No *i*-sums for Nissim (and Shalom)

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Abstract. Lappin and Francez (1994) present a theory of donkey anaphora which, they claim, captures both their existential and their universal readings, while maintaining a uniform representation of donkey pronouns. This paper shows that their analysis does not in fact assign the correct truth conditions to donkey sentences and so does not account correctly for the distribution of readings. An alternative analysis is proposed which retains LF's uniform representation for donkey pronouns, but abandons their analysis in terms of *i*-sums and the corollary derivation of universal readings by means of a maximality constraint. On the proposed analysis, donkey pronouns are uniformly represented with free variables over (Skolemized) choice functions, as in Chierchia's (1992) E-type analysis. The quantification associated with them is inferred quantification over choice functions. Universal readings arise as in Chierchia (1992) when all possible values for the free variable in the representation of a donkey pronoun are salient. For existential readings, a pragmatic account in the spirit of LF's analysis in terms of a cardinality constraint is maintained.

Key words: Donkey anaphora, E-type pronouns, strong and weak readings, *i*-sums

1 Introduction

Sentences with intrasentential donkey anaphora are known to give rise to both universal and existential readings. These are exemplified in (1-a) and (1-b) respectively.[1]

(1) a. Every farmer who has a credit card hides it in the barn.
= Every farmer who has a credit card hides **every credit card she has** in the barn.
b. Every farmer who has a credit card uses it to buy a donkey.
= Every farmer who has a credit card uses **some credit card she has** to buy a donkey.

[1] Throughout, I restrict myself to donkey sentences with relative clauses. Extensions to other kinds of donkey sentences, e.g. ones with conditional form, are left for another occasion.

Lappin and Francez (1994) (henceforth, somewhat ironically, LF) present an analysis of donkey anaphora which assigns a uniform representation to donkey pronouns and on which the distribution of weak and strong readings is pragmatically determined. In this short paper, I show that this analysis does not in fact account correctly for the distribution of readings, because it assigns the wrong truth conditions for donkey sentences in which the subject NP involves a downward increasing determiner, such as (2).

(2) No farmer who has a credit card uses it to buy a donkey.
  a. No farmer who has a credit card uses **any** of her credit cards to buy a donkey.
  b. No farmer who has a credit card uses **all** of her credit cards to buy a donkey.

The only reading available for (2) is the negated existential reading paraphrased in (2-a). However, LF's theory does not assign this reading to the sentence (contrary to their claim), but rather assigns to it the unavailable (or strongly dispreferred) reading in (3-b).

This is a serious flaw, and calls into question the correctness of the pragmatic approach, which LF advocate over alternatives such as Kanazawa's 1994 semantic theory in terms of monotonicity. I argue however that LF's pragmatic approach can (and should) be maintained. In particular, I argue that donkey pronouns should be represented as free variables over Skolemized choice functions as in Chierchia (1992), but that (unlike in Chierchia's theory), they should be uniformly so represented. It follows that donkey pronouns never have quantificational force. My proposal is that the universal force in universal readings comes from inferred quantification over choice functions. In this respect, donkey pronouns are interpreted as free choice items, on a par with free choice indefinites headed by *any*. Existential readings are derived as in LF's account, from the presence of a world knowledge based "cardinality constraint" associated with the main predicate in the donkey sentence. In all cases, the quantification is over choice functions rather than individuals. Thus, the theory proposed is a version of LF's theory in which the representation of donkey pronouns is retained, but the analysis of quantificational force is modified to incorporate elements of Chierchia's analysis.

The paper is structured as follows. Section 2 describes LF's *i*-sums analysis of donkey sentences. Section 2.1 shows the problem with that analysis. Section 3 describes my alternative proposal. Section 4 summarizes.

