Indefinites: an extra-argument-slot analysis

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

1. Introduction

This paper discusses indefinite noun phrases in the form of *a (certain) woman* in the argument position of a verb, with special attention being paid to indefinites containing a bound variable in their nominal restriction.

It has been observed that the scope of strong quantifiers such as universal quantifiers is roughly clause bound, while the scope of indefinites is not constrained in this way.[1]

(1) a. Every teacher said that *a student* smoked at school. $\forall > \exists$, $\exists > \forall$
b. A teacher said that *every student* smoked at school. $\exists > \forall$, $*\exists > \forall$

(1a) has a reading which says that there is one student such that all the teachers said that the student smoked. This 'wide scope reading' of indefinites is problematic because the universal quantifier in the embedded clause in (1b) cannot take scope over the main clause. (1b) does not have the reading that says that for each student, a possibly different teacher said that the student smoked. Based on covert quantifier raising (QR) in May (1977), we might simply assume an exceptional long-distance movement only for indefinites (cf. Beghelli & Stowell 1996). But this would involve giving up the uniformity of QR as a syntactic movement. Rather than postulating an exceptional movement for indefinites, Reinhart (1997) uses Choice Functions, which can generate the reading that is roughly equivalent to the exceptional scope reading of indefinites.

However, Winter (2001) argues that neither the QR analysis nor the simple choice function analysis can explain one of the readings of the following sentence (cf. Winter 2001:116).

[1] ($\forall > \exists$) means that $\forall$ takes wide scope over $\exists$. See Carpenter (1997: 255) for the summary of typical scope islands for quantifiers in general and the exceptional behaviours of indefinites in this regard.

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(2) Every boy$_1$ who hates [$_{NP}$ *a* (*certain*) *woman* he$_1$ knows] will develop a serious complex.

(2) has a reading in which each boy develops a complex if he hates a certain woman that he knows, e.g. each boy's mother.[2] This reading is problematic because it is different from either the narrow scope reading of the indefinite over the universal, in which each boy develops a complex if he hates any woman that he knows, or the wide scope reading, in which there is one woman such that all the boys will develop a complex if they hate that woman.[3]

In order to explain this reading, Winter (2001) 'skolemizes' his choice function, which generates a reading in which a particular relation (e.g. the motherhood relation) holds for all the *boy-woman* pairs. Winter's analysis is empirically adequate, but because it is still a choice function analysis, it requires an existential closure operation on the choice/Skolem function variable. This operation, like an exceptional QR for indefinites, is not constrained by standard syntactic islands. If an alternative theory can explain the various readings of indefinites without assuming a syntactically unconstrained operation, that theory is preferable. Also, choice/Skolem function analyses make use of function variables to which we need to assign the choice/Skolem function property. This complicates the derivation of logical expressions from the lexical levels, and it is not clear whether the degree of complication is linguistically well motivated. Winter's analysis has another kind of problem. According to his analysis, the argument slot that a bound pronoun introduces into the logical form 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 indefinites as in Schwarzschild (2002), I argue that indefinites are lexically equipped with an extra argument slot, 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 logical form of a sentence containing an indefinite in a Categorial Grammar derivation. I use **g** and **z** operators in Jacobson (1999) and show how we can percolate the extra argument slot of the indefinite into a later stage of the derivation and then have it bound by a quantifier.

In Section 2, I explain the logical notations I use. In section 3, I explain the basic idea of choice functions. 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 slot. Section 7 formalizes this idea in a Categorial Grammar framework. Section 8 gives extensions and Section 9 gives a summary.

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[2] Following Winter, I use the word *certain* to facilitate this reading.

[3] The narrow scope reading of the indefinite is possible only without the word *certain*. (2) does not have the indefinite wide scope reading because the pronoun inside the indefinite is bound by the universal quantifier.

2. Semantic types of logical expressions

In this section, I describe my assumptions about the semantic component as well as the notation that I use for semantic representations. I use logical notations to represent the meanings that are paired with phonological strings. These logical expressions are compositionally derived through syntactic derivation. They represent the encoded meanings of phonological strings, which can be enriched further by pragmatic inferences outside the grammar module.

I use higher order logical expressions. Each logical expression has a 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 (3b).

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

Other than **e** and **t** in (3a), I use another basic type $\boldsymbol{\sigma}$ for a tense variable. I also introduce an underspecified type $\boldsymbol{\tau}$, which can be instantiated as one of the basic types.[4] I show the semantic type of a logical expression as a subscript (e.g. $\mathbf{woman'}_{\mathbf{et}}$ or $\mathbf{hate'}_{\mathbf{e(et)}}$) but for readability, I give the semantic types of some frequently used expressions beforehand, and keep on using these expressions with these semantic types unless otherwise specified. More logical expressions are introduced later. First, I assign types to variables.

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

I use English words as metalanguage to represent logical expressions. I attach a prime mark to **constant** logical expressions, as opposed to variables. Here are some of the constants I use in the paper.

(5) 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

This section explains the basic idea of choice functions as background knowledge. A major motivation for the use of choice function is the exceptional scope taking of indefinites, as opposed to universal quantifiers, which do not show exceptional scope. Consider the sentences in (1) again, repeated here as (6a) and (7b).

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[4] $\boldsymbol{\tau}$ co-varies with the type of the quantifier that binds the extra argument slot of indefinites. $\boldsymbol{\tau}$ is usually instantiated as **e**, because usually a quantifier over individuals (e.g. *every boy*) binds this argument slot. In section 8.2, however, $\boldsymbol{\tau}$ is instantiated as type $\boldsymbol{\sigma}$, because the tense operator binds this argument slot there.

(6) a. Every teacher said that a student smoked at school.
b. $\exists x[\text{student}'(x)\ \&\ \forall y\ [\text{teacher}'(y) \rightarrow \text{say}'([\text{smoke}'(x)]_t)(y)]]$

(7) a. A teacher said that every student smoked at school.
b. $*\forall x[\text{student}'(x) \rightarrow \exists y\ [\text{teacher}'(y)\ \&\ \text{say}'([\text{smoke}'(x)]_t)(y)]]$

The sentence (6a) has a reading that says that there is one student $\boldsymbol{x}$ such that for every teacher $\boldsymbol{y}$, $\boldsymbol{y}$ says that $\boldsymbol{x}$ smoked at school. Ignoring the tense, the wide scope logical form for the indefinite in (6b) represents this reading. However, if we change the positions of the indefinite and the universal quantifier, the corresponding wide scope reading for the universal quantifier is not available. (7a) does not have the reading (7b), which says that for each student $\boldsymbol{x}$, there is a possibly different teacher $\boldsymbol{y}$ who said that $\boldsymbol{x}$ smoked at school.

It has been observed that the scope of a quantificational noun phrase (QNP) cannot cross a tensed clause boundary (e.g. Fodor & Sag 1982:367-370, Reinhart 1995:3-4 and Winter 2001:82-85). (7b) suggests that universal quantifiers are subject to this locality constraint but (6b) suggests that the scope of indefinites is not. We could apply a long distance QR only to indefinites, but this strategy would involve giving up the uniformity of QR as a syntactic movement.[5]

For Reinhart (1997) and Winter (1997), the alleged exceptional scope reading of indefinites is derived by a totally different mechanism from QR, that is, choice functions.[6] A choice function applies to a set of individuals denoted by the nominal restriction and chooses a member from this set, if the set is not empty.[7]

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

In (8), $\boldsymbol{A}$ represents a nominal restriction set of type (et), like the set of students. A function $\boldsymbol{f}$ of type (et)e maps sets of individuals to individuals. We need to assign the choice function property **CH′** to the function $\boldsymbol{f}$, so that $\boldsymbol{f}$ maps a set of individuals to a member of the set. Note that without this restriction, $\boldsymbol{f}$ might map a set of individuals to an individual that is not a member of the set. In (9b) and (9c) below, the function $\boldsymbol{f}$ with the choice function property **CH′** chooses a student from the set of students, and the chosen student acts as the type e argument of the logical expression **smoke′**.

