DE GRUYTER OPEN

STUDIES IN LOGIC, GRAMMAR AND RHETORIC 46 (59) 2016

DOI: 10.1515/slgr-2016-0039

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SEMANTICS WITH DEPENDENT TYPES FOR INDEFINITES

Abstract. The paper proposes a new semantics with dependent types for indefinites, encompassing both the data related to their exceptional scopal behavior and the data related to their anaphoric (dynamic) properties. The proposal builds on the formal system combining generalized quantifiers ([Mostowski 1957], [Lindström 1966]) with dependent types ([Martin-Löf 1972], [Makkai 1995]) in [Grudzińska & Zawadowski 2014] and [Grudzińska & Zawadowski 2016].

Keywords: indefinites, exceptional scopes, unbound anaphora, dependent type.

1. Indefinites

This paper is about scopal and anaphoric (dynamic) properties of indefinite descriptions (indefinites for short) – natural language expressions such as *a man* or *some women*. On the classical view with roots in Frege's and Russell's work, indefinites have been interpreted as existential quantifiers. Starting in the early 80's, however, it has been observed that indefinites often behave more like referring expressions (e.g. *John*, *Mary*) and differ from standard quantifier expressions (e.g. *every man*, *most women*) with respect to their scopal and anaphoric (dynamic) properties. More precisely, indefinites can be distinguished by their characteristic dichotomous behavior. In some contexts they behave like standard quantifier expressions; in some other contexts they exhibit quasi-referential properties. Generalized Quantifier Theory ([Barwise & Cooper 1981]), the dominant paradigm for studying natural language quantification since the 70-80s, has proved unsuccessful in dealing with the quasi-referential behavior of indefinites. This has led to the abandonment of the treatment of indefinites in the form of generalized quantifiers and has opened up a new stage

ISBN 978-83-7431-501-2 ISSN 0860-150X

of research with a battery of diverse tools developed for modeling their non-standard behavior: individual/plural variables ([Kamp 1981], [Kamp & Reyle 1993]), choice/Skolem function variables ([Reinhart 1997], [Winter 1997], [Kratzer 1998], [Steedman 2012]), dynamic existential quantification ([Groenendijk & Stokhof 1991], [Van den Berg 1996]). The main goal of this paper is to argue that adopting a new type-theoretic approach (with dependent types) to generalized quantification allows us to restore a uniformly quantificational account of the dichotomous behavior of indefinites.

The paper is organized as follows. Section 2 introduces informally the main features of our new semantics with dependent types: (i) many-typed (many-sorted) analysis, (ii) dependent types, and (iii) generalized quantification extended to dependent types. In Section 3, I postulate ambiguity in indefinites. Following a number of authors ([Fodor & Sag 1982], [Kratzer 1998]), I assume that indefinites are ambiguous between a general (quantificational) and a specific (referential) interpretation. But unlike the existing proposals, our type-theoretic approach allows us to tie this ambiguity to the variability in type assignment. Finally, Sections 3.1 and 3.2 use our semantics with dependent types to model scopal and anaphoric (dynamic) properties of indefinites, respectively.

2. Semantics with dependent types

In my joint work with Marek Zawadowski, we have developed a new type-theoretical semantics for natural language quantification ([Grudzińska & Zawadowski 2014], [Grudzińska 2015], [Grudzińska & Zawadowski 2016]). The main novelty of our approach lies in combining elements from the two (sometimes considered rival) semantic frameworks: classical Montague-style semantics [Montague 1974]) and modern type theories with dependent types ([Ranta 1994], [Fernando 2001], [Cooper 2004], [Luo 2012a], [Bekki 2014]).

Like in the classical Montague-style semantics, our approach makes essential use of generalized quantifiers ([Mostowski 1957], [Lindström 1966], [Barwise & Cooper 1981]). But in the spirit of the modern type-theoretic framework, we adopt a many-typed (many-sorted) analysis (in place of a standard single-sorted analysis). Like in the modern type theories, we have type dependency in our system ([Martin-Löf 1972], [Makkai 1995]). But whereas the existing modern type-theoretic approaches have been either proof-theoretic: [Ranta 1994], [Luo 2012a], [Luo 2012b], [Bekki 2014]) or involved a combination of proof-theoretic and model-theoretic elements: [Fernando 2001], [Cooper 2004]), our semantics is purely model-theoretic

with truth and reference being basic concepts (and no proofs). This combination of elements allows us to shed new lights on the puzzling behavior of indefinites.

