Anaphoric Uses of Relative Pronouns

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1. Introduction

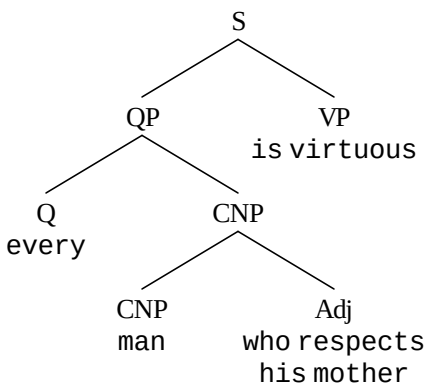
Recall that the restrictive-relative-clause functor RRCF – which is variously spelled, but whose canonical spelling is `'that'` – is categorially rendered as follows.

$$\begin{aligned} \text{type(RRCF)} &= \text{VP}\rightarrow\text{Adj} \\ &=_{df} (\text{N}\rightarrow\text{S})\rightarrow[(\text{N}_0\rightarrow\text{S})\rightarrow(\text{N}_0\rightarrow\text{S})] \end{aligned}$$

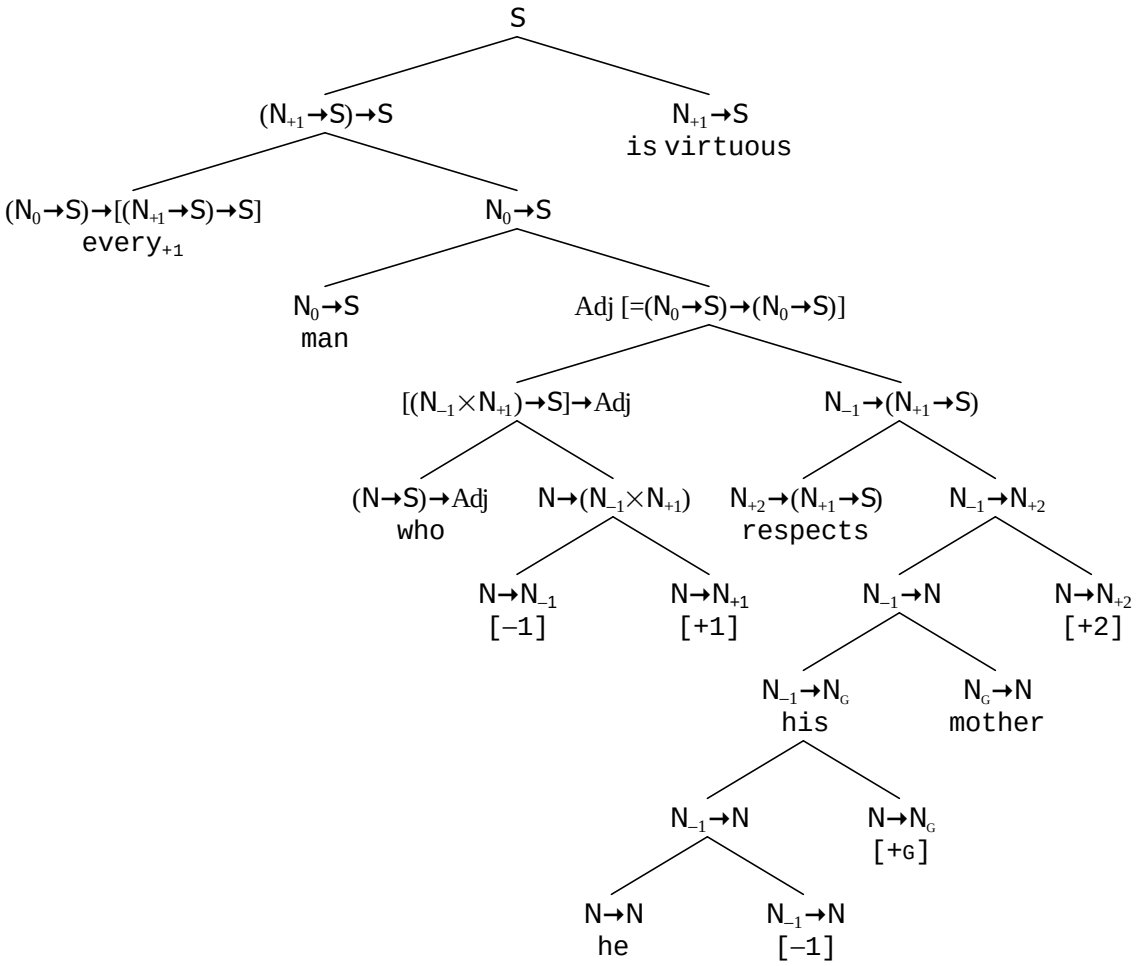
We now consider how this functor interacts with standard-anaphoric pronouns. Consider the following simple example.

`every man who respects his mother is virtuous`

Although there are other readings of this sentence, let us concentrate on the salient one, according to which the pronoun stem `'he'` is anaphoric to a phrase present in the example. The question of course is – what is `'he'` anaphoric to? If we insist that the antecedent of a pronoun [i.e., pro-NP] is an NP, then `'he'` must be anaphoric to `'every man'`, or to `'every man who respects his mother'`. The latter can be ruled out, since a pronoun cannot be anaphoric to a phrase that contains it. The former can be ruled out, since `'every man'` is not a constituent of the above sentence, as we see in the following syntactic-tree.



What we have instead is that 'he' is anaphoric to 'who', which is accordingly regarded as an honorary NP. Categorially speaking, however, these concerns are largely irrelevant, as we immediately see when we construct the categorial diagram.



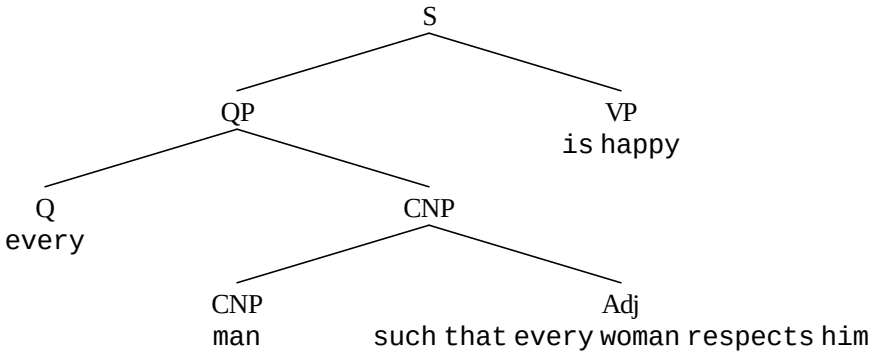
We observe that, according to this analysis, 'he' is not officially anaphoric to 'man', but is still governed by it with respect to person, number, and gender. We can account for number-agreement and gender-agreement in the semantics. For example, in the semantic treatment of gender and number, ⟦he⟧ is the identity-function restricted to male individuals (singular-entities), which percolates up in the semantic tree, to the point at which we obtain an adjective-object that is restricted to male individuals, which can be validly applied to ⟦man⟧. On the other hand, ⟦she⟧ is the identity-function restricted to female individuals, which percolates up the tree to the point at which we obtain an adjective-object that cannot be validly applied to ⟦man⟧, which results in semantic ill-formedness.

2. 'Such That'

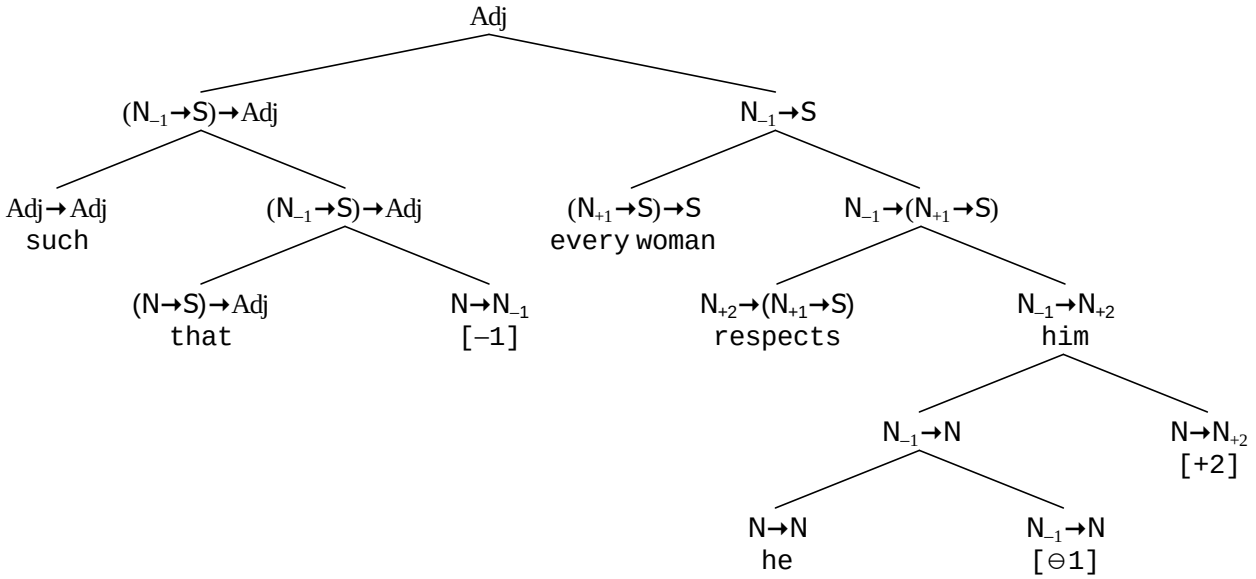
The phrase 'such that' appears in philosophical and linguistic discourse, although it is neither colloquial nor poetic. In this section, we consider how this phrase works within the framework of categorial grammar. The following is a typical example, which also illustrates its colloquial awkwardness.

every man such that every woman respects him is happy

The following is a fairly natural syntactic analysis.