(9) a. Every teacher said that some/a student smoked at school.
b. $\exists f_{(et)e}[\text{CH}'(f)\ \&\ \forall x\ [\ \text{teacher}'(x) \rightarrow \text{say}'([\text{smoke}'(\boldsymbol{f}(\textbf{student}'))]_t)(x)]]$
c. $\forall x[\text{teacher}'(x) \rightarrow \text{say}'([\exists f_{(et)e}[\text{CH}'(f)\ \&\ \text{smoke}'(\boldsymbol{f}(\textbf{student}'))]]_t)(x)]$

[5] Ideally, we should avoid a syntactic operation that is not subject to locality constraints. However, as I discuss in section 5.1, the existential closure that Winter applies to choice function variables is not subject to locality constraints either. I also agree with the comment made by an anonymous reviewer that there is a trade-off between accepting an exceptional QR only for indefinites and use of choice functions (a new complication to the theory).

[6] Reinhart uses both QR and choice functions to explain various readings of indefinites, while Winter explains all the readings using only choice functions. In this paper, I only discuss Winter's analysis.

[7] I ignore the empty set problem of choice functions. Because of this, I do not apply another function of type **(et)e → (et)t** to the function variable $\boldsymbol{f}$ to generate a generalized quantifier as Winter does. The difference does not influence my arguments against Winter's analysis.

(9b) means that there is a function ***f*** such that ***f*** is a choice function and for each teacher ***x***, ***x*** said that the student that ***f*** picks out smoked at school. Because the existential force associated with the function variable is outside the scope of the universal quantifier, ***f*** is 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, though in choice function analyses, the indefinite does not move to a higher position to take wide scope. The idea is to leave the nominal expression *a 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 scope over the in-situ function variable.[8] In (9c), the existential closure on the function variable ***f*** is introduced within the scope of the universal quantifier. This means that for each teacher ***x***, there is a possibly different choice function ***f*** involved. Because each ***f*** can choose a different student out of the student set, the identity of the student can co-vary with the teacher. This corresponds to the narrow scope reading of the indefinite.

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

4. Indefinites with a bound variable and Winter's solution

Winter (1997, 2001) argues that the definition of choice functions in (8) cannot explain one particular reading of indefinite noun phrases with a bound variable in the nominal restriction.

(10) a. Every boy_1 who hates $[_{\text{NP}}$ *a (certain) woman* he_1 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.

(10a) has the reading (10b). In this reading, the woman involved 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 woman who falls under a specific relation to him, for example, his mother, not if he hates some woman or other whom he knows.

We need to clarify the strange 'specificity' in (10b), in which the woman is not just some woman or other but can still co-vary with each boy. We could define it in terms of a different specific woman for each boy, like Mary for Tom and Nancy for Sid. But Cormack (p.c.) says that if she forces herself to get this reading, it has to be the case that a fixed relation holds for every pair of a boy and a woman, like the relation between a boy and his mother. Winter (2004) assumes that the reading (10b) is defined in terms of a function that maps the set of women each boy knows to another function that maps each boy to a member of that set. In some contexts, this second function can be understood as the fixed relation holding for every pair of a boy and the woman for him, like the motherhood relation. In section 6, I adopt this assumption in a different framework from Winter's. In this section, however, I explain the

[8] Winter (2001) does not specify at what level of representation an existential closure applies. In this paper, I assume for convenience that it is introduced at LF. The function variable ***f*** is encoded with a phonologically null determiner head that selects the indefinite NP *a student* as its complement. The indefinite itself denotes just a set of individuals. The formulation is necessary for explaining different uses of indefinites (see Winter 2005:770 for details).

strange specificity rather informally. The woman is specific in that each boy has only one truth-conditionally relevant woman. That is, it is not just an arbitrarily chosen woman. But the relevant woman can still co-vary with each boy.

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

(11) a. $\exists f_{(et)e}[\text{CH}'(f)\ \&\ \forall x[\text{boy}'(x)\ \&\ \text{hate}'(f(\lambda y.[\text{woman}'(y)\ \&$ $\text{know}'(y)(x)])(x)] \rightarrow \text{develop\_a\_complex}'_{et}(x)]$

b. $\forall x[[\text{boy}'(x)\ \&\ \exists f_{(et)e}[\text{CH}'(f)\ \&\ \text{hate}'(f(\lambda y.[\text{woman}'(y)\ \&\ \text{know}'(y)(x)]))(x)]] \rightarrow$ $\text{develop\_a\_complex}'_{et}(x)]$

(12) a. $\exists y[\text{woman}'(y)\ \&\ \forall x[[\text{boy}'(x)\ \&\ \text{know}'(y)(x)\ \&\ \text{hate}'(y)(x)] \rightarrow$ $\text{develop\_a\_complex}'_{et}(x)]]$

b. $\forall x[[\text{boy}'(x)\ \&\ \exists y[\text{woman}'(y)\ \&\ \text{know}'(y)(x)\ \&\ \text{hate}'(y)(x)]] \rightarrow$ $\text{develop\_a\_complex}'_{et}(x)]$ (cf. Winter 2001:116)

Neither the indefinite wide scope logical form in (11a) nor the corresponding classical indefinite wide scope logical form in (12a) represent the required interpretation. (11a) says that there is a choice function ***f*** such that for every boy ***x***, if ***x*** hates the individual ***y*** that ***f*** chooses from 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 (11a) 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 (11a) because the existential quantifier binding ***f*** takes wide scope over the universal quantifier. If the function ***f*** is one and the same, and the set from which ***f*** chooses an individual is one and the same, ***f*** chooses one and the same individual for all the boys. But the reading in (10b) implies that even if all the boys know exactly the same set of women, we should still be able to choose a different specific woman for each boy. For example, for each boy, we can choose his mother.

Neither the indefinite narrow-scope logical form of the choice function analysis, given in (11b), nor its truth conditional equivalent in the classical notation, given in (12b), represent the reading in (10b) either. These narrow-scope logical forms say that for each 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 (10b) 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 (12

(12) do not represent the reading (10b), the problem is not only for a choice function analysis. It is a problem for any analysis that explains the co-variation possibility of an indefinite solely in terms of the relative scope of the existential quantifier that is associated with the indefinite.

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, as in (10a). Then the arity of the Skolem function is just one (the superscript on SK^1 indicates the arity).

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

The idea is that when a pronoun appears in the nominal restriction, the type of the logical expression for the nominal restriction is (e(et)), as in (14) for the nominal restriction *woman he knows* in (10a).

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

For the sentence in (10a), the function $\boldsymbol{g}$ in (13) corresponds to the logical expression given in (14), which denotes a function that maps each individual $\boldsymbol{m}$ to a set of women that $\boldsymbol{m}$ knows. If this $\boldsymbol{g}$ is applied to each boy $\boldsymbol{x}$, we get a possibly different set of women for each $\boldsymbol{x}$. The Skolem function $\boldsymbol{f}$ defined in (13) denotes a function that maps each (e(et)) function $\boldsymbol{g}$ to another function $\boldsymbol{f(g)}$, which in turn maps each individual $\boldsymbol{x}$ to a member of the set denoted by $\boldsymbol{g(x)}$. If $\boldsymbol{x}$ is a boy, $\boldsymbol{g(x)}$ denotes a set of women for the boy $\boldsymbol{x}$. Now, what happens if $\boldsymbol{g(x)}$ denotes one and the same woman-set for every boy $\boldsymbol{x}$. $\boldsymbol{f(g)}$ in (13) can still map each boy $\boldsymbol{x}$ to a different member of the woman-set denoted by $\boldsymbol{g(x)}$. In other words, even if $\boldsymbol{g(x)}$ denotes one and the same set of individuals, $\boldsymbol{f(g)}$ can still map each individual $\boldsymbol{x}$ to a different member of that same set. Let me show this point in Winter's logical form in (15) for the sentence in (10a) with the reading (10b).

