond to the semantic type (et) .¹⁷ N for *boy* corresponds to (et) as well. NP for *Tom* corresponds to the type e .¹⁸ I assume that referential noun phrases are lexically type e with the category NP ,¹⁹ while quantificational noun phrases (QNPs) have higher order types and the corresponding syntactic categories, which are explained later.

I adopt Jacobson's variable free framework, but like Jacobson, I use variables bound by lambda operators, because it is notationally easier to follow than an alternative notation using only constants and combinators. The basic rule is that whenever a variable is used in a logical expression, it has to be bound within that expression. Whenever a logical entry is of the form $\lambda x_\tau \alpha_{(\tau,\sigma)}(x)$, it can be η reduced to $\alpha_{(\tau,\sigma)}$, provided α does not have another variable x in it. This means that as long as we do not use a free variable at any stage of derivation, we can represent the same derivation without using any variables as well (see Steedman 2000: Chapter 8). But again, I do not show this rigorously variable free notation in this paper.

Adjacent lexical items are combined based on their syntactic categories, and the output is combined with another item, and when all the lexical items given by the lexical insertion are used up, a logical form is derived at the sentential node, unless the derivation crashes because of some well-formedness condition violation. The well-formedness conditions are based on lexical information coupled with some minimal combinatoric rules.

Categorial Grammar Derivation should ideally be represented so that we can check how the three lexical entries are combined into bigger chunks, but for lack of space, I only show the derivations of syntactic categories and logical expressions. The resultant logical forms are the Grammar – Meaning interface representations, which will then enter into pragmatic inferences, after some format changes between the Grammar module and the Interpretational module.

¹⁷ In English, only the latter is a possible lexical intransitive-verb category.

¹⁸ NP roughly corresponds to DP in a Minimalist framework, though some DP s correspond to a higher order category like $S/_R (S/_L NP)$.

¹⁹ In a syntactic derivation, a Combinator might be used to raise this noun phrase into a higher order type like $((et)t)$.

7.2 Derivations

I show a detailed derivation of a sentence in (27), which is simpler than Winter's sentence in (8a). For lack of space, I do not give a derivation of the sentence (8a), but I give a rough idea about how we can apply the system to the sentence at the end of this sub-section.

(27) Every boy loves a certain girl.

(28) a. *girl* : $\langle \textit{girl} ; \mathbf{N} ; \lambda x_e \textit{girl}'_{\text{et}}(x) \rangle$

b. *boy* : $\langle \textit{boy} ; \mathbf{N} ; \lambda x_e \textit{boy}'_{\text{et}}(x) \rangle$

c. *love* : $\langle \textit{love} ; ((\mathbf{S}/\mathbf{LNP})/\mathbf{RNP}) \{ \text{or TV} \} ; \lambda x_e \lambda y_e \textit{love}'_{\text{e(et)}}(x)(y) \rangle$

d. *a* : $\langle a ; \mathbf{N}^{\mathbf{U}}/\mathbf{RN} ; \lambda \mathbf{B}_{\text{et}} \lambda u_{\tau} \lambda x_e a'_{(\text{et})(\tau(\text{et}))}(\mathbf{B})(u)(x) \rangle$

e. *a certain* : $\langle a \textit{ certain} ; \mathbf{N}^{\mathbf{U}}/\mathbf{RN} ; \lambda \mathbf{B}_{\text{et}} \lambda u_{\tau} \lambda x_e \textit{sg}'_{(\text{et})(\tau(\text{et}))}(\mathbf{B})(u)(x) \rangle$

f. *every* (Nom): $\langle \textit{every} ; (\mathbf{S}/\mathbf{R}(\mathbf{S}/\mathbf{LNP}))/\mathbf{RN} ; \lambda \mathbf{A}_{\text{et}} \lambda \mathbf{B}_{\text{et}} \forall x_e [A(x) \rightarrow B(x)] \rangle$

g. *some**(Acc): $\langle \emptyset ; ((\mathbf{S}/\mathbf{LNP})/\mathbf{LTV})/\mathbf{RN} ; \lambda \mathbf{A}_{\text{et}} \lambda \mathbf{P}_{\text{e(et)}} \lambda x_e \exists y_e [A(y) \& P(y)(x)] \rangle$

The words to the left of the colons are the lexical items. Each lexical item has three entries as in (26). I have put elaborated lambda expressions like $\lambda x. \lambda y. \textit{like}'(x)(y)$, rather than the η reduced **like'** in order to make it easier for the semantics to be checked.