2.1. Montague-style semantics vs many-sorted analysis

While Montague-style semantics ([Montague 1974]) is single-sorted in the sense that it includes one type **e** of all entities (strictly speaking, it has two basic types: type **e** and type **t** of truth values, and a recursive definition of functional types), our analysis is many-sorted in the sense that it includes many basic types. On the Montague-style analysis, a quantifier phrase like *some woman* is interpreted over the universe of all entities E, i.e. *some woman* denotes the set of subsets of E

$$\|\exists x : woman\ x\| = \{X \subseteq E : \|woman\| \cap X \neq \emptyset\}.$$

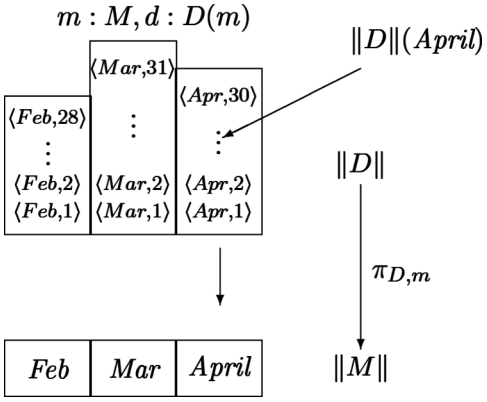
On our analysis, a quantifier phrase like *some woman* is interpreted over the type *Woman*, i.e. *some woman* denotes the set of all non-empty subsets of the set of women

$$\|\exists_{w:Woman}\| = \{X \subseteq \|Woman\| :\ X \neq \emptyset\}.$$

As a result of our many-sorted analysis, we also have a polymorphic interpretation of predicates, i.e. predicates like *love* are interpreted over types (e.g. *Man*, *Woman*, ...), and not over the universe of all entities.

2.2. Dependent types, generalized quantifiers on dependent types

In a system with many types, we can have dependent types. One natural language example of such a dependence of types is that for any month m, there is a type $D(m)$ of the days in that month



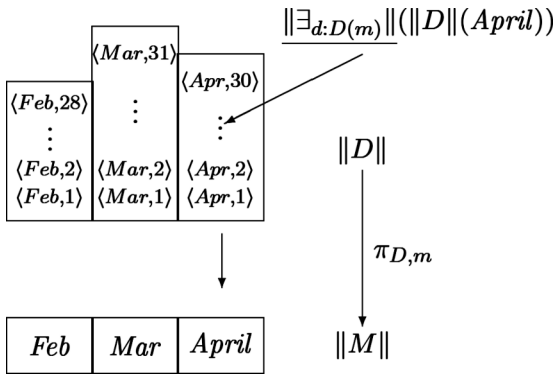
If we interpret type M as a set $\|M\|$ of months, then we can interpret type D as a set of the days of the months in $\|M\|$, i.e. as a set of pairs

$$\|D\| = \{\langle a, k\rangle : k \text{ is (the number of) a day in month } a\ \}$$

equipped with the projection $\pi : \|D\| \to \|M\|$. The particular sets $\|D\|(a)$ of the days of the month a can be recovered as the *fibers* of this projection (the preimages of $\{a\}$ under π)

$$\|D\|(a) = \{d \in \|D\| : \pi(d) = a\}.$$

By combining generalized quantifiers with dependent types, our semantics introduces quantification over fibers, e.g. existential quantification over the fiber of the days of April $\|D\|(April)$ (as in *some days of April*)



As will be argued below, adopting this new type-theoretic approach (with dependent types) to generalized quantification allows a uniformly quantificational account of the systematically dichotomous behavior of indefinites.

3. Ambiguity in indefinites

Unlike the so-called standard quantifier phrases (e.g. *every student*, *most students*), indefinites (e.g. *some student*, *three students*) have been observed to exhibit a characteristic ambiguity between the so-called general (quantificational) and specific (referential) reading. To give an example, I can make a general claim using a sentence *I have been friends with some student* and my use of the indefinite will not imply that I am thinking about any particular student. But I can also use the same sentence to make a specific claim and my use of the indefinite will introduce some particular

one student that I have in mind. Following a number of authors ([Fodor & Sag 1982], [Kratzer 1998]), I assume that indefinites are semantically ambiguous between a general (quantificational) and a specific (referential) interpretation. But unlike the existing ambiguity accounts, our type-theoretic approach allows us to tie this ambiguity to the variability in type assignment. The proposal is as follows. A standard quantifier phrase such as *every student* can only combine the determiner *every* with

- the variable of the 'standard' type *Student*, interpreted as the set of all students (given in the context) – $\|Student\|$.