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

The type (e(et)) function $\boldsymbol{g}$ in (13) is $\boldsymbol{\lambda m.\lambda n.[\text{woman}'(n)\ \&\ \text{know}'(n)(m)]}$ in (15). In a context in which all the boys know exactly the same set of women, this $\boldsymbol{g}$ function maps every boy $\boldsymbol{x}$ to the same set of women. However, even in this context, the function $\boldsymbol{f(\lambda m.\lambda n.[\text{woman}'(n)\ \&\ \text{know}'(n)(m)])}$ in (15) can still map each boy $\boldsymbol{x}$ to a different member of that same set of women. This is possible because of the highlighted second argument $\boldsymbol{x}$ of the function $\boldsymbol{f}$ in (15). In (15), this argument $\boldsymbol{x}$ is bound by the universal quantifier in *every boy* and consequently, we can choose a different woman for each boy $\boldsymbol{x}$. Notice that (15) still says that we pick out a specific kind of woman for each boy, rather than whichever woman it is in the set of women. The existential quantifier $\exists\boldsymbol{f}$ takes wide scope over the universal quantifier and there is only one function $\boldsymbol{f}$ involved for every boy $\boldsymbol{x}$.[9] The logical form does not lead to the exhaustive narrow scope reading as in (11b) or
(12b).

In summary, the apparent specificity in (10b) is explained in terms of the widest scope of the existential quantifier binding the function variable, which leads to the use of 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 choose a different woman for each boy from that same set, because of the function's second argument $\boldsymbol{x}$, which is bound by the universal quantifier in *every boy*. In the next section, I explain two problems with Winter's analysis.

[9] The fixed function $\boldsymbol{f}$ leads to the fixed relation holding for all the *boy-woman* pairs, as in Cormack's reading on page 381. In order to get the narrow scope reading (in which each boy develops a complex if he hates any woman that he knows), Winter applies an existential closure in a position lower than the universal quantifier as well, implying that an existential closure can be introduced in structurally different places. See section 5.1.

5. Problems
5.1. Unconstrained existential closure

Winter uses a Skolemized function $\boldsymbol{f}$ as in (13) only for indefinite noun phrases with a pronoun inside the nominal restriction, to explain the strange reading as in (10b). The various 'scope readings' of indefinites are explained in terms of different positions at which an existential closure is applied to the function variable $\boldsymbol{f}$, whether the nominal restriction has a bound pronoun or not. For example, in (16), we can think of either the same girl for all the boys, or a possibly different girl for each boy, and Winter explains these readings by applying an existential closure in alternative positions, as in (16b) and (16c).

(16) a. Every boy said that Bob loves a girl.
b. $\exists f_{(et)e}[\mathbf{CH'(}\boldsymbol{f}\mathbf{)}\ \&\ \forall x[\mathrm{boy}'(x) \rightarrow \mathrm{say}'_{(t(et))}([\mathrm{love}'(\boldsymbol{f}(\mathrm{girl}'))(\mathrm{b}')]_t)(x)]]$ $\exists > \forall$
c. $\forall x[\mathrm{boy}'(x) \rightarrow \exists f_{(et)e}[\mathbf{CH'(}\boldsymbol{f}\mathbf{)}\ \&\ \mathrm{say}'_{(t(et))}([\mathrm{love}'(\boldsymbol{f}(\mathrm{girl}'))(\mathrm{b}')]_t)(x)]]$ $\forall > \exists$

However, the existential closure operation is no more structurally constrained than the exceptional scope movement for indefinites in QR based analyses. In

(1616b), closure is applied in a position outside the tensed clause where the indefinite is located, and in (17a) with the reading (17b), closure would have to be applied outside the complex NP in which the indefinite *a (certain) student* is placed.

(17) a. Every teacher over-heard [$_{\mathrm{NP}}$ the rumour that a (certain) student smoked at school].
b. There is one student such that every teacher over-heard the rumour that he smoked at school.

The choice-function logical form in (18a) is claimed to represent this reading in a better way than the LF representation in (18b), which covertly moves the indefinite out of the complex NP island at LF.

(18) a. $\exists \boldsymbol{f}$ [CH′($\boldsymbol{f}$) & [every teacher over-heard [$_{\mathrm{NP}}$ the rumour [that $\boldsymbol{f}$(student) smoked at school]]]]
b. [**some student**$_1$ [every teacher over-heard [$_{\mathrm{NP}}$ the rumour [that $\mathbf{t_1}$ smoked at school]]]]

However, it is questionable whether introducing an unconstrained existential closure operation just to explain the exceptional scope taking of indefinites is any better than assuming an unconstrained covert movement just for that purpose. Also, if we adopt the idea of Inclusiveness as in Chomsky (1995) and assume that all information comes from lexicon, we need to assume that the function variable $\boldsymbol{f}$ and the existential closure operator come from some lexical information as well. Remember that a mere existential closure over $\boldsymbol{f}$ is not enough; the function $\boldsymbol{f}$ has to have the choice function property denoted by **CH′**. We need an operation as in (19), where the existential closure is applied at the top of the logical form (the closure should alternatively be applicable somewhere within the scope of the universal quantifier as well, to derive the narrow scope reading of the indefinite).

(19) ECC ($\lambda f. \forall x$ [boy′(x) → say′([love′($\boldsymbol{f}$(girl′))(b′)]$_t$)(x)]) =
$\exists f_{(et)e}$[CH′(f) & $\forall x$ [boy′(x) → say′([love′($\boldsymbol{f}$(girl′))(b′)]$_t$)(x)]], where
$\mathrm{ECC}_{(((et)e)t)t} \stackrel{\mathrm{def}}{=} \lambda Q_{((et)e)t}.Q \cap \mathrm{CH}' \neq \varnothing$. (cf. Winter 2001:131)

The details in (19) are not essential here, but the existential closure operator **ECC** has to introduce not only an existential quantifier binding the variable ***f***, but also the choice function property **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 with Winter's analysis is that his Skolem function logical form can not directly mark the binding relation between a 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 (20b).

(20) a. Every boy$_1$ said that he$_1$ smokes.
b. $\forall x$[boy′(x) → say′([smoke′(x)]$_t$)(x)]

In contrast to this, the external argument slot of the verb *know* in Winter's Skolem function logical form cannot be directly bound by the universal quantifier.

(21) *$\exists f_{(e(et))(ee)}$[SK^1(f) & $\forall \boldsymbol{x}$ [[boy′(x) & hate′(f (λn.[woman′(n) & know′(n)($\boldsymbol{x}$)])(x)) (x)] → develop_a_complex′(x)]]

The logical form in (21) 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*. Note that the following β reduction would be illicit in Winter's logical form in (15), repeated below as (23a), as it would collapse the two arguments of ***f*** into one (i.e. replacing ***x*** for ***m*** while deleting λ***m*** would be illegal in 15).

(22) ($\lambda m.\lambda n$.[woman´(n)&know´(n)(m)])(x) $\Rightarrow_{\beta\,\mathrm{red.}}$ λn.[woman´(n)&know´(n)(x)]

We cannot bind the ***m*** slot in this way either.

In Winter's logical form in (23a), 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 (13), repeated here as (23b).

