PLING 228: Frameworks

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Review of Heim's dynamic semantics

As we saw last time, a classical semantics can't capture the apparent binding relation in the following – at least not w/o implausible assumptions about the mapping from overt syntax to logical form:

(1) A man walked in. He sat down.
A man walked in and he sat down.

Compare:

(2) Every man walked in. He sat down.
Every man walked in and he sat sown.

In fact Heim argued convincingly that the type of behaviour of indefinites illustrated above cannot be accounted for in full generality by making ad hoc assumptions about the syntax-l.f. mapping (nor explained away pragmatically in a straightforward way).

(3) a. If a farmer owns a donkey, he beats it.
b. Every farmer who owns a donkey beats it.

Here we do not obtain the right truth conditions by giving 'a donkey' widest scope, nor can 'it' be assumed to refer to some particular donkey. We appear to have semantic binding between the indefinite and pronoun, but the indefinite also appears to be in the scope of 'if'/'every' which precludes accounting for the binding by familiar mechanisms.

Heim's system allows indefinite/existential quantifiers to bind pronouns across sentences/from embedded positions as in (3-a). (In fact it dispenses with existential quantifiers completely and uses just variables, but as we will see this is assumption is non-essential.)

Crudely put it can be said to work as follows, focusing on (1).

(1) Wx. Sx.

Variables don't take single objects as values but rather can be associated with a range of possible values – in the case of Wx in the above, those that would witness the classical existential quantification $\exists x Wx$. These are stored (as part of a "file") and instances of x in subsequent predications, here Sx, function to further constrain those possible values to Ss. Thus the whole sequence ends up carrying the information that there is a man, "x", who walked in and sat down. In a slightly metaphorical sense, then, variables might be thought of as standing for "indefinite" or "partial" objects (?).

> **today's plan:** Discuss examples like (3-a) and show how Heim treated them using this machinery. We will then discuss limitations of this account.

Files

Given a set W of worlds, a set O of objects, and a set V of variables, and a set A of partial functions g from V to O:

A file is a set F of pairs of $\langle g, w\rangle$ where for each $\langle g', w'\rangle$ and $\langle g'', w''\rangle$ in F, g and g' share the same domain, called F_D.[1]

Adding a discourse referent

$F[x] = \{\langle g, w\rangle : \exists\langle g', w\rangle \in F, g'[x]g\}$

(where $g'[x]g$ means that g and g' differ only in x)

Update effect of atomic sentences on files

if x is in domain of x, $F[Px] = \{\langle g, w\rangle \in F : g(x)$ satisfies P in $w\}$
otherwise $F[Px] = \{\langle g, w\rangle \in F[x] : g(x)$ satisfies P in $w\}$

[1] This is our second notion from last time, in notion 1 it is just a set of assignment functions with the same domain).

Update effects of complex sentences

$F[\phi \ \& \ \psi] = F[\phi][\psi]$

$F[\neg\phi] = F \ominus F[\phi]$

$F \ominus F' = \{\langle g, w\rangle \in F$: there is no $\langle g', w\rangle \in F'$ such that $g' \geq g\}$ (where $g' \geq g$ if g' agrees with g in the domain of g).

$F[\phi \to \psi] = F \ominus F[\phi][\neg\psi]$

note on negation

Quick illustration of the rule for negation. Suppose $F = \{\langle\emptyset, u\rangle, \langle\emptyset, v\rangle\}$, and let $D = \{a, b\}$. Suppose a is P in w and nothing is in v . Then

$F[\neg Px]$

$= F \ominus Px$

$= \{\langle\emptyset, u\rangle, \langle\emptyset, v\rangle\} \ominus \{\langle x \to a, u\rangle\}$

$= \{\langle\emptyset, v\rangle\}$

So, the update effect of $\neg\phi$ is to make a file incompatible with (further) update with ϕ.