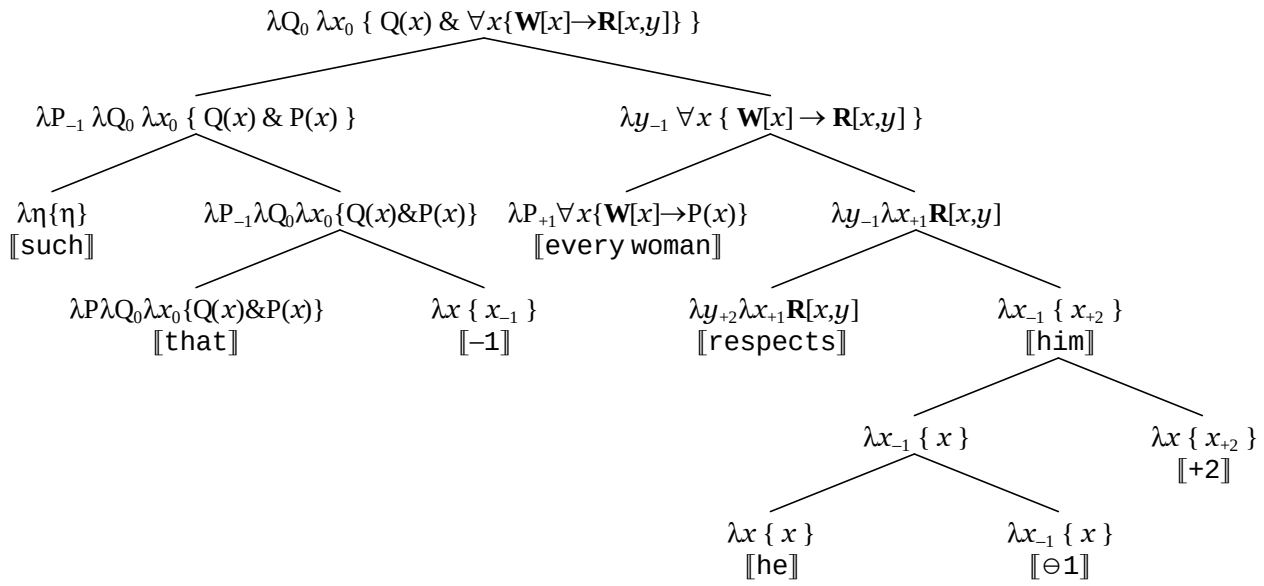
The obvious remaining question is – how do we analyze the phrase 'such that every woman respects him'? We propose that 'such that' is a functor that takes an open-sentence and delivers an adjective.[1] This is achieved categorially by continuing to treat 'that' as the canonical restrictive-relative-clause functor, as before, and treating 'such' as an essentially-anaphoric [empty] pro-adjective. This yields the following categorial tree.



Note carefully that the above analysis employs the non-duplicating version of [–1], given the peculiar nature of 'that' and 'such that'.

The following is the associated semantic tree.

[1] This rules out "autistic" phrases such as 'such that snow is white' and 'such that 2+2=4', which are regarded as acceptable by some logicians, but are bizarre at best.



3. Restrictive versus Non-Restrictive Relative Clauses

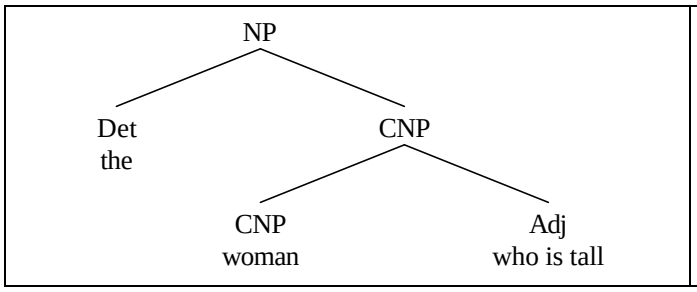
We have already discussed restrictive relative clauses at length. In the next few sections, we discuss non-restrictive relative clauses. The following pairs illustrate the difference.

(r1) `the woman-who-is-tall`
(r2) `there is exactly one woman-who-is-tall`

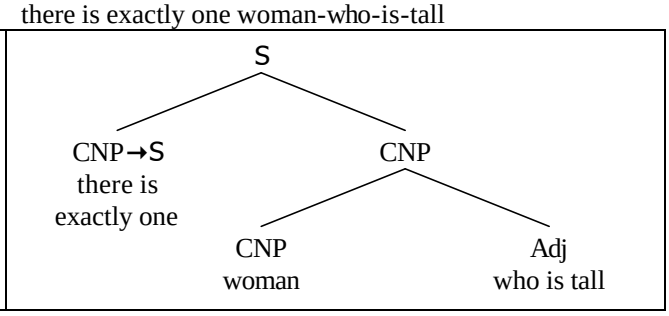
(n1) `the woman … who is tall`
(n2) `there is exactly one woman … who is tall`

The exaggerated punctuation has been included to accentuate the difference. In the first pair, `'woman who is tall'` forms a constituent, but not in the second pair, in which there is a definite logical/phonological break between `'woman'` and `'who'`. Semantically speaking, in the first case, there may be many women in the relevant situation, but exactly one of them is tall. In the second case, there is exactly one woman in the situation, and she is tall. The overall syntactic structures are given as follows.

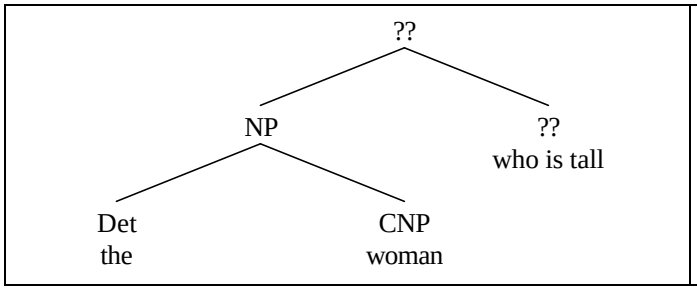
the woman-who-is-tall



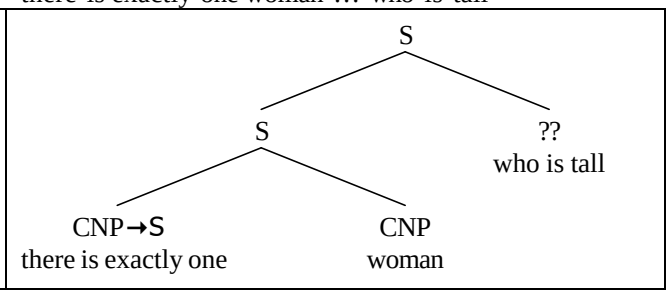
there is exactly one woman-who-is-tall



the woman … who is tall



there is exactly one woman … who is tall



4. Adjectives Revisited

At this point, since we treat restrictive relative clauses as a species of adjective, it is useful to reconsider adjectives. Adjectives are modifiers. A **modifier** – more specifically, a K-modifier – is a functor of type K→K. An **adjective** is a noun-modifier.

Since there are two kinds of nouns – proper-nouns and common-nouns – there are in principle two kinds of adjectives. On the one hand, an ordinary noun is a **common-noun adjective**, which has the following type.

$$\begin{array}{lll} \text{type(CN-Adj)} & = & \text{CNP}\rightarrow\text{CNP} \\ & =_{df} & (\mathsf{N}_0\rightarrow\mathsf{S})\rightarrow(\mathsf{N}_0\rightarrow\mathsf{S}) \end{array}$$

Recall that N_0 is a null-inflected proper-noun-phrase, the inflection of which distinguishes it from an uninflected VP $[\mathsf{N}\rightarrow\mathsf{S}]$, and from a θ-inflected VP $[\mathsf{N}_\theta\rightarrow\mathsf{S}]$.