(23) a. $\exists f_{(e(et))(ee)}$[SK^1(f) & $\forall x$[[boy′(x) & hate′(f ($\lambda \boldsymbol{m}.\lambda n$.[woman′($n$) & know′($n$)($\boldsymbol{m}$)])($\boldsymbol{x}$)) ($x$)] → develop_a_complex′($x$)]]
b. $\mathrm{SK}^1_{((e(et))(ee))t} \stackrel{\mathrm{def}}{=} \lambda f_{((e(et))(ee))}.\forall g_{(e(et))}\ \forall x_e\ [\, g(x) \neq \varnothing \rightarrow g(x)(f(g)(x))]$

As we have already seen, ***f(g)*** used for the crucial sentence in (10a) 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 so that $\boldsymbol{f}(\boldsymbol{g})$ maps each individual $\boldsymbol{x}$ to a member of the set denoted by $\boldsymbol{g}(\boldsymbol{y})$, where $x \neq y$. If we applied this alternative definition to (23a), then, $\boldsymbol{m}$ and $\boldsymbol{x}$ 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 (23b). But in (19), it is the existential closure operator **ECC** that introduces the choice function property **CH′**. **ECC** would presumably be associated with the indefinite NP via the choice function variable $\boldsymbol{f}$, with or without the existence of a bound pronoun. It is not easy to modify the definition of **ECC** in such a way that the definition of the Skolem function property in (23b) is directly associated with the lexical information of the bound pronoun in the nominal restriction of the indefinite. Even if we could come up with a rule like that without violating Inclusiveness, the interpretational contribution of the bound pronoun *he* would still be different in the standard binding case as in (20) and in a case like (23a). Winter's logical form at least goes against the spirit of semantic compositionality, which predicts that the contribution of the bound pronoun to deriving the binding relation should be the same both for (20) and (23a).

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

In summary, Winter's analysis not only requires the introduction of the choice/Skolem function property during syntactic derivation but also an unconstrained existential closure operation over function variables in the derived logical form. It is not clear whether this additional complication of the theory is linguistically well-motivated. The other problem I have discussed is that Winter's logical form cannot directly represent the binding relation holding between the quantifier and the pronoun bound by it. This poses a problem for semantic compositionality.

6. Domain restriction

In this section, I informally motivate a domain restriction analysis with an inherent argument slot for the indefinite, and argue that it solves the problems I mentioned in the previous 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 example (24).

(24) a. Every boy who hates a (certain) woman develops a complex

b. $\exists x[\mathrm{woman}'(x)\ \&\ \forall y[[\mathrm{boy}'(y)\ \&\ \mathrm{hate}'(x)(y)] \rightarrow \mathrm{develop\_a\_complex}'_{et}(y)]]$

c. $\forall y[[\mathrm{boy}'(y)\ \&\ \exists x[\mathrm{woman}'(x)\ \&\ \mathrm{hate}'(x)(y)]] \rightarrow \mathrm{develop\_a\_complex}'_{et}(y)]$

In (24a), when the domain of the set of women is pragmatically restricted to a singleton set, the assertion is made only about the unique member of the set. Thus, we can get the wide scope reading equivalent while assuming only the narrow scope linguistic meaning, given in (24c), where the pragmatic domain restriction enables us to talk about the unique woman.

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 (24a) 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 (24b). (24b) is trivially true when there is an $\boldsymbol{x}$ such that $\boldsymbol{x}$ is a woman and no boy hates $\boldsymbol{x}$, even if there is another woman $\boldsymbol{y}$ such that a boy who hates $\boldsymbol{y}$ does not develop a complex. This wide scope logical form does not correctly represent the specific reading of (24a). What we want to capture instead is the non-arbitrariness of the choice of a woman. Each boy develops a complex only if he hates a specific woman, say, Mary; not when he hates some woman or other.

This is explained in the domain restriction analysis. If the domain is restricted to a singleton, the other members of the original set that are excluded from the domain are irrelevant. On the other hand, if the sentence is understood as an assertion about women in general, the domain is not restricted to 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 (24a) 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 (24b) 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 that the pragmatic domain restriction is worked out on the basis of the linguistic meaning of the sentence and the relevant contextual information. This explains why in a normal context, it is difficult to restrict the domain in a way such that the meaning of the main clause: *Every boy…develops a complex*, becomes irrelevant in some sense 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 (25). 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 (25). Their criticism is aimed at the lexical ambiguity analysis of indefinites in Fodor & Sag (1982), which gives the widest scope to a referential indefinite. The criticism is not meant to be against the domain restriction analysis. However, if the domain restriction analysis always gives the widest scope when the domain is restricted to a singleton, it is subject to the same criticism.[10]

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

(25) has a reading that says that for each student $\boldsymbol{x}$, there is a possibly different problem $\boldsymbol{y}$ in Chomsky 1995, and $\boldsymbol{x}$ discussed all the analyses that solved $\boldsymbol{y}$. If the domain restriction to a singleton set is insensitive to other elements in the sentence, we predict incorrectly that whenever the domain is restricted to a singleton, *a certain problem* has to denote one and the same problem for all the students.

[10] Cormack & Kempson (1991) also mentions the existence of the intermediate reading, though unlike Ruys and Abusch, they take a pragmatic approach to explain this reading.

One way to solve this problem is to assume that the indefinite has an inherent argument slot on which the domain restriction is dependent. When this inherent argument slot is bound by the universal quantifier *every student* in (25), the domain restriction can be done differently for each student. Thus, we can pick out a different problem for each student.

The sentences in (26) (cf. Winter 2004:331) will fall under the same sort of explanation.

(26) a. Every student_1 admired a (certain) teacher – his_1 homeroom teacher.
b. A woman that every man_1 loves is his_1 mother.

(26a) 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, the domain restriction has to be made 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 (26a) and (26b) are a problem for 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 the 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.[11] In the relevant reading of (26a), the sentence is true if and only if the function mapping each student to a singleton teacher-set for him is the same as the function mapping each student to a singleton homeroom-teacher-set for him. In the same way, we can explain the relevant reading of (26b) by assuming 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.

Motivated by 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.[12] Schwarzschild assumes that the dependency of the domain restriction is pragmatically derived without linguistic encoding, but I assume that indefinite noun phrases are lexically equipped with this extra argument slot, in order to compositionally derive the required dependency relations in the logical forms. I start with the sentence in (27a). (27b) represents the reading in question.

(27) a. Every boy_1 respects a (certain) man (– his_1 father).
b. $\forall x[\text{boy}'(x) \rightarrow \exists y[\text{sg}'(\text{man}')(x)(y) \wedge \text{respect}'(y)(x)]]$

In (27b), **sg′** is of type ((et)(e(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.[13] 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***.

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[11] Winter (2004) uses a similar argument to support his Skolem function analysis of indefinites.

[12] I do not discuss 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.

[13] In the formal section, I slightly change the type of the extra argument slot of indefinites. See (31e) and the following text.

Following Jacobson (1999), if the nominal restriction of the indefinite noun phrase has a pronoun in it, the semantic type of the logical expression for the nominal restriction is (e(et)), rather than (et), which is for a nominal restriction without a pronoun. In Winter's sentence (10a), repeated here as (28a), the nominal restriction *woman he knows* is paired with the logical expression **λ*x*.λ*y*.[woman′(*y*) & 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 ((et)(e(et))), we cannot use a simple function application to merge the two expressions. We need to use a Geach Combinator (which we see shortly) to merge **sg′** with the nominal restriction. For lack of space, I do not show a derivation for this, 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 in question: (10b). The normalized interface logical form in (28b) represents this reading.

(28) a. Every boy$_1$ who hates [$_{NP}$ *a (certain) woman* he$_1$ knows] will develop a serious complex.

b. $\forall x[[\text{boy}'(x)\ \&\ \exists y[\text{sg}'(\lambda z.[\text{woman}'(z)\ \&\ \text{know}'(z)(x)])(\boldsymbol{x})(y)\ \&\ \text{hates}'(y)(x)]] \rightarrow \text{develop\_a\_complex}'(x)]$

The logical form in (28b) means that, given a set of women 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 women. In (28b), the highlighted second argument ***x*** of **sg′** marks the dependency of the domain restriction on ***x***.