2 Lappin and Francez's 1994 Analysis

LF's analysis of donkey anaphora is a version of the E-type analysis found in Lappin (1989) and Neal (1990), i.e. one in which donkey pronouns are analyzed not as bound variables but as functions from individuals to collections of individuals. The difference is that LF model collections of individuals as *i*-sums (Link 1983), and this allows them to give a formal definition for the notion of a maximal collection of individuals. An i-sum is a special kind of individual formed by a summation operation $\vee_i$ on individuals in the domain of quantification E. Intuitively, an i-sum is simply a grouping of one or more atomic individuals. LF introduce the following notations and definitions:

i For any one-place predicate P the denotation of which is a subset of E, LF use the notation $^*P$ for a one-place predicate the denotation of which is the set of i-sums in the closure of P under $\vee$.

ii For any binary relation R, $^*R$ is a binary relation between atomic individuals and *i-sums*, such that $\langle a, b\rangle \in {}^*R$ iff a is atomic and b is an i-sum of individuals that stand in relation R to a.

iii If $^*R$ is interpreted distributively, then $\langle a, b\rangle \in {}^*R$ iff a bears R to every atomic part of b. If $\neg^*R$ is interpreted distributively, then $\langle a, b\rangle \in \neg^*R$ iff a doesn't bear R to any atomic part of b.

Donkey pronouns are represented as functions from individuals to i-sums. For example, a sentence like (1-a), repeated in (3-a), is represented as in (3-b).

(3) a. Every farmer who has a credit card hides it in the barn.
b. $(\text{Farmer} \cap \{x : \{y :^* \text{has}(x, y)\} \cap \text{credit-card} \neq \emptyset\}) \subseteq \{z :^* \text{hides-in-barn}(z, f(z))\}$

In (3-b), f is a function defined for any farmer who has at least one credit card.[2] To any such farmer, f assigns a member of the set of i-sums of credit cards she has (i.e. a member of $\{y :^* \text{has}(x, y)\} \cap \text{credit-card}\}$).

To get universal readings, LF assume that the functions f in the representation of donkey pronouns are subject to a default maximality constraint. Since the range of f is always a set of i-sums , this set has a supremum, i.e. an element of which all other elements in the set are parts. The maximality constraint requires f to choose the supremum element of its range. The truth conditions in (3-b) then say that the set of credit-card owning farmers is a subset of the set of individuals such that they hide the i-sum consisting of all credit cards they own in the barn. This is the universal reading.

LF propose that existential readings of donkey sentences arise when the maximality constraint is suspended. In this case, the function f becomes a choice function. For any individual, it chooses a (possibly non-maximal) i-sum from the relevant set of i-sums , generating the existential reading.

In this way, a single representation generates both existential and universal readings of donkey sentences. What determines which reading is generated is whether the maximality constraint applies or not. This, in turn, is determined by world knowledge. In some cases, the predicate containing the donkey pronoun describes an eventuality which implies restrictions on the cardinality of the participant(s) denoted by the donkey pronoun. For example, the relevant predicate in (1-b), repeated in (4), is *uses it to buy a donkey*, where *it* is, for any farmer, some i-sum of credit cards she has.

[2] There is a question as to how to ensure that f is resolved to be the intended function. I ignore this question here.

(4) Every farmer who has a credit card uses it to buy a donkey.

Events of purchasing something with a credit card are normally associated with a restriction on the number of credit cards used. Normally, only one card is used to make a purchase. To accommodate this cardinality restriction, the maximality constraint is suspended, so that non-maximal i-sums might be chosen. The predicate in (1-b) on the other hand, *hides it in the barn*, is not associated with any such cardinality restriction – there is no world knowledge limit on how many credit cards one might hide in a barn. Therefore, nothing overrides the default maximality constraint in that case, and the universal reading is preferred.

2.1 The Problem

Where this analysis goes wrong is in cases where the subject determiner is monotone decreasing, such as (2) repeated in (5).

(5) No farmer who has a credit card uses it to buy a donkey.