In addition to common-noun adjectives, there are **proper-noun adjectives**, which are categorially rendered as follows.

$$\begin{array}{lll} \text{type(PN-Adj)} & = & \bar{\mathsf{N}}\rightarrow\bar{\mathsf{N}} \\ & = & (\mathsf{N}\rightarrow\mathsf{S})\rightarrow(\mathsf{N}\rightarrow\mathsf{S}) \end{array}$$

Notice that this type is an **allomorph**[2] of the earlier type, so the difference between them can easily go undetected. Notice also that the proposed type does not look exactly like a proper-noun modifier. It is accordingly useful to transform it as follows.[3]

$$\begin{array}{lll} (\mathsf{N}\rightarrow\mathsf{S})\rightarrow(\mathsf{N}\rightarrow\mathsf{S}) & \equiv & \mathsf{N}\rightarrow[(\mathsf{N}\rightarrow\mathsf{S})\rightarrow\mathsf{S}] \\ & \equiv & \mathsf{N}\rightarrow\text{QP} \end{array}$$

In this guise, the functor takes a proper-noun phrase and delivers a QP, which is dual to a proper-noun phrase. See later examples for how this works in practice.

The obvious question is whether there are any proper-noun adjectives. I think there are, as illustrated in the following simple examples.

evil Bart
curious George

Here, it is fairly clear that the adjectives modify proper-nouns. The following examples are more interesting, since they are ambiguous.

the industrious Chinese
the stupid president

The first one is well-known, but is perhaps a little bit out of date.[4] It also involves a plural term, which we prefer to avoid when we can. So let us concentrate on the second example, which is singular and up to date.

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[2] Two types are **allomorphs** (of each other) precisely when they are identical except for the inflectional subscripts. For example, common-noun phrases $[\mathsf{N}_0\rightarrow\mathsf{S}]$ and verb phrases $[\mathsf{N}_\theta\rightarrow\mathsf{S}]$ are allomorphs.

[3] This corresponds to the logical principle of permutation. $A\rightarrow(B\rightarrow C)\equiv B\rightarrow(A\rightarrow C)$.

It is evident that it is ambiguous between the following readings involving relative clauses – in one case, restrictive; in the other case, non-restrictive.

the president-who-is-stupid
the president, who is stupid

For example, in the first case, we are talking about a collection of presidents, and we are referring to the stupid one. On the other hand, in the second case, we are talking about exactly one president, who we are (parenthetically) remarking is stupid.

We next note that our earlier examples of proper-noun modifiers can be paraphrased using non-restrictive relative clauses.

Bart (who is evil)
George (who is curious)

5. Initial Proposal

We propose the following parallel.

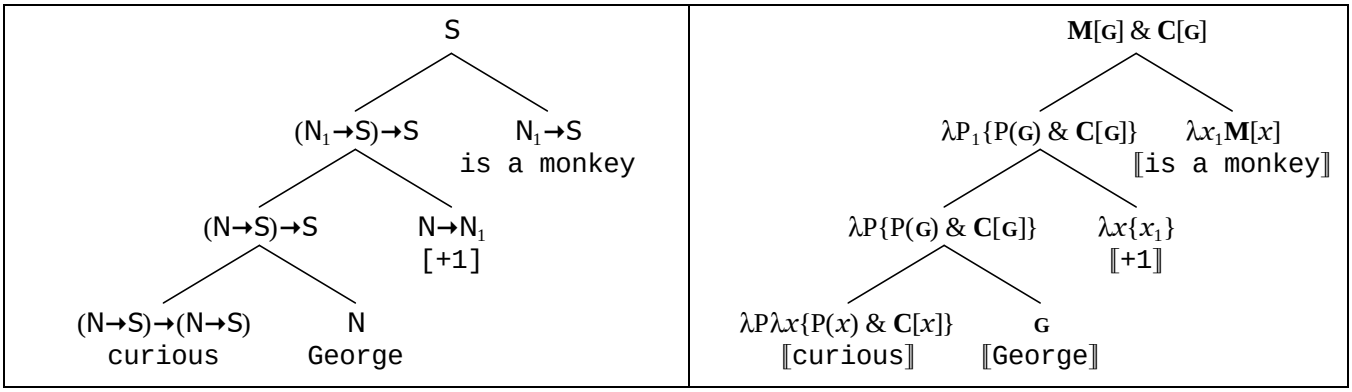
common-noun adjectives	≈	restrictive relative clauses
proper-noun adjectives	≈	non-restrictive relative clauses

In particular, we propose the following categorial identities.

type(NRCF)	=	VP → CN-Adj
	$=_{df}$	$(N \rightarrow S) \rightarrow [(N_0 \rightarrow S) \rightarrow (N_0 \rightarrow S)]$
type(RRCF)	=	VP → PN-Adj
	$=_{df}$	$(N \rightarrow S) \rightarrow [(N \rightarrow S) \rightarrow (N \rightarrow S)]$

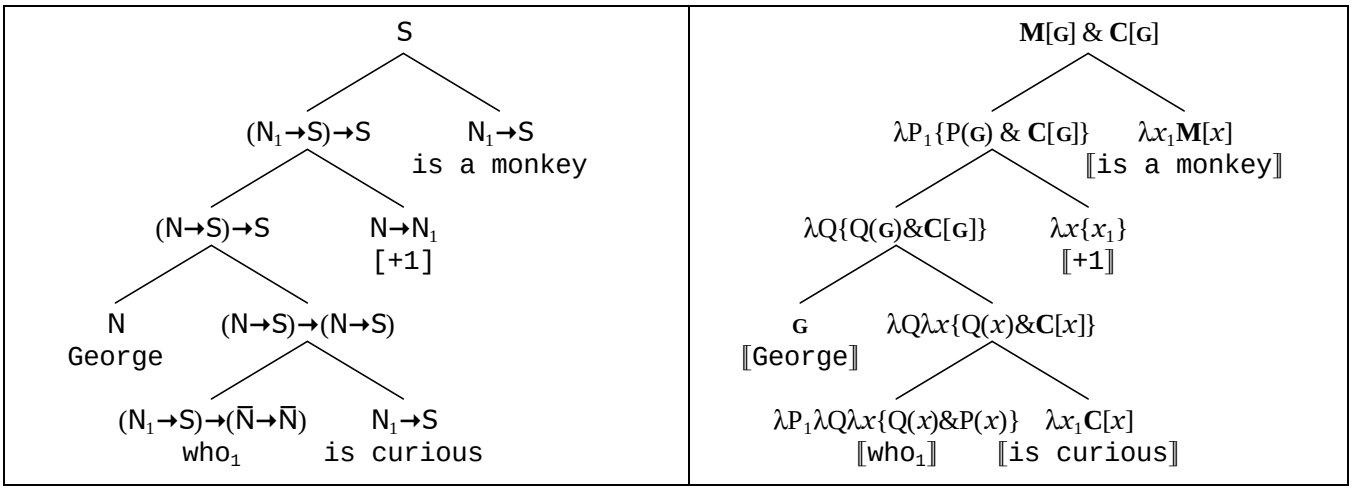
6. Examples

1. `curious George is a monkey`

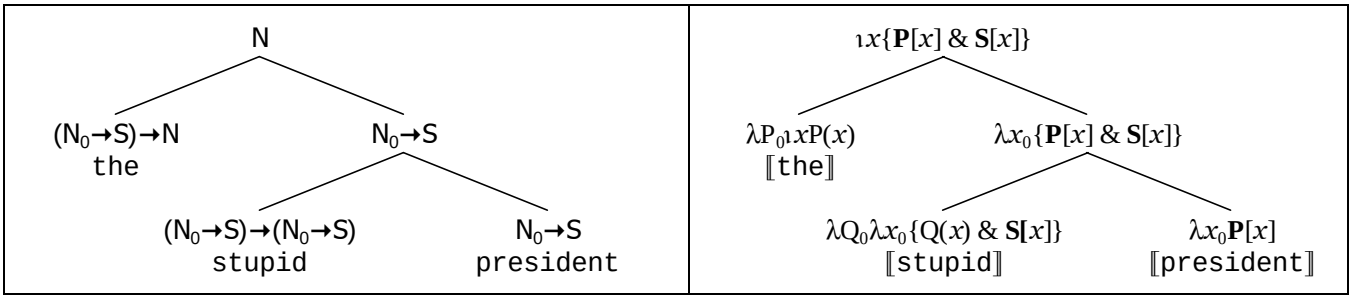


[4] It is not that the Chinese are no longer thought to be industrious. Rather, it is no longer considered politically-correct to stereotype groups.