I first explain the quantificational determiner entries, and then the indefinite entries. The determiner *some** in (28g) has a null phonological entry (\emptyset means null). This item is inserted into a syntactic derivation as a sister of an indefinite *a* (*certain*) *girl*. The reason I do not give the existential logical expression in (28g) to the indefinite article *a* is that an indefinite noun phrase can be interpreted non-existentially, like as predicate in a copula construction or as generic. Whether we should associate the inherent argument slot with *some** or *a* (*certain*) depends partly on whether we can derive the function reading in a non-argument position as well. Look at (29).

(29) a. Every boy mistakenly believed that Mary was a certain woman.

b. Every boy mistakenly believed Mary to be a certain woman.

Can we pick out a different woman for each boy in this predicative position? Though the judgment is subtle, I understand that the identity of the woman can co-vary with each boy, and associate an inherent argument slot with *a* (*certain*).²⁰

(28f) and (28g) are for the subject QNP and the object QNP respectively. TV in (28g) (and in (28c)) is used for notational convenience only, in order to represent the transitive verb category ((S/LNP)/RNP). In the lexicon, a QNP should be represented as a uniform set of three entries for both the positions. I do not show how I can do this, but assume that these specific QNP entries can somehow be derived from a uniform triplet of QNP entries using a polymorphic category and logical form.²¹

We need to explain an asymmetry between the subject position and the object position in terms of a domain-restriction dependency possibility. For example, the domain restriction of an indefinite in the subject position does not seem to be able to be dependent on the object universal.

- (30) a. A certain woman loves every boy.
 b. *? For each boy *x*, there is a possibly different specific woman *y* such that *y* loves *x*.

(30a) does not seem to have the reading (30b)²². However, there is a cross-linguistic variation about this judgment. In Japanese, the corresponding indefinite in the subject indefinite can be dependent on a universal QNP in the object position.

- (31) a. aru jyosei-ga subete-no dansei-o aishite-iru.
 certain woman-nom all-gen man-acc love-stative.
 “A certain woman loves every man.” *a* > every , ? every > *a*
- b. aru jyosei-ga sorezore-no dansei-o aishite-iru.
 certain woman-nom each-gen man-acc love-stative.
 “A certain woman loves each man.” each > *a*, ? *a* > each

The notation *every* > *a* means the woman can co-vary with each man. *a* > *every* means that there is one and the same woman for all the men. With the standard universal *subeteno* in (31a), the co-variation is dis-preferred, but seems still

²⁰ I assume that an indefinite in this position denotes a set of entities without a quantificational force. The quantificational determiner *some** is lacking in this position.

²¹ See Steedman 2000: 71.

²² Some native speakers say that they have this reading all right.

possible. In (31b), where an obligatorily distributive universal *sorezore-no* is used, the dependency of the indefinite to the universal in the object position is easy to get, and for some speakers, it is even obligatory. Even though I do not need to formulate the Categorical Grammar derivation in exactly the same way in Japanese and English, some kinds of common rules are certainly required. The fact that the obligatory distributivity of the universal influences the inverse dependency might be suggesting some scope switching operation is actually a matter of inference, rather than a syntactic operation. But in an OV language, scrambling also comes into the picture, so I leave this issue for further research, while formulating a derivation in this section so that only an indefinite in the object position can be dependent on the subject universal in terms of the domain restriction.

The expression *a certain* is of the semantic type $((et)(\tau(et)))$ and its encoded meaning sg' denotes a function I explained for (24) and (25). The type τ is a basic semantic type. It is normally type e , but I keep it under-specified, so that the τ slot can be filled out by an expression denoting a tense argument or an event or a world argument. The expression $sg'(\mathbf{woman}')$ is of type $(\tau(et))$ and this denotes a function that maps an entity u to a singleton woman set for u .²³ The singleton woman set can co-vary with u , but because $sg'(\mathbf{woman}')$ denotes one and the same function for every u , we cannot simply map u to whichever singleton set it is. This explains why one fixed relation has to hold between each boy and the woman for him in the reading (8b) of Winter's example (see pp 4-5 in this chapter).

The extra argument slot u is represented as superscript U in N^U/RN in the syntactic category. U is normally NP, but it might be also a category for a tense or for a world.

