Free Variable Economy

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Abstract

Several authors have recently argued that semantic interpretation is subject to *economy constraints*. In particular, Fox (1999) argued that the interpretation of pronouns is subject to BINDING ECONOMY, which favors local binding over non-local binding. The present paper points out a problem for BINDING ECONOMY. The aim, then, is to see if this problem can be resolved in a conservative way, that is, preserving the general idea that interpretation is subject to economy constraints. The suggested solution is to consider a different economy criterion. The proposed constraint, FREE VARIABLE ECONOMY, disfavors free variables rather than non-local binding. It avoids the problem that BINDING ECONOMY runs into, and preserves the general idea that semantic interpretation is subject to economy constraints.

1 Economy and Semantic Interpretation

Several authors have recently argued that semantic interpretation is subject to *economy constraints* (cf. Fox, 1999; Reinhart, 2006). The general idea is that one logical form is ungrammatical if there is an alternative logical form which is:

1. semantically equivalent
2. syntactically simpler / more economical

To make this general idea more precise, we have to answer two questions:

1. When are two logical forms semantically equivalent?
2. When is one logical form simpler / more economical than another?

In this paper, I will focus on the second question. More particularly, I will be concerned with a measure of economy, proposed by Fox (1999), which says that logical forms in which pronouns are bound *locally* are more economical than logical forms in which pronouns are bound non-locally. Fox has shown that the associated

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economy constraint, which I will refer to as BINDING ECONOMY, accounts for a range of interesting data. Most strikingly, it deals with a long-standing problem in the theory of VP-ellipsis, known as Dahl's puzzle (Dahl, 1973).

However, I will point out below that a variant of Dahl's puzzle is problematic for BINDING ECONOMY. My aim, then, is to resolve this problem in a conservative way. That is, I will try to preserve the general idea that semantic interpretation is subject to economy constraints, as well as the basic assumptions about the syntax-semantics interface and the nature of pronominal anaphora that proponents of this idea generally presuppose. My strategy will be to reconsider the question when a certain logical form should count as more economical than another. Fox's measure of economy is concerned with *locality* of pronominal binding. The measure of economy that I will propose is concerned with *free variables*. The associated economy constraint, FREE VARIABLE ECONOMY, disfavors free variables rather than non-local binding. This will be shown to resolve the problem that BINDING ECONOMY runs into.

The paper is organized as follows. First, some theoretical assumptions, terminology, and notation will be fixed in section 2. BINDING ECONOMY will be presented in section 3, followed by the new problematic data in section 4. Finally, FREE VARIABLE ECONOMY will be presented in section 5, and section 6 concludes.

2 Preliminaries

Let me start by fixing some theoretical assumptions, terminology and notation.

Syntax-semantics interface. I will assume that syntax generates logical forms (LFs), and that these logical forms are associated with a certain semantic meaning (or with an expression in the typed lambda-calculus representing such a meaning) in a compositional fashion, along the lines of Heim and Kratzer (1998).

Bound and referential pronouns. I will assume a basic distinction between bound and referential pronouns (cf. Reinhart, 1983). Pronouns may or may not be indexed at LF. A pronoun with an index n is interpreted as a variable x_n (the index is called a *binding* index in this case). If a pronoun is not indexed, it is taken to refer to some contextually salient individual.

Movement and abstraction. I will assume that wh-movement and quantifier raising work as follows. If a wh-element moves it receives a binder index n, which is adjoined to it in superscript (e.g., $[\text{who}]^3$). It also leaves behind a trace which has that same index n as its binding index (e.g., the trace of $[\text{who}]^3$ would be t_3).

(1) $[_{\text{TP}}\ \text{X}\ [_{\text{DP}}\ \text{wh}]\ \text{Y}] \quad \Rightarrow \quad [_{\text{TP}}\ [_{\text{DP}}\ \text{wh}]^n\ [_{\text{TP}}\ \text{X}\ \text{t}_n\ \text{Y}]]$ (wh-movement)

The same goes for quantifier raising: if a determiner phrase undergoes QR it receives a binder index n and leaves behind a trace which has that same index n as its binding index.

(2) $[_{\text{TP}}\ \text{X}\ [_{\text{DP}}\ \text{Q}]\ \text{Y}] \quad \Rightarrow \quad [_{\text{TP}}\ [_{\text{DP}}\ \text{Q}]^n\ [_{\text{TP}}\ \text{X}\ \text{t}_n\ \text{Y}]]$ (quantifier raising)

I will assume that determiner phrases always undergo QR. This assumption will make some of the formulations below run smoother, but nothing hinges on it.