2. George, who is curious, is a monkey

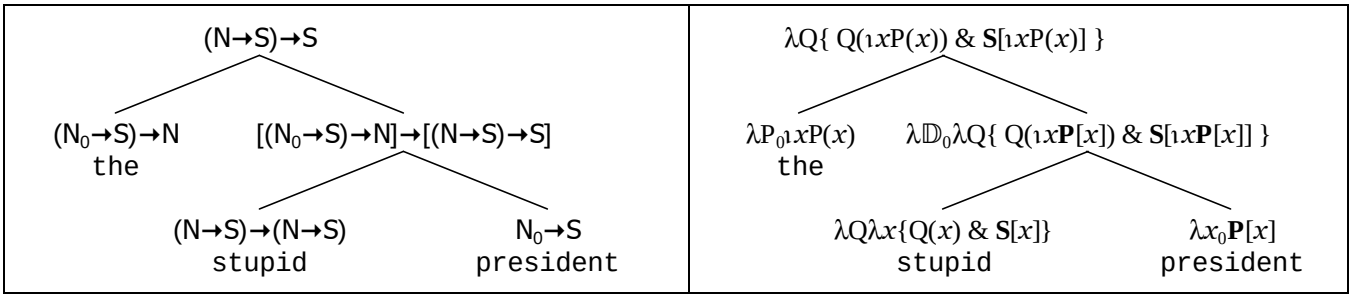


3. the stupid president



Here, the adjective 'stupid' is a common-noun-phrase modifier – or alternatively speaking, it is restrictive.

4. the stupid president



Here, the adjective 'stupid' is a proper-noun-phrase modifier – or alternatively speaking, it is non-restrictive. The bottom composition is underwritten by the following derivation.

(1)	$(N\rightarrow S)\rightarrow(N\rightarrow S)$	1	Pr	$\lambda Q\lambda x\{Q(x)$ & $\mathbf{S}[x]\}$
(2)	$N_0\rightarrow S$	2	Pr	$\lambda x_0\mathbf{P}[x]$
(3)	$(N_0\rightarrow S)\rightarrow N$	3	As	$\lambda P_0\imath xP(x)$
(4)	$N\rightarrow S$	4	As	Q
(5)	$N\rightarrow S$	14	1,4,$\rightarrow$O	$\lambda x\{Q(x)$ & $\mathbf{S}[x]\}$
(6)	N	23	2,3,$\rightarrow$O	$\imath x\mathbf{P}[x]$
(7)	S	1234	5,6,$\rightarrow$O	$Q(\imath x\mathbf{P}[x])$ & $\mathbf{S}[\imath x\mathbf{P}[x]]$
(8)	$\bar{N}_0\rightarrow N$	123	4-7,$\rightarrow$I	$\lambda Q\{ Q(\imath x\mathbf{P}[x])$ & $\mathbf{S}[\imath x\mathbf{P}[x]] \}$
(9)	$\bar{N}_0\rightarrow N.\rightarrow\bar{N}_0\rightarrow N$	12	3-8,$\rightarrow$I	$\lambda\mathbb{D}_0\lambda Q\{ Q(\imath x\mathbf{P}[x])$ & $\mathbf{S}[\imath x\mathbf{P}[x]] \}$

7. The Official Proposal

The above account works well for many situations that arise in which a relative pronoun is used to form a non-restrictive relative clause. Unfortunately, it proposes a somewhat unnatural syntax in the manner in which the case-inflection is deferred. We can perhaps live with this. What is worse, however, is that the above account does not work very well for more complicated cases.

First, it does not easily account for numerical constructions such as the following.

`there is exactly one woman, who is tall`

where the comma inflection indicates that the relative clause is to be understood as non-restrictive.[5]

Second, it does not easily account for complex plural non-restrictive clauses such as the following.

`the senators, every one of whom is honorable, are in session`

A more plausible account of the above sentence proposes that it is equivalent to:

`the senators (`***`and`*** `every one of` ***`them`*** `is honorable) are in session`

where the pronoun-stem `'they'` is anaphoric to `'the senators'`. Or, more generally, but simplifying to singular-terms, the new account proposes that:

`the` *CNP*`, who is` *Adj*`,` *VP*

is equivalent to

`[the` *CNP*`]`$_\alpha$ `(and [he/she/it]`$_\alpha$ `is` *Adj*`)` *VP*

This is not the theory, of course, but only a heuristic for achieving the theory.

We propose the following new categorial analysis of non-restrictive relative pronouns, which is followed by the old analysis, for comparison.

[5] This example turns out to be a major headache, which we treat in the chapter on non-standard anaphoric pronouns.

new	type(wh…)	=	(N→S)→[S→(N→S)]
	⟦wh…⟧	=	λPλΦλx\{ Φ & P(x) \}

old	type(wh…)	=	(N→S)→[(N→S)→(N→S)]
	⟦wh…⟧	=	λPλQλx\{ Q(x) & P(x) \}

Notice how similar the two analyses are. We further note that the new semantic analysis has the following feature.

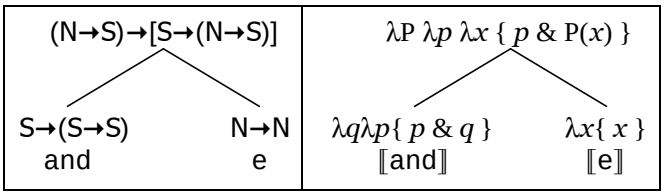
⟦wh…⟧ = ⟦and e⟧

where 'e' serves as the essentially-anaphoric pronoun-root. This underwrites the following semantic equivalence.

Kay, who is virtuous, is happy

Kay, and she is virtuous, is happy

Let's see what happens grammatically when we combine 'and' with 'e'.



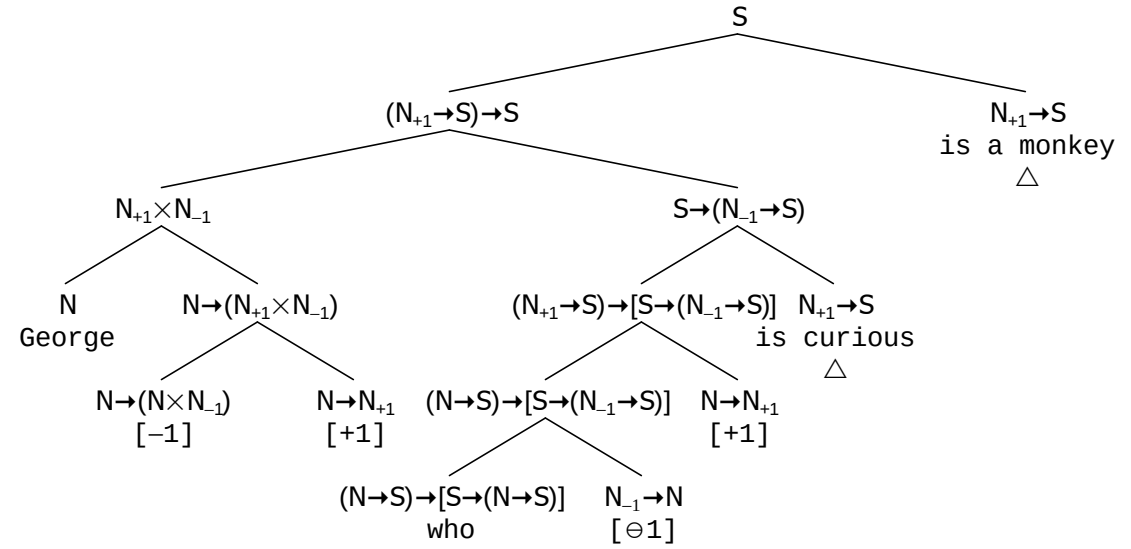
The following is the associated derivation.