The indefinite article *a* on its own is of type $((et)(\tau(et)))$ and has an inherent argument slot u , but unlike sg' , the expression a' does not assign a singleton requirement to the input set. Only when pragmatics restricts the domain to a singleton, the expression $a'(\mathbf{woman}')(u)$ is interpreted as a singleton, relativized to an element u .

Some explanation is required for the syntactic category with a superscript N^U . Think about a case in which U is NP. Jacobson (1999) assumes that a pronoun like *he* or *she* has the semantic type (ee) : $\lambda x.x$, denoting an identity function from individuals to individuals. An expression containing this pronoun as its part inherits the type e argument slot of this identity function till a later stage of derivation. The syntactic category of a pronoun is NP^{NP} and the syntactic category of an expression containing a pronoun is XP^{NP} . XP^{NP} normally behaves just like a standard XP when it is merged with another expression. For example, XP^{NP} cannot be merged with the category NP directly, even if the semantic types match. The mechanism is the same

²³ I discuss the constant status of sg' in section 8.3.

when U is any other category. The superscript entry is inherited till a later stage of derivation by Jacobson's Geach combinator²⁴:

- (32) a. Syntax: $\mathbf{g}(Y/X) = Y^U/X^U$.
 b. Semantics: If f is a function of type (a,b) then $\mathbf{g}(f)$ is a function of type ((u,a),(u,b)), where $\mathbf{g}(f) = \lambda V_{u,a} [\lambda U_u [f(V(U))]]_b$.
 (Jacobson 1999: 138)

Because I uniformly defined verbs as argument of QNPs, I modify Jacobson's combinator \mathbf{g} , so that it can be applied to QNPs.

- (33) a. Syntax: $\mathbf{g}^q((X/R(X/LNP))/RN) = (X^U/R(X/LNP))/RN^U$,
 $\mathbf{g}^q((X/L(X/RNP))/RN) = (X^U/L(X/RNP))/RN^U$,
 where X is either S(/L...) or S(/R...), and U is some category.
 b. Semantics: $\mathbf{g}^q(\lambda A_{et} \lambda P^n_{e(e^1 \dots (e^n, t))} \lambda X_{e^1} \dots \lambda X_{e^n} \exists X_e [A(x) \& P^n(x)(x^1) \dots (x^n)])$
 $= \lambda A^1_{\tau(et)} \lambda P^n_{e(e^1 \dots (e^n, t))} \lambda v_{\tau} \lambda X_{e^1} \dots \lambda X_{e^n} \exists X_e [A^1(v)(x) \& P^n(x)(x^1) \dots (x^n)]$
 (E.g., if we deal with a subject QNP, P is of type (et) for S/LNP.)

For example, *some** in the object position is mapped into the following:

Syntax: $\mathbf{g}^q(((S/LNP)/LTV))/RN) = ((S/LNP)^U/LTV)/RN^U$

Semantics: $\mathbf{g}^q(\lambda A_{et} \lambda P_{e(et)} \lambda y_e \exists X_e [A(x) \& P(x)(y)]) =$
 $\lambda A^1_{\tau(et)} \lambda P_{e(et)} \lambda v_{\tau} \lambda y_e \exists X_e [A^1(v)(x) \& P(x)(y)]$

The point is that this quantifier entry percolates an extra argument slot in its first input argument of the category N^U across a verb category (e.g., TV) onto the output category when the QNP is merged with this verbal category. In this respect, even though I percolate the extra argument slot of the nominal restriction through the quantificational determiner category, the operation still preserves the mechanism of Jacobson's original \mathbf{g} combinator, which compositionally transmits this argument slot through the TV category. Notice that the superscript category U does not

²⁴ A recursive use of the combinator is required to combine a function containing a pronoun with an argument containing another pronoun, like combining *his teacher* with *lives her husband* in *John₁ said that [his₁ teacher]₂ lives her₂ husband*. In my treatment of the indefinite, this corresponds to a sentence like *Every boy who hates a certain woman will have a certain problem*. I do not deal with a complex example like that in this paper.

appear on the argument category TV; the superscript passes through this TV argument.