A trace with a binding index n is interpreted as a variable x_n, and a constituent of the form X^nY is interpreted as:

(3) $\text{X}'(\lambda x_n.\text{Y}')$

where X' is the interpretation of X and Y' is the interpretation of Y. This composition rule embodies what Heim and Kratzer (1998) call *predicate abstraction*. As a result, the logical form in (4) is interpreted as (5):

(4) $[\text{John}]^1[\text{t}_1 \text{ called his}_1 \text{ mother}]$

(5) $\textsc{john}(\lambda x_1.\ x_1\ \textsc{called}\ x_1\text{'s}\ \textsc{mother})$

Binding and reference. To define binding we first have to specify one auxiliary notion, namely that of *c-command* (cf. Reinhart, 1983). One constituent A c-commands another constituent B iff (i) A does not dominate B and (ii) all branching nodes that dominate A also dominate B.

Now let A be a determiner phrase with a binder index, and let B be a pronoun with a binding index. Then we say that A binds B iff:

(i) A's binder index matches B's binding index,

(ii) A c-commands B, and

(iii) A does not c-command any other DP which satisfies (i) and (ii).

This notion of binding is what Heim and Kratzer (1998) and Büring (2005b) call *semantic binding* and what Reinhart (2006) calls *A-binding*. To see what it amounts to consider example (4) above: according to the definition, [John] binds [his] in this logical form. To enhance readability, I will often use the following graphical notation:

(6) John called his mother.

Think of (6) as shorthand for (4): the arrow indicates that [his] is bound by [John].

For referential pronouns I will also use a graphical notation. For instance, if [his] is taken to refer to John, I will write:

(7) John called his mother.
↓
John

VP ellipsis. The literature is very much divided on the nature of VP ellipsis (cf. Johnson 2008 for discussion). I will assume that the meaning of an elided VP is contextually retrieved, typically from an overt VP in the surrounding discourse (cf. Hardt, 1993; Kehler, 2002; Roelofsen, 2008), but I should emphasize that, as far as I can see, the discussion below does not hinge on this assumption.

The graphical notation introduced above will be useful in depicting the possible interpretations of elided VPs. Consider example (8):

(8) Max called his mother and Bob did too.

This sentence is ambiguous. It could be taken to mean that Max and Bob both called *Max's* mother. This is called the *strict* reading. But it could also be taken to mean that Max and Bob both called *their own* mother. This is called the *sloppy* reading. I assume that the strict reading arises if the pronoun in the source clause (the clause containing the antecedent VP) is taken to refer to Max. In this case, the pronoun in the target clause (the clause containing the elided VP) will also be taken to refer to Max (the "reconstructed" VP is printed in gray):

(9) Max called his mother and Bob called his mother too.
↓ ↓
Max Max

The sloppy reading arises when the pronoun in the source clause is *bound*. In this case, the pronoun in the target clause will also be bound. Only, in the source clause it is bound by [Max], while in the target clause it is bound by [Bob]:

(10) Max called his mother and Bob called his mother too.

I think it will be helpful to think of sloppy readings graphically: they arise when pronouns are, as it were, "bound in parallel" (cf. Fox, 1999; Büring, 2005a).

3 Binding Economy

We are now ready to have a closer look at BINDING ECONOMY. The idea is perhaps best illustrated by means of an example. Consider the following two logical forms:

(11) Max said that he called his mother.

(12) Max said that he called his mother.

These logical forms are semantically equivalent: they are associated with exactly the same semantic meaning. The difference is that in (11), the second pronoun, [his], is bound *locally*, by [he], while in (12) it is bound non-locally by [Max]. The idea behind BINDING ECONOMY is that logical forms like (12) are ungrammatical because of the existence of more economical logical forms like (11). To give a general and precise formulation of BINDING ECONOMY, we first have to specify which kind of structures it considers to be *alternatives*.

Alternatives. Two LF constituents are alternatives iff they are (i) semantically equivalent, and (ii) formally identical modulo binding indices on pronouns.

Next, we must specify what it means for one alternative to be more economical than another.

Economy Measure. Suppose that Σ and Π are alternatives. Then we say that Π is more economical than Σ if and only if there is a pronoun P and determiner phrases A and B in Σ and Π such that:

1. A binds P in Σ;
2. B binds P in Π;
3. A c-commands B in Σ and Π.

Now we are ready to state BINDING ECONOMY.

Binding Economy.
An LF constituent is ruled out if it has a more economical alternative.