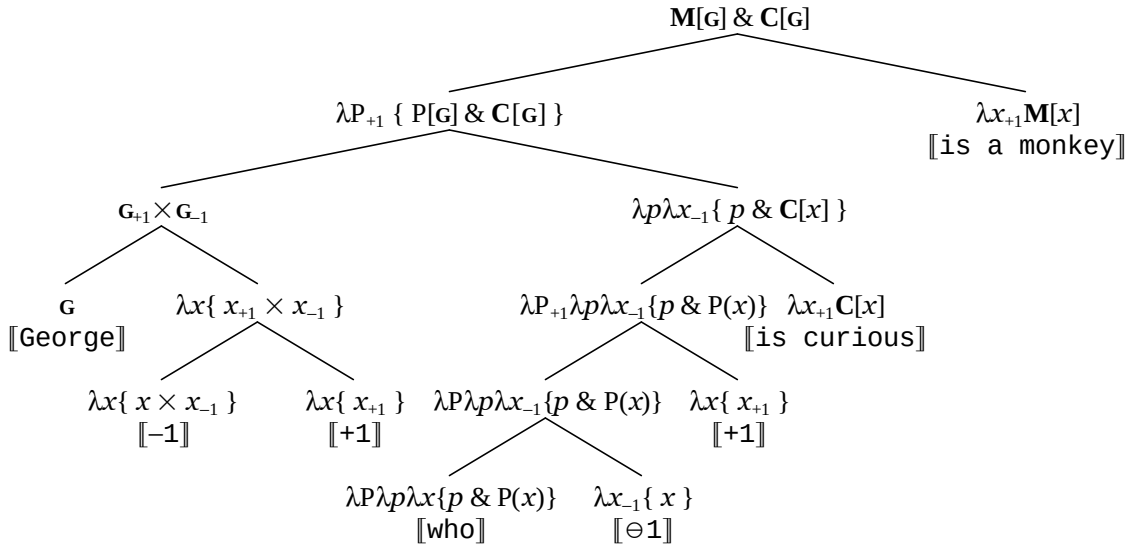
(1)	S→(S→S)	1	Pr	λqλp\{ p & q \}
(2)	N→N	2	Pr	λx\{ x \}
(3)	N→S	3	As	P
(4)	S	4	As	p
(5)	N	5	As	x
(6)	N	25	2,5,→O	x
(7)	S	235	3,6,→O	P(x)
(8)	S→S	1235	1,7,→O	λp\{ p & P(x) \}
(9)	S	12345	4,8,→O	p & P(x)
(10)	N→S	1234	5-9,→I	λx\{ p & P(x) \}
(11)	S→(N→S)	123	4-10,→I	λpλx\{ p & P(x) \}
(12)	(N→S)→[S→(N→S)]	12	3-11,→I	λPλpλx\{ p & P(x) \}

8. Examples

Now, let's see how this type operates *in situ*.

1. George, who is curious, is a monkey





The composition of ⟦George⟧ and ⟦who is curious⟧ is underwritten by the following derivation.

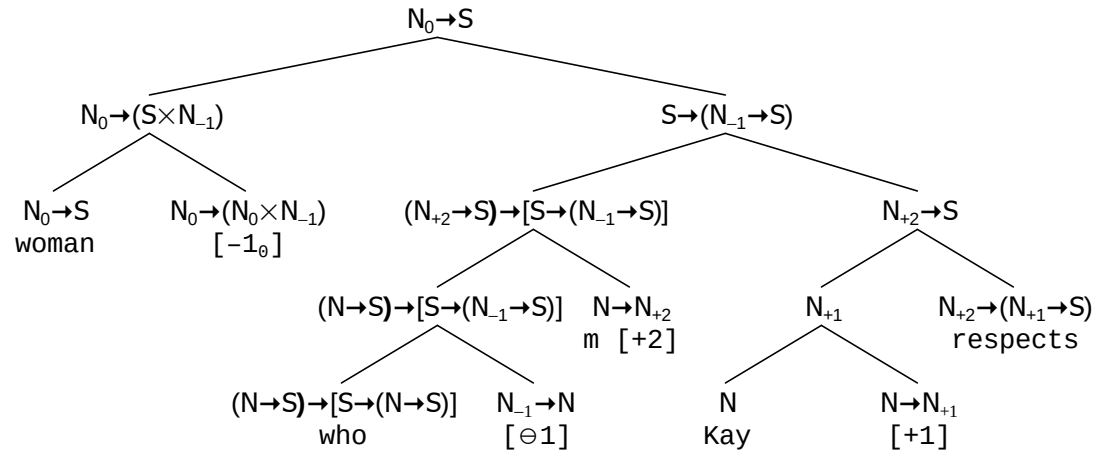
(1)	$S\rightarrow(N_{-1}\rightarrow S)$	1	Pr	$\lambda p\ \lambda x_{-1}\{\ p\ \&\ \mathbf{C}[x]\ \}$	
(2)	$N_{+1}\times N_{-1}$	23	Pr	$\mathbf{G}_{-1}\times\mathbf{G}_{+1}$	
(3)	N_{+1}	2	$2,\times O_1$	$\mathbf{G}_{-1}$	
(4)	N_{-1}	3	$2,\times O_2$	$\mathbf{G}_{+1}$	
(5)	$N_{+1}\rightarrow S$	5	As	P_{+1}	$\lambda x_{+1}P(x)$
(6)	S	35	$4,5,\rightarrow O$	$P(\mathbf{G})$	
(7)	$N_{-1}\rightarrow S$	135	$1,6,\rightarrow O$	$\lambda x_{-1}\ \{\ P(\mathbf{G})\ \&\ \mathbf{C}[x]\ \}$	
(8)	S	1235	$3,7,\rightarrow O$	$P(\mathbf{G})\ \&\ \mathbf{C}[x]$	
(9)	$(N_{+1}\rightarrow S)\rightarrow S$	123	5-8,→I	$\lambda P_{+1}\ \{\ P(\mathbf{G})\ \&\ \mathbf{C}[x]\ \}$	

9. Restrictive Relative Pronouns Revisited

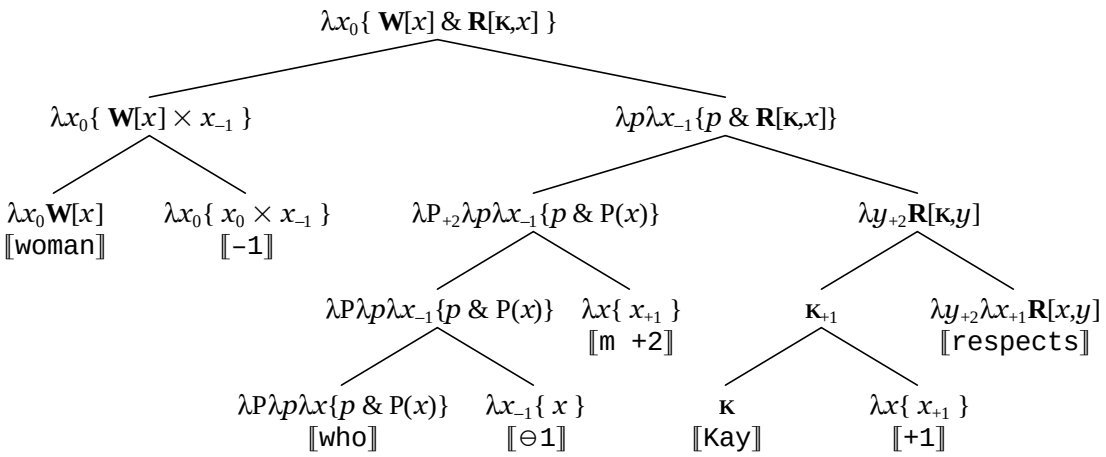
We now revisit restrictive relative clauses, and in particular propose a new treatment according to which they are categorially identical to non-restrictive relative pronouns *and* categorially-anaphoric to their antecedents.[6] Consider the following.

```
woman whom Kay respects
```

As it stands, this is a common-noun phrase, and we have a fairly straightforward analysis of it. But what happens if we syntactically force an anaphoric connection between the common-noun `'woman'` and the relative pronoun `'whom'`, as follows. The following is the associated tree. Note in particular the type of `'who'`.



Notice that the anaphoric closing-inflection [–1] is a bit different from, but still an allomorph of, our earlier account, which is here customized to inflect common-noun phrases.



[6] Note, however, that we are inclined to exclude `'that'` from this treatment, since it is not a pronoun.

10. The Official Proposal for all Relative Pronouns

We now officially propose the following analysis of relative pronouns.

type(wh…)	=	(N→S)→[S→(N→S)]
⟦wh…⟧	=	λPλ*p*λ*x*{ *p* & P(*x*) }

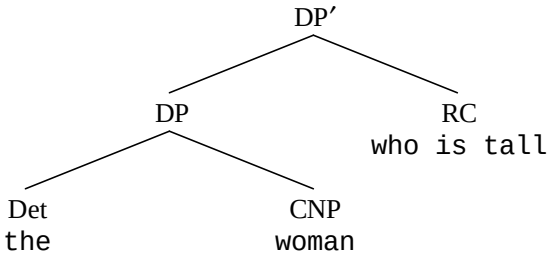
Furthermore, the difference between restrictive and non-restrictive uses resolves to what phrase the pronoun is anaphoric to. In particular:

anaphoric to common-noun phrase	restrictive
anaphoric to proper-noun phrase	non-restrictive

Let us illustrate the proposal using two of our original phrases.