An indefinite such as *some student*, on the other hand, is ambiguous allowing a combination of the determiner *some* and either

- the variable of the 'standard' type *Student*, interpreted as the set of all students (given in the context) – $\|Student\|$ (as above), or
- the variable of the 'referential' type *Student**, interpreted as a certain set containing a single student that the speaker has in mind – $\|Student*\|$.

This distinction among quantifiers has been also analyzed in presuppositional terms. Standard quantifiers are said to presuppose their domains, whereas indefinites need not be such presupposition inducers (e.g. [Geurts & van der Sandt 1991], [Dobrovie-Sorin & Beyssade 2012] among others). I propose to adopt a similar idea. 'Standard' types always occur relative to some given/preceding context, whereas 'referential' types are not so anchored – they are relativized to the speaker. A hearer knows that the speaker's use of the specific indefinite is restricted to a singleton. But only the speaker can tell what exactly this restriction consists of (for a similar solution, see e.g. [Kratzer 1998], [Schwarzschild 2002]).

3.1. Indefinites and their scopes

The postulated ambiguity in indefinites allows us to account for their systematic dichotomous scopal behavior, as evidenced by three phenomena: scopes in complex sentences, co-variation readings in simple sentences, and the phenomenon of the so-called intermediate scopes.

3.1.1. Scopes in complex sentences

The first of the phenomena to be discussed relates to the difference observed between standard quantifiers embedded in scope islands (relative clauses, if-clauses), on the one hand, and indefinites, on the other. The scope of standard quantifiers (e.g. *every teacher*) is clause-bounded (examples from [Endriss 2009]):

(6a) Anne has read some book that every teacher recommended.

Sentence (6a) only supports one reading saying that Anne has read some particular book that has the property of having been recommended by every teacher (narrow scope reading for *every teacher*: *some book* > *every teacher*). Sentence (6a) cannot mean that for every teacher it holds that Anne has read some book that he or she recommended (exceptional wide scope reading for *every teacher*: *every teacher* > *some book*). Indefinites (e.g. *some teacher*), on the other hand, appear to take exceptional wide scopes out of clausal islands:

(6b) Anne has read every book that some teacher recommended.

Sentence (6b) can be understood to mean two things: that Anne has read every book that has the property of having been recommended by a teacher, some or other (narrow scope reading for *some teacher*: *every book* > *some teacher*); or that there is some particular teacher such that Anne has read every book that he or she recommended (exceptional wide scope reading for the indefinite: *some teacher* > *every book*).

As explained above, I take an indefinite *some teacher* to be ambiguous between a general reading (where we quantify over the set of all teachers $\|Teacher\|$) and a specific reading (where we quantify over a certain set containing a single teacher that the speaker has in mind $\|Teacher^*\|$). On this analysis, indefinites on both general and specific readings pattern with other quantifiers and obey the usual scope constraints. If they receive a general interpretation, they exhibit local scopes. If they receive a specific interpretation, they appear to take exceptional wide scopes. A specific indefinite *some teacher* has as extension (denotation) a singleton set whose only element is a singleton set containing a certain teacher that the speaker has in mind – this analysis gives a narrow scope reading that is indistinguishable from the exceptional wide scope (referential) reading.

The adopted solution can be easily extended to account for Ruys' observation on scopal properties of plural indefinites ([Ruys 1992]):

(7) If three relatives of mine die, I will inherit a house.

Sentence (7) allows a narrow scope reading saying that if any three of my relatives die, I will inherit a house. Or it can mean that there are three particular relatives of mine such that if they all die, I inherit a house. As observed by Ruys, the latter reading is not a distributive wide scope reading for this sentence. On a distributive wide scope reading, sentence (7) would mean that there are three relatives of mine for each of whom it holds that if he or she dies, I will inherit a house. On such a reading, I could inherit

a house if only one of these three relatives dies, and sentence (7) is not intuitively true in such a situation. Sentence (7) appears to allow an exceptional wide scope reading only in the weak existential sense but not in the strong distributive sense. On my analysis, plural indefinites (e.g. *three relatives*) again pattern with other quantifiers and obey the usual scope constraints. If they receive a general interpretation, they exhibit local scopes. If they receive a specific interpretation, they appear to take exceptional wide scopes but only in the required sense. A specific indefinite *three relatives* has as extension a singleton set whose only element is the set consisting of a certain triple of students that the speaker has in mind – this analysis gives a narrow scope reading indistinguishable from the exceptional wide scope reading in the weak existential sense. And since specific indefinites on my analysis do not scope out of clausal islands (in that case, if-clauses), it is obvious why sentence (7) cannot exhibit an exceptional wide scope in the strong distributive sense.

