Indefinites and Sluicing. A type logical approach

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Abstract

Following Jäger (2001a), we propose to extend the Lambek calculus with two additional implications, where the first one models anaphora and the second one indefiniteness. Both pronouns and indefinites are interpreted as (possibly partial) identity functions, but they give rise to different types and are thus subject to different interpretation strategies. The descriptive content of indefinites is interpreted as a domain restriction on the corresponding function. The resulting grammar of indefinites treats the scopal behavior of these NPs in an empirically adequate way. Furthermore it leads to a straightforward surface compositional analysis of Sluicing. The assumed division of labor between syntax and semantics in Sluicing is in accordance with the facts; Sluicing is correctly predicted to be insensitive to syntactic islands, but sensitive to morphological features of the antecedent.

1 The type logical treatment of anaphora

In Jäger (2001a) a type logical version of Jacobson's (1999) variable free grammar of anaphora is given and successfully applied to VP ellipsis. To this end, the associative Lambek calculus **L** is extended with a third implication "|", where $A|B$ is the type of an anaphoric expression of type A which requires an antecedent of type B. Semantically this corresponds to a function from B-denotations to A-denotations. The behavior of the new implication is governed by the following sequent rules (we replace the rule of use from Jäger 2001a by a somewhat stronger version, but the difference is irrelevant for all practical purposes).

$$\frac{X \Rightarrow M : A \qquad Y, x : A, Z, y : B, W \Rightarrow N : C}{Y, X, Z, w : B|A, W \Rightarrow N[M/x][wM/y] : C}\,[|L]$$

$$\frac{X, x : A, Y \Rightarrow M : B}{X, y : A|C, Y \Rightarrow \lambda z.M[yz/x] : B|C}\,[|R]$$

The first rule is responsible for anaphora resolution, while the second one ensures that anaphora slots can percolate up in larger syntactic structures. All relevant instances of Jacobson's combinators **Z** and **G** are theorems of the resulting logic. If we adopt the Jacobsonian type assignment $np|np$ and meaning assignment λxx for anaphoric pronouns, her CCG-analysis of pronominal anaphora thus mainly carries over to this type logical system.[1] In Jäger (2001a) it is furthermore shown that we obtain a straightforward account of VP ellipsis if we assume that the stranded auxiliary *did* in constructions like (1) has type $(np\backslash s)|(np\backslash s)$ and denotes the identity function on properties.

(1) John entered before Bill did.

2 A type logical grammar of indefinites

We propose that the semantics of indefinite NPs is similar to the one of anaphoric pronouns. Consider a simple minimal pair such as

[1] The main difference is that the type logical version predicts linear precedence to be the licensing structural configuration for anaphora where Jacobson assumes a version of c-command. The interested reader is referred to Jäger (2001b) for further discussion of this issue.

(2) a. It moved
b. Something moved

According to the analysis mentioned above, (2a) has the category $s|np$ (i.e. it is a clause containing one unresolved pronoun) and the meaning representation $\lambda x.\text{MOVE'}x$, i.e. it denotes the property of moving. The central claim of the present paper is that (2b) should be analyzed analogously; its meaning representation is also $\lambda x.\text{MOVE'}x$. The two sentences differ in truth conditions and in their semantic contribution to larger constructions because they belong to different syntactic categories. To implement this idea, we extend the Lambek calculus with another binary connective, $\leadsto$. The intuition here is that a sign of category $A \leadsto B$ is like a sign of category B except that it introduces a discourse referent of the type corresponding to category A. So an indefinite NP will receive the category $np \leadsto np$, and a sentence containing an indefinite has the category $np \leadsto s$. (In linguistic applications, A will always be instantiated with np.) A sign of category $A \leadsto B$ denotes a function from A-denotations to B-denotations, so

$$Dom(A \leadsto B) = Dom(B|A) = Dom(A\backslash B) = Dom(B/A) = Dom(B)^{Dom(A)}$$

A simple indefinite like *something*, having category $np \leadsto np$, thus denotes a Skolem function. This function is lexically specified to be the identity function λxx, so *something* comes out as synonymous with *it*.

