Pronouns and variable binding

1 Pronouns

Recall the "free" vs "bound" terminology for variables. This is useful for natural language sentences as well:

(1) a. John likes Mary. — a sentence with no variables; not assignment-sensitive

b. John likes him. — a sentence with a variable; assignment-sensitive

c. Every boy likes himself. — a sentence with a variable; *not* assignment-sensitive

We'll formalize this by giving each pronoun a numerical *index*. Let's call the mapping between free variables and their values *assignment*. We'll compute denotations relative to an *assignment function*, which is a function from the set of indices ($\mathbb{N}$) to D_e.

(2) **Pronouns Rule (to be replaced later):**
If α is a pronoun, g is a variable assignment, and $g(i)$ is defined, then $[\![\alpha_i]\!]^g = g(i)$.

(3) Suppose g is a function and $g(3) = \text{Sam} \in D_e$.

a. $[\![\text{him}_3]\!]^g = \text{Sam}$

b. $[\![\text{John likes him}_3]\!]^g = 1$ iff John likes Sam

Q: Does it matter what g returns for other values in (3)?
A: No. It might even be undefined for other values.

Q: Why did we use 3? Does the number matter?
A: The choice of number was arbitrary, but it is important whether or not we reuse numbers:

(4) a. He_2 thinks that he_2 is smart.

b. He_2 thinks that he_7 is smart.

Q: Does the assignment function affect other parts of the sentence?
A: No. "John" and "likes" are *constants*, meaning their values are the same no matter the assignment: for any assignment function f, $[\![\text{John}]\!]^f = \text{John}$.

Warning: There's a section of H&K (pp. 92–109) where they just use notation like $[\![\text{him}]\!]^{\text{John}} = \text{John}$, which only accommodates one variable at a time, but then they introduce their actual notation on page 110, which we use here.

2 Rules with assignments

In order to work with assignment functions, we need to modify all our existing rules so that they pass assignment functions. These definitions are based on H&K p. 95:

(5) **Terminal Nodes (TN):** (unchanged)
If α is a terminal node, $[\![\alpha]\!]$ is specified in the lexicon.[1]

(6) **Non-branching Nodes (NN):**
If α is a non-branching node, and β is its daughter node, then, for any assignment g, $[\![\alpha]\!]^g = [\![\beta]\!]^g$.

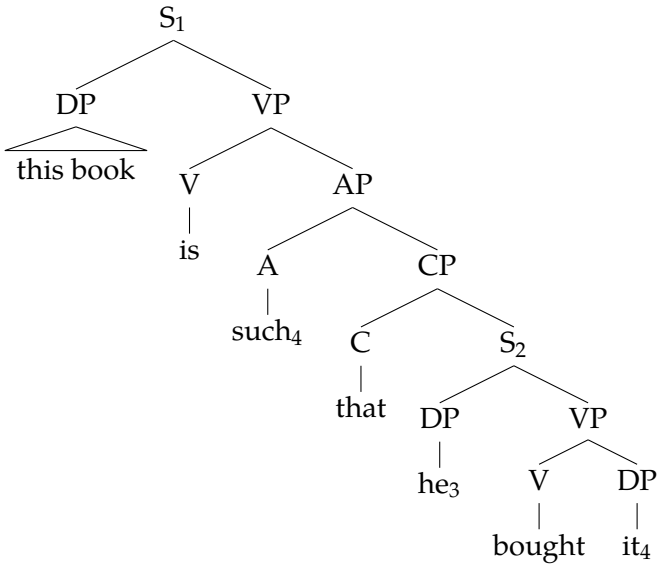
(7) **Functional Application (FA):**
If α is a branching node, $\{\beta, \gamma\}$ is the set of α's daughters, then, for any assignment g, if $[\![\beta]\!]^g$ is a function whose domain contains $[\![\gamma]\!]^g$, then $[\![\alpha]\!]^g = [\![\beta]\!]^g([\![\gamma]\!]^g)$.

(8) **Predicate Modification (PM):**
If α is a branching node, $\{\beta, \gamma\}$ is the set of α's daughters, then, for any assignment g, if $[\![\beta]\!]^g$ and $[\![\gamma]\!]^g$ are both of type $\langle e, t\rangle$, then $[\![\alpha]\!]^g = \lambda x \in D_e \,.\, [\![\beta]\!]^g(x) = 1$ and $[\![\gamma]\!]^g = 1$.