The external argument ***x*** in the formula **know′(*z*)(*x*)** corresponds to the bound pronoun *he***.** In (28b), 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 (49) on page 397 for one motivation for this formulation. Notice that, unlike in Winter's logical form in (15), the binding relation between the universal quantifier and the bound pronoun *he* is directly represented in (28b).

As in Schwarzschild's analysis, the phrase *a certain* changes the set to a singleton set. This forces a specific reading, but this specificity can be relativized because of the inherent argument slot of the indefinite. The 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 to a singleton set by 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 noticeable with indefinite noun phrases without a *certain* because the domain is usually not restricted to a singleton set with this type of indefinites. With this normal type of indefinites, the domain is usually restricted to a set that still contains several members. This is why we tend to get the exhaustive reading when this type of indefinites appears in the nominal restriction of a universal noun phrase. In order to restrict the domain to a singleton and get an exceptional wide scope reading,[15] we need a special pragmatic context. Some speakers never get an exceptional scope reading with the normal

[14] This logical expression is the same as (14) in Winter's Skolem function analysis. However, unlike Winter's Skolem function, **sg′** has an inherent argument slot, independent of the argument slot introduced by the pronoun.

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

indefinite *a boy*. I suppose this is because the existence of the more specific expression *a certain boy* blocks the application of the pragmatic domain restriction to a singleton set.

While the linguistic information introduces the domain restriction, how the domain is restricted in a particular use of such a sentence is a matter of pragmatics. I will not discuss the pragmatic process in detail. But roughly, when the indefinite *a certain woman* is used or when the indefinite *a woman* is interpreted specifically, the hearer assumes that the speaker must have some evidence in mind which supports the set being restricted to 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 supporting evidence does not have to be a specific individual; it can be a specific relation. The linguistic meaning says that there is a certain relation holding between an element binding the inherent argument slot of the indefinite and the resultant singleton member of the woman set. A particular relation that the hearer takes the speaker to have in mind can count as a ground supporting the singleton domain restriction. It might be the son-mother relation as in (26b).

In this section, I argued that the 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 the 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. Categorial Grammar and derivation of logical forms

Following Categorial 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.

(29) lexical item: <*phonological form*; syntactic category; logical expression>

For example, the three entries for the lexical item *boy* are: <*boy* ; N ; $\text{boy}'_{\mathbf{et}}$>.

I follow Jacobson's notation for syntactic categories in Jacobson (1999). The functor category $X/_RY$ selects the category Y to the right and the result category after the merge is X. The category $X/_LY$ is merged with the category Y to the left, and the result is the category X**.**

There is a systematic mapping between syntactic categories and semantic types. But the mapping is not necessarily one to one. Both $S/_LNP$ for an intransitive verb (e.g. *smoke*) and N for a common noun (e.g. *boy*) correspond to the type (et). NP for *Tom* corresponds to the type e. I assume that referential noun phrases are lexically type e with the category NP, while quantificational noun phrases (QNPs) have a lexically higher order type with the corresponding syntactic category, which I show later.

Adjacent items are successively combined based on their syntactic categories, and when all the lexical items given by the lexical insertion are used up, a logical form is derived at the sentential node.

Categorial Grammar derivations should ideally be represented so that we can check how all three entries of lexical items 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.

7.2. Derivations

I show a detailed derivation of a sentence in (30), which is simpler than Winter's sentence in (10a). For lack of space, I do not give a derivation of Winter's sentence in (10a), but I give a rough idea about how we can apply the system to that sentence at the end of this sub-section.

(30) Every boy loves a certain girl.

(31) a. *girl*: $<\mathit{girl}\ ;\ \mathrm{N}\ ;\ \lambda x_{e}.\mathrm{girl}'_{et}(x)>$
b. *boy*: $<\mathit{boy}\ ;\ \mathrm{N}\ ;\ \lambda x_{e}.\mathrm{boy}'_{et}(x)>$
c. *love*: $<\mathit{love}\ ;\ ((\mathrm{S}/_{\mathrm{L}}\mathrm{NP})/_{\mathrm{R}}\mathrm{NP})\ \{\text{or TV}\}\ ;\ \lambda x_{e}.\lambda y_{e}.\mathrm{love}'_{e(et)}(x)(y)>$
d. *a*: $<\mathit{a}\ ;\ \mathrm{N}^{\mathrm{U}}/_{\mathrm{R}}\mathrm{N}\ ;\ \lambda B_{et}.\ \lambda u_{\tau}.\ \lambda x_{e}.\ \mathrm{a}'_{(et)(\tau(et))}(B)(u)(x)>$
e. *a certain*: $<\mathit{a\ certain}\ ;\ \mathrm{N}^{\mathrm{U}}/_{\mathrm{R}}\mathrm{N}\ ;\ \lambda B_{et}.\ \lambda u_{\tau}.\lambda x_{e}.\ \mathrm{sg}'_{(et)(\tau(et))}(B)(u)(x)>$
f. *every* (Nom): $<\mathit{every}\ ;\ (\mathrm{S}/_{\mathrm{R}}(\mathrm{S}/_{\mathrm{L}}\mathrm{NP}))/_{\mathrm{R}}\mathrm{N}\ ;\ \lambda A_{et}.\lambda B_{et}.\ \forall x_{e}[A(x)\rightarrow B(x)]>$
g. _some*_(Acc): $<\varnothing\ ;((\mathrm{S}/_{\mathrm{L}}\mathrm{NP})/_{\mathrm{L}}\mathrm{TV})/_{\mathrm{R}}\mathrm{N};\ \lambda A_{et}.\lambda P_{e(et)}.\lambda x_{e}.\exists y_{e}[A(y)\ \&\ P(y)(x)]>$

The words to the left of the colons are the lexical items. Each lexical item has three entries as in (29). I have put elaborated lambda expressions such as $\boldsymbol{\lambda x.\lambda y.\mathrm{love}'(x)(y)}$, rather than the equivalent η reduced form, **love′**, 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 (31g) has a null phonological entry (∅ means null). This item is inserted into a syntactic derivation as a sister of the indefinite *a (certain) girl*. The reason I do not encode the existential quantifier in (31g) into the meaning of the indefinite article *a* itself is that an indefinite noun phrase can be interpreted non-existentially, for example as a predicate in the copula construction or as generic.

Whether I associate the extra argument slot of indefinites with _some*_ or *a (certain)* depends partly on whether we can get the dependent specific reading for an indefinite noun phrase in a non-argument position as well. Consider (32).

(32) 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 with the indefinites in these predicative positions? Though the judgment is subtle, I understand that the identity of the woman can co-vary with each boy in (32), which suggests that we need to associate the inherent argument slot with *a (certain)*.

(31f) and (31g) are for the subject QNP and the object QNP respectively. TV in (31g) (and in (31c)) is used for notational convenience only, in order to represent the transitive verb category $((\mathrm{S}/_{\mathrm{L}}\mathrm{NP})/_{\mathrm{R}}\mathrm{NP})$.

We need to explain an asymmetry between subject position and object position in terms of the domain-restriction dependency. For example, in (33), the domain restriction of the indefinite in the subject position does not seem to be able to be dependent on the universal quantifier in the object position so easily.

(33) a. A certain woman loves every boy.
b. *? For each boy $\boldsymbol{x}$, $\boldsymbol{x}$ is loved by $\boldsymbol{x}$'s mother (for example).