As observed by Chierchia (1992), such sentences only receive a negated existential interpretation. Thus, (5) says that there is no credit card owned by a farmer that was used in a donkey purchase. LF claim to capture this fact, and their analysis proceeds as follows. (5) receives the representation in (6), where I use $\mathsf{\$don}$ for the relation *a used b to by a donkey*

(6) $(\text{Farmer} \cap \{x : \{y :^{*} \text{has}(x, y)\} \cap \text{credit-card} \neq \emptyset\}) \cap \{z :^{*} \mathsf{\$don}(z, f(z))\} = \emptyset$

This representation is equivalent to the one in (7).

(7) $(\text{Farmer} \cap \{x : \{y :^{*} \text{has}(x, y)\} \cap \text{credit-card} \neq \emptyset\}) \subseteq \{z : \neg^{*}\mathsf{\$don}(z, f(z))\}$

Since there is no cardinality restriction associated with the negative predicate in (7) (there is no limit on how many credit cards you can avoid using when purchasing a donkey), the maximality constraint applies, yielding the universal reading.

But this is the wrong universal reading. The required reading is a *negated existential* reading. The reading in (7) is, in effect, a negated universal reading. Both the representation in (7) and the one in (6) are true iff there is no credit card owning farmer such that she used the maximal i-sum of credit cards she has (i.e. the i-sum consisting of all of her credit cards) to buy a donkey.

In fact, it would seem LF's analysis cannot generate the correct reading. Consider again the representation in (6). Like their representation of all other donkey sentences, this representation too gives rise to two readings. Strictly speaking, the representation says that no credit card owning farmer used an i-sum of cards to buy a donkey. If the maximality constraint applies, the relevant i-sum is the maximal one consisting of, for any farmer a, all of a's credit cards, yielding the undesired negated universal reading. If maximality is suspended, the relevant i-sum is, for any farmer a, some i-sum of credit cards owned by

a. This is again the wrong reading, requiring only that for every farmer, there is some credit card they did not use to buy a donkey. Thus, LFs analysis produces wrong results regardless of whether maximality applies or not.

What went wrong? The problem is rooted in how universal force is derived. The intuition about donkey sentences with monotone decreasing quantifiers is that they give rise to negated existential readings. A negated existential is (classically) equivalent to a universal ($\neg\exists x[P(x)] \equiv \forall x[\neg P(x)]$). However, the i-sums account does not actually involve universal quantification. Instead, it imitates universal force by allowing donkey pronouns to refer to maximal pluralities. Maximal pluralities are scopeless, and this has the effect of "freezing" the scope of their universal force so that they are always interpreted as if a low scope universal quantifier was involved. But the the relevant negated existential readings are equivalent to readings in which a universal has scope *over* negation, not under it.

2.2 Distributivity Is Not Enough

It may seem that this problem is easily overcome within LF's system if all relations between individuals and i-sums are interpreted distributively. The definition of distributivity for any such relation $*R$ was given in (ii) above. For example, consider the scope of the quantifier in (7):

(8) $\{z : \neg^{*}\$\mathsf{don}(z, f(z))\}$

Suppose that $f(z)$ is the maximal i-sum of credit cards owned by z. If the relation $*\$\mathsf{don}$ is read distributively, the representation in (7) becomes equivalent to (9), which does capture the desired reading. Following LF, I use Π for the atomic part-of relation.

(9) $(\text{Farmer} \cap \{x : \{y :^{*} \text{has}(x, y)\} \cap \text{credit-card} \neq \emptyset\}) \subseteq \{z : \forall c(c \Pi f(z))(\neg\$\mathsf{don}(z, c))\}$

Furthermore, it is clear that distributivity is in any case required for other donkey sentences with universal readings, such as (1-a) above or (10), which does not commit the speaker to the existence of any single event in which a farmer sacrifices all of her donkey to Zeus.

(10) Every farmer who has a donkey sacrifices it to Zeus.