I could have used Jacobson's original **g** in (32) on the quantificational determiner *some**, so that an extra-argument slot of type τ , which is introduced by *a* (*certain*), is percolated to the QNP level (e.g.: $[_{QNP} some*[_{NU} a certain[_N girl]]]$). Then I could have raised the type of the corresponding argument of the transitive verb so that it could take in a QNP as an argument.²⁵ After that, I could have either applied Jacobson's original **g** to this argument-raised verb to further percolate the extra-argument slot of type τ in the argument QNP^U , or I could have used Jacobson's original **z** combinator, which I explain later, on this argument-raised verb without modifying it, to bind this extra-argument slot at the next stage of the derivation. However, the original intuition about the super-script category U is that the category XP^U behaves exactly like the category XP in its combination possibilities with another category, except for the operations required to derive the binding/dependency relation between the lexical item that introduces this U category and the category that acts as the binder of this extra argument slot. **g** and **z** operators are used specifically for fixing this binding/dependency relation, so it is architecturally understandable that the existence of an inherent argument slot triggers the use of these operators. But it seems odd to apply an argument raising to a verb and change the argument – functor relation between the verb and a QNP just because of the existence of this U superscript category.²⁶

On the other hand, my modifications of the **g** operator above and the **z** operator below do not really change the original definition of these operators. The basic idea of fixing the binding relation between the subject position and the object position through the mediating verb is preserved in my definition. In that sense, the modified operators might just be an applicational variant of the original operators. In this paper, I just make probably superfluous modifications of the operators to preserve the original function – argument relation between a QNP and a verb, whether the QNP has an inherent argument slot or not. But I leave this issue as an open question.

The superscript category U can technically be any syntactic category but in this paper, I limit it to a category that is originated with some lexical item as

²⁵ See Hendriks (1987) for a system that uses this argument raising, as well as an argument lowering and a value raising, to explain the scope ambiguity and some other phenomena.

²⁶ This is based on the assumption that a QNP is normally merged as a functor applied to a verb as its argument. See Dowty (1988) for a treatment of a QNP in an object position as a function taking in the verb category as an argument. Alternatively, I could have assumed that a QNP is normally merged as an argument of a verb, whether it appears in the subject position or in an object position. Then, I could have used Jacobson's original Combinators without modification. I leave this formulation for further research, but notice that this enables us to assume that the type of a QNP is ((et)t), whether it appears in the subject position or in an object position.

superscript, like NP in NP^{NP} with a pronoun *he* or U in $\text{N}^{\text{U}}/\text{R}\text{N}$ with the indefinite *a* (*certain*). Correspondingly, I limit the under-specified semantic type to the underspecified basic type τ , (which is for the variables ν and u). In this paper, the only possible lexical extra argument slots are either of type e or of type τ , where type τ is a polymorphic type that can be instantiated as type e .

With this modified Geach rule, the object QNP can then be merged with a normal transitive verb category and carry the extra argument slot over until the VP level category gets merged with the subject QNP.

As I said above, I re-formulate Jacobson's binding operator \mathbf{z} .

- (34) a. Syntax: $\mathbf{z}^{\mathbf{q}}(\text{S}/_{\text{R}}(\text{S}/_{\text{L}}\text{NP})) \equiv \text{S}/_{\text{R}}(\text{S}/_{\text{L}}\text{NP})^{\text{U}}$
- b. Semantics²⁷: $\mathbf{z}^{\mathbf{q}}_{((\text{et})\text{t})((\tau(\text{et})\text{t}))} \stackrel{\text{def}}{=} \lambda\text{Q}_{(\text{et})\text{t}}. \lambda\text{R}^1_{\tau(\text{et})}. \text{Q}(\lambda\text{x}. \text{R}^1(\text{x})(\text{x}))$
 e.g. we can get $[\lambda\text{R}^1_{\tau(\text{et})}. \forall\text{x}_e [\text{A}_{\text{et}}(\text{x}) \rightarrow \text{R}^1(\text{x})(\text{x})]]$ as an output.
- c. \mathbf{z}^0 Syntax: $\mathbf{z}^0((\text{S}/_{\text{L}}\text{NP})/\text{R}\text{NP}) \equiv (\text{S}/_{\text{L}}\text{NP})/\text{R}\text{NP}^{\text{NP}}$
- d. \mathbf{z}^0 Semantics: $\mathbf{z}^0_{(e(\text{et}))((ee)(\text{et}))} \stackrel{\text{def}}{=} \lambda\text{R}^1_{e(\text{et})}. \lambda\text{f}_{ee}. \lambda_e. \text{R}^1(\text{f}(\text{x}))(\text{x})$
 (c,d: cf. Jacobson 1999:132).