The above example should illustrate why $\ominus$ is needed to give a general compositional rule for $\neg\phi$: new variables can be added, as in the case of Px above, in which case F and $F[\phi]$ are disjoint. Notice that if x is already in the domain of F, the update effect of $\neg Px$ behaves in the more familiar, purely eliminative way: $F[\neg Px] = F - F[Px]$.

Donkey anaphora

The phenomenon exhibited by the famous examples (3-a) discussed above is called donkey anaphora.

The definition of the conditional we gave above is not Heim's but is useful to illustrate the general way in which her system handles donkey anaphora.

(4) If a farmer owns a donkey, he beats it.
$(Fx \ \& \ Dy \ \& \ Oxy) \to Bxy$

Let's compute the update effect. First we know that:

$F[(Fx\&Dy\&Oxy) \to Bxy] =$
$F \ominus F[Fx\&Dy\&Oxy][\neg Bxy] =$
$F \ominus F[Fx][Dy][Oxy][\neg Bxy]$

Let's suppose:

i. $F = \{\langle\emptyset, w1\rangle, \langle\emptyset, w2\rangle\}$
two farmers, a and b, and at most two donkeys $d1$, $d2$:

ii. in $w1$ farmer a owns both of the donkeys d_1 and d_2

iii. in $w2$ farmer b owns donkey d_1, d_2 is dead.

iv. in $w3$ both donkeys dead.

Then we have that

$$F[Fx] = \left\{\begin{array}{l} \langle\ x \to a\ , w1\rangle, \\ \langle\ x \to b\ , w1\rangle, \\ \langle\ x \to a\ , w2\rangle, \\ \langle\ x \to b\ , w2\rangle, \\ \langle\ x \to a\ , w3\rangle, \\ \langle\ x \to b\ , w3\rangle \end{array}\right\}$$

$\Rightarrow$ info hypothetically added that there's a farmer, x,

$$F[Fx][Dy] = \left\{\begin{array}{ll} \left\langle\begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w1\right\rangle, & \left\langle\begin{bmatrix} x \to a \\ y \to d_2 \end{bmatrix}, w1\right\rangle, \\ \left\langle\begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w1\right\rangle, & \left\langle\begin{bmatrix} x \to b \\ y \to d_2 \end{bmatrix}, w1\right\rangle, \\ \left\langle\begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w2\right\rangle, & \left\langle\begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w2\right\rangle \end{array}\right\}$$

$\Rightarrow$ and further that there's a donkey, y,

$$F[Fx][Dy][Oxy] = \left\{\left\langle\begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w1\right\rangle, \left\langle\begin{bmatrix} x \to a \\ y \to d_2 \end{bmatrix}, w1\right\rangle, \left\langle\begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w2\right\rangle\right\}$$

$\Rightarrow$ and further that x owns y,

Let's now suppose that:

iv. in $w1$ farmer a beats d_1 but not d_2.

v. in $w2$ farmer b beats d_1.

Then,

$$\begin{aligned}
&F[Fx][Dy][Oxy][\neg Bxy] \\
&= F[Fx][Dy][Oxy] \ominus F[Fx][Dy][Oxy][Bxy] \\
&= F[Fx][Dy][Oxy] \ominus \left\{ \left\langle \begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w1 \right\rangle, \left\langle \begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w2 \right\rangle \right\} \\
&= \left\{ \left\langle \begin{bmatrix} x \to a \\ y \to d_2 \end{bmatrix}, w1 \right\rangle \right\}
\end{aligned}$$

$\Rightarrow$ and finally that x doesn't beat y.

Now the final result:

$F \ominus \big[F[Fx][Dy][Oxy][\neg Bxy]\big] = \{\langle \emptyset, w2\rangle, \langle \emptyset, w3\rangle\}$

To summarise: the update effect of $(Fx \& Dy \& Oxy) \to Bxy$ on our file F was to eliminate $w1$ [that is, $\langle \emptyset, w1\rangle$]. Put another way it added the (worldly) info that every farmer beats all his donkeys. $w1$ was "subtracted" because it would survive updating F with the info that there's a farmer who doesn't own his donkey.