It might even be that singular donkey pronouns *must* be interpreted distributively, given the impossibility of examples like (11):

(11) #Every farmer who has a pig gathers it in the sty at night.

Unfortunately, allowing or requiring distributive readings of donkey pronouns does not alleviate the problem. This is because the representation in (7), from which (9) is derived, is not a representation of the relevant donkey sentence (2), but merely a logically equivalent representation. The actual representation is the one in (6), repeated in (12).

(12) $(\text{Farmer} \cap \{x : \{y :^* \text{has}(x,y)\} \cap \text{credit-card} \neq \emptyset\}) \cap \{z :^* \$\mathsf{don}(z, f(z))\} = \emptyset$

It is crucial to LF's account that one can move from the representation in (12) to the one in (7) as a matter of pragmatic inference. However, once donkey pronouns are interpreted distributively, the two representations are no longer logically equivalent. This can easily be seen by comparing (9) with a version of (12) in which distributivity is explicitly represented. The two representations are given in (13). (CC stands for credit card.)

(13) a. $(\text{Farmer} \cap \{x : \{y :^* \text{has}(x,y)\} \cap \text{CC} \neq \emptyset\}) \cap \{z : \forall c(c \mathit{\Pi} f(z))(\$\mathsf{don}(z,c))\} = \emptyset$

b. $(\text{Farmer} \cap \{x : \{y :^* \text{has}(x,y)\} \cap \text{CC} \neq \emptyset\}) \subseteq \{z : \forall c(c \mathit{\Pi} f(z))(\neg\$\mathsf{don}(z,c))\}$

Generally, $A \cap B = \emptyset$ is equivalent to $A \subseteq C$ iff $C = \overline{B}$. This is clearly not the case in (13). The complement of the set $\{z : \forall c(c \mathit{\Pi} f(z))(\$\mathsf{don}(z,c))\}$ is $\{z : \exists c(c \mathit{\Pi} f(z))(\neg\$\mathsf{don}(z,c))\}$, not $\{z : \forall c(c \mathit{\Pi} f(z))(\neg\$\mathsf{don}(z,c))\}$. Of course, the representation in (13-a) is not the correct one for the relevant sentence. This representation says that no card-owning farmer uses each of her credit cards to buy a donkey. The sentence says no farmer uses *any* of her cards to do so. Thus, even assuming distributivity, LF assign the wrong truth conditions to donkey sentences with a monotone decreasing determiner.

3 An Alternative Analysis

I believe that the key to overcoming the problem with LF's analysis lies in viewing the monotone decreasing cases not as negated existentials but as universals. Recall that what is needed is for universal force to outscope negation. In this section, I suggest that this can be done leaving LFs representation almost unchanged, but that this requires abandoning the idea that donkey pronouns are interpreted as *i*-sums, as well as the related idea that universal force comes from a maximality constraint. Instead, I adopt Chierchia's (1992) E-type strategy, where the representation of donkey pronouns involves a free variable over Skolemized choice functions (i.e. functions mapping sets to individuals, not to *i*-sums). Universal readings involve universal quantification over choice functions. Donkey pronouns on a universal reading are therefore interpreted like free choice indefinites. Donkey pronouns with existential readings are interpreted as simple indefinites. Thus, the sentences in (14)-(16) are given the paraphrases in the (a) examples. In particular, (14) is paraphrased with *any* rather than the usual *every*.

(14) Every farmer who has a credit card hides it in the barn.

a. Every farmer who has a credit card hides *any* credit card she has in the barn.

(15) Every farmer who has a credit card used it to purchase a donkey.

a. Every farmer who has a credit card used some credit card she has to purchase a donkey.

(16) No farmer who has a credit card uses it to purchase a donkey.

a. No farmer who has a donkey uses any of the credit cards she has to purchase a donkey.

These sentences then receive the representations in (17)-(19) respectively, where the choice function variable f remains free.