That this postulated ambiguity in indefinites is real receives support from cross-linguistics studies. As described by [Matthewson 1999], a subset of indefinites in Lillooet Salish, indefinites with a marker *ti* or its variants, take obligatory exceptional wide scope in sentences involving islands. The remaining subset of indefinites, indefinites with a marker *ku*, show obligatory narrow scope in such sentences. These markers overtly encode the ambiguity that I postulate for English: Lillooet Salish's determiners unambiguously specify whether they are general or specific.

3.1.2. Co-variation readings

The ambiguity in indefinites also shows up in sentences like the following example:

(8) Every man loves a woman.

As observed by [Hintikka 1986], [Groenendijk & Stokhof 1984], [Endriss 2009], this sentence allows two co-variation readings:

- standard narrow scope reading: $\forall_{m:M}\exists_{w:W} Love(m, w)$, and
- functional reading: $\forall_{m:M} Love(m, f(m))$.

Obviously, the function involved cannot be just any function: $\exists f \forall_{m:M} Love(m, f(m))$. The last formula is truth-conditionally indistinguishable from the narrow scope reading. The function involved must be either a familiar function such as the *current partner*-function or the context must be so constructed that the hearer's attention is drawn to some particular function.

One can differentiate empirically between the two readings by means of their possible continuations ([Groenendijk & Stokhof 1984], [Endriss 2009]). On the narrow scope reading, (8) supports a continuation:

(8a) Namely, John loves Mary, Bill, Sue, Tom, Anne and Sue, ...

On the functional reading, (8) licenses a continuation:

(8b) Namely, her current partner.

The two readings again can be distinguished by the kind of an indefinite involved: respectively either a general indefinite or a specific indefinite involving a silent bound pronoun (e.g. *his/her*) or some other function inducing element. That the narrow scope/functional ambiguity is related to the kind of an indefinite involved also finds support in Matthewson's cross-linguistic work. In Lillooet Salish, co-variation readings can be achieved by the use of indefinites with a marker *ku*. If we translate (8) using *ku*, we will obtain the narrow scope reading where every man loves a potentially different woman. If we translate (8) using *ti* (or its variants), we will only get the reading for a specific indefinite where there is just one woman whom all the men love. Co-variation readings are possible for specific indefinites but only in the presence of a bound pronoun – specific indefinites equipped with bound pronouns always yield functional readings.

3.1.3. Intermediate scopes

One last and presumably most controversial reading observed with indefinites is the so-called intermediate scope reading. Consider an example in (9) (from [Chierchia 2001]):

(9) Every linguist has studied every solution that some problem might have.

As observed in [Abusch 1994], [Farkas 1981], [Ruys 1992], [Reinhart 1997] among others, sentence (9) allows an intermediate scope reading saying that for every linguist there is a possibly different problem such that he or she has studied every solution that this problem might have. This reading could still be called exceptional intermediate scope reading, for the indefinite takes exceptional scope out of its island, but not widest scope over *every linguist*.

Following Krazter's observation ([Kratzer 1998]), I assume that the apparent intermediate readings observed in examples like (9) are in fact functional readings and they only become available when there is a contextually salient function, e.g. a function pairing each of the linguists with

some particular problem, say the *most intensively investigated problem*-function. This allows to maintain the ambiguity claim. General indefinites yield the narrowest scope. Specific indefinites, on the other hand, can receive either the widest scope reading or functional readings in the sense explained above (masquerading as intermediate scope readings). Data from Lillooet Salish again provides support for the adopted ambiguity position. In sentences involving scope islands, narrowest scope readings are achieved by the use of non-specific indefinites (indefinites with a marker *ku*). Specific indefinites (indefinites with a marker *ti* or its variants) are interpreted with widest scope, unless a bound pronoun is present. The presence of bound pronouns always licenses pseudo-intermediate (functional) interpretations.