Note that if in (iv.) it had been assumed that a beats *both* $d1$ and $d2$, $F[Fx][Dy][Oxy][\neg Bxy]$ would have been $\emptyset$ and thus $w1$ would also have been retained in the final update.

Tripartite quantification

How about (3-b), 'Every farmer who owns a donkey beats it'? We could represent this in various ways in the Heimian system above.

In fact however, Heim defined her semantics for natural language (English) rather than a simple logical language like the above. Thus for reasons of syntactic plausibility and semantic necessity she assumed "tripartite" structures for quantificational sentences (including conditionals, as we will see below). That is something like:

(5) Every [farmer who owns a donkey] [beats it]

Or bringing it closer to our system above:

(6) Every [Fy & Dx & Oxy] [Bxy]

Heim's proposal for interpreting such structures is the following:

Heim's update rule for 'every'

$F\big[\text{Every } \phi\ \psi\big] = \{\langle g, w\rangle \in F$: for every $\langle g', w\rangle \in F[\phi]$ such that $g' \geq g$, there is a $\langle g'', w\rangle \in F[\phi][\psi]$ such that $g'' \geq g'\}$

Heim further assumed, about the syntax-semantics mapping, that the variable associated with a noun in a quantified noun phrase like 'every farmer' (y above) must not already be in the variable domain.

example.

Let's return to our toy F above and compute the update effect of (6) according to this rule.

According to the rule we retain from F just those assignment-worlds in F **all of** whom's extensions in $F[Fx][Dy][Oxy]$ – the "restrictor" – have extensions themselves in $F[Fx][Dy][Oxy][Bxy]$ – the nuclear scope.

From above $F[Fx][Dy][Oxy] =$

$$\left\{ \left\langle \begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w1 \right\rangle, \left\langle \begin{bmatrix} x \to a \\ y \to d_2 \end{bmatrix}, w1 \right\rangle, \left\langle \begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w2 \right\rangle \right\}.$$

and $F[Fx][Dy][Oxy][Bxy] =$

$$F[Fx][Dy][Oxy][Bxy] = \left\{ \left\langle \begin{bmatrix} x \to a \\ y \to d_1 \end{bmatrix}, w1 \right\rangle, \left\langle \begin{bmatrix} x \to b \\ y \to d_1 \end{bmatrix}, w2 \right\rangle \right\}$$

This means that we keep $w3$ (trivially) and $w2$ but not $w1$. The reason is that $\left\langle \begin{bmatrix} x \to a \\ y \to d_2 \end{bmatrix}, w1 \right\rangle$ extends $\langle \emptyset, w1\rangle$ from F, but does not have an extension in $F[Fx][Dy][Oxy][Bxy]$.

In summary: The update effect of (3-b) is the same as that of (3-a). Farmers must beat all their donkeys. An interesting feature of this treatment is that 'every' does not function in the familiar way as a binder of a variable associated with 'farmer'. Rather it quantifies over extensions of of world-assignments, which amounts in this case to quantifying "unselectively", over **farmer-donkey** pairs.

As we will see this leads to problems. But first

good (?) results

(7) If a bishop meets a bishop, he blesses him. [Heim, 1990]

(8) If a woman buys a sage plant, she buys eight others along with it. [Heim, 1990]

These examples were take to suggest that a purely formal means of tracking anaphoric relations is necessary. Heim's system provides this since the pronouns are linked to their indefinite binders by simple variable identity: e.g. the first bishop and first (?) pronoun are represented with x, the second pair with y. Heim argues that there does not appear to be plausible, sufficient information to resolve the anaphoric relationship by interpreting the pronoun as (literally) a (stand in) for a description as in Evans [1977], Cooper [1979]). But it is not clear in hindsight that such examples provide a strong argument for dynamic view.