The property of introducing a discourse referent can be inherited from sub-constituents to super-constituents. Formulated in type logical terms, this means that the deductive behavior of $\leadsto$ is governed by the following rule, which is entirely analogous to the rule of proof of the anaphora slash.

$$\frac{X, x : A, Y \Rightarrow M : B}{X, y : C \leadsto A, Y \Rightarrow \lambda z.M[yz/x] : C \leadsto B}[\leadsto]$$

It is easy to see that this rule, as well as the two rules for the anaphora slash, have the subformula property. Furthermore, Lambek's (1958) proof of Cut elimination smoothly carries over to the extended Lambek calculus. The resulting system is thus guaranteed to be decidable and to have the finite reading property (i.e. there are only finitely many Cut free proofs for each theorem).

Indefinites are not anaphoric; the argument slot that is created by an indefinite can thus not be filled by anaphora resolution. In type logical terms, this means that the logic of $\leadsto$ is solely determined by the rule $[\leadsto]$. There is not counterpart of the rule of use of the anaphora slash for $\leadsto$. (This can be regarded as a proof theoretic implementation of Heim's 1982 Novelty Condition.)

The syntactic derivation of (2b) is given in figure 1. If we plug in the lexical semantics λxx for *something* and MOVE' for *moved*, we obtain the sentence meaning $\lambda v.\text{MOVE'}v$ for (2b).

$$\dfrac{\dfrac{\dfrac{}{x : np \Rightarrow x : np}[id] \qquad \dfrac{}{y : s \Rightarrow y : s}[id]}{z : np, w : np\backslash s \Rightarrow wz : s}[\backslash L]}{u : np \leadsto np, w : np\backslash s \Rightarrow \lambda v.w(uv) : np \leadsto s}[\leadsto]$$

Figure 1: Derivation for (2b)

In the general case, indefinite descriptions come with a non-trivial descriptive content. We analyze the descriptive information as a restriction on the domain of the corresponding function. The denotation of the indefinite description *a cup*, for instance, would come out as the identity function on the set of cups. To express partial functions in the typed λ-calculus, we extend its syntax and semantics in the following way:

Definition 1

- If M and ϕ are terms of types σ and t respectively and v is a variable of type τ, then $\lambda v_\phi M$ is a term of type $\langle \tau, \sigma \rangle$.
- $\|\lambda v_\phi M\|_g = \{\langle a, \|M\|_{g[v\to a]}\rangle : \|\phi\|_{g[v\to a]} = 1\}$

The lexical entry for the indefinite article is given in (3b); its meaning is a function from a set to the identity function over this set. Given this, the sequent in (3c) is a theorem, and the meaning of the sentence (3a) is thus (3d), i.e. it denotes the partial truth-valued function that returns 1 for each cup that moved, 0 for each cup that didn't move, and that is undefined for all non-cups.

(3)
a. A cup moved
b. a – $\lambda P x_{Px}.x : (np \rightsquigarrow np)/n$
c. $y : (np \rightsquigarrow np)/n, z : n, w : np\backslash s \Rightarrow \lambda u.w(yzu) : np \rightsquigarrow s$
d. $\lambda u.\text{MOVE'}((\lambda x_{\text{CUP'}x}.x)u)$
$(\equiv \lambda u_{\text{CUP'}u}.\text{MOVE'}u)$

3 Truth and negation

Since sentence denotations need not be truth values in the present system but may be partial truth-valued function of any arity, truth has to be defined polymorphically, and it has to be relativized to the syntactic category of the sentence in question. (This will ensure that (2a) and (b) will have different truth conditions despite their identical denotations.) Furthermore, we follow Dekker (2000) in relativizing truth to sequences of objects (that supply the referents of unbound pronouns). So truth is defined as a four place relation between a sentence denotation (expressed by the meta-variable α below), a syntactic category (where we use the meta-variable S), a model (which is suppressed in the notation below) and a sequence of individuals $\vec{e}$. ($c\vec{e}$ is the sequence that results if you add c as top element to the sequence $\vec{e}$.)