3 *Such that* relatives

The English expression *such that* allows us to construct relative clauses without movement.[2]

(9) ? This book is such$_4$ that he$_3$ bought it$_4$. ($g(3)$ = John)



[1] H&K proposes (p. 94) to still use $[\![\alpha]\!]$ without an assignment function superscript for *constants*, i.e. if $[\![\alpha]\!]^g$ is the same value for all assignment functions g.

[2] Unfortunately, the use of *such that* sounds "unlyrical" (Quine, 1960, §23)... but we'll ignore that here.

Here, (9) does not seem assignment-dependent. But the Principle of Compositionality states that $[\![S_1]\!]$ be computed based on the meaning of $[\![S_2]\!]$, which contains a pronoun and *is* assignment-dependent.

Idea: *Such* binds *it*, doing the work of creating a *predicate* out of the assignment-dependent sentence "John bought it."

(10) ***Such* Rule (temporary):**[3]
$[\![\text{such}_i\ \gamma]\!]^g = \lambda x_e\ .\ [\![\gamma]\!]^{[i \mapsto x]||g}$

$[i \mapsto x] \,||\, g$ is the *combination* of functions $[i \mapsto x]$ and g:

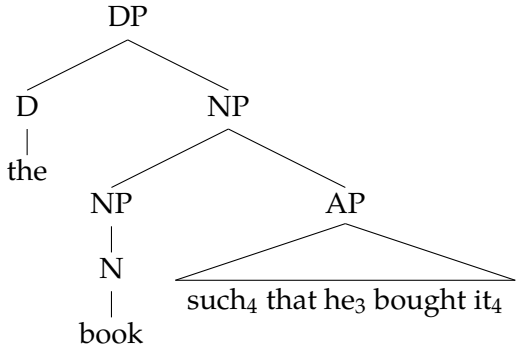
(11) **Definition: function combination**
$$f \,||\, g \equiv \lambda x\ .\ \begin{cases} f(x) & \text{if } x \in \text{domain}(f) \\ g(x) & \text{otherwise} \end{cases}$$
Read "f or else g."

Let's compute $[\![S_1]\!]^g$ with the following global assignment function: $g = \begin{bmatrix} 3 \mapsto \text{John} \\ 11 \mapsto \text{Tama} \end{bmatrix}$.
Assume $[\![\text{that}]\!] = \text{Id}$.

Warning: H&K uses $g^{x/i}$ notation for $[i \mapsto x] \,||\, g$, but I think it's confusing so I don't use it.[4]
We can also use *such that* to construct (slightly awkward) *relative clauses*:

(12) ? the book such$_4$ that he$_3$ bought it$_4$

The semantics for *such* above works perfectly fine here.



[3] "Such" does not have a type. That's why it can only be interpreted using the *Such* Rule.
[4] For one, I've also seen very similar notation "$g(x/a)$" for a function that maps x to a, which is the reverse of what H&K mean in their x/i.

4 Binding more or less than one variable

Binding multiple variables:

(13) ? This book is such$_4$ that he$_3$ bought it$_4$ and then gave it$_4$ to Sarah.

(14) ? every book such$_4$ that he$_3$ bought it$_4$ and then gave it$_4$ to Sarah

Binding no variables (vacuous binding):

(15) * This book is such$_4$ that today is Monday.

(16) * every book such$_4$ that today is Monday

The ungrammaticality of these examples shows that binding *no* variables is disallowed by the grammar. This is called *vacuous binding*.

5 Traces & Pronouns

(17) **The interpretation of movement (revised):** replaces the previous movement rule
Pick an arbitrary index i.

a. The base position of movement is replaced with a *trace* with index i: t_i.

b. A *binder index i* is adjoined right under the target position of the movement chain.

(18) **Traces and Pronouns Rule (T&P):** replaces Pronouns Rule in (2)
If α is a pronoun or trace, g is a variable assignment, and $g(i)$ is defined, then $[\![\alpha_i]\!]^g = g(i)$.

(19) **Predicate Abstraction (PA):** (H&K p. 186 version)
replaces previous rule for λ nodes in the tree and the *Such* Rule (10)[5]
Let α be a branching node with daughters β and γ, where β dominates only a numerical index i. Then, for any assignment g, $[\![\alpha]\!]^g = \lambda x\ .\ [\![\gamma]\!]^{[i \mapsto x]||g}$.

We can use T&P and PA to compute a relative clause like (20). See tree on next page.