(17) $(\text{Farmer} \cap \{x : \{y : \text{has}(x, y)\} \cap \text{CC} \neq \emptyset\}) \subseteq \{z : \text{hide-in-barn}(z, f(z))\}$

(18) $(\text{Farmer} \cap \{x : \{y : \text{has}(x, y)\} \cap \text{CC} \neq \emptyset\}) \subseteq \{z : \$\mathsf{don}(z, f(z))\}$

(19) $(\text{Farmer} \cap \{x : \{y : \text{has}(x, y)\} \cap \text{CC} \neq \emptyset\}) \cap \{z : \$\mathsf{don}(z, f(z))\} = \emptyset$

Since these representations involve a free variable they cannot be associated with a determinate meaning without the variable being either bound or else provided with a value from context. In the simplest cases, the common ground reduces the range of the choice functions to a singleton set, thus reducing the number of functions that are possible values for f to just one. This would be the case with sentences such as (20), where the only value for f is the function mapping every individual to their nose.

(20) Every farmer who has a nose uses it to smell the freshly plowed fields after the rain.

However, I follow much of the literature (including Heim, Chierchia, and LF) in assuming that in the cases under consideration, no such uniqueness presupposition is involved. Therefore, in these cases, what context needs to provide is either a particular choice function, or else a binder. Obviously, context does not provide a particular choice function when universal readings are involved, and it seems that usually this is not what happens when existential readings are involved either. For example, the speaker would usually not have a particular way of choosing a credit card in mind when she utters (15). The question is then how universal and existential readings arise, in the absence. An answer should, ideally, also explain why they have the distribution they do.

My proposal is that the quantification associated with donkey pronouns is over choice functions, not over individuals. The force of quantification is by default universal (as in Chierchia's and LF's theories), with existential readings arising pragmatically through world knowledge based inferences. The proposal thus integrates Chierchia's intuition about universal readings with LF's intuition about existential ones.

3.1 Universal readings

Chierchia (1992:160) makes the point that the standard assumption in logic is that formulae with free variables are true iff they are true under all assignments of values to the variables. The same principle is, according to him, at play when donkey pronouns are interpreted as choice functions. In any donkey sentence, a set of choice functions is made salient, such as the set of functions mapping each farmer to one (or more) of her credit cards. Since all of these functions are equally salient, the sentence is interpreted as true iff it is true relative to all the functions in this set. This is how universal readings arise. Thus, the representation in (17) is true iff it is true for all choice functions from farmers to credit cards they have.

The monotone decreasing cases which formed the problem for LF's account now fall out as a simple case of a universal reading. The representation in (19) is true iff it is true relative to all values for f. These are the correct truth conditions. On this interpretation, the representation becomes equivalent to (21), where F is the set of functions from farmers to credit cards they have. (21) captures the fact that the relevant reading is a negated existential.

(21) $(\text{Farmer} \cap \{x : \{y : \text{has}(x, y)\} \cap \text{CC} \neq \emptyset\}) \cap \{z : \exists f \in F[\$\mathsf{don}(z, f(z))]\} = \emptyset$

An attractive feature of this analysis of universal readings is that it automatically captures the fact that donkey sentences with universal readings are interpreted distributively. For example, consider the traditional (22).

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

A speaker uttering this sentence (say, a medieval monk) is not commited to the existence of any event in which a farmer beats all of her donkeys at the same time. The collectivity of donkeys need not be a participant in the eventuality described. All that the sentence commits the speaker to is the proposition that any relevant donkey is (habitually) beaten by its owner.

3.2 Existential readings

Chierchia's analysis does not extend to existential readings. To generate those, he posits a second strategy of interpretation for donkey sentences involving dynamic binding as in Groenendijk and Stokhoff's (1991) DPL. As LF point out, this is an unintuitive result. How then do existential readings arise? LF explain such readings as arising from the presence of a world knowledge based inference. According to them, the maximality constraint that gives rise to universal readings is cancelled when the main predicate in the donkey sentence is associated with a *cardinality constraint*. A cardinality constraint is a world knowledge based inference about the cardinality of the proto-patient participant of the described eventuality. For example, consider (23).