The two very influential and similar in spirit approaches to indefinites have been proposed in [Kratzer 1998] and [Schwarzschild 2002]. The so-called choice function approaches ([Kratzer 1998]) model the meaning of *some student* using a choice function picking an element from the set of students, and the meaning of *three students* – using a choice function picking a three-membered set from the set of three-membered sets of students. [Kratzer 1998] claims that indefinites are ambiguous between a generalized quantifier interpretation and a choice function interpretation. Quantificational indefinites yield the narrowest scope. Specific (choice function) indefinites, on the other hand, can receive either a referential reading or a bound variable (functional) reading. To model bound variable (functional) readings, Kratzer extends her version of choice functional approach with parameterized choice functions. The problem with this approach is that it employs two very different mechanisms to explain the behavior of indefinites: the generalized quantifier theory and the parameterized choice function mechanism. Our new type-theoretic approach to generalized quantification allows us to provide a uniform mechanism accounting for the complicated array of scopal data.

Similarly to my type-theoretic analysis, approaches relying on domain restriction ([Schwarzschild 2002]) assume a unitary analysis of indefinites as existential quantifiers. On this view, however, the domain of an indefinite can be contextually (via pragmatic mechanism) narrowed down to one individual, and its scope is then neutralized – this gives referential readings. To explain on Schwarzschild's example: *Everyone at the party voted to watch a movie that Phil said was his favorite.* It is plausible to assume that Phil has only one favorite movie and that that was the one he mentioned to the guests at the party. In that case the domain of the existential quantifier *a movie that Phil said was his favorite* is narrowed down to a singleton

set, and hence the indefinite becomes scopeless. In [Schwarzschild 2002], the mechanism is further enriched with the assumption that the domain restriction of a singleton indefinite can involve bound variables – this accounts for the pseudo-intermediate qua functional readings. The problem with this approach is that sentences involving indefinites like (6b) or (7) are systematically ambiguous between an exceptional wide scope reading and a narrow scope reading. Postulating a pragmatic mechanism that systematically allows some reading to come through seems very ad hoc. If a class of expressions systematically allows some interpretation, it is more natural to assume that they actually possess the relevant reading as a matter of their semantics.

3.2. Indefinites and their dynamic behavior

The postulated ambiguity in indefinites also translates into their dichotomous dynamic behavior, as illustrated by discourse anaphora, 'donkey anaphora', and the phenomenon of quantificational subordination.

3.2.1. Discourse anaphora

First, there is a case of discourse (inter-sentential) anaphora, where pronouns and their antecedents occur in different sentences. Whereas standard quantifiers (e.g. *most students*) license only the so-called maximal anaphora, indefinites (e.g. *three students*) have been observed to support non-maximal anaphora. Compare (10) and (11):

(10) Most students entered. They had a question about the exam.

(11) Three students entered. They had a question about the exam.

In discourse fragment (10), the anaphoric pronoun *they* clearly refers to the entire set of students who entered. In discourse fragment (11) (on its specific reading), the anaphoric pronoun *they* does not refer to the set of all students who entered, but rather to just the three students that the speaker had in mind. This can be evidenced by applying a test taken from [Szabolcsi 1997]:

(12) Most students entered. ♯ Perhaps there were other students who did the same.

(13) Three students entered. Perhaps there were other students who did the same.

The fact that the continuation in (12) is infelicitous (there is nothing *others* can refer to) shows that anaphora is maximal. The fact that the continuation in (13) can be felicitous shows that anaphoric relation with three students

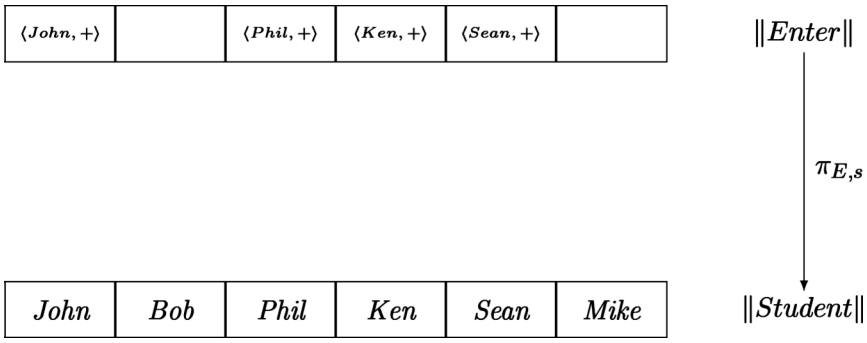
involves just the three students mentioned no matter whether there were actually more than three students that came in.