(34c) and (34d) are a particular instantiation of Jacobson's original \mathbf{z} . \mathbf{z}^0 is for a transitive verb when there is one bound pronoun in the object NP. When we deal with an indefinite without any (bound) pronoun in it, I do not use the type (e,e) expression f_{ee} to derive the extra-argument slot of the indefinite. And as I explained before, when we merge a transitive verb with its object QNP, it is the object QNP that is a functor and the transitive verb is the argument of the QNP. So I modify \mathbf{z} for the subject QNP.²⁸ An important point is that this binding operator is applicable only when the input argument carries an extra type e (or type τ) position, which means there is either a bound pronoun or the indefinite *a* (*certain*) in the nominal restriction of the object (Q)NP.

I show a derivation for (27): *Every boy loves a certain girl*.²⁹ First I compose a nominal restriction set.³⁰

²⁷ Notice the first argument position of type τ of R^1 is for an extra argument slot to deal with either a pronoun or an indefinite in the object QNP. The superscript R^1 means that R^1 has one extra argument slot.

²⁸ In order to allow the first object to bind a pronoun in the following object position in a ditransitive verb construction, I would need to define \mathbf{z} for an object QNP as well, while still disallowing an object QNP to bind a pronoun in the subject.

The current definition correctly prohibits the subject quantifier from binding a pronoun in its own nominal restriction through \mathbf{z} operation.

²⁹ I omit the derivation of a phonological form.

$$\begin{array}{l}
(35) \text{ Syntax:} \quad \frac{\frac{\text{a certain}}{N^U/RN} \quad \frac{\text{girl}}{N}_{fa}}{N^U} \\
\text{Semantics:} \quad \frac{\frac{\text{a certain}}{\lambda B_{et}.\lambda u_\tau.\lambda x_e.sg'(B)(u)(x)} \quad \frac{\text{girl}}{\lambda x_e.girl'(x)}_{fa}}{\lambda u.\lambda x.sg'(girl')(u)(x)}
\end{array}$$

Remember that u_τ corresponds to the superscript category U and this position is compositionally transmitted into later stages of the derivation until some element binds it. sg' is of type $((et)(\tau(et)))$. At the last line of the Semantic derivation in (35), the lambda expression $\lambda x.girl'(x)$ is η reduced to $girl'$. Both are of type (et) and they are logically equivalent.

(36) Syntax³¹:

$$\frac{\frac{g^q(\text{some}^*)}{((S/LNP)^U/LTV)/RN^U} \quad \frac{\text{a certain girl}_D}{N^U_{fa}}}{((S/LNP)^U/LTV)}$$

(37) Semantics:

$$\frac{\frac{g^q(\text{some}^*)}{\lambda A^1_{\tau(et)}.\lambda P_{e(et)}.\lambda v_\tau.\lambda z_e.\exists y_e[A^1(v)(y) \ \& \ P(y)(z)]} \quad \frac{\text{a certain girl}_D}{\lambda u.\lambda x.sg'(girl')(u)(x)}_{fa}}{\lambda P.\lambda v.\lambda z.\exists y[[\lambda u.\lambda x.sg'(girl')(u)(x)](v)(y) \ \& \ P(y)(z)]}_{\beta \text{ reduction}}$$

$$\lambda P.\lambda v.\lambda z.\exists y[sg'(girl')(v)(y) \ \& \ P(y)(z)]$$

There are two applications of β reduction on the last line: v fills out the u argument slot and y fills out the x argument slot.³² The inherent argument slot u encoded with *a certain girl* is inherited as v , after the concatenation with the phonologically null existential quantifier *some**, through use of the Geach combinator g^q .

Next, we merge this result with a transitive verb *loves*.

³⁰ At the end of a derivation line, **fa** is forward function application. **ba** is backward function application. **D** means that I have omitted the derivation from the lexical level up to that stage of the derivation.

³¹ When a **g** or **z** is used on a lexical item on the top line, I attach it to that item directly, to show which item the operation is applied to.

³² Note that all the variables are bound by some operator at each step of the derivation. This means that a derivation without using variables should be possible, though I do not prove it here.