(23) Every person who had a dime put it in the meter.

An event of putting dimes in a meter normally involves a limit on how many dimes can be inserted at a time. In other words, in any such event, some dimes will be inserted, others will not, and this information is, usually, in the common ground. In the current analysis, there is no maximality constraint for the cardinality constraint to cancel. However, the same reasoning can be applied to explain why the equal salience of all choice functions as possible values for the free variable in the representation of a donkey pronoun is cancelled. For example, in the case of (23), since the common ground will normally entail that some dimes are used and others are not, it follows that for very person, some choice functions will choose dimes they did *not* put in the meter. Therefore, the default universal quantification over choice functions is overriden and (23) has a preferred existential reading.

Similarly for (15). This sentence describes events of using a credit card to purchase a donkey. While such events are perhaps not very common, we can deduce from other events of credit card purchases that they protoypically involve the buyer choosing a single credit card. Thus, the common ground normally includes the information that, if more than one choice of credit card exists for a farmer, then some of the choices will not be made. Therefore, the context entails that it is not the case that (18) (the representation of (15)) is true relative to all relevant choice functions. The only plausible assertion is then that it is true relative to *some* choice of a credit (though the context need not specify which one).

This contrasts with sentence (14). In order for this sentence to be true, each relevant farmer must participate in an event or a series of events in which she hides credit cards in the barn. But world knowledge does not tell us that there is a limit on how many things one can hide: you can hide whatever you have. Furthermore, if there is reason to hide one credit card, then the same reason is probably good reason to hide all of them. So, when this sentence is uttered, the common ground normally does not entail that there are credit cards that are not hidden, and the sentence is evaluated relative to all relevant functions. Thus, LF's cardinality constraint can be maintained as the explanation for existential readings even if their analysis of universal readings is not.

4 Summary and conclusions

This paper has demonstrated that the theory of donkey anaphora presented in Lappin and Francez (1994) does not assign correct truth conditions to donkey sentences with monotone decreasing quantifiers in the subject. However, I argued that this does not jeopardize the core intuition of their analysis. In particular, donkey pronouns can still be uniformly represented with free variables over functions, and the distribution of readings can still be viewed as arising from pragmatically motivated overriding of defaults. What I suggested should be abandoned is LF's view that donkey pronouns involve functions from individuals to *i*-sums, as well as their derivation of universal readings by means of a maximality constraint. Instead, I suggested following Chierchia in viewing such readings are arising from inferred quantification over Skolemized choice functions. In the default case, all possible values for the free variable are under consideration, and universal readings arise. Thus, the universal force associated with donkey pronouns is similar to the force of free choice indefinites. Existential readings arise when, due to world knowledge about the nature of the eventuality involved, the common ground entails that a universal reading is false. In this case, the interpretation is naturally weakened to an assertion about the existence of at least one value for the free variable.

Much more needs to be said about what kinds of predicates give rise to cardinality constraints and about the distribution of existential and universal readings. In particular, since the publication of LF's paper, several authors have argued the relevance of various other semantic and pragmatic properties of predicates and/or their arguments for determining readings. These include sentence and lexical aspect (Merchant and Giannakidou 1998; Geurts 2002), Yoon's (1996) distinction between total and partial predicates, and Geurt's (2002) intriguing distinction between protoypical and marginal individuals. I find that all of these proposals have convincing aspects. Furthermore, I did not discuss here the semantic approach in Kanazawa (1994) (though LF provide some discussion of his approach, including some objections). Discussion of these works goes beyond the scope of this paper, whose modest goal is only to show how an analysis more or less in line with LF's main ideas can be provided which does not assign wrong truth conditions to donkey sentences with downward increasing determiners.

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