Empirical evidence for this constraint mainly comes from a notorious puzzle concerning VP ellipsis, dating back to (Dahl, 1973). Consider the following sentence:

(13) Max said that he called his mother and Bob did too.

Notice that the second conjunct contains an elided VP, and that the overt VP in the first conjunct contains two pronouns. We may expect, then, that this sentence has at least four readings: one in which both pronouns are interpreted strictly, one in which they are both interpreted sloppily, and two "mixed" readings where one of the pronouns is interpreted strictly and the other sloppily. Surprisingly, one of these mixed readings is not available (in neutral contexts):

(13) Max said that he called his mother and Bob did too.

a. ...Bob too said that Max called Max's mother. [strict-strict]
b. ...Bob too said that Bob called Bob's mother. [sloppy-sloppy]
c. ...Bob too said that Bob called Max's mother. [sloppy-strict]
d. #...Bob too said that Max called Bob's mother. [strict-sloppy]

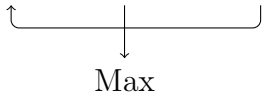
Thus, the challenge is to account for the fact that (13-a), (13-b), and (13-c) are possible readings of the target clause in (13), while (13-d) is not.

BINDING ECONOMY accounts for this fact. To see this, first consider the strict-sloppy reading in (13-d). This reading corresponds to the following LF:

(14) Max said he called his mother and Bob said he called his mother too.

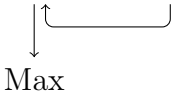
Consider the first conjunct of this logical form:

(15) Max said he called his mother.



This constituent has a more economical alternative:

(16) Max said he called his mother.



As a consequence, BINDING ECONOMY rules out (15), and therefore also (14). Thus, (13-d) cannot be derived as a reading for (13), as desired.

The other three readings, (13-a), (13-b), and (13-c), *can* be derived, through the following three logical forms. None of these involves non-local binding.

(17) Max said he called his mother and Bob said he called his mother too.

(18) Max said he called his mother and Bob said he called his mother too.

(19) Max said he called his mother and Bob said he called his mother too.

4 Problem for Binding Economy

Consider the following sentence:

(20) No student said he liked his paper, but
every student thought the teacher would.

This sentence has the following *strict* reading (among others):

(21) . . . every student x thought the teacher would like x's paper.

BINDING ECONOMY wrongly blocks this reading. To see this, consider the corresponding logical from:

(22) NoS said he liked his paper, but everyS thought T would like his paper.

The first conjunct has a more economical alternative:

(23) NoS said he liked his paper.

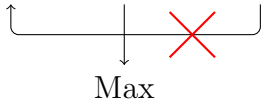
Thus, BINDING ECONOMY rules out (22). Notice that example (20) is very similar to Dahl's original example. If we strip off the second conjuncts, we are left with:

(24) Max said he called his mother.

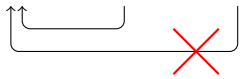
(25) NoS said he liked his paper.

The only relevant difference is that the subject of (24) is a referential determiner phrase, whereas the subject of (25) is a quantifying determiner phrase. In both cases, BINDING ECONOMY predicts that non-local binding of [his] is ungrammatical. Graphically:

(24) Max said he called his mother.



(25) NoS said he liked his paper.



In the case of (24) this is a welcome prediction, as it accounts for Dahl's puzzle. But in the case of (25) it is not, because it blocks the strict reading of (20).

It is worth noting that this problem carries over to alternative accounts of Dahl's puzzle such as those of Kehler (1993), Fiengo and May (1994), and Schlenker (2005).

5 Free Variable Economy

I will try to overcome this impasse in a way that preserves the general idea that semantic interpretation is subject to economy constraints. BINDING ECONOMY was derived from this general idea by assuming that one logical form is more economical than another if the pronominal binding relations it encodes are more local. This particular assumption seems to be problematic, but that does not mean that the general idea must be given up. There may be other measures of economy. Below, I will formulate such a measure. It is concerned with *free variables*, which are defined as follows:

Free Variables. Let Σ be an LF constituent, and let P be an indexed pronoun in Σ that is not bound within Σ. Then the index on P is called a free variable in Σ.