(38) Syntax:

$$\frac{\frac{\text{love}}{\text{TV}} \quad \frac{\mathbf{g}^q(\text{some}^*) a \text{ certain girl}}{\text{(S/LNP)}^U / \text{LTV}}}{\text{(S/LNP)}^U} \text{ba}$$

(39) Semantics:

$$\frac{\frac{\text{love}}{\lambda m_e. \lambda n_e. \text{love}'(m)(n)} \quad \frac{\mathbf{g}^q(\text{some}^*) a \text{ certain girl}}{\lambda P_{e(\text{et})}. \lambda v_\tau. \lambda z_e. \exists y_e [\text{sg}'(\text{girl}')(v)(y) \ \& \ P(y)(z)]}}{\lambda v_\tau. \lambda z_e. \exists y_e [\text{sg}'(\text{girl}')(v)(y) \ \& \ [\lambda m_e. \lambda n_e. \text{love}'(m)(n)](y)(z)]}} \text{ba}}{\lambda v. \lambda z. \exists y [(\text{sg}'(\text{girl}'))(v)(y) \ \& \ \text{love}'(y)(z)]} \beta \text{ reduction}$$

Again, there are two applications of β reduction on the last line. Lastly, we let the subject quantifier bind both the v and x positions, by using the \mathbf{z}^q combinator.

(40) Syntax³³:

$$\frac{\frac{\text{Every boy}}{\text{S/R(S/LNP)}^{\mathbf{z}^q}} \text{D} \quad \frac{\text{loves a certain girl}}{\text{(S/LNP)}^U} \text{D}}{\text{S/R(S/LNP)}^{\text{NP}} \text{fa}} \text{S}$$

The under-specified category U can be fleshed out as NP, and the concatenation is successful. In the same way, the under-specified argument slot v of type τ can be filled out by a variable m of type e , which is bound by the universal quantifier. The external argument slot z of the verb **love'** is also filled out by m , which again is bound by the universal quantifier.

(41) Semantics:

$$\frac{\frac{\text{Every boy}}{\lambda B_{\text{et}}. \forall m_e [\text{boy}'(m) \rightarrow B(m)]} \text{D} \quad \frac{\text{loves a certain girl}}{\lambda v_\tau. \lambda z. \exists y [\text{sg}'(\text{girl}')(v)(y) \ \& \ \text{love}'(y)(z)]} \text{D}}{\lambda B_{e(\text{et})}^1. \forall m [\text{boy}'(m) \rightarrow B^1(m)(m)] \text{fa}} \beta \text{ reduction}}{\forall m [\text{boy}'(m) \rightarrow (\lambda v_\tau. \lambda z. \exists y [\text{sg}'(\text{girl}')(v)(y) \ \& \ \text{love}'(y)(z)])(m)(m)]} \beta \text{ reduction}$$

$$\forall m [\text{boy}'(m) \rightarrow \exists y [(\text{sg}'(\text{girl}'))(m)(y) \ \& \ \text{love}'(y)(m)]]$$

The β reduced logical form in the bottom line says that for each boy m , there is a possibly different singleton girl-set, and m loves the singleton member y of that set.

³³ When \mathbf{g} or \mathbf{z} is used at an intermediate stage of derivation, I put it at the end of the line. The item above the line is the input to the operation, and the one below the line is the output.

For lack of space, I do not show the derivation for Winter's sentence in (8a), repeated here as

- (42) Every boy₁ who hates [_{NP} *a (certain) woman* he₁ knows] will develop a serious complex. (cf. Winter 2001: 116)

The mechanism should be essentially the same, but the application needs more sophistication. The bound pronoun *he* is lexically interpreted as identity function of type (e,e) as in Jacobson (1999)³⁴.

- (43) *he*: $\langle he ; NP^{NP} ; \lambda x.x \rangle$

The pronoun introduces another argument slot (, which is of type e for a pronoun,) on top of the one introduced by the indefinite *a certain* (, which is of type τ , as we already saw). By using a Geach combinator, these two extra argument slots can be separately percolated to later stages of derivation and can be bound by either the same operator or by different operators (see section 8.1 for some motivation for this assumption). The definition and the application of **g** and **z** combinators needs some more sophistication to enable this but I leave this as well as a full derivation of (8a) for a separate paper.

In this section, I showed a sample derivation of a simple logical form based on my proposal. In the next section, I mention some extensions of the domain restriction analysis with an extra argument slot.