The overall interpretational architecture of our semantic system is two-dimensional ([Grudzińska & Zawadowski 2014], [Grudzińska & Zawadowski 2016]). The two dimensions to the meaning of a sentence in our system are: the truth value of a sentence and the dynamic effects introduced by the sentence (dynamic extensions of context). Context for us is a sequence of type specifications of the individual variables:

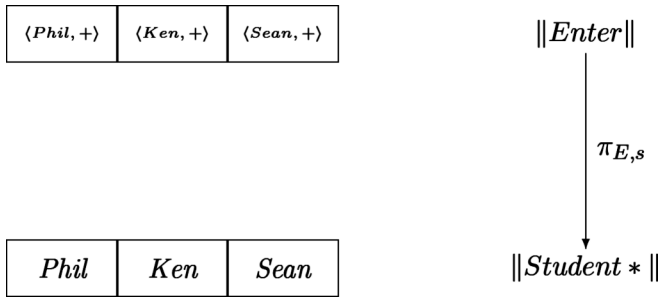
$$x : X, \quad y : Y(x), \quad z : Z(x, y), \ldots$$

x *is a variable of type* X,
y *is a variable of type* $Y(x)$,
z *is a variable of type* $Z(x, y), \ldots$

We say that a sentence extends context by some possibly dependent types. In our work, we have defined a new algorithm for the interpretation of the possible dynamic effects (dynamic extensions of context) associated with natural language quantification ([Grudzińska & Zawadowski 2014], [Grudzińska & Zawadowski 2016]). What the algorithm gives us in the case of maximal anaphora is that the first sentence of (10) involving a standard quantifier *most students* extends the context by adding the type interpreted as the set of all students who entered, i.e. the predicate *Enter* interpreted over the 'standard' type *Student*



The first sentence of (11) involving an indefinite *three students*, on the other hand, allows two kinds of contributions to context: it can extend the context by adding either the type interpreted as the set of all students who entered (as above) or the type interpreted as a certain set of three students that the speaker has in mind, i.e. the predicate *Enter* interpreted over the 'referential' type *Three Students**



I follow [Lappin & Francez 1994] in assuming that anaphoric pronouns are subject to a maximality constraint, i.e. by default they are treated as universal quantifiers. Thus on our analysis, the pronoun *they* in the second sentence of (10) and (11) quantifies universally over the interpretations of the respective types, allowing accordingly either a maximal or non-maximal continuation: Each and every of the students who entered (each and every of some particular three students who entered) had a question about the exam.

This account builds maximality/non-maximality into the semantics of indefinites. The currently dominant dynamic semantic paradigm ([Kamp & Reyle 1993], [Van den Berg 1996]) also builds maximality/non-maximality into the semantics of quantifier phrases. In both DRT ([Kamp & Reyle 1993]) and plural extensions of DPL (e.g. [Van den Berg 1996], [Brasoveanu 2008]), the analysis of standard quantification is built on the generalized theory of determiners as relations between sets of individuals. For example, *most* in the first sentence of (10) relates two sets to each other: the restrictor set of students to the nuclear set of people who entered. In plural extensions of DPL, the exhaustivity of standard quantifiers is accounted for by means of the maximality operator M. To give an informal characterization, $Mx(\varphi)$ is true for a set assigned to x, if there is no larger value that can be assigned to x which would also make φ true. Standard quantifiers change context by adding maximal plural referents (sets) corresponding to the scope set (the intersection of the restrictor set and the nuclear set, e.g. the maximal set of students who entered). The analysis of specific indefinites uses dynamic existential quantification over plural referents (sets). The problem with the dynamic approaches is that they again employ very different mechanisms to explain dynamic behavior of quantifiers: dynamic 'maximized' generalized quantification for maximal anaphora observed with standard quantifiers and dynamic existential quantification for specific indefinites and non-maximal anaphora. On our proposal, the observed dynamic effects fall out uniformly as a consequence of the adopted type-theoretic approach to generalized quantification.

3.2.2. 'Donkey anaphora'

Another sort of case is the so-called 'donkey (intrasentential) anaphora', where a quantifier antecedent is contained inside a relative clause (or if-clause) and a pronoun is outside that clause but is related anaphorically to the antecedent:

(14) Every farmer who owns a donkey beats it.