(33a) does not easily get the reading (33b). In the system that I show below, the extra argument slot of **sg′** associated with the indefinite *a certain woman* can only be bound by a quantifier that is merged later in the derivation. In non-Categorial grammar terminology, this means that the extra argument slot can only be bound by a c-commanding operator. The question is what happens when we apply to the universal quantifier *every boy* in (33a) a mechanism that is equivalent to QR to allow the universal to take scope over the subject position. But then we would expect a weak cross over effect when this universal NP 'crosses over' the extra argument slot introduced by the subject indefinite, if the universal binds this extra argument slot. It would be the same kind of effect as we observe in (34b)[16]

(34) a. Who does every boy_1 love? – His_1 mother.
b. ??Who loves every boy_1? – His_1 mother.

We would expect that (33b) as a reading of (33a) is comparable to (34b). That is, this reading would be difficult to get, but it would not be totally impossible. Some speakers of English do accept reading (33b) in the right context, which might support the hypothesis that the indefinite introduces an extra argument slot. I do not go into detail here for lack of space, but the interaction between the extra argument slot of indefinites and the scope-taking mechanism of strong quantifiers is certainly worth more research.

Getting back to (31e), the logical expression **sg′** for *a certain* is of the type ((et)(τ(et))), where **sg′** denotes a function I explained for (27) and (28). The type τ is an underspecified basic semantic type for the extra argument slot of the indefinite. This slot is usually bound by a quantifier over individuals (e.g. *every boy*) and so τ is usually instantiated as type e. But sometimes the tense operator might bind this argument slot, as we see in section 8.2. This is why I keep the type τ under-specified so that I can cover all the possible binders of the extra argument slot of indefinites. The expression **sg′(woman′)** is of type (τ(et)) and this denotes a function that maps an entity $\boldsymbol{u}$ to a singleton woman set for $\boldsymbol{u}$.[17] The singleton woman set can co-vary with $\boldsymbol{u}$, but because **sg′(woman′)** denotes the same function for every $\boldsymbol{u}$, we cannot simply map $\boldsymbol{u}$ 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 (10b) of Winter's example.

The extra argument slot $\boldsymbol{u}$ of the indefinite corresponds to the superscript U in $N^U/_R N$ in the syntactic category. U is normally instantiated as NP, but I keep it underspecified along with its semantic type τ for the reason I explained in the preceding paragraph.

The indefinite article *a* on its own is of type ((et)(τ(et))) and has the inherent argument slot $\boldsymbol{u}$, 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 is the expression **a′(woman′)** interpreted as a function that maps an individual $\boldsymbol{u}$ to $\boldsymbol{u}$'s singleton set.

An explanation is required for the syntactic category with a superscript category: N^X, where X is used as a category variable for notational convenience. Jacobson (1999) assumes that a pronoun like *he* or *she* has the semantic type (ee): $\boldsymbol{\lambda x.x}$, denoting an identity function from individuals to individuals. The syntactic category of pronouns is NP^{NP}. NP^{NP} is different from $NP/_L NP$ or $NP/_R NP$, though the three categories would have the same semantic type:

[16] I would like to thank an anonymous reviewer for pointing this out and for suggesting the examples in (34).
[17] I discuss the constant status of **sg′** in the sub-section 8.3.

(e,e). Because the syntactic categories determine a merge, we cannot merge NP^{NP} with an argument category NP, even though the semantic types of the two categories match. We need to apply a combinator to the functor category $X/_L NP$ or $X/_R NP$ first, before we merge the result with NP^{NP} as argument. If we want to percolate the super-script category till a later stage of derivation, then we apply Jacobson's Geach combinator **g** to $X/_L NP$ (or $X/_R NP$) to derive the functor category $X/_L NP^{NP}$ (or $X/_R NP^{NP}$).[18] If we want to bind (or identify) this super-script category with another argument category of the functor category (e.g. X in $X/_R NP$ might have another argument as in $(S/_L NP)/_R NP$), then we can apply Jacobson's 'binding' combinator **z**. The super-script category U of indefinites can either be percolated or bound/identified in the same ways.

I first show Jacobson's Geach combinator **g**. I use the underspecified super-script category U in the definitions of the **g** and **z** combinators for convenience.

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

Because I uniformly defined QNPs as functors over verbs, rather than treating QNPs as argument of verbs, I modify Jacobson's combinator **g**, so that it can be applied to QNPs.

(36) a. Syntax: $\mathbf{g^q}((X/_R(X/_L NP))/_R N) = (X^U/_R(X/_L NP))/_R N^U$,
$\mathbf{g^q}\,((X/_L(X/_R NP))/_R N) = (X^U/_L(X/_R NP))/_R N^U$,
where X is either $S(/_L...)$ or $S(/_R...)$, and U is some category.
b. Semantics: $\mathbf{g^q}(\lambda A_{et}.\lambda P^n{}_{e(e1\ldots(en,\, t))}.\, \lambda x_{e1}\ldots\lambda x_{en}.\, \exists x_e[A(x)\ \&\ P^n(x)(x_1)\ldots(x_n)])$
$= \lambda A^1{}_{\tau(et)}.\lambda P^n{}_{e(e1\ldots(en,\, t))}.\, \lambda v_\tau.\lambda x_{e1}\ldots\lambda x_{en}.\, \exists x_e[A^1(v)(x)\ \&\ P^n(x)(x_1)\ldots(x_n)]$
(E.g., if we deal with a subject QNP, P^0 is of type (et) for $S/_L NP$.)

If we apply $\mathbf{g^q}$ to *some** in the object position, then we get the following.

(37) Syntax: $\mathbf{g^q}(((S/_L NP)/_L TV))/_R N) = ((S/_L NP)^U/_L TV)/_R N^U$

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 result category $((S/_L NP)^U/_L TV)/_R N^U$ in (37) percolates the extra argument slot in its first argument category N^U across the verb category TV onto the output category $(S/_L NP)^U$, when the QNP is merged with the transitive verb. In this respect, even though I percolate the extra argument slot of the nominal restriction by means of the quantificational determiner category, the operation still preserves the basic mechanism of Jacobson's original **g** combinator, which compositionally transmits this argument slot via the TV category.

I could have applied Jacobson's original **g** in (35) to 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 (i.e. $[_{QNP^U}$ *some**$[_{N^U}$ *a certain* $[_N$ *girl*$]]]$). Then I could have raised the type of the corresponding argument of the transitive verb so that the verb could take in a QNP as an

[18] 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 *likes her husband* in *John$_1$ said that [his$_1$ teacher]$_2$ likes her$_2$ 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.

argument.[19] 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 $\mathrm{QNP}^{\mathrm{U}}$, or I could have used Jacobson's original **z** combinator (which I explain later) on this argument-raised verb without modifying it, so as 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 X^{U} behaves exactly like the category X 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. The **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 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.[20]

On the other hand, the 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 subject position and object position through a mediating verb is preserved in my modifications. In that sense, the modified operators could be interpreted as simply an applicational variant of the original operators.

For Jacobson, a superscript category can technically be any syntactic category but I limit it to a category that originates as a superscript in a lexical category, like NP in $\mathrm{NP}^{\mathrm{NP}}$ for a pronoun *he* or U in $\mathrm{N}^{\mathrm{U}}/_{\mathrm{R}}\mathrm{N}$ for the indefinite *a* (*certain)*. The corresponding semantic types are **e** and $\boldsymbol{\tau}$, where $\boldsymbol{\tau}$ is a polymorphic type that is usually instantiated as type **e**, as we have seen.

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 category gets merged with the subject QNP.

As I said above, I re-formulate Jacobson's binding operator **z**.