8 Extensions (Speculation)

8.1 Multiple binding

Jacobson's **g** rules are able to accumulate more than one extra argument position into the output categories, to deal with multiple bound pronouns appearing in a sentence³⁵:

- (44) Every father₁ [_{VP} told [_{his}₁ son]₂ [_{CP} that he₁ would buy him₂ a present]].

³⁴ Following Jacobson (1999), I assume that the three entries for the lexical item *he* is as in (43), whether it is a bound pronoun or not. Cormack (pc) distinguishes a bound pronoun from an un-bound pronoun lexically.

³⁵ See Jacobson 1999, section 2.2.4. (pp.137 – 144) for her formulation.

At the derivational stage of the embedded CP, the composed logical form should be of the type $(e(et))$ with the syntactic category $(S^{NP})^{NP}$. One of the pronouns inside the embedded CP (i.e. *him*₂) gets bound before the matrix VP is completed, but by the matrix VP level, we have got another bound pronoun and at that level, there are again two extra argument positions. After that, both of them get bound by the subject QNP *every father*. So nothing in this mechanism should stop the different extra argument slots introduced by the indefinite *a (certain)* and a bound pronoun as separate arguments until a later stage of derivation. Then the subject universal quantifier can bind both of them at the same time.

Do we need a ‘wide scope’ specific reading in which the extra argument slot introduced by the pronoun and the type τ argument slot with the indefinite *a (certain)* are bound by different operators in the sentence? Think about (45):

- (45) Every psychiatrist says that every child₁ who hates a certain woman he₁ knows will develop a complex.

Does the relation between each child and the woman x have to be the same for all the psychiatrists? It is not easy to get the reading: *For each psychiatrist, there is a possibly different relation holding between each child and the woman concerned*, but this difficulty might be just a matter of processing difficulty of the complex sentence.

It is possible to formulate the theory in a way such that whenever some pronoun in the nominal restriction gets bound, the extra-argument slot introduced with the indefinite also has to be bound. But I do not see a strong reason to add that extra condition, so I just assume that a further percolation of the indefinite argument across the universal *every child* in (45) is linguistically possible, but because it is pragmatics that actually restricts the domain within that linguistic information, relativizing the domain restriction both to a bound pronoun and to an inherent indefinite argument is quite difficult, as a matter of non-linguistic interpretation.

8.2 Wide scope indefinites: Bound by the tense operator?

In order to explain the reading corresponding to the inverse scope reading of the indefinite, I need to have the extra argument slot of the indefinite bound by an element other than a quantifier in a QNP. One candidate might be a tense operator that can be higher than the subject QNP in the syntactic structure.

- (46) a. Every boy loves a certain girl. (Inverse scope: *a certain* > *every*)

- b. $\exists t_{\sigma}[G'_{(\sigma,t)}(t) \ \& \ \{\forall x [\text{boy}'(x) \rightarrow \exists y [(\text{sg}'(\text{woman}'))(x)(y) \ \& \ \text{love}'(y)(x)]\}]_{(\sigma,t)}(t)]$ ³⁶
- c. $\exists t_{\sigma}[G'_{(\sigma,t)}(t) \ \& \ \{\forall x [\text{boy}'(x) \rightarrow \exists y [(\text{sg}'(\text{woman}'))(t)(y) \ \& \ \text{love}'(y)(x)]\}]_{(\sigma,t)}(t)]$

However, tense does not always takes wide scope over the subject QDP.

- (47) a. Every kid ran.
 b. A student frequently interrupted class to ask a question.
 (cf. Carpenter 1994: 3)

(47a) has a reading in which each kid ran at a possibly different time, and (47b) has a reading in which one and the same student interrupted class several times. This does not necessarily stops us from using a tense operator to explain the wide scope of an indefinite over another QNP, as long as Tense can at least sometimes takes the widest scope, but the issue requires further research in terms of the interaction of the scopes of QNPs and tense or some other operators that can bind the extra argument slot of an indefinite.

8.3 The constant sg'

The treatment of sg' as constant expression needs some more consideration. In (48), the hearer is usually not expected to know the identity of the specific relationship that is supposed to hold between every pair of a boy and the man for him, even though the father – son relationship is a possible relation that the speaker can have in mind, as is shown in the parentheses to the right of the sentence.

- (48) Every boy₁ respects a (certain) man (, that is, his father₁).