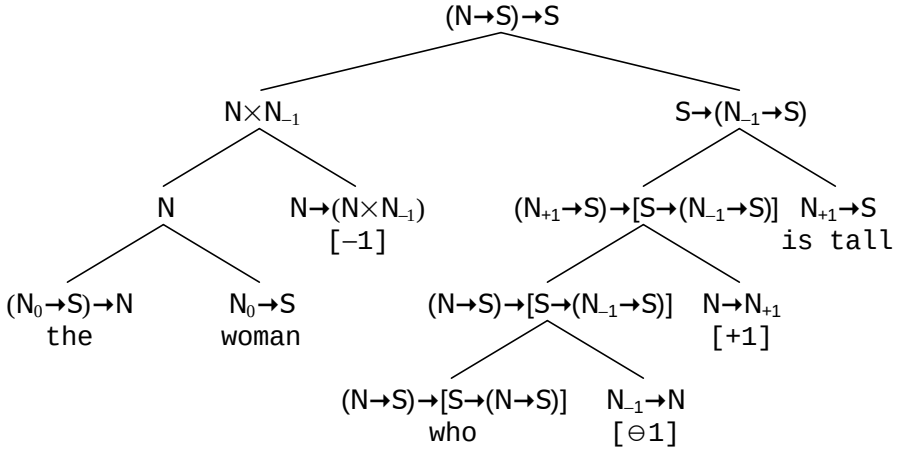
(r1) `the woman-who-is-tall`
(n1) `the woman … who is tall`

We propose in particular that these have the same surface trees.

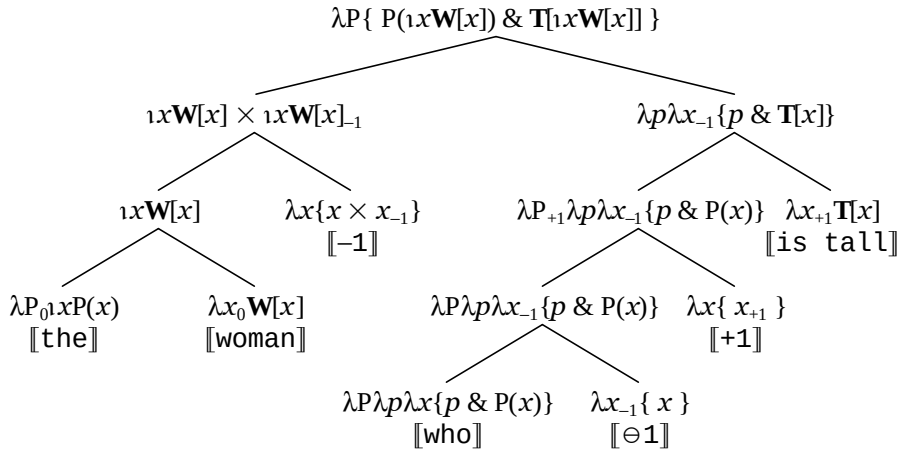


The semantic difference can only be unpacked by specifying the anaphoric dependencies. In particular, if `'who'` is anaphoric to the DP `'the woman'`, then it is non-restrictive. On the other hand, if `'who'` is anaphoric to the CNP `'woman'`, then it is restrictive.

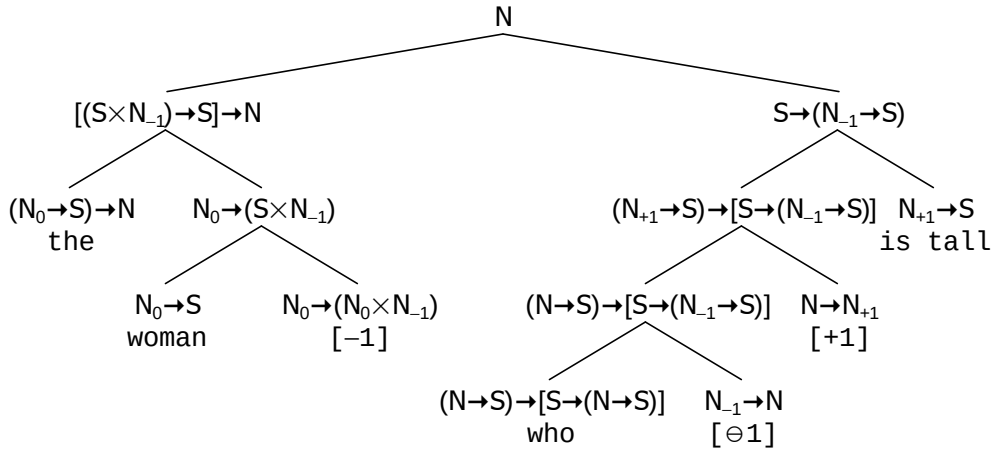
1. `the woman, who is tall` [non-restrictive]



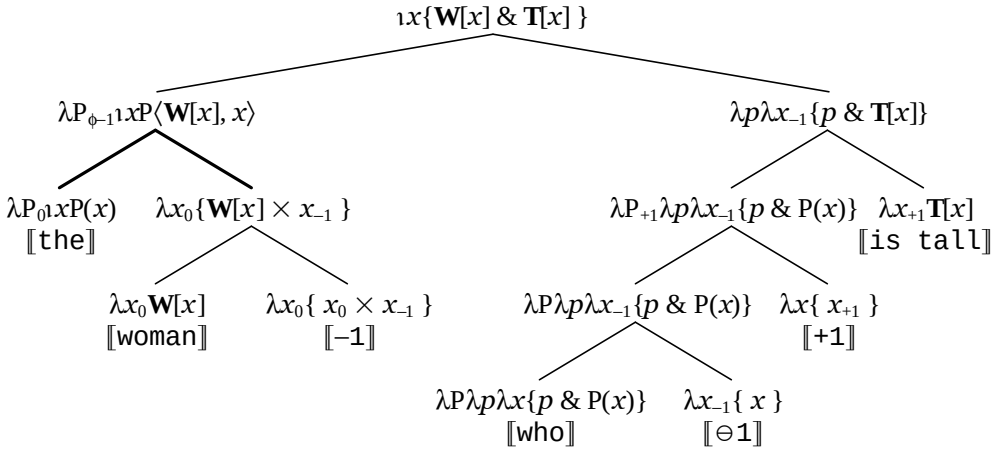
Note that the anaphoric-inflection `[−1]` is applied to the DP `'the woman'`. The following is the associated semantic tree.



2. `the woman who is tall` [restrictive]



Note that the anaphoric-inflection `[−1]` is applied to the CNP `'woman'`. Also note that an allomorph of `[−1]` applies to CNPs. The following is the associated semantic tree.



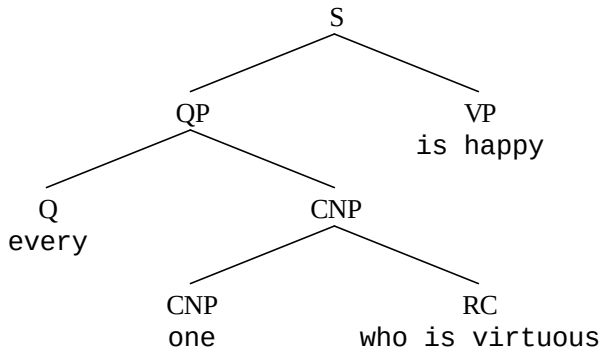
The key computation [bold-faced] is underwritten by the following derivation.

(1)	$(N_0 \to S) \to N$	1	Pr	$\lambda P_0\, \imath x\, P(x)$	
(2)	$N_0 \to (S \times N_{-1})$	2	Pr	$\lambda x_0 \{\mathbf{W}[x] \times x_{-1}\}$	
(3)	$(S \times N_{-1}) \to S$	3	As	$P_{\phi-1}$	$\lambda\langle p, x_{-1}\rangle P\langle p, x\rangle$
(4)	N_0	4	As	x_0	
(5)	$S \times N_{-1}$	24	2,4,→O	$\mathbf{W}[x] \times x_{-1}$	
(6)	S	234	3,5,→O	$P(\mathbf{W}[x] \times x)$	$P\langle \mathbf{W}[x], x\rangle$
(7)	$N_0 \to S$	23	4-6,→I	$\lambda x_0 P\langle \mathbf{W}[x], x\rangle$	
(8)	N	123	1,7,→O	$\imath x\, P\langle \mathbf{W}[x], x\rangle$	
(9)	$[(S \times N_{-1}) \to S] \to N$	12	3-8,→I	$\lambda P_{\phi-1} \imath x\, P\langle \mathbf{W}[x], x\rangle$	

