

Semantics of Relative Clauses in Categorical Grammar

First, recall the basic semantics for a sentence like ‘Every girl met John’:

$$(1) \quad \boxed{\begin{array}{c} \begin{array}{ccc} \frac{\text{every}}{(S/(S\backslash NP))/N} & \frac{\text{girl}}{N} & \frac{\text{met}}{(S\backslash NP)/NP} & \frac{\text{John}}{NP} \\ \lambda p \lambda q. \forall x [p(x) \rightarrow q(x)] & \lambda x. \text{girl}'(x) & \lambda x \lambda y. \text{met}'(x)(y) & \text{john}' \end{array} \\ \hline \begin{array}{ccc} S/(S\backslash NP) & & S\backslash NP & \\ \lambda q. \forall x [\text{girl}'(x) \rightarrow q(x)] & & \lambda y. \text{met}'(\text{john}')(y) & \end{array} \\ \hline S \\ \forall x [\text{girl}'(x) \rightarrow \text{met}'(\text{john}')(x)] \end{array}} \rightarrow$$

The way to think of this is that ‘every’ expresses a relation between the *two properties* that fill its two slots:

- The property of being a girl, or $\lambda x. \text{girl}'(x)$, contributed by ‘girl’. This fills the blue slot.
- The property of being someone that met John, or $\lambda y. \text{met}'(\text{john}')(y)$, contributed by ‘met John’. This fills the red slot.

The category of ‘every’ says that it looks for an N, then a $S\backslash NP$. Both of these syntactic categories correspond to the semantic type $e \rightarrow t$; that is, properties, or functions from entities to truth values. The meaning of ‘every’ tells us which particular relation holds between the two provided properties it expresses: it says that everything that has the first property (the one that fills the blue slot), also has the second property (the one that fills the red slot).

Now consider the more complicated sentence with a relative clause added:

$$(2) \quad \text{Every girl who saw Bill met John}$$

In this sentence, the first property is now the property of being a girl who saw Bill, or “being a girl *and* being someone that saw Bill”, which is represented by:

$$(3) \quad \lambda x. \text{girl}'(x) \wedge \text{saw}'(\text{bill}')(x)$$

So the “big picture” of the derivation of (2) has exactly the same shape as the derivation in (1). The first property we give to ‘every’, filling the blue slot, is just bigger and more complicated:

$$(4) \quad \boxed{\begin{array}{c} \begin{array}{ccc} \frac{\text{every}}{(S/(S\backslash NP))/N} & \frac{\text{girl who saw Bill}}{N} & \frac{\text{met}}{(S\backslash NP)/NP} & \frac{\text{John}}{NP} \\ \lambda p \lambda q. \forall x [p(x) \rightarrow q(x)] & \lambda x. \text{girl}'(x) \wedge \text{saw}'(\text{bill}')(x) & \lambda x \lambda y. \text{met}'(x)(y) & \text{john}' \end{array} \\ \hline \begin{array}{ccc} S/(S\backslash NP) & & S\backslash NP & \\ \lambda q. \forall x [\text{girl}'(x) \wedge \text{saw}'(\text{bill}')(x) \rightarrow q(x)] & & \lambda y. \text{met}'(\text{john}')(y) & \end{array} \\ \hline S \\ \forall x [\text{girl}'(x) \wedge \text{saw}'(\text{bill}')(x) \rightarrow \text{met}'(\text{john}')(x)] \end{array}} \rightarrow$$

Now our task is to show that we can put together ‘girl who saw Bill’ into a chunk with category N and the semantics in (3). This happens as follows:

$$(5) \quad \boxed{\begin{array}{c} \frac{\frac{\frac{\text{girl}}{N} \quad \frac{\frac{\text{who}}{(N \setminus N)/(S \setminus NP)} \quad \frac{\frac{\frac{\text{saw}}{(S \setminus NP)/NP} \quad \frac{\text{Bill}}{NP}}{\lambda x \lambda y. \text{saw}'(x)(y)}}{\lambda p \lambda q \lambda z. q(z) \wedge p(z)}}{\lambda y. \text{saw}'(\text{bill}')(y)}}{\lambda z. \text{girl}'(z) \wedge \text{saw}'(\text{bill}')(z)}}{\lambda z. \text{girl}'(z) \wedge \text{saw}'(\text{bill}')(z)}} \end{array}}$$

The way to think of this is that ‘who’ combines with *two properties* that fill its two slots:

- The property of being someone that saw Bill, or $\lambda y. \text{saw}'(\text{bill}')(y)$, contributed by ‘saw Bill’. This fills the orange slot.
- The property of being a girl, or $\lambda x. \text{girl}'(x)$, contributed by ‘girl’. This fills the green slot.

What ‘who’ does with these two properties is tie them together into one, new, bigger property with the ‘and’ symbol (\wedge).

Extra: Modification via adjectives

Now consider an analogous sentence where ‘girl’ is modified not by a relative clause (‘who saw Bill’), but by an adjective (‘tall’):

(6) Every tall girl saw Bill

As in Homework 1, an adjective like ‘tall’ (or ‘big’, or ‘red’) has syntactic type N/N, so the first property that will be given to ‘every’ gets put together like this:

$$(7) \quad \boxed{\frac{\frac{\text{tall}}{N/N} \quad \frac{\text{girl}}{N}}{N} >}$$

Try to derive the following as the meaning of the sentence in (6):

(8) $\forall x[(\text{girl}'(x) \wedge \text{tall}'(x)) \rightarrow \text{saw}'(\text{bill}')(x)]$

Remember that since ‘tall’ has syntactic type N/N, it will have as its semantic type $(e \rightarrow t) \rightarrow (e \rightarrow t)$, i.e. it is a function from properties to properties.