(38) a. Syntax: $\mathbf{z^q}(\mathrm{S}/_{\mathrm{R}}(\mathrm{S}/_{\mathrm{L}}\mathrm{NP})) = \mathrm{S}/_{\mathrm{R}}(\mathrm{S}/_{\mathrm{L}}\mathrm{NP})^{\mathrm{U}}$

b. Semantics: $\mathbf{z^q}_{((et)t)\,((\tau(et))t)} \stackrel{\mathrm{def}}{=} \lambda Q_{(et)t.}\ \lambda R^1{}_{\tau(et).}\ Q(\lambda x.R^1(x)(x))$

e.g. we can get $\lambda R^1{}_{\tau(et).}\forall x_e[\mathrm{boy}'(x) \rightarrow R^1(x)(x)]$ for $\mathbf{z^q}$(*every boy*).

c. $\mathbf{z^0}$ Syntax: $\mathbf{z^0}\ ((\mathrm{S}/_{\mathrm{L}}\mathrm{NP})/_{\mathrm{R}}\mathrm{NP}) = (\mathrm{S}/_{\mathrm{L}}\mathrm{NP})/_{\mathrm{R}}\mathrm{NP}^{\mathrm{NP}}$

d. $\mathbf{z^0}$ Semantics: $\mathbf{z^0}_{\ (e(et))((ee)(et))} \stackrel{\mathrm{def}}{=} \lambda R^1{}_{e(et).}\lambda f_{ee.}\lambda_{e.}R^1(f(x))(x)$

(c,d: cf. Jacobson 1999:132)

(38c) and (38d) are a particular instantiation of Jacobson's original **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 $\boldsymbol{f}_{\mathbf{ee}}$ 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 the functor and the transitive verb is the

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

[20] 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 alternative formulation for further research.

argument of the QNP. So I modify **z** for the subject QNP.[21] An important point is that this binding operator is applicable only when the input argument has the super-script category U (or NP), as in the VP category with the superscript: $(S/_L NP)^U$. This 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 (30): *Every boy loves a certain girl*. First I compose a nominal restriction set. At the end of a horizontal 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.

(39) Syntax:

$$\frac{\dfrac{\text{a certain}}{N^U/_R N} \qquad \dfrac{\text{girl}}{N}}{N^U}\ \text{fa}$$

Semantics:

$$\frac{\dfrac{\text{a certain}}{\lambda B_{et}.\lambda u_{\tau}.\lambda x.\text{sg}'(B)(u)(x)} \qquad \dfrac{\text{girl}}{\lambda x.\text{girl}'(x)}}{\lambda u.\lambda x.\text{sg}'(\text{girl}')(u)(x)}\ \text{fa}$$

Remember that $\boldsymbol{u_\tau}$ 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)(τ(et))). At the last line of the semantic derivation in (39), the lambda expression $\boldsymbol{\lambda x.\text{girl}'(x)}$ is η reduced to **girl′**. Both are of type (et) and they are logically equivalent.

(40) Syntax:

$$\frac{\dfrac{\mathbf{g^q}\ (\text{some*})}{((S/_L NP)^U /_L TV)/_R N^U} \qquad \dfrac{\text{a certain girl}}{N^U}\ \text{D}}{((S/_L NP)^U /_L TV)}\ \text{fa}$$

(41) Semantics:

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

In (41), there are two applications of β reduction on the last line: $\boldsymbol{v}$ fills out the $\boldsymbol{u}$ argument slot and $\boldsymbol{y}$ fills out the $\boldsymbol{x}$ argument slot. The inherent argument slot $\boldsymbol{u}$ encoded with *a certain girl* is inherited as $\boldsymbol{v}$, after the merge with the phonologically null existential quantifier *some**, through use of the Geach combinator $\mathbf{g^q}$.

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

[21] 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 **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 by using the **z** combinator.

(42) Syntax:

$$\begin{array}{ll} \underline{\text{love}} & \underline{\mathbf{g^q}\ \text{(some*)}\ \textit{a}\ \text{certain girl}}\ {}_{\mathrm{D}} \\ \text{TV} & (S/_{L}NP)^{U}/_{L}TV \\ \hline \multicolumn{2}{c}{(S/_{L}NP)^{U}} \end{array}\ {}_{\mathrm{ba}}$$

(43) Semantics:

$$\begin{array}{ll} \underline{\text{love}} & \underline{\mathbf{g^q}\ \text{(some*)}\ \textit{a}\ \text{certain girl}}\ {}_{\mathrm{D}} \\ \lambda m.\lambda n.\text{love}'(m)(n) & \lambda P_{e(et)}.\lambda v_{\tau}.\lambda z.\exists y[\text{sg}'(\text{girl}')(v)(y)\ \&\ P(y)(z)] \\ \hline \multicolumn{2}{l}{\underline{\lambda v.\lambda z.\exists y[\text{sg}'(\text{girl}')(v)(y)\ \&\ \lambda m.\lambda n.[\text{love}'(m)(n)](y)(z)]]}\ {}_{\beta\ \text{reduction}}} \\ \multicolumn{2}{l}{\lambda v.\lambda z.\exists y[(\text{sg}'(\text{girl}'))(v)(y)\ \&\ \text{love}'(y)(z)]]} \end{array}\ {}_{\mathrm{ba}}$$

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

(44) Syntax:

$$\begin{array}{ll} \underline{\text{Every boy}}\ {}_{\mathrm{D}} & \underline{\text{loves a certain girl}}\ {}_{\mathrm{D}} \\ \underline{S/_{R}(S/_{L}NP)}\ {}_{\mathbf{z^q}} & (S/_{L}NP)^{U} \\ S/_{R}(S/_{L}NP)^{NP} & \\ \hline \multicolumn{2}{c}{S} \end{array}\ {}_{\mathrm{fa}}$$

In (44), the underspecified category U is instantiated as NP, and the concatenation is successful. In the same way, in (45), the underspecified argument slot ***v*** of type τ is filled out by the variable ***m*** of type e, which is then 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.

(45) Semantics:

$$\begin{array}{ll} \underline{\text{Every boy}}\ {}_{\mathrm{D}} & \underline{\text{loves a certain girl}}\ {}_{\mathrm{D}} \\ \underline{\lambda B_{et}.\forall m[\text{boy}'(m) \rightarrow B(m)]}\ {}_{\mathbf{z^q}} & \lambda v_{\tau}.\lambda z.\exists y[\text{sg}'(\text{girl}')(v)(y)\ \&\ \text{love}'(y)(z)] \\ \lambda B^{1}_{e(et)}.\forall m[\text{boy}'(m) \rightarrow B^{1}(m)(m)] & \\ \hline \multicolumn{2}{l}{\underline{\forall m[\text{boy}'(m) \rightarrow (\lambda v.\lambda z.\exists y[\text{sg}'(\text{girl}')(v)(y)\ \&\ \text{love}'(y)(z)])(m)(m)]}\ {}_{\beta\ \text{reduction}}} \\ \multicolumn{2}{l}{\forall m[\text{boy}'(m) \rightarrow \exists y[(\text{sg}'(\text{girl}'))(m)(y)\ \&\ \text{love}'(y)(m)]]} \end{array}\ {}_{\mathrm{fa}}$$

The *β* reduced logical form in the bottom line in (45) says that for each boy ***m***, there is a possibly different singleton girl-set, and ***m*** loves the singleton member ***y*** of that set. For lack of space, I do not show the derivation for Winter's sentence in (10a), repeated here as (46).

(46) Every boy$_1$ who hates [$_{NP}$ *a (certain) woman* he$_1$ knows] will develop a serious complex. (cf. Winter 2001:116)

The mechanism is essentially the same. The bound pronoun *he* is lexically interpreted as identity function of type (e,e) as in Jacobson (1999).

(47) *he:* <*he* ; NP^{NP} ; $\lambda x.x$>

The pronoun introduces another argument slot (which is of type e) on top of the one introduced by the indefinite *a certain* (which is of type τ). 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). I leave the details for another 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** combinator allows us to accumulate more than one extra argument slot into the output categories, to deal with multiple bound pronouns appearing in a sentence.