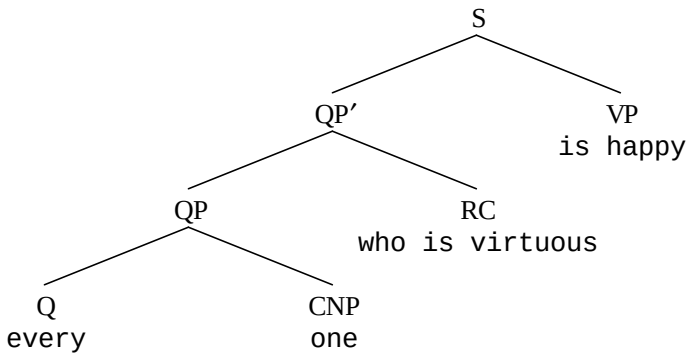
11. Further Examples

1. `everyone who is virtuous is happy`

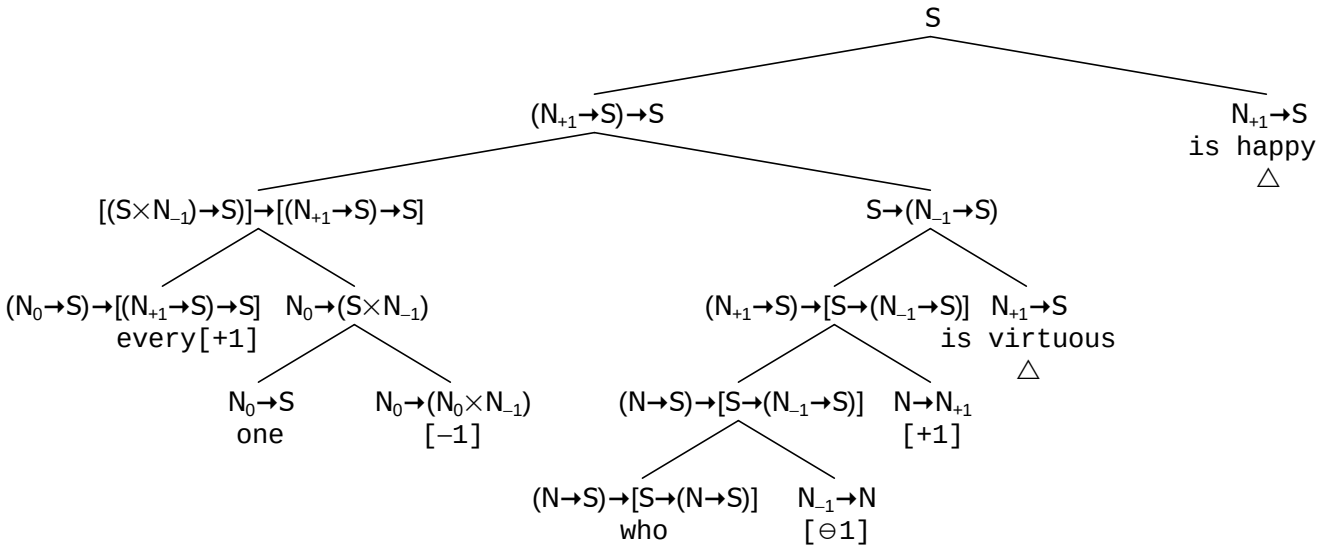
The phonetic and orthographic structure of this sentence evidently treats `'everyone'` as a constituent, yet the conventional analysis of relative clauses does not, proposing the following gerrymandered structure.



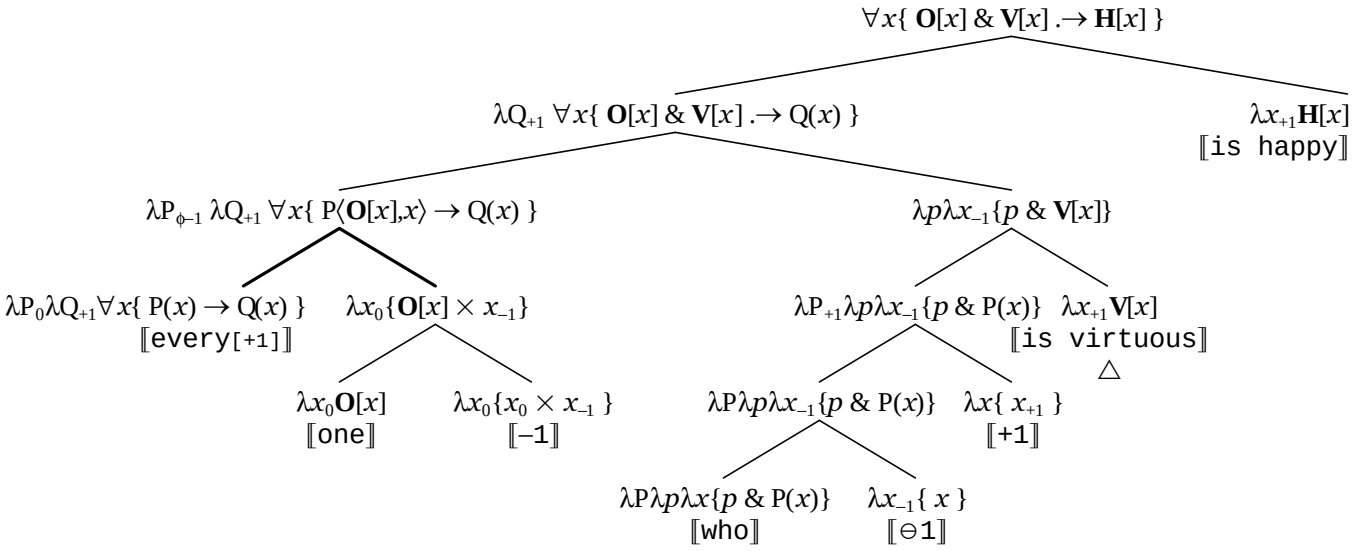
Our new proposal enables us to reunite `'every'` and `'one'`, as follows, to obtain the following overall structure.



The detailed structure is as follows.



The following is the associated semantic tree [where $\mathbf{O}[\alpha] =_{df} \lambda(\alpha \text{ is a person})$]



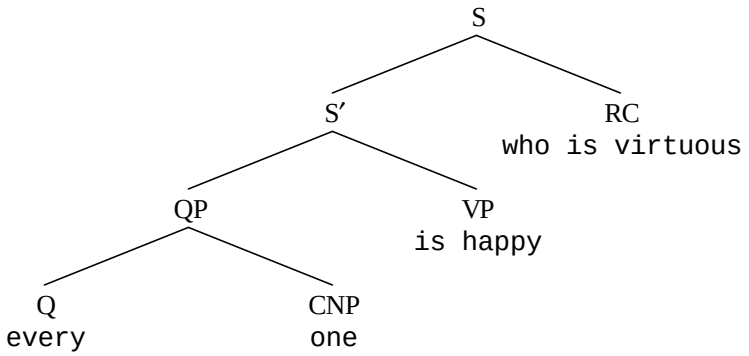
The key computation [bold-faced] is underwritten by the following derivation.

(1)	$(N_0 \to S) \to [(N \to S) \to S]$	1	Pr	$\lambda P_0 \lambda Q \forall x\{ P(x) \to Q(x) \}$	
(2)	$N_0 \to (S \times N_{-1})$	2	Pr	$\lambda x_0\{\mathbf{O}[x] \times x_{-1}\}$	
(3)	$(S \times N_{-1}) \to S$	3	As	$P_{\phi-1}$	$\lambda\langle p,x_{-1}\rangle P\langle p,x\rangle$
(4)	N_0	4	As	x_0	
(5)	$S \times N_{-1}$	24	2,4,→O	$\mathbf{O}[x] \times x_{-1}$	
(6)	S	234	3,5,→O	$P(\mathbf{O}[x] \times x)$	$P\langle \mathbf{O}[x], x\rangle$
(7)	$N_0 \to S$	23	4-6,→I	$\lambda x_0 P\langle \mathbf{O}[x], x\rangle$	
(8)	$(N \to S) \to S$	123	1,7,→O	$\lambda Q \forall x\{ P\langle \mathbf{O}[x], x\rangle \to Q(x) \}$	
(9)	$[(S \times N_{-1}) \to S] \to [(N \to S) \to S]$	12	3-8,→I	$\lambda P_{\phi-1} \lambda Q \forall x\{ P\langle \mathbf{O}[x], x\rangle \to Q(x) \}$	

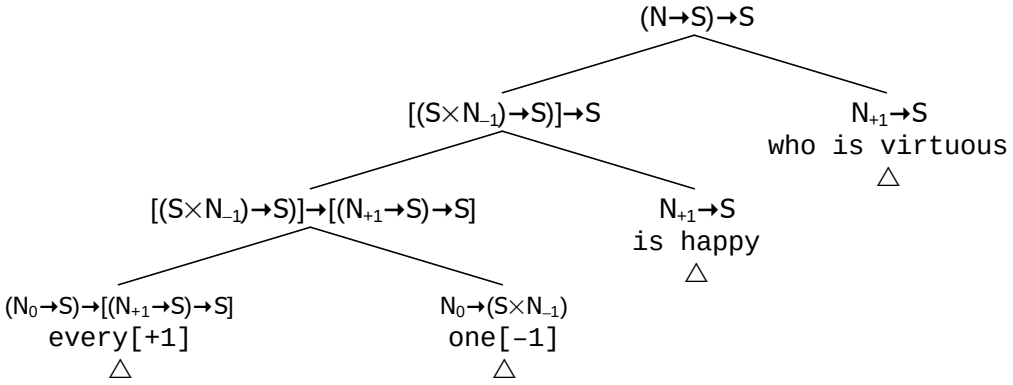
This example demonstrates how the new analysis of relative clauses allows them to be structurally separated from the common-noun phrase. The following example, which simply permutes the VP and the RC, demonstrates that they can be even further separated.