Let me give some examples (I must return here to using indices instead of arrows):

(26) a. $[[\text{Max}]^2\ [\text{t}_2\ \text{called his}_2\ \text{mother}]]$
b. $[[\text{Max}]^2\ [\text{t}_2\ \text{called his}_1\ \text{mother}]]$
c. $[[\text{he}_1]^2\ [\text{t}_2\ \text{called his}_1\ \text{mother}]]$
d. $[[\text{he}_1]^2\ [\text{t}_2\ \text{called his}_2\ \text{mother}]]$

(26-a) does not contain any free variables, because the pronoun it contains is bound within the given constituent. (26-b) does contain a free variable, because the pronoun [his] has a binding index, and is not bound within the given constituent. (26-c) also contains one free variable. Notice that we are not counting *occurrences* of free variables. The constituent contains two unbound pronouns, but both have the same index, so there is only one free variable. If one of the pronouns is bound, as in (26-d), the number of free variables does not change, it is still one.

In terms of free variables, we can define the following economy measure:

Economy Measure. Suppose that Σ and Π are alternatives. Then we say that Π is more economical that Σ if and only if some sub-constituent Π' of Π contains fewer free variables than the corresponding sub-constituent Σ' of Σ.

Now we are ready to state FREE VARIABLE ECONOMY.

Free Variable Economy.
An LF constituent is ruled out if it has a more economical alternative.

Notice that the formulation of FREE VARIABLE ECONOMY is identical to that of BINDING ECONOMY. The only thing that has changed is the measure of economy.

Free Variable Economy accounts for Dahl's puzzle, and it does *not* rule out the strict reading of (20). In other words, it prohibits non-local binding in (24) but not in (25). To see this, first consider (24), repeated in (27) using index-notation:

(27) [[Max]^1 [t_1 said that [[he]^2 [t_2 called his$_1$ mother]]]]
↓
Max

This logical form has the following alternative:

(28) [Max]^1 [t_1 said that [[he]^2 [t_2 called his$_2$ mother]]]
↓
Max

The only difference between (27) and (28) is that in (27), [his] is bound by [Max], while in (28), it is bound by [he]. The two logical forms are semantically equivalent, and, crucially, (28) is more economical than (27). To see this, consider the embedded clause. In (27), the embedded clause contains a free variable; in (28) it does not. This is enough for (28) to be considered more economical than (27), and thus for FREE VARIABLE ECONOMY to account for Dahl's puzzle.

Now consider (25), repeated in (29) using index-notation. Recall that this logical form should *not* be ruled out (otherwise the strict reading of (20) cannot be derived).

(29) [[No student]^1 [t_1 said that [[he$_1$]^2 [t_2 liked his$_1$ paper]]]]

This logical form has the following alternative:

(30) [[No student]^1 [t_1 said that [[he$_1$]^2 [t_2 liked his$_2$ paper]]]]

But this alternative is *not* more economical. Consider, in particular, the embedded clause. In (29), neither [he] nor [his] is bound within the embedded clause, but both carry the same index, so the embedded clause contains *one* free variable. In (30), [his] is bound within the embedded clause, but [he] is not, so the clause still contains one free variable. Thus, the embedded clause in (30) does not contain fewer free variables than the embedded clause in (29). It can be shown that no other constituent in (30) contains fewer free variables than the corresponding constituent in (29), and that the same holds for other alternatives of (29). Thus, FREE VARIABLE ECONOMY does not rule out (29) and correctly derives the strict reading of (20).

6 Conclusion

We have considered the idea that semantic interpretation is subject to economy constraints. We focused on one particular measure of economy, proposed by Fox (1999). This measure favors local pronominal binding over non-local binding. The resulting economy constraint, BINDING ECONOMY, accounts for a long-standing puzzle concerning VP ellipsis, dating back to Dahl (1973).

We have seen, however, that a variant of Dahl's original puzzle is problematic for BINDING ECONOMY. In response to this, we have considered an alternative measure of economy. This measure disfavors *free variables*. The resulting economy constraint, FREE VARIABLE ECONOMY, accounts for Dahl's original puzzle, and also for the variant that was shown to be problematic for BINDING ECONOMY.

The general strategy in this paper was to try and resolve the encountered problem in such a way that as much of the general theoretical assumptions that were taken as a starting point would be preserved (the idea that semantic interpretation is subject to economy constraints, but also even more basic assumptions about the syntax-semantics interface, the nature of pronominal anaphora and VP ellipsis, etcetera). Whether these assumptions are ultimately justifiable, is a different issue. In (Roelofsen, 2008), I argue against some of them and eventually present a different outlook, especially on the nature of pronominal anaphora and VP ellipsis. Of course, this also leads to a different account of the data discussed here. The outlines of such an account are sketched in (Roelofsen, 2008). Economy continues to play a role there, but not in the process of generating grammatical logical forms. Rather, it affects the process of anaphora resolution. I believe that this may ultimately be more realistic, but in order to uphold such a claim, many details still have to worked out. That's for the future.

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