(48) Every father$_1$ [$_{VP}$ told [his$_1$ son]$_2$ [$_{CP}$ that he$_1$ would buy him$_2$ a present]].

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 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 remaining 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? Consider (49).

(49) Every psychiatrist says that every child$_1$ who hates a certain woman he$_1$ knows will develop a complex.

Does the relation between each child and the woman $\boldsymbol{x}$ 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 might be due to difficulty processing 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 (49) 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 the tense operator that can be higher than the subject QNP in the syntactic structure.

(50) a. Every boy loves a certain girl. (Inverse scope: *a certain* > *every*)
b. $\exists t_\sigma[G'_{(\sigma,t)}(t)$ & $\{\forall x[\text{boy}'(x) \rightarrow \exists y[(\text{sg}'(\text{woman}'))(x)(y)$ & $\text{love}'(y)(x)]]\}_{(\sigma,t)}(t)]$[22]
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, the tense operator does not always take wide scope over the subject quantifier.

(51) a. Every kid ran.
b. A friend often came to see Tom in London. (cf. Carpenter 1994: 3)[23]

(51a) has a reading in which each kid ran at a possibly different time, and (51b) has a reading in which one and the same friend visited Tom many times. This does not necessarily stop us from using the tense operator to explain the wide scope of the indefinite over another QNP, as long as the tense operator can at least sometimes take the widest scope, but the issue requires further research in terms of the interaction of the scopes of QNPs and the tense or some other operators that can bind the extra argument slot of indefinites.

8.3. The constant sg′

The treatment of **sg′** as a constant expression needs some more consideration. In (52) below, 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.

(52) Every boy$_1$ respects a (certain) man (that is, his father$_1$).

The function denoted by **sg′(man′)** can map an individual ***x*** to the same singleton set that the function denoted by **λ*x*.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 is not always the case. In a different context, **sg′(man′)** should also be able to denote a function that maps an individual ***x*** to the same singleton set that the function denoted by **λ*x*.the_maternal_grandfather_of′(*x*)** does. The functor **sg′** is like a constant in that it does not scopally interact with other quantificational elements, but it is like a variable in that its denotation is not rigidly fixed with regard to a model, as the denotations of standard constants are. I briefly discuss four candidate solutions to fix this problem.

First, it is not clear whether we have to assume that **sg′(man′)** and **λ*x*.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 **sg′**

[22] **{ }(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.
[23] The page number is of the electric version. I have failed to find the page numbers of the journal version.

so that **sg′(man′)** denotes a function that maps an individual ***x*** to another function that maps a situation ***s*** to a singleton *man*-set for ***x*** in ***s***. The resultant expression **sg′(man′) (*x*) (*s*)** would then denote a singleton *man*-set that can co-vary with each person ***x*** and with each situation ***s***. The domain restriction of a nominal restriction set is hugely context-dependent, which supplies some motivation for assuming 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 could make the interpretation of **sg′** dependent on a situation after syntax, by using a formal semantic system as in Barwise & Cooper (1991). But I do not think that assuming another formal level of representation on top of syntax is well-motivated enough at the moment, even if it helps make the syntax simpler.

As a second solution, we could assume some logical expressions that act as a kind of place-holder for a constant expression, or to assume underspecified constant expressions, like arbitrary individuals in Fine (1985), though in the case in question, the expression **sg′** is not a basic 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, I could redefine **sg′** as a variable, say, **g**, and apply an existential closure to this variable only at the highest position of the structural representation, as in (53).

(53) $\exists g[\text{singleton}'(g)\ \&\ \forall x[\text{boy}'(x) \rightarrow \exists y[g(\text{man}')(x)(y)\ \&\ \text{respect}'(y)(x)]]]$
g: ((et)(τ(et))), singleton′: (((et)(τ(et)))t)

This existential closure operation 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. This existential closure might be applied to all the variables that have failed to be bound by any operators in the syntax, for some reason connected with interpretation. But even if we justified the existential closure operation in this way, we would still need to associate the property denoted by **singleton′** with the existential closure operator, as we saw in (19), which might go against the spirit of semantic compositionality, as we have already seen.

The fourth candidate solution is to associate the super-script category and the inherent argument slot with the nominal restriction, rather than the expression *a (certain)*. The normalized logical form for (52) would then be as in (54), with the modified lexical entries.

(54) a. $\forall x[\text{boy}'(x) \rightarrow \exists y[\text{sg}_2'(\text{man}_2'(x))(y)\ \&\ \text{respect}'(y)(x))]]$
b. *man₂*: <*man* ; N^U ; $\lambda x.\lambda y.\text{man}_2'(x)(y)$>
c. *a certain*: <*a certain* ; $N/_RN$; $\lambda B_{et.}\lambda x_{e.}\ \text{sg}_2'{}_{(et)(et)}(B)(x)$ >
d. *a*: <*a* ; $N/_RN$; $\lambda B_{et.}\lambda x_{e.}\ \text{a}_2'{}_{(et)(et)}(B)(x)$>

The common noun *man* in (54b) is lexically given the category N^U and the type (τ(et)). As before, U is usually instantiated as NP and the type τ, as type e. Then we get the category and the type that are usually given to a relational noun such as *mother* or *father*. The logical expression $\mathbf{man_2'(x)}$ denotes a set of men that is possibly different for each individual ***x***. The logical expression for *a certain* is now the functor $\mathbf{sg_2'}$ of type ((et)(et)), which denotes a function that maps this set of men to a singleton set of men, which is again possibly different for each individual ***x***. We need to apply a Geach combinator to (54c) before we merge the result with (54b), percolating the superscript category U and the extra argument slot $\boldsymbol{x}$ of type τ till a later stage of the derivation. In (54a), the extra-argument slot ends up being bound by the universal quantifier in *every boy*. Then we get the desired reading that says that for each boy $\boldsymbol{x}$, there is a possibly different singleton *man*-set and $\boldsymbol{x}$ respects the unique member of that set, e.g. $\boldsymbol{x}$'s father $\boldsymbol{y}$ in (52). The logical expression $\mathbf{a_2}'$ for the indefinite article *a* is just an identity function that maps a set of individuals to the same set of individuals, but we can still pragmatically restrict the domain of this set to a singleton. Then, because of the inherent argument slot associated with the common noun *man*, we can have the same dependent specific reading. As in (31g), the existential quantifier is associated with the phonologically null lexical item *some**. Thus, if the indefinite *a man* is placed in a downward entailing environment as in Winter's example (10a), and if the domain is not restricted to a singleton, then we can get the exhaustive reading, as we have already seen.

An interesting implication of this fourth solution is that the domain restriction dependency is no longer limited to indefinites. If common nouns are generally equipped with this extra argument slot, then the domain restriction applicable to other QNPs should also be able to be dependent on another quantificational element. This seems to be correct, as we can see for (55). The set of weak points would naturally be different for each player.

(55) Only those players who got rid of every weak point could play in the Major League.

Treating common nouns in general as if they were relational nouns might need more linguistic justification, but this fourth solution does not require any major modification of the formal use of logical expressions. Note also that nothing special has been added to the syntax. Both the **g** and **z** combinators are independently motivated to deal with bound pronoun interpretations.

I assume that the second and the fourth solutions are most promising. For the second solution, some extension of the definition of constant expressions might be independently necessary if we use a logical language as metalanguage to represent the cognitive meanings of natural language expressions. The fourth solution is better in that it does not make any major modification of the formal use of logical expressions. I leave the final decision for further research. In this section, I have considered some of the loose ends of my analysis. The next section gives a summary of the 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 $\boldsymbol{\tau}$. 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 with some modification, I showed how this extra argument slot of an indefinite is compositionally percolated in a syntactic derivation and then gets bound by another element in the sentence.

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