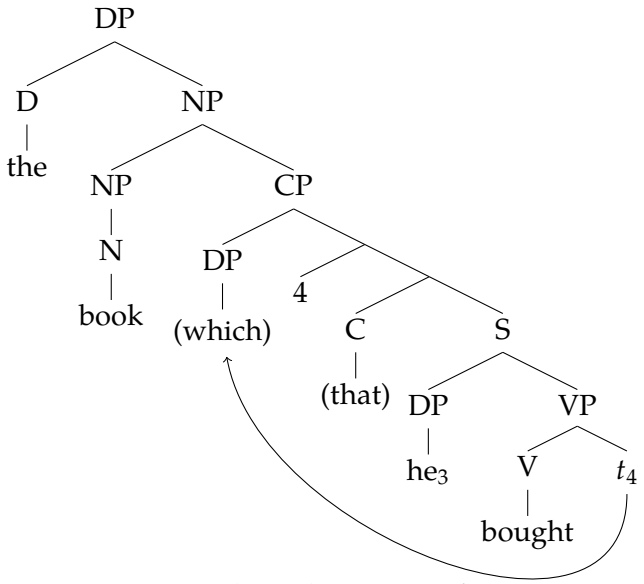
(20) the/every book that he$_3$ bought ___ (he_3 is free)

A motivation for thinking that traces and pronouns really are deeply related is the fact that relative clauses can simultaneously bind both traces and pronouns:

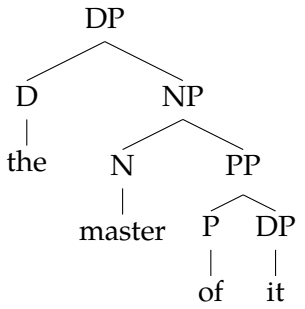
(21) the/every dog that greeted its(/his/her) master (Heim and Kratzer, 1998, p. 245)

Exercise: Compute (20) and (21).

[5]We can think of "such" as the pronunciation of a lexicalized binder index, not generated through movement.



Assume that "its master" is represented as "the master of it":



6 Variable binding

Quantifiers can also bind pronouns:

(22) Every boy loves his mother.
'Every boy is such that (x loves x's mother).'

(23) No man noticed the snake next to him. (Heim and Kratzer, 1998, p. 201)
'No man is such that (x noticed the snake next to x).'

Exercise: Compute (22) or (23). Notice that the VP-internal subject hypothesis makes a contribution.

Now consider the possible readings of (24):

(24) A friend of his upset every boy.

a. 'There is a friend of y that upset every boy.' (*his* = y free)
LF: [A friend of his$_5$] [7 [every boy] [6 t_7 upset t_6]]

b. 'For every boy x, a friend of y upset x.' (*his* = y free)
LF: [Every boy] [3 [a friend of him$_5$] upset t_3]

c. 'For every boy x, a friend of x upset x.' (*his* bound)
LF: [Every boy] [3 [a friend of him$_3$] upset t_3]

► There is no surface scope reading (a friend > every boy) where *his* is bound.

7 Variable binding and scope

The examples in this section are from Fox (1999, p. 160), citing Lebeaux (1995).

(25) a. [At least one soldier]$_1$ seems (to Napoleon) [t_1 to be likely t_1 to die in every battle].
$^{\checkmark}\forall > \exists$, $^{\checkmark}\exists > \forall$

b. [One soldier] is expected (by Napoleon) [t to die in every battle]. $^{\checkmark}\forall > \exists$, $^{\checkmark}\exists > \forall$

We could imagine the scope ambiguities above could involve (a) long QR of *every battle* and/or (b) reconstruction of the subject into a lower trace position. But notice:

(26) a. [At least one soldier]$_1$ seems to himself$_1$ [t_1 to be likely t_1 to die in every battle].
$^{*}\forall > \exists$, $^{\checkmark}\exists > \forall$

b. [At least one soldier]$_1$ seems to his$_1$ commander(s) [t_1 to be likely t_1 to die in every battle]. $^{*}\forall > \exists$, $^{\checkmark}\exists > \forall$

c. [One soldier]$_1$ is expected by his$_1$ commander(s) [t_1 to die in every battle].
$^{*}\forall > \exists$, $^{\checkmark}\exists > \forall$

► Variable binding requires the binding quantifier to take scope above the pronoun, restricting possibilities for scope-taking.

References

Fox, Danny. 1999. Reconstruction, binding theory, and the interpretation of chains. *Linguistic Inquiry* 30:157–196.

Heim, Irene, and Angelika Kratzer. 1998. *Semantics in generative grammar*. Malden, Massachusetts: Blackwell.

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Quine, Willard Van Orman. 1960. *Word and object*. Cambridge.