2. `everyone is happy who is virtuous`

The following is the overall structure.



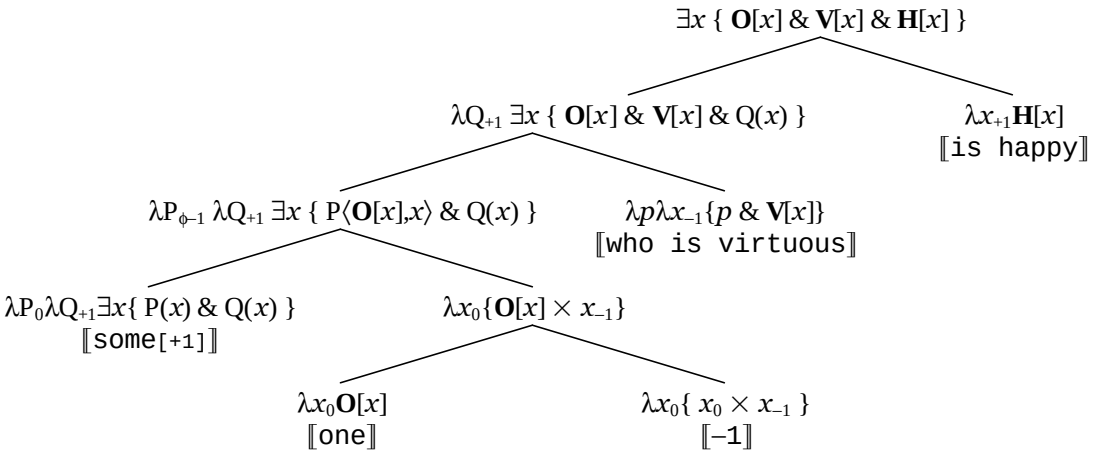
The overall categorial structure is as follows.



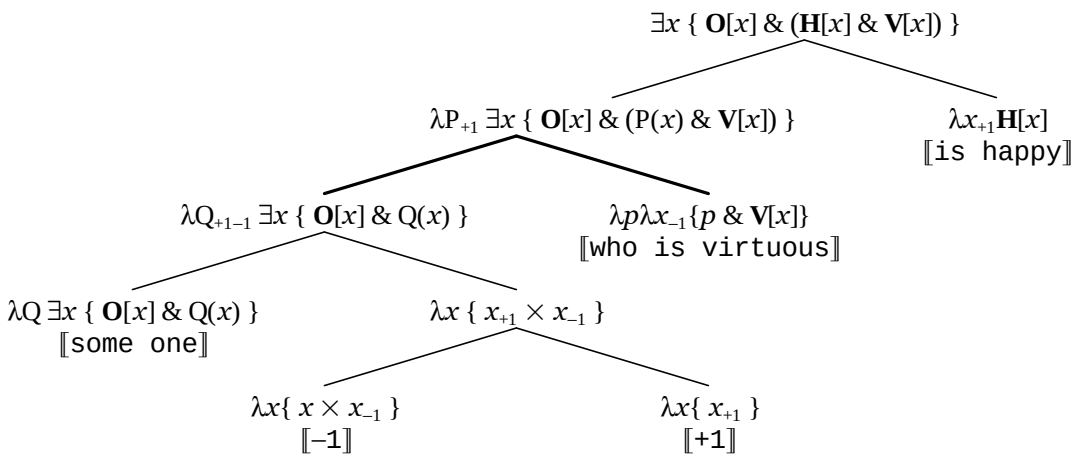
The associated semantic-tree is very similar to the previous example, and is left as an exercise.

The next two examples demonstrate that, on occasion, the restrictive and non-restrictive readings of a relative clause are equivalent.

3. `some one who is virtuous is happy` [restrictive]



4. `some one, who is virtuous, is happy` [non-restrictive]

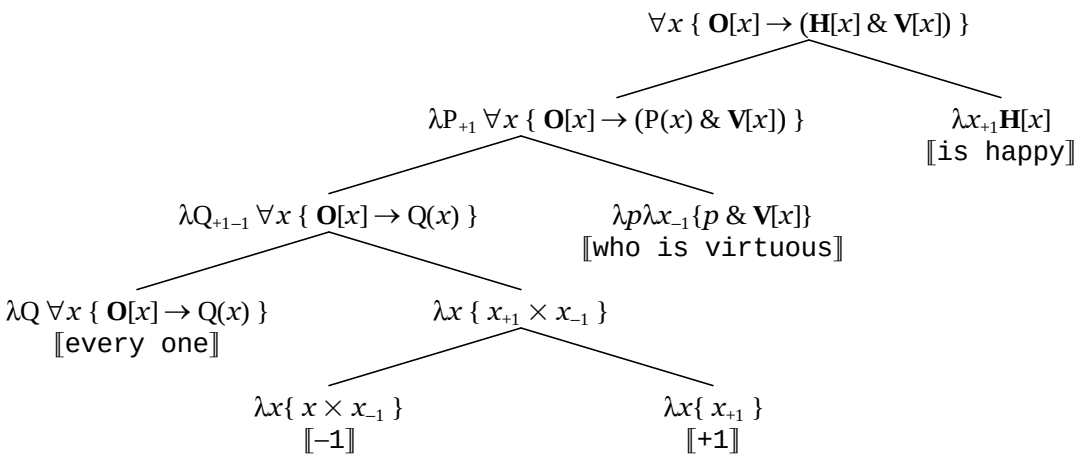


The key computation [bold-faced] is underwritten by the following derivation.

(1)	$[(N_{+1}\times N_{-1})\to S]\to S$	1	Pr	$\lambda Q_{+1-1}\,\exists x\{\ \mathbf{O}[x]\ \&\ Q(x)\ \}$	
(2)	$S\to(N_{-1}\to S)$	2	Pr	$\lambda p\lambda x_{-1}\{\ p\ \&\ \mathbf{V}[x]\ \}$	
(3)	$N_{+1}\to S$	3	As	P_{+1}	$\lambda x_{+1}P(x)$
(4)	$N_{+1}\times N_{-1}$	45	As	$x_{+1}\times x_{-1}$	$\langle x_{+1}, x_{-1}\rangle$
(5)	N_{+1}	4	$4,\times O_1$	x_{+1}	
(6)	N_{-1}	5	$4,\times O_2$	x_{-1}	
(7)	S	34	$3,5,\to O$	$P(x)$	
(8)	$N_{-1}\to S$	234	$2,7,\to O$	$\lambda x_{-1}\{\ P(x)\ \&\ \mathbf{V}[x]\ \}$	
(9)	S	2345	$6,8,\to O$	$P(x)\ \&\ \mathbf{V}[x]$	
(10)	$(N_{+1}\times N_{-1})\to S$	23	$4\text{-}9,\to I$	$\lambda\langle x_{+1}, x_{-1}\rangle\{\ P(x)\ \&\ \mathbf{V}[x]\ \}$	
(11)	S	123	$1,10,\to O$	$\exists x\{\ \mathbf{O}[x]\ \&\ P(x)\ \&\ \mathbf{V}[x]\ \}$	
(12)	$(N_{+1}\to S)\to S$	12	$3\text{-}11,\to I$	$\lambda P_{+1}\,\exists x\{\ \mathbf{O}[x]\ \&\ P(x)\ \&\ \mathbf{V}[x]\ \}$	

The final example exhibits a situation in which the non-restrictive reading of a relative clause is somewhat strange, but has a well-defined semantic interpretation that one should expect it to have. What makes the example grammatically treacherous is that `'every'` is syntactically-singular, but has a plural-like meaning.

5. every one, who is virtuous, is happy [non-restrictive]



This semantic tree suggests the following colloquial paraphrase of the parenthetical relative clause.

everyone is happy (and virtuous)