Definition 2 (Truth)

$$\begin{array}{rcl} \vec{e} \models \alpha : s & \text{iff} & \alpha = 1 \\ c\vec{e} \models \alpha : S|np & \text{iff} & \vec{e} \models (\alpha c) : S \\ \vec{e} \models \alpha : np \rightsquigarrow S & \text{iff} & \vec{e} \models (\bigcup_{\alpha c \text{ is defined}} (\alpha c)) : S \end{array}$$

Intuitively, the argument slots originating from pronouns are filled by the elements of the sequence $\vec{e}$, while the slots coming from indefinites are existentially bound.
It is easy to see that the truth conditions of our examples come out as expected, i.e. (2) is true wrt. a sequence iff the first element of this sequence moved, (2b) is true if something moved, and (3a) if some cup moved.
As in Dynamic Predicate Logic or in Dekker's Predicate Logic with Anaphora, negation is an operation that operates on the truth conditions of its operand rather than on its meaning directly. In the present system this means that negation is relativized to the syntactic category of its operand. As in the truth definitions above, argument slots originating from indefinites are existentially closed, while those coming from pronouns are passed further up.

Definition 3 (Negation)

$$\begin{aligned} \sim \alpha : s &= 1 - \alpha \\ \sim \alpha : S|A &= \lambda c. \sim (\alpha c) \\ \sim \alpha : A \rightsquigarrow S &= \sim (\bigcup_{c \in Dom(A)} \alpha c) \end{aligned}$$

We assume that the arguments of other propositional operators (like conjunctions or verbs of propositional attitudes) undergo a similar operation of existential closure as well.

4 Linguistic consequences

Consider the following construction:

(4) If a cup moved, the ghost is present

Suppose that the particle *if* has the polymorphic category $S_1/S_1/S_2$ (where $S_{1/2}$ range over sentential categories) and the meaning representation $\lambda pq.(\neg p \vee q)$ (where $\neg$ is the syntactic counterpart of the semantic negation operation defined above, and $\phi \vee \psi$ abbreviates $\neg(\neg\phi \wedge \neg\psi)$). To simplify the discussion, we ignore the internal structure of the main clause *the ghost is present* and represent its meaning as GHOST_IS_PRESENT. Given this, (4) is predicted to be structurally ambiguous—depending on the stage in the derivation where the rule [$\rightsquigarrow$] is applied—and to receive the following two semantic representations:

(5) a. $\neg\lambda u_{\text{CUP'}u}\text{MOVE'}u \vee \text{GHOST\_IS\_PRESENT}$
b. $\lambda u_{\text{CUP'}u}.\neg\text{MOVE'}u \vee \text{GHOST\_IS\_PRESENT}$

According to the truth definitions given above, (a) is true if either no cup moved or the ghost is present—i.e. the indefinite has narrow scope wrt. the conditional—and (b) is true if there is a certain cup u such that either u doesn't move or the ghost is present. This corresponds to the specific reading of the indefinite *a cup*.
This example illustrates the following noteworthy properties of the present analysis of indefinites:

A An indefinite can take scope over each clause it is contained in, and it scopally interacts with superordinate propositional operators like negation. However, the scoping mechanism for indefinites is entirely independent of the type logical scoping mechanism for genuine quantifiers (like Moortgat's 1996 *in situ* binder), and if quantifier scope is clause bounded or otherwise restricted, this has no implications for the scope of indefinites. So the unrestricted scope taking behavior of indefinites is expected.

B The present theory assumes that indefinites are interpreted *in situ*. Therefore the scope of indefinites is not subject to constraints on movement. Nonetheless the descriptive content of an indefinite—being interpreted as a domain restriction on a function—is inherited by its super-constituent after semantic composition. This ensures that the existential impact of an indefinite and its descriptive content are never unduly divorced.

C No particular problem arises if the extension of the descriptive content of an indefinite is empty. For instance, if there were no cups, both (3a) and (4) in the reading (5b) would denote the empty function and would therefore be false.
The second and third point pose problems for other *in situ* theories of indefinites like the choice function approach (see for instance the discussion in Geurts 2000), and it has been argued that some kind of movement analysis is inevitable for these reasons.

The present approach demonstrates that the empirical facts can be analyzed in a surface compositional way.
Last but not least it should be mentioned that Dekker's treatment of donkey anaphora can be incorporated into the present system without major problems by designing a polymorphic version of conjunction. Space prevents us from pursuing this issue further; the interested reader is referred to Jäger (2001b).

5 Sluicing

This grammar of indefinites, paired with the mentioned type logical treatment of anaphora, leads to a straightforward surface compositional analysis of Sluicing. This is a version of ellipsis where under certain contextual conditions, a bare *wh*-phrase stands proxy for an entire question. The source clause is typically a declarative clause which contains an indefinite NP. The target clause is interpreted as the question that is obtained if this indefinite is replaced by a *wh*-phrase. For example, the Sluicing construction in (6a) is interpreted as (6b).