A second result is that the treatment of universal (as opposed to existential) quantification does not result in new variables being added to the domain. I.e. no new discourse referents are introduced and so there should not be further possibilities for anaphora (2).

Back to conditionals

Heim's treatment of donkey anaphora owes much to Lewis [1975], who made two important observations. First, that 'if' clauses seem to behave like restrictors of the domain of quantification of adverbial or modal expressions

(9) Usually, if John comes, Mary is upset.
"On most occasions on which John comes, Mary is upset"

Second, that when they do, the adverbial behaves as if it "unselectively" binds indefinites in its scope

(10) Always/usually, if a woman come to his office, John hits on her.
"John hits on most/all women that come to his office"

Following ideas of Lewis (and Kratzer), Heim assumed a tripartite structure for sentences like (10),

(11) Always [if a woman comes to John's office] [John hits on her]

and she proposed a semantics for such structures essentially identical to her treatment of (3-b). The adverb quantifies over (extensions of) assignment-worlds in a file. The result is that in a sentence with multiple indefinites, parallel to (3-b), the quantification is again effectively over farmer-donkey pairs:

(12) Always/usually, if a farmer owns a donkey, he beats it.

The proportion problem

As Heim [1990] noted this feature of her account gives rise to what is known as the Proportion Problem. Consider:

(13) a. Most farmers who own a donkey beat it.
b. Usually if a farmer owns a donkey he beats it.

As noted these on Heim's system will effectively involve proportional quantification over farmer-donkey pairs: most such pairs such that the farmer owns the donkey must be such that he beats it. But this is clearly not right. To take her example suppose 1 farmer is rich but cruel and beats all 200 donkeys he owns. The other 99 farmers do not beat their single donkey. Clearly (13-a) is false. It involve counting of farmers not farmer donkey pairs. Same for (b).

Notice that the problem here arises from an otherwise plausible lexical entry (given Heim's system) for 'most'/'usually', along the lines of:

Heimian update rule for 'most'

$F\big[\text{Most/Usually } \phi\, \psi\big] = \{\langle g, w\rangle \in F : \text{for most } \langle g', w\rangle \in F[\phi] \text{ such that } g' \geq g, \text{ there is a } \langle g'', w\rangle \in F[\phi][\psi] \text{ such that } g'' \geq g'\}$

The issue here is not just with ‘most’, as Chierchia points out:

(14) At least two farmers who own a donkey beat it.

This should be false in our scenario of the rich but cruel farmer, but comes out true on Heim's semantics.

Universal vs. existential readings

As we saw, Heim's treatment of (3-a) is effectively universal quantification over farmer-donkey paris. But that seems too strong in other cases:

(15) a. Every person who had a credit card used it to pay the bill. (Cooper)
b. Everyone person who has a dime will put it in the meter. (Pelletier and Schubert)

What we get in this case is called an Existential Reading – as opposed to the apparently Universal one found in (3-b), and which Heim predicts.

Similar variation appears to be attested with other quantifiers, though it has been claimed that there are preferences for Universal vs. Existential depending on the quantifier.

(16) a. No father who has a teenage son lends him the car on weekdays. (Rooth 1987)
existential
b. No one who has an umbrella leaves it at home on a day like this. (Chierchia)
universal

next time

More on these problems and possible fixes.

References

Robin Cooper. The interpretation of pronouns. In F. Heny and H. Schnelle, editors, *Syntax and Semantics 10: Selections from the Third Gröningen Round Table*, pages 61–122. Academic Press, 1979.

Gareth Evans. Pronouns, quantifiers and relative clauses. *Canadian Journal of Philosophy*, 7:467–536, 1977.

Irene Heim. E-type pronouns and donkey anaphora. *Linguistics and Philosophy*, 13:137–177, 1990.

David Lewis. Adverbs of quantification. In Edward L. Keenan, editor, *Formal Semantics of Natural Language*. Cambridge University Press, 1975.