The function denoted by $\text{sg}'(\text{man}')$ can map an individual x to the same singleton set that the function denoted by $\lambda x.\text{the_father_of}'(x)$ does, where the second function maps an individual x to the singleton set that contains the father of x as its unique member. But this should not be always the case. In a different context, sg' should also be able to denote a function that maps an individual x to the same singleton set that the function denoted by $\lambda x.\text{the_maternal_grandfather_of}'(x)$ does. sg' is like a constant in that it does not scopally interact with other

³⁶ $\{ \}_{(t)}$ is a notational device that shows that the logical expression in $\{ \}$ is a function from a time t to a proposition. σ is a type for an expression denoting a tense. G' is some constant like **Present'**, **Past'**, etc.

quantificational elements, but it is like a variable in that its denotation does not seem to be as rigidly fixed with regard to a model as the denotations of standard constants. I briefly discuss three possibilities to fix this problem.

First, it is not clear whether we have to assume that $\mathbf{sg}'(\mathbf{man}')$ and $\lambda x.\mathbf{the_father_of}'(x)$ are logically equivalent in order to enable them to denote functions that map the same individuals to the same singleton sets in some context. In the denotational definition of a function, two functions are identical if they map exactly the same inputs to exactly the same outputs. But a little modification might solve the problem. For example, we could modify the interpretation of \mathbf{sg}' and assume that \mathbf{sg}' denotes a function that maps a situation to a possibly different singleton set in that situation. The domain restriction of a nominal restriction set is hugely context dependent, which gives some motivation to assume a situation argument of the domain restriction operator. But assuming an argument slot for a situation as well as the type τ argument slot makes the formalism even more complex, and requires further empirical justification. I leave it for further research.³⁷

As second possibility, we could assume some logical expressions that act as a kind of place-holder for a constant expression, or to assume under-specified constant expressions, like arbitrary individuals in Fine (1985), though in the case at issue, the expression \mathbf{sg}' is of a higher order type. Arguably, there might be more natural language expressions that should be treated as 'arbitrary constants.' But this requires further empirical justification. And this solution changes the basic definition of a logical language in some sense, which we might want to avoid if we can help it.

Thirdly, we might apply an existential closure only at the highest position of the structural representation, as in (49).

$$(49) \quad \exists g [SG'(g) \ \& \ \forall x[\mathbf{boy}'(x) \rightarrow \exists y[g(\mathbf{man}')(x)(y) \ \& \ \mathbf{respect}'(y)(x)]]]$$

$$g: ((\text{et})(\tau(\text{et}))), \quad SG': (((\text{et})(\tau(\text{et})))t)$$

This existential closure is not introduced at an intermediate stage of a syntactic derivation and because of this, we could assume that this operation is introduced after syntax. An existential closure might be applied to the variables that have not been bound by operators in syntax, for some interpretation reason. But we still need

³⁷ I could make the interpretation of $\mathbf{sg}'(\mathbf{man}')$ dependent on a situation after syntax, by using a formal semantic system as in Barwise and Cooper (1991). But I do not think assuming another formal level of representation on top of syntax is not well-motivated enough at the moment, even if it helps make syntax simpler.

to associate the property denoted by SG' with the existential closure operator, as we saw in (17), and I think this goes against the spirit of semantic compositionality.

Personally, I suspect that some extension of the definition of constant expressions is independently necessary if we use a logical language as meta language to represent the cognitive meanings of natural language expressions. But I leave further justification of this claim for further research. In this section, I have considered some of the loose ends of my analysis. In the next section, I give a summary of my proposal.

9 Summary

This paper has given an analysis of an indefinite in an argument position of a verb. I adopted Schwarzschild's domain restriction analysis. When the domain of an indefinite nominal restriction set is restricted into a singleton set, we get the impression that the utterance is about a specific individual. But this specific individual can co-vary with some other element in the sentence. In order to derive the intermediate scope reading and the functional reading of the indefinite, I argued that the expression *a* (*certain*) has an extra argument slot of the under-specified type τ . If this slot is bound by a universal quantifier in *every boy*, the domain is restricted in a different way for each boy, which leads to a relativized specific reading.

By using Jacobson's **g** and **z** operators, I showed how this extra argument slot of an indefinite is compositionally transmitted through a syntactic derivation and then gets bound by another element in the sentence without using a free variable at any stage of the derivation.

The exact definition of a logical constant at the level of cognitive linguistic meaning and the issue of exactly how **g** and **z** operators should be used to deal with an indefinite are left for further research.

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