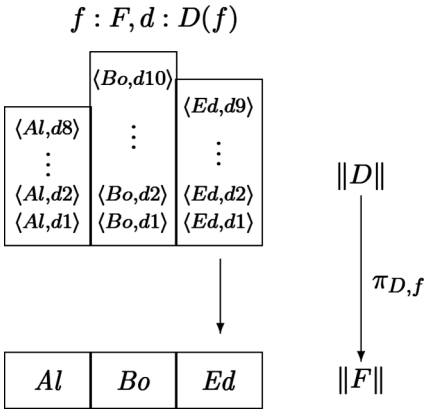
Previous accounts of 'donkey sentences' have been designed to account either for their universal readings ([Groenendijk & Stokhof 1991], [Kamp & Reyle 1993] among others) or for the occurrence of uniqueness effects ([Cooper 1979], [Kadmon 1987] among others):

- universal reading: *Every farmer who owns a donkey beats* EVERY *donkey he owns*;
- uniqueness reading: *Every farmer who owns a donkey beats* THE *(unique) donkey he owns.*

I take universal readings vs uniqueness effects in 'donkey sentences' to be yet another manifestation of the same familiar dichotomy running through the behavior of indefinites.

To account for the universal readings, our analysis makes crucial use of dependent types and quantification over fibers ([Grudzińska & Zawadowski 2014], [Grudzińska & Zawadowski 2016]). What our algorithm gives us in this case is that the modified common noun *farmer who owns a donkey* of sentence (14) extends the context by adding two newly formed types:

- the type F interpreted as **the set of farmers who own some donkeys**
- the dependent type D interpreted for the farmer a in the set of farmers who own some donkeys as **the set of donkeys owned by the farmer a**



The main clause quantifies universally over the respective interpretations, yielding the desired universal truth conditions: Every farmer who owns a donkey beats each and every donkey in the corresponding fiber of the donkeys owned. Importantly, this solution does not run into the 'proportion problem'. Since we quantify over farmers and the respective fibers of the donkeys owned (and not over $\langle farmer, donkey \rangle$ pairs), a sentence like *Most farmers who own a donkey beat it* comes out false if there are ten farmers who own one donkey and never beat them, and one farmer who owns twenty donkeys and beats all of them. Furthermore, 'donkey sentences' have been also claimed to be ambiguous between (i) strong (universal) reading: *Every farmer who owns a donkey beats* EVERY *donkey he owns*, and (ii) weak (existential) reading: *Every farmer who owns a donkey beats* AT LEAST ONE *donkey he owns*. Our analysis can accommodate this observation by taking the weak reading to simply employ the quantifier *some* in place of *every* (e.g. we can assume that pragmatic factors (world knowledge, discourse context) can sometimes override the maximality constraint associated with anaphoric pronouns, i.e. under special circumstances, anaphoric pronouns can be treated as existential quantifiers).

Uniqueness effects in 'donkey sentences' can be treated as an instance of functional readings involving specific indefinites. Consider again example in (8):

(8) Every man loves a woman.

As already discussed, this sentence allows two co-variation readings:

- standard narrow scope reading: $\forall_{m:M} \exists_{w:W} Love(m, w)$, and
- functional reading: $\forall_{m:M} Love(m, f(m))$.

and the two readings can be empirically distinguished by means of their possible continuations. On the narrow scope reading, (8) supports a continuation:

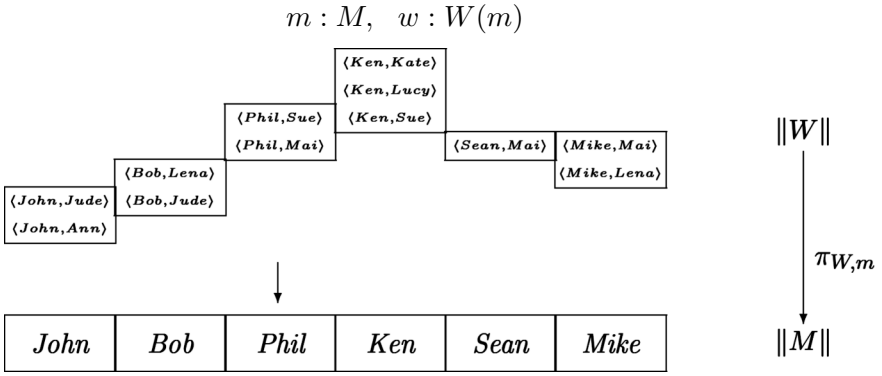
(8a) Namely, John loves Anne and Jude, Bob, Jude and Lena, Sean, Mai, ...