(6) a. A cup moved, and Bill wonders which cup
b. A cup moved, and Bill wonders which cup moved

We assume that the *wh*-determiner *which* in an embedded question like in (6b) has the lexical entry given in (7a). (We adopt Moortgat's 1988 gap operator "$\uparrow$", i.e. $s \uparrow np$ is the type of a clause with an np gap. q is the type of embedded questions. The predicate Q^+ denotes the positive extension of the predicate Q. This means that $\|Q^+\|c = 1$ iff $\|Q\|c = 1$, and $\|Q^+\|c = 0$ otherwise.) The question (7b) thus receives the semantic representation (7c).

(7) a. which cup moved
b. which – $q/(s \uparrow np)/n : \lambda PQ?x.Px \wedge Q^+x$
c. $?x.\text{CUP'}x \wedge \text{MOVE'}x$

Now consider a Sluicing construction like (6a). The antecedent clause has the category $np \rightsquigarrow s$, i.e. it is a clause containing an indefinite. Its interpretation is $\lambda v_{\text{CUP'}v}\text{MOVE'}v$. We assume that the *wh*-word *which* has the same interpretation here as in the non-elliptical interpretation, but a different category. The second lexical entry for *which* is

(8) which – $q|(np \rightsquigarrow s)/n : \lambda PQ?x.Px \wedge Q^+x$

So if we combine *which* with a common noun like *cup*, we get an item of type $q|(np \rightsquigarrow s)$, i.e. an anaphoric embedded question which needs an antecedent of type $np \rightsquigarrow s$, i.e. a clause containing an indefinite. Plugging in the meaning of the antecedent in the example (6a), the embedded question receives the resolved meaning $?x\text{CUP'}x \wedge (\lambda x_{\text{CUP'}}\text{MOVE'}x)^+x$, which is equivalent to $?x.\text{CUP'}x \wedge \text{MOVE'}x$. This analysis handles the essential empirical characteristics of Sluicing correctly:

A It follows from the type of the *wh*-phrase in Sluicing constructions that the antecedent clause has to contain an indefinite which corresponds to the *wh*-phrase in the elliptical clause. So the oddity of (9) is predicted.

(9) *The cup moved, and Bill wonders which cup

B Sluicing is island insensitive. This means that Sluicing constructions are grammatical even if their non-elliptical counterparts are deviant due to an island violation. A typical example is (10) (taken from Chung et al. 1995), where the non-elliptical version involves a violation of the Complex NP Constraint.

(10) a. The administration has issued a statement that it is willing to meet with one of the student groups, but I'm not sure which one

b. *The administration has issued a statement that it is willing to meet with one of the student groups, but I'm not sure which one the administration has issued a statement that it is willing to meet with

Under the present approach this is predicted because the elliptical and the non-elliptical construction are not transformationally related. For the Sluicing construction to be grammatical, it is sufficient that the antecedent clause contains a wide scope indefinite, and the scope of indefinites is not subject to island constraints.

C The descriptive part of the antecedent indefinite is interpreted as an additional restriction on the interrogative operator in the ellipsis site. For example, the next two sentences are correctly predicted to be synonymous.

(11) John invited a philosopher, but I don't know {which philosopher/who}

D In case marking languages it can be observed that the indefinite in the source clause must have the same case as the corresponding *wh*-phrase in the target clause. The following German example (from Ross 1969) illustrates this point:

(12) Er will jemandem schmeicheln, aber sie wissen nicht {wem / *wen}
HE WANTS SOMEONE$_{\text{DAT}}$ FLATTER BUT THEY KNOW NOT {WHO$_{\text{DAT}}$ / WHO$_{\text{ACC}}$}
'He wants to flatter someone, but they don't know whom'

This generalization can easily be covered if we represent morphological information in the syntactic categories. Let us say simplifyingly that a name in dative case has the category $np(dat)$. An indefinite in dative case would then receive the category $np(dat) \leadsto np(dat)$, and a clause containing such an indefinite has the category $np(dat) \leadsto s$. A sluiced *wh*-phrase in dative like *wem* above has the category $q|(np(dat) \leadsto s)$, i.e. it requires a clause containing an indefinite in dative as antecedent.

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