On the functional reading, (8) licenses a continuation:

(8b) Namely, her current partner.

This observation can be straightforwardly accounted for in our semantics. The two-fold contribution to context is modeled as follows:

- on the narrow scope reading, the first sentence extends the context by adding the dependent type



making (8a) a possible continuation.

- on the functional reading, the first sentence contributes to context a discourse referent of function type, say the *current partner*-function, making (8b) a possible continuation.

Similarly, on my analysis of the 'donkey sentence' in (14), the modified common noun *farmer who owns a donkey* involving a specific indefinite (equipped with a silent bound pronoun or some other function inducing element) introduces into the context some particular function, e.g. *the least favorite donkey*-function. The pronoun *it* relates to this function, yielding the desired uniqueness effect: Every farmer who owns a donkey beats the (unique) least favorite donkey he owns.

3.2.3. Quantificational subordination

That the two-fold contribution to context (dependent type/function) is linguistically real is further strengthened by a survey found in [Wang, McCready & Asher 2006] (the focus of the survey was on whether and how different rhetorical relations enhance singular continuations). Observe a difference between the following two pairs tested:

(A) Every man loves a woman. He sends her flowers. (**A**)
Every man loves a woman. They send them flowers. (>**A**)

(B) Every student wrote a paper. He submitted it to a journal. (**M**)
Every student wrote a paper. They submitted them to a journal. (>**A**)

Examples in (A) and (B) are instances of quantificational subordination where pronouns (*her*, *it*, *them*) depend on antecedents (*a woman*, *a paper*) introduced under the scope of quantifiers (*every man*, *every student*). In both (A) and (B) plural continuations are rated better than acceptable >**A** by the subjects. This is as predicted by my proposal: the first sentences

in (A) and (B) allow a narrow scope reading, extend the context by adding a dependent type and hence support plural continuations. A contrast between (A) and (B) can be observed with singular continuations. While the singular continuation is rated acceptable **A** in (A), it is found only marginal **M** in (B). This difference in judgments can be accounted for by assuming that subjects were more prone to 'functionally' interpret a sentence in (A) than one in (B). Sentence in (A) strongly suggests a functional reading (for every man there is a certain woman he loves, namely his current partner), extends the context by adding this function and hence licenses a singular continuation. Sentence in (B) lacks an obvious functional reading and so blocks a singular continuation. Also, both (A) and (B) sentences allow a plural/singular continuation:

(C) They send her flowers. (**A**)
They submitted it to a journal. (>**A**)

This is a continuation licensed by a sentence (A)/(B) involving a referential (non-functional) specific indefinite. That it is less acceptable with the (A) sentence than with the (B) sentence further supports our claim that the functional reading is a very likely reading for (A).

The observation that functional readings seem to have a more limited distribution than narrow scope readings (e.g. in Ionin 2010]) can be explained by the fact that the function involved in functional anaphora must be either a familiar function such as the *current partner*-function or the context must be so constructed that the hearer's attention is drawn to some particular function.

4. Conclusion

In this paper, I have highlighted a systematic dichotomy running through the behavior of indefinites

Scopes and dynamics	*General interpretation*	*Specific intepretation*
Scopes in complex sentences	*Local (clause-bounded) scopes*	*Referential readings*
Co-variation readings	*Narrow scope readings*	*Functional readings*
Intermediate scopes	*Narrow scope readings*	*Functional readings*
Discourse anaphora	*Maximal anaphora*	*Non-maximal anaphora*
'Donkey anaphora'	*Universal readings*	*Functional readings*
Quantificational subordination	*Pl (dependent) anaphora*	*Sing (functional) anaphora*

Quantificational indefinites obey usual scope constraints, license narrow scope readings, and support maximal anaphora. Specific indefinites exhibit exceptional scope behavior, license functional readings, and support non-maximal anaphora. Universal readings vs uniqueness effects in 'donkey sentences' (as well as plural vs singular quantificational subordination) constitute yet another manifestation of the same dichotomy running through the behavior of indefinites. It was my intention in this paper to show that adopting a new type-theoretic approach (with dependent types) to generalized quantification allows us to restore a uniformly quantificational account of the dichotomous nature of indefinites.

Acknowledgments

The work of Justyna Grudzińska was funded by the National Science Center on the basis of decision DEC-2012/07/B/